CHAPTER 7. LIQUID STREAM TREATMENT ALTERNATIVES

The McMinnville Water Reclamation Facility (WRF) has a history of consistent compliance with the treatment requirements set forth in its National Pollutant Discharge Elimination System (NPDES) permit. However, as the WRF faces increased flows and loads from a growing population and the potential for more restrictive future permit requirements, it will be necessary to upgrade many of the liquid stream treatment processes. The planning and implementation of these improvements will ensure that the WRF continues to satisfy its permit requirements in the years to come. The primary objective of this chapter is to evaluate long-term wastewater management program alternatives that address anticipated environmental, regulatory, growth, and community issues.

WASTEWATER MANAGEMENT STRATEGIES

Prior to evaluating each unit treatment process at the WRF, it is useful to consider potential long-term wastewater management strategies. These strategies represent “big-picture” approaches to wastewater treatment. This section presents evaluation criteria, the potential management strategies, alternative screening, and a recommended approach.

Management Strategy Evaluation Criteria

The criteria used to evaluate alternative management strategies include regulatory, conveyance and treatment of wet weather flows, operation and maintenance (O&M), and implementation. An effective management strategy includes a suite of treatment technologies and controls that provide the flexibility to meet the anticipated requirements.

Regulatory Criteria. In order to establish design criteria for future treatment facilities, it is necessary to consider anticipated future treatment requirements. Chapter 5 presents a detailed analysis of the anticipated treatment requirements. This section reviews key criteria.

- *Thermal Limits.* The current NPDES permit includes an excess thermal load limitation (weekly average - 160 Million Kcals/day). However, it is anticipated that the temperature TMDL for the South Yamhill River could be revised to include a more stringent thermal load allocation in the future. Hence, opportunities to reduce temperature should be considered in the planning process.
- *Nutrient Limits.* Summer ammonia concentration and mass limitations vary with South Yamhill River flow. The WRF has periodically experienced difficulty in complying with effluent ammonia limits in the past, although not in recent years.

  The existing TMDL sets phosphorus limits for the WRF. Based on an analysis of the available data, biological nutrient removal (BNR) alone may be adequate to meet the phosphorus limitation if it is expressed as ortho-P.

- *Mass Discharge Limits.* As plant flow increases above the current design flows, it will be necessary to decrease the effluent total suspended solids (TSS) and biochemical oxygen demand (BOD) concentrations in order to maintain compliance with mass discharge limits.
- *Mixing Zone.* The 2005 mixing zone study has been updated, and the minimum dilutions for the McMinnville outfall have been recalculated following the procedures established in the Regulatory Mixing Zone Internal Management Directive (DEQ, December 2007). These new dilutions are 1.4:1 at the ZID, based on 1Q10 low flow conditions, and 2.6:1 at the MZB, based on critical summer 7Q10 low flow conditions.
- *Toxics.* Using the new mixing zone dilutions and effluent data from June 2004 through June 2008, the Reasonable Potential Analysis (RPA) for the WRF indicated that there is not a reasonable potential for any metal or cyanide to cause an exceedance of aquatic life criteria in the receiving water. A similar result is obtained for human health criteria, except for arsenic. However, DEQ is currently not establishing effluent limitations based on the human health criteria for arsenic.
- *Metals.* Without the conservative assumptions embedded in the RPA calculations, the current effluent metal concentrations are all well below the regulatory thresholds.
- *Silver.* A preliminary RPA using the new mixing zone dilutions indicates that there may be a reasonable potential for silver toxicity. However, as stated above, this finding is based on the use of a multiplier to increase the actual effluent data. Also, an examination of the effluent data indicates that the silver effluent concentrations responsible for the positive reasonable potential finding could be considered as outlier values, and not representative of normal discharge conditions. The City is planning to make this case in the NPDES permit renewal application, and an effluent silver limitation is not expected in the permit. There are no known industrial silver dischargers, so both the source and the potential solution to reduce effluent silver concentrations are unclear at this time.
- *Turbidity.* The WRF complies with the current turbidity standards set in the NPDES permit. It is probable that a new turbidity standard may be approved in the future that may affect the turbidity limitation.
- *Mercury.* It is possible that a new permit effluent limit for mercury will be issued when the Willamette TMDL is revised – currently scheduled for 2011.
- *PBTs.* Persistent bioaccumulative and toxic (PBT) pollutants are chemicals that are toxic, persist in the environment, bioaccumulate in food chains, and pose risks to human health and ecosystems. PBTs are currently unregulated; however, concern over these constituents is increasing and they could be regulated in the future.

Wet Weather Criteria. The fundamental factor that will trigger the need to upgrade certain treatment processes is higher peak flows. The following factors should be considered:

- *Sanitary Sewer Overflows (SSOs).* Oregon’s current SSO rules prohibit overflows from the collection system during a less than 5-year 24-hour, wet weather storm and during a less than 10-year 24-hour summer storm. The WRF has reported SSOs in the past during peak flow events.

- Blending policy. Blending is defined as the practice of diverting excess flow around the secondary treatment system during peak flow events and recombining with secondary effluent prior to disinfection and discharge. The WRF was designed to operate using blending when flow exceeds the secondary treatment capacity of approximately 23 mgd. Future permits may not allow blending, thus alternatives considered for improvements to the WRF should include the possibility of no future blending.

- Bacteria standard compliance. When operating in a blended treatment mode during peak flow conditions, compliance with the bacteria standard can be challenging as the performance of the UV disinfection system is adversely affected by the dilute raw sewage.

O&M Considerations. The operation and maintenance of a wastewater treatment facility covers a broad spectrum of tasks required to assure reliable performance. The following factors were considered:

- *Increased Loading.* The ability to expand in order to accommodate growth needs to be considered in the planning process. From a financing perspective, it is often beneficial to expand treatment facilities incrementally as growth occurs.
- *Performance.* The recommended facility improvements should meet or exceed the anticipated treatment requirements.
- *Operational Flexibility.* The facility improvements should provide operational flexibility such as the ability to isolate equipment, operate in different modes and to control processes.
- *Reliability.* The recommended design for each unit process should be evaluated to ensure quality, proven performance, ability to take units out of service for maintenance, and bypassing capability.
- *Maintainability.* The design should consider non-proprietary components, parts availability.
- *Odors.* Recommended facilities should create minimal odor or suitable for addition of odor containment and treatment.
- *Environmental.* The recommended management strategy should minimize impacts to river quality, and minimize energy and chemical usage.

Implementation. To simplify implementation, the preferred management strategy should be compatible with the existing wastewater management program. Considerations under this criterion include:

- A capital improvement schedule with achievable cash flow demands
- Land availability
- Ability to maintain facilities in operation during construction.
- Acceptability to stakeholders and the public.

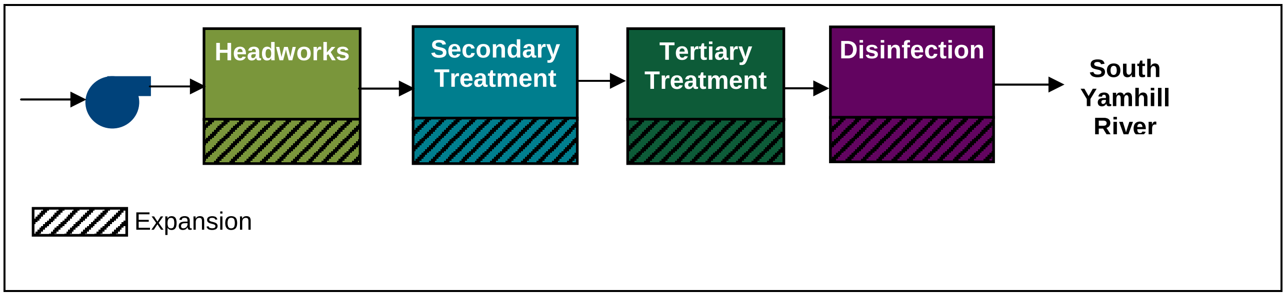
Development of Management Strategies

Based on the criteria outlined above, various management strategies were identified and reviewed in the October 10, 2007 workshop. This section presents a summary of dry weather and wet weather management strategies.

Dry Weather Strategies. Seven dry weather alternatives were identified:

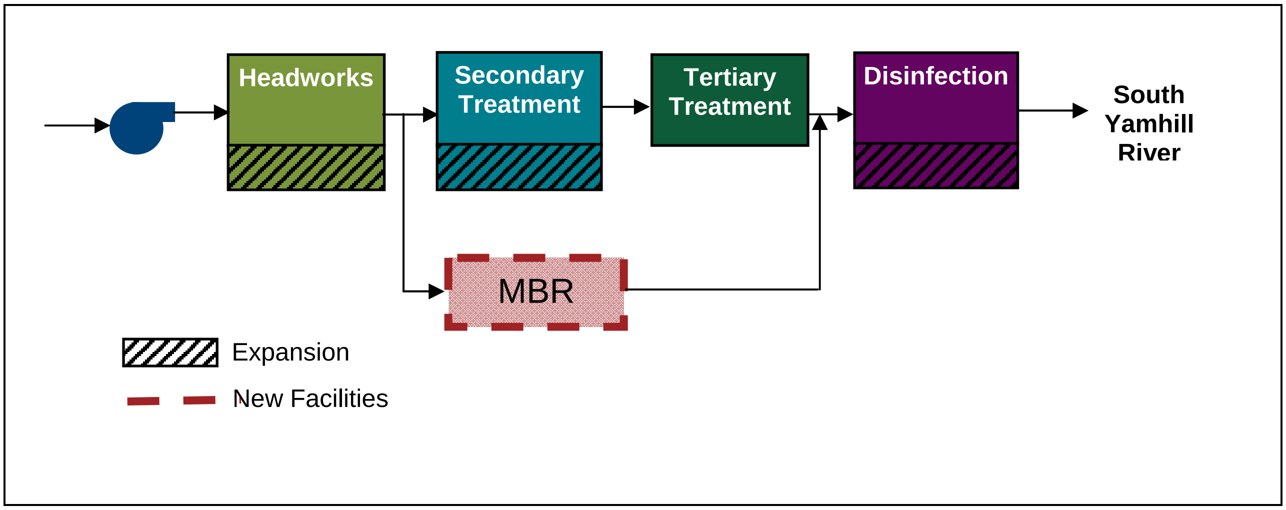
- *DW1. Expand Existing Facilities.* This alternative involves continued operation of the WRF in the same manner as it currently operates, except with expanded unit processes to accommodate the increase in flows and loads due to population growth and commercial/industrial development. A schematic of this alternative is presented in Figure 7-1.

Figure 7-1. Dry Weather Alternative Management Strategy: Expansion of Existing Facilities



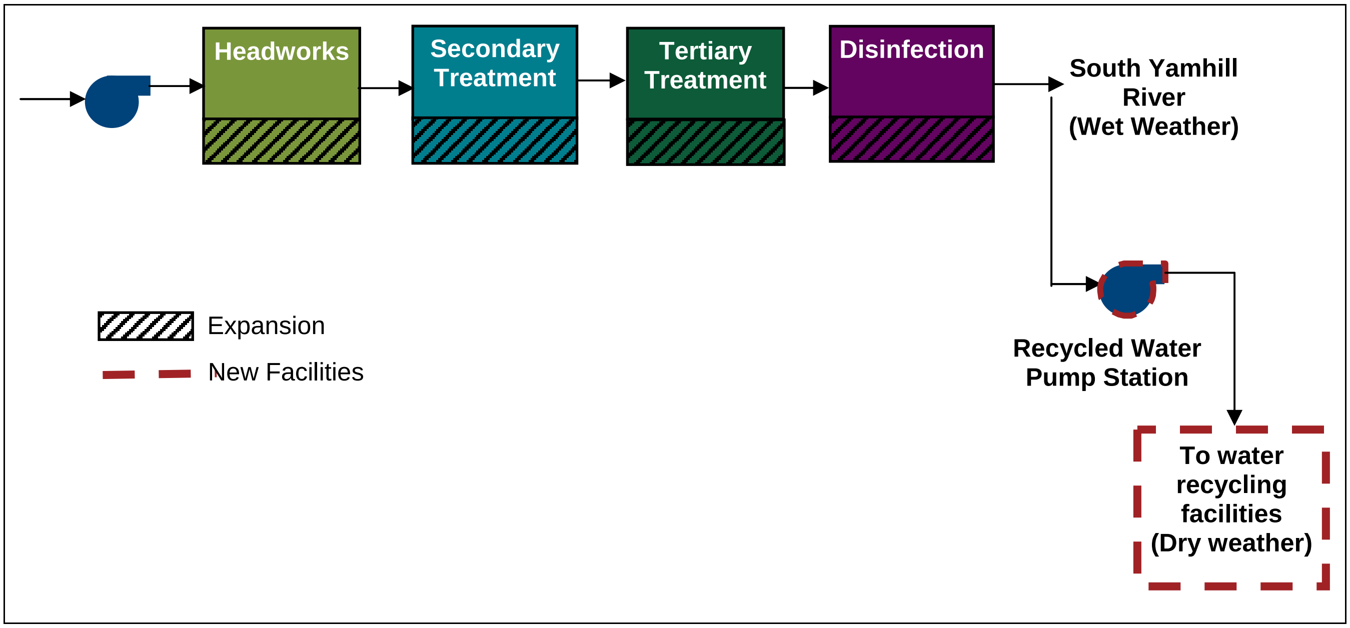
- *DW2. Membrane Treatment.* Under this alternative, a new membrane bioreactor (MBR) unit process would be added to provide secondary and tertiary treatment for a portion of the screened and degritted wastewater. The existing secondary and tertiary treatment units would continue to operate at their current capacity. A schematic of this alternative is presented in Figure 7-2.

Figure 7-2. Dry Weather Alternative Management Strategy: Membrane Treatment



- *DW3. Dry Weather Reuse.* In this alternative, the WRF would produce recycled water for urban and agricultural irrigation. Sufficient recycled water demands would be identified such that effluent discharge to the South Yamhill River would discontinue during the dry weather season. The reuse program would rely on deficit irrigation of crops to eliminate the need for storage reservoirs. That is, the recycled water would be applied to the crops at less than agronomic rates during peak demand periods. A schematic of this alternative is presented in Figure 7-3.

Figure 7-3. Dry Weather Alternative Management Strategy: Dry Weather Reuse



- *DW4. Zero Discharge.* This alternative would involve irrigation of disinfected tertiary effluent during the dry weather season and construction of storage basins to retain effluent during the non-irrigation season (wet weather). Based on a preliminary assessment, this alternative would require 5,200 acres of land during dry weather season for irrigation and a 780-acre, 15-foot-deep reservoir for storage during the wet weather season. A schematic of this alternative is presented in Figure 7-4.

- *DW5. Subsurface discharge.* Indirect discharge to the river by means of subsurface infiltration in conformance with DEQ's IMD for wastewater disposal into groundwater or hyporheic water would help the WRF achieve compliance with potential more stringent thermal limits by using shallow groundwater to cool the effluent before it reaches the river. A schematic of this alternative is presented in Figure 7-5.

- *DW6. Effluent cooling.* Another strategy for maintaining compliance with thermal limits is to provide mechanical cooling prior to discharge (Figure 7-6). The major components of an effluent cooling system for the WRF could include a mechanical chiller, cooling tower, or heat exchanger.

Figure 7-4. Dry Weather Alternative Management Strategy: Zero Discharge

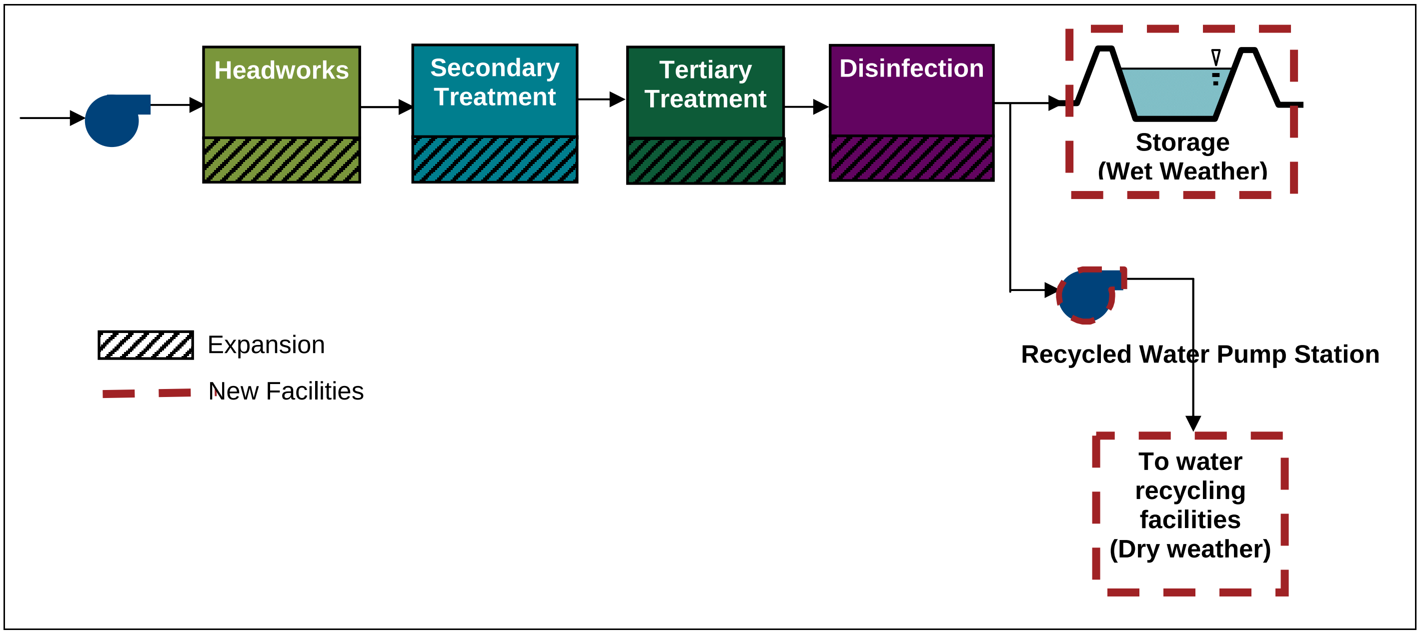
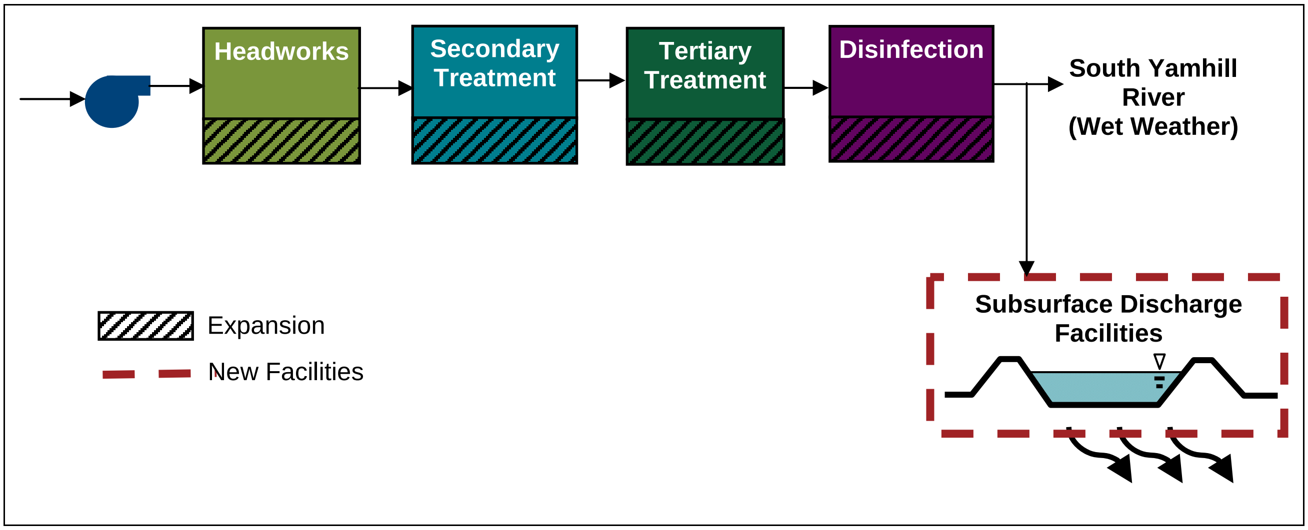


Figure 7-5. Dry Weather Alternative Management Strategy: Subsurface Discharge



- *<u>DW7. River temperature mitigation.</u>* In this alternative, the WRF would plant trees in riparian areas to provide shading and cool the river. In addition to providing temperature reduction benefits, planting trees along the river would also enhance riparian habitat, and can help combat stream bank erosion. This would likely involve trading temperature mitigation to meet the desired temperature limit.

- *<u>DW8.</u> Constructed Wetlands*. Constructed wetlands provide another opportunity for compliance with thermal limits. The shading provided by emergent wetlands cools the effluent prior to discharge (Figure 7-7). Discharge from the wetlands to the river could be via an outfall diffuser or subsurface discharge. Constructed wetlands are examined in greater detail in Chapter 9.

Figure 7-6. Dry Weather Alternative Management Strategy: Effluent Cooling

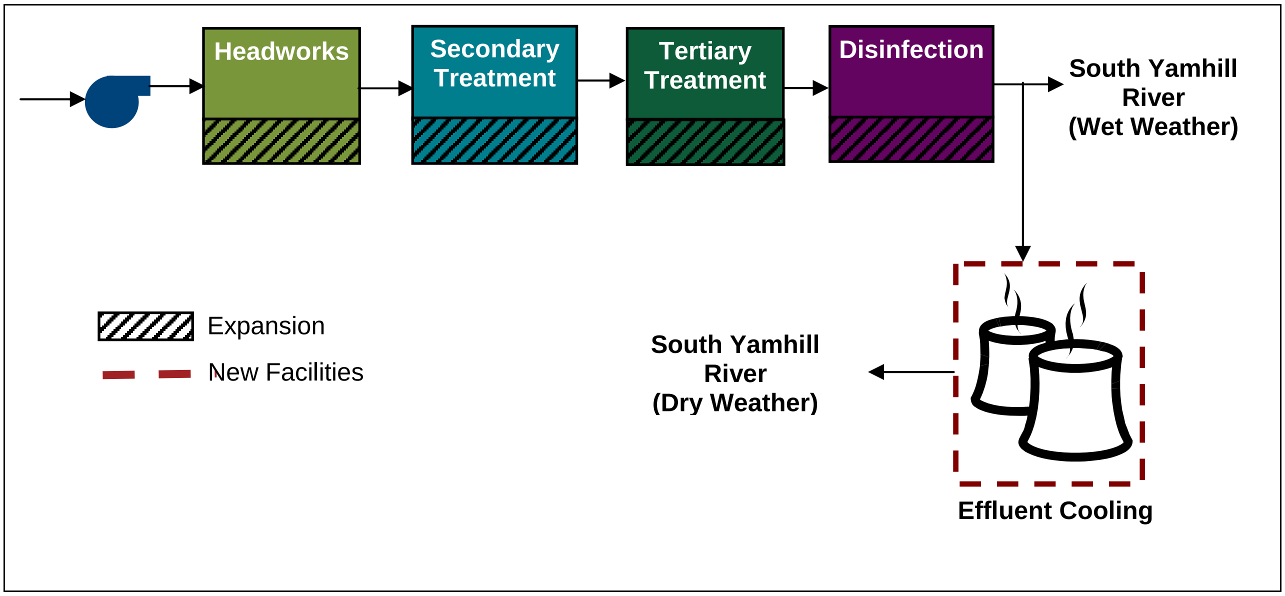
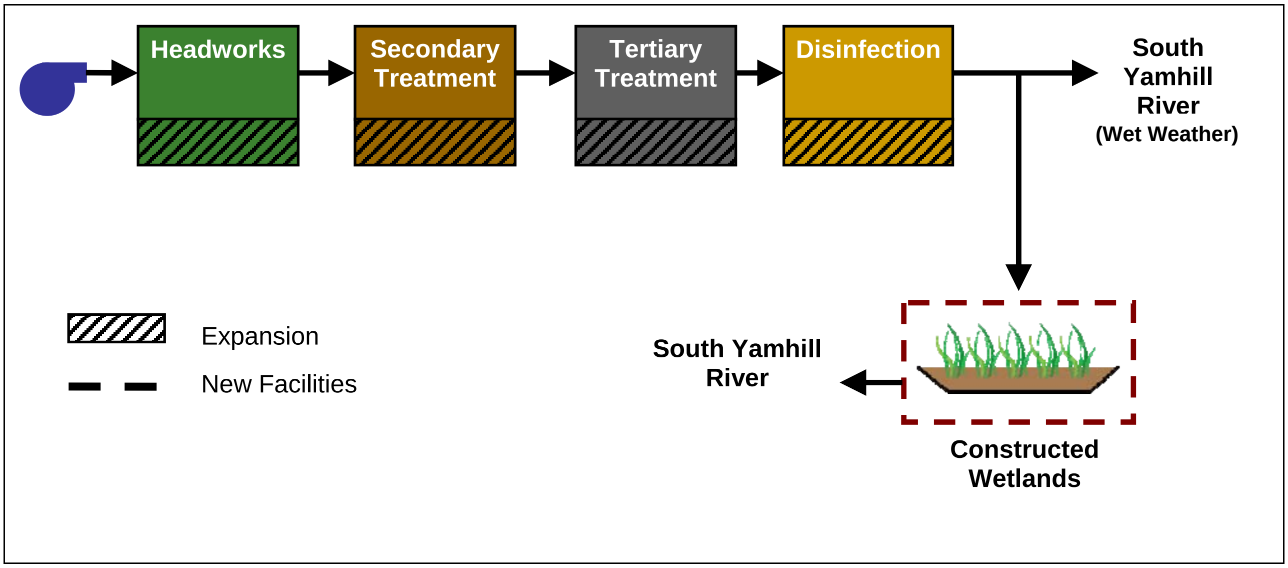


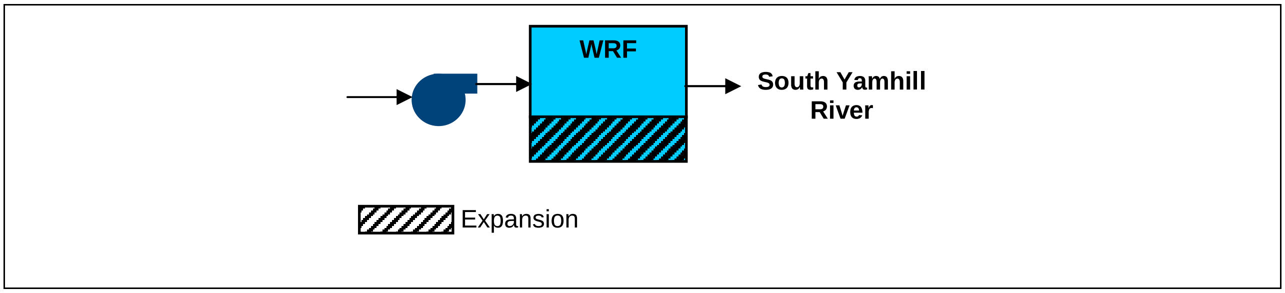
Figure 7-7 Dry Weather Alternative Management Strategy: Constructed Wetlands



Wet Weather Strategies. Five wet weather management strategies have been identified for consideration:

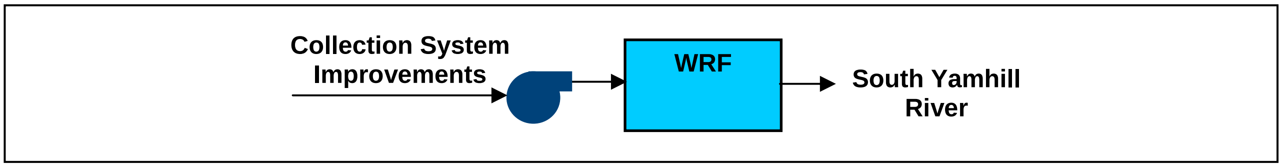
- *WW1. Expand WRF.* Under this strategy, the WRF would be expanded so that the entire peak flow receives secondary treatment prior to discharge during the wet weather season (Figure 7-8). Each unit process would be expanded to hydraulically allow for the treatment of the build-out peak hour flow of 55 mgd. The treatment processes requiring expansion include the headworks, aeration basins, secondary clarifiers, and the disinfection system. Expansions would also be required for the Raw Sewage Pump Station (RSPS), influent force mains, and outfall.

Figure 7-8. Wet Weather Alternative Management Strategy: Expansion of WRF



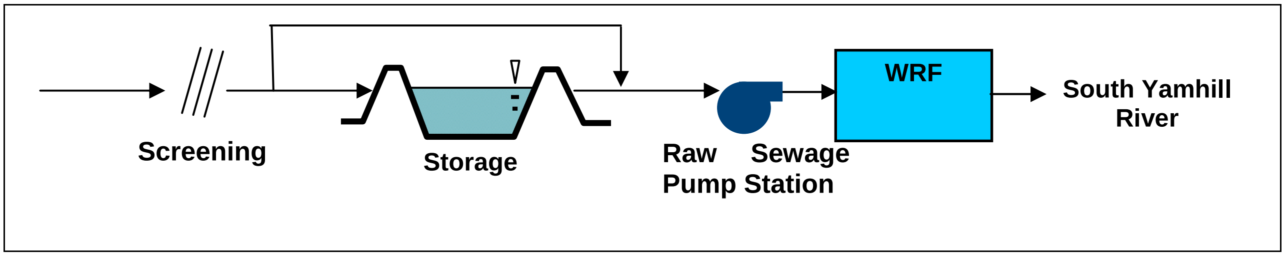
- *WW2. Collection System Improvements.* In this alternative, it is assumed that collection system rehabilitation work in the WRF's service area would be sufficient to reduce the peak flow entering the treatment facility such that no significant hydraulic expansions would be required (Figure 7-9).

Figure 7-9. Wet Weather Alternative Management Strategy: Collection System Improvements



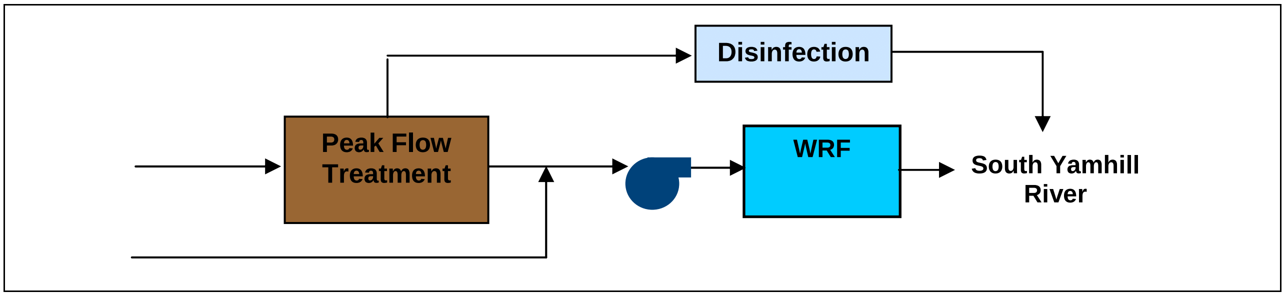
- *WW3. Peak Flow Attenuation Through Storage.* Under this alternative, peak flows in excess of the WRF's capacity would be screened and temporarily stored. The stored wastewater would be routed back to the WRF after the high influent flows subside. By attenuating peak wet weather flows in this manner, the required hydraulic capacity of many unit processes at the WRF would be reduced, thus eliminating the need for capacity expansions. This strategy would require construction of sufficient raw sewage storage capacity for the anticipated flows in excess of the WRF's treatment capacity. The most convenient location for such a storage facility would be the old McMinnville treatment plant site. A schematic of this alternative is presented in Figure 7-10.

Figure 7-10. Wet Weather Alternative Management Strategy: Peak Flow Attenuation Through Storage



- *WW4. Satellite Treatment Facilities.* This alternative involves treatment of excess peak flows using a ballasted sand sedimentation system at the old treatment plant site. Actiflo® is a ballasted sand sedimentation process manufactured by Kruger. The system utilizes a flocculating clarification process which incorporates microsand ballasting to enhance solids removal. The ballasting results in a floc with rapid settling characteristics. This process is ideal for high wet weather flows, due to its small footprint and rapid start up time. A schematic of this alternative is presented in Figure 7-11.

Figure 7-11. Wet Weather Alternative Management Strategy: Satellite Treatment Facility



- *WW5. Peak Flow Treatment Facilities at WRF*. This alternative is similar to the previous alternative; however, the ballasted sand sedimentation system would be constructed at the WRF site. This set-up would enable the plant personnel to use the system during wet weather season for peak flow treatment. During dry weather season, the process could be used to enhance phosphorus removal with the addition of alum. Capacity expansions to the RSPS, influent force mains, and outfall would be required.

Management Strategy Screening

An assessment of each wastewater management strategy is crucial to help guide the subsequent facilities planning. An initial assessment of wastewater management strategies was conducted at an October 10, 2007 workshop with WRF personnel (Table 7-1). This section screens dry and wet weather management strategies based on the criteria discussed above and issues developed at the workshop. The results of the screening process are summarized in Table 7-1 and discussed below.

Screening of Dry Weather Strategies. In most cases, it is most cost effective to utilize existing treatment capacity whenever possible. The exceptions to this generality are when existing facilities are in poor condition or are not capable of meeting performance requirements. Neither of these conditions apply to the WRF at the current time. Consequently, all dry weather strategies would retain the WRF's existing liquid stream treatment processes. The screening process is summarized as follows:

- Strategy *DW1. Expand Existing Facilities* increases the capacity the WRF with similar treatment processes. In reviewing Table 7-1, it becomes apparent that this strategy is applicable if regulatory requirements do not change appreciably in the future.

Table 7-1. Initial Management Strategy Assessment from October 2007 Workshop

Alternative Strategy	Wet Weather Issue				Dry Weather Issue							
	Increased Flows and Loads	Elimination of SSOs	Elimination of Blended Treatment	Compliance with Bacteria Standard	Stringent Mass Limits	Stringent Nutrients Limits	Stringent Thermal Limits	Toxics Compliance Issues	Stringent Turbidity Limits	Elimination of Daily Mass Discharge Exemption	PBTs	Reliability Improvements
Dry Weather Strategies												
Expand Existing Facilities	🟦	🟦										
Membrane Treatment	🟦				🟦	🟦		🟦	🟦			
Dry Weather Reuse					🟦	🟦	🟦	🟦	🟦			
Zero Discharge											🟦	
Subsurface discharge						🟦	🟦	🟦	🟦			
Effluent cooling							🟦					
River temperature mitigation							🟦					
Constructed Wetlands							🟦					
Wet Weather Strategies												
Expand WRF	🟫	🟫	🟫	🟫								
Collection System Improvements	🟫	🟫	🟫	🟫								
Peak Flow Attenuation Through Storage	🟫	🟫	🟫	🟫						🟫		🟫
Satellite Treatment Facilities	🟫	🟫	🟫	🟫								
Peak Flow Treatment Facilities at WRF	🟫	🟫	🟫	🟫								

🟦 **Meets Dry Weather Criteria**

🟫 **Meets Wet Weather Criteria**

- Strategy *DW2. Membrane Treatment* is similar to Strategy DW1 with the exception that secondary and tertiary treatment process expansion is accomplished through the addition of an MBR. While MBRs create high quality effluent, they are significantly more expensive than conventional treatment processes and have limited peak flow handling capability. However, technological advances in membrane technology have resulted in decreased membrane costs over time – at least relative to other treatment options. This strategy could help achieve permit compliance with possible future, more stringent mass discharge and nutrient limits (Table 7-1).
- Strategy *DW3. Dry Weather Reuse* would add effluent reuse to an expanded WRF (Strategy *DW1*). Effluent reuse would permit compliance with a wide range of potential future regulatory issues, including temperature and toxic substances.
- Strategy *DW4. Zero Discharge* would be by far the most expensive and difficult to implement, requiring nearly 10 square miles of land. Assuming a land cost of $10,000 per acre, the cost of land alone would exceed $60 million. Adding the cost of treatment facility expansions; conveyance pump stations and pipelines; and irrigation systems would make this strategy essentially financially infeasible. In addition, the difficulties that would be faced in acquiring over 6,000 acres of suitable, nearby agricultural land could be nearly insurmountable. This strategy is eliminated due to high cost and implementation difficulty.
- Strategies *DW5. Subsurface Discharge, DW6. Effluent Cooling, DW7. River Temperature Mitigation* and *DW8. Constructed Wetlands* are all essentially Strategy *DW1* with additional measures taken to comply with potentially more stringent thermal discharge restrictions. These strategies do not offer significant advantages in compliance with potential future more stringent limits for mass discharges, toxics, or nutrients (Table 7-1). Strategy *DW6. Effluent Cooling* would be comparatively complex and energy intensive and is therefore eliminated from further consideration. Subsurface discharge, reuse, mitigation, and wetlands are all generally recognized as more cost effective and considered more environmentally beneficial from a holistic perspective. Consequently, these strategies are retained for further consideration.

The remaining dry weather wastewater management strategies consist of:

- *DW1.* Expand Existing Facilities
- *DW2.* Membrane Treatment
- *DW3.* Dry Weather Reuse
- *DW5.* Subsurface Discharge
- *DW7.* River Temperature Mitigation
- *DW8.* Constructed Wetlands

Screening of Wet Weather Strategies. As discussed previously, work conducted as part of the *Conveyance System Master Plan* concluded that Strategy *WW2. Collection System Improvements* is the most cost effective approach. The screening matrix in Table 7-2 indicates that this strategy also is most beneficial from a non-economic standpoint.

As discussed in the *Conveyance System Master Plan*, validation of infiltration and inflow (I/I) removal success is a key element of Strategy *WW2*. If the validation process, recommended to first occur in 2010, indicates that I/I removal success does not conform to projected levels, reevaluation of the cost effectiveness of this strategy would be warranted and the recommended strategy should be revisited. Consequently, all wet weather management strategies are retained.

Recommended Wastewater Management Strategies

Two primary uncertainties affect the evaluation of wastewater management strategies:

- Future regulatory requirements (dry weather)
- Effectiveness of collection system rehabilitation program (wet weather)

The most effective response to uncertainty is program flexibility. In addition, basing initial capital expenditures on “favorable” outcomes of uncertain conditions minimizes the potential for incurring costs for facilities that later prove to be unnecessary.

Recommended Dry Weather Strategy. Future regulatory requirements are the driving force behind dry weather management strategy selection. As discussed above, all of the dry weather management strategies discussed above incorporate the WRF’s existing liquid stream treatment facilities. Consequently, the long-term management strategy can be viewed as phasing improvements to accommodate changing regulatory demands. The starting point in this phased approach – and therefore the recommended management strategy – is *DW1. Expand Existing Facilities*. If regulatory requirements change in the future, the screening matrix provided in Table 7-2 can be used as a guide to update management strategy selection as dictated by the nature of the changes.

Recommended Wet Weather Strategy. Much like dry weather management strategies, implementation of the appropriate wet weather strategy can be viewed as a phased process. Based on information currently available, *WW2. Collection System Improvements* is the most cost effective and is therefore recommended. In addition, there is relatively little risk that rehabilitating portions of the collection system would result in significant non-beneficial expenditures. As discussed previously, the City should periodically review the effectiveness of collection system rehabilitation through monitoring, modeling, and updating the cost effectiveness analysis. If these reviews indicate that a modified approach is warranted at some point in the future, adjustments can be made at that time.

WRF Design Peak Flow Capacity

The cost effectiveness analysis for I/I removal and peak flow reduction presented in Chapter 6 of the *Conveyance System Master Plan* concluded the following:

- Providing peak flow attenuation through storage is not cost effective.
- The most cost effective approach for current conditions is to maintain the WRF’s current peak flow capacity of 32 mgd and reduce peak flows to match this capacity through collection system rehabilitation.

Table 7-2. Wastewater Management Strategy Screening Matrix

	Dry Weather/Regulatory Criteria								Wet Weather Criteria					Operation and Maintenance Criteria								
Strategy	Stringent Dry Weather Mass Limits	Stringent Nutrient Limits	Stringent Thermal Limits	Toxics and Metals Compliance Issues	Effluent Silver Limits	Stringent Turbidity Limits	Elimination of Daily Mass Discharge Exemption	PBTs	Increased Peak Flows	Stringent Mass Limits	Elimination of Blended Treatment	Elimination of SSOs	Compliance with Bacteria Standard	Increased loading	Performance	Operational flexibility	Reliability	Maintainability	Odors	Environmental	Implementation	Relative cost
Dry Weather Strategies																						
DW1. Expand Existing Facilities	0	0	-	-	-	0	0	-	+	NA	+	NA	0	+	0	0	+	+	0	0	+	+
DW2. Membrane Treatment	+	+	-	-	-	+	+	-	-	+	0	NA	0	+	+	+	0	-	0	-	+	-
DW3. Dry Weather Reuse	+	+	+	+	+	+	+	+	NA	NA	NA	NA	NA	+	+	+	+	-	0	+	-	-
DW4. Zero Discharge	+	+	+	+	+	+	+	+	NA	+	NA	NA	+	+	+	0	+	-	-	0	-	-
DW5. Subsurface Discharge	-	-	+	0	0	+	-	-	NA	NA	NA	NA	NA	+	0	+	0	0	0	+	-	-
DW6. Effluent Cooling	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-	NA	-	+	-
DW7. River Temperature Mitigation	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	+	NA	+	-	-
DW8: Constructed Wetlands	NA	NA	+	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	0	0	+	-	-
Wet Weather Strategies																						
WW1. Expand WRF	NA	NA	NA	NA	NA	NA	NA	NA	+	-	-	NA	-	+	0	+	0	0	0	-	+	-
WW2. Collection System Improvements	NA	NA	NA	NA	NA	NA	NA	NA	+	+	+	+	+	NA	0	0	+	0	0	+	-	+
WW3. Peak Flow Attenuation Through Storage	NA	NA	NA	NA	NA	NA	NA	NA	+	0	+	+	+	NA	+	+	+	-	-	-	-	-
WW4. Satellite Treatment Facilities	NA	NA	NA	NA	NA	NA	NA	NA	+	-	0	+	+	NA	-	+	0	-	-	-	-	-

Legend
+ = Positive 0 = Neutral - = Negative NA = Not Applicable

- Improvements should initially be based on the 5-year, 24-hour storm with no antecedent precipitation.
- Improvements should focus on collection system rehabilitation as opposed to conveyance and treatment improvements.

A phased approach to peak flow management was recommended. The initial phase of improvements should include select collection system rehabilitation projects as well as the means to define system performance and assess I/I reduction levels resulting from these initial rehabilitation efforts. To achieve this, permanent flow monitors would be placed in the system and the resulting data combined with monitored flows at select pump stations and routinely analyzed. This would also provide the ability to assess the accuracy of hydraulic model predictions, and develop refinements.

The *Conveyance System Master Plan* further recommended that the City reevaluate this approach in 2010 and thereafter in conjunction with discharge permit renewals. These re-evaluations would determine if any refinements are warranted and would include:

- Update the model based on collection system flow monitoring data.
- Assess the effectiveness of rehabilitation efforts based on monitoring data and the updated model.
- Update the cost-effectiveness determination (rehabilitation/conveyance/treatment/storage) based on the latest available information.
- Review compliance history and actual consequences of overflows.
- Adjust design storm selection and peak flow management approach as appropriate.

Until this re-evaluation is completed, WRF improvements will be based on the recommended 32 mgd peak hour flow (PHF) design capacity. It is recognized that the collection system rehabilitation work will also reduce I/I during other wet weather high flow conditions. In contrast, average wet weather flow rates and all dry weather flow rates would be essentially unaffected. Therefore, given the recommended PHF of 32 mgd and the average flows presented in Chapter 4, it is possible to develop updated flow estimates for use in evaluating and sizing WRF treatment facilities. The approach used to develop the flow estimates relied both on additional collection system modeling (for MDWWF), and recurrence probability techniques described in DEQ flow analysis guidelines (for MWWWF). The resulting WRF design flows are summarized in Table 7-3.

Table 7-3. WRF Design Flows after Collection System Rehabilitation

Description	Existing	Buildout
Wastewater Flows:		
Base Residential Sanitary Flow	1.7	2.5
Base Commercial/Industrial Sanitary Flow	1.0	2.6
Base Sanitary Flow	2.7	5.1
Dry Weather Infiltration	0.6	1.0
Average Summer Flow (ASF)	3.0	5.6
Average Dry Weather Flow (ADWF)	3.3	6.1
Average Annual Flow (AAF)	5.4	10
Average Wet Weather Flow (AWWF)	7.2	12
Maximum Month Dry Weather Flow (MMDWF)	6.1	11
Maximum Week Dry Weather Flow (MWDWF)	7	12
Maximum Day Dry Weather Flow (MDDWF)	12	20
Maximum Month Wet Weather Flow (MMWWF)	12	20
Maximum Week Wet Weather Flow (MWWWF)	22	26
Maximum Day Wet Weather Flow (MDWWF)	31	31
Peak Hour Flow (PHF)	32	32

Influent Pumping and Preliminary treatment Alternatives

All influent pumping is currently provided at the Raw Sewage Pump Station (RSPS) located at the old treatment plant site. Preliminary treatment facilities are presently provided in two locations – at the RSPS site and at the WRF. These consist of a mechanically-cleaned coarse screen just upstream of the RSPS, two continuously-cleaned screens at the WRF and a vortex grit removal tank at the WRF. All influent pumping will continue to be provided at the RSPS site. Both locations were evaluated for expansions to the preliminary treatment facilities in the event that significant hydraulic expansions and/or peak flow storage facilities were needed. Since the projected buildout PHF is within the capacities of the existing facilities, no storage will be required and the significant expense of alternative preliminary treatment strategies would not result in a benefit to the plant. Consequently, no further development of these options was prepared.

Raw Sewage Pump Station

Since the projected PHF to the Raw Sewage Pump Station (RSPS) is within the current firm pumping capacity of the station, no capacity expansion will be required. Improvement recommendations are therefore directed at correcting the operational and maintenance issues associated with the station previously identified in Chapter 3. These include:

1. Vibration study and corrective measures
2. Pump and screen programming changes

3. Suction valve maintainability improvements
4. Drain pump replacement
5. Structural repairs
6. Pipe support modifications
7. Electrical Switchgear repairs and maintenance

Each of these recommendations is discussed in Chapter 10.

Screening at the WRF Headworks

Projected peak hour flow conditions match the original design capacity of the existing WRF influent screening facilities. Consequently, improvements are limited to providing added component reliability and correcting current performance issues as described in Chapter 3.

Improvement Alternatives. The following alternatives were identified for influent screening enhancements at the WRF headworks:

- Screening Alternative 1: Add a third screen channel and mechanically cleaned screen. This alternative would provide sufficient redundancy so that the facility would be able to handle the PHF with one screen out of service.

- Screening Alternative 2: Add a bypass channel. This alternative is similar to Screening Alternative 1 except that the new channel would be equipped with a manually cleaned screen.

- Screening Alternative 3: Provide an automatic screen lifting system. This alternative would add an automatic lifting system to the existing influent screens so that they would be pulled from the channel in the event that they fail to prevent hydraulic overloading of the remaining screen, and possible overtopping of the screening channels.

Hydraulic Considerations. The existing two mechanical screens each have a rated hydraulic capacity of 17 mgd. Consequently, a single screen would be able to provide adequate capacity during all dry weather flow conditions and two screens have sufficient capacity for projected peak flow conditions. Consequently, during peak flow events, the facility is at risk of flooding if one of the mechanical screens were to be unavailable.

Removing an inoperable screen from its channel would relieve any hydraulic restrictions. However, it would also result in most of the flow preferentially passing through the open channel as the remaining screen would impart headloss even though it remained fully operational.

A third channel (with either a manual or mechanically-cleaned screen) would provide the redundant hydraulic capacity required to handle peak flow conditions in the event of the loss of one of the mechanical screens.

Hydraulic conditions in the downstream grit removal and flow splitter structures have resulted in the operating water depths in the screen channels that are deeper than anticipated. Consequently, velocities in the channels are lower than optimal, resulting in conditions favorable to the settling of grit material in the screening channels.

Economic Evaluation of Alternatives. Estimated capital costs for the three influent screening alternatives are presented in Table 7-4.

Table 7-4. Capital Cost Comparison of Influent Screening Alternatives

	Alternative Capital Cost, $1,000		
	Alternative 1: Additional Channel & Mechanical Screen	Alternative 2: Additional Channel & Manual Screen	Alternative 3: Automatic Screen Lifting System
Building Modifications	352	148	27
Mechanical & Piping	253	83	34
Electrical/I&C (20%)	121	46	12
Subtotal	726	277	73
General Conditions (10%)	73	28	7
Contractor's Overhead & Profit (15%)	109	42	11
Subtotal	908	347	91
Contingencies (30%)	272	104	27
Subtotal	1,180	451	118
Engineering & Administration (25%)	295	113	30
Total Capital Cost	1,475	564	148

Estimated annual operation and maintenance costs for the three screening alternatives are presented in Table 7-5.

The least cost alternative is Alternative 3 – the automatic screen lifting system. Control of this system would use an upstream channel level monitoring system that would be used to activate the lifting mechanism. The upstream channel covers would also need to be replaced so that they could be moved out of the way when a screen was lifted.

Alternatives 1 and 2 would be significantly more expensive than Alternative 3 due to the need to construct a parallel channel in the existing structure and provide a means of incorporating the parallel channel into the existing flow scheme.

Alternative 1 would be the most expensive alternative due to the installation of another mechanically-cleaned screen and the need to expand screenings room to the east.

Table 7-5. Operation and Maintenance Cost Comparison of Influent Screening Alternatives

	Alternative O&M Cost, $1,000		
	Alternative 1: Additional Channel & Mechanical Screen	Alternative 2: Additional Channel & Manual Screen	Alternative 3: Automatic Screen Lifting System
Labor	25	5	10
Maintenance Materials	3	1	1
Total Annual O&M	28	6	11

A present worth cost comparison for the three screening alternatives are presented in Table 7-6.

Table 7-6. Economic Comparison of Influent Screening Alternatives

	Alternative Costs, $1,000		
	Alternative 1: Additional Channel & Mechanical Screen	Alternative 2: Additional Channel & Manual Screen	Alternative 3: Automatic Screen Lifting System
Total Capital Cost	1,475	564	148
Total Annual O&M Cost	28	6	11
Total Present Worth	1,809	636	279

Non-Economic Evaluation of Alternatives. The comparison of non-economic factors for influent screening alternatives is presented in Table 7-7.

Grit Removal

Improvements to the WRF’s grit removal facilities are needed to provide sufficient capacity at the projected PHF flow condition at the plant and to correct operational and performance deficiencies that were identified in Chapter 3.

Table 7-7. Non-Economic Comparison of Influent Screening Alternatives

Evaluation Criteria	Alternative 1: Add Channel & Mechanical Screen	Alternative 2: Add Channel & Manually-Cleaned Screen	Alternative 3: Automatic Screen Lifting System
Operation & Maintenance Considerations	Some additional maintenance required to care for the additional mechanical screen.	Use of bypass channel would require regular operator attention during use to insure that the manual screen remained clear enough to pass the needed flow.	No manual cleaning of screens would be required. However, during screen failure large solids would pass to downstream processes and would be more difficult to remove from these locations.
Reliability	No interruption in screening function would occur during an equipment outage.	No interruption in screening function would occur during an equipment outage although screening effectiveness would be reduced due to larger openings in the manual screen.	Potential impacts downstream due to bypassing of the influent screens when a unit has been raised.
Odors	Standby channel will need to be kept clean to avoid odor nuisances.	Standby channel will need to be kept clean to avoid odor nuisances.	No change to existing situation.
Flexibility	Additional options for removing a screen from service	No change	No change
Complexity	Moderately simple. Standby screen channel would be activated whenever a mechanically cleaned screen failed and when flows exceeded capacity of remaining screen. Standby screen would need to be activated.	Simplest. Standby manual screen channel would be activated whenever a mechanically cleaned screen failed and when flows exceeded capacity of remaining screen.	Additional monitoring of water levels in screening channels required. Screen lifting would be initiated upon detection of high water level plus failed screen mechanism.
Energy Use	No measurable effect.	No measurable effect.	No measurable effect.

Improvement Alternatives. The following alternatives were identified for providing grit removal.

- Alternative 1: One additional, identically-sized, vortex tank would be constructed adjacent to the existing tank as contemplated in the original design to provide sufficient capacity for the PHF condition and to enable plant staff to remove one grit tank from service during dry weather. This option would include modifications to the existing grit tank to correct existing hydraulic deficiencies.
- Alternative 2: Replace the vortex tank with an aerated grit removal system at the WRF sized to handle the projected PHF condition. At least two aerated grit tanks would be constructed in order to enable WRF staff to remove one from service for maintenance during dry weather.

Of these alternatives, the only one that would be viable would be the construction of an additional vortex grit removal tank. Aerated grit tanks are more expensive than vortex tanks due to their larger volume and the greater use of mechanical equipment. Furthermore, the existing headworks area lacks the room to replace the vortex tank with aerated grit tanks. Consequently, aerated grit removal would only be feasible if the entire headworks facilities were relocated to a different portion of the plant. The cost of accomplishing this would be prohibitive. The estimated cost of adding an additional vortex grit removal tank is summarized in the Table 7-8.

Table 7-8. Estimated Capital Costs for an Additional Vortex Grit Removal Tank

Item	Cost, dollars
Base Construction Cost	839,000
Electrical/IC (20%)	168,000
Mobilization/Demobilization (10%)	101,000
Contractor's Overhead and Profit (15%)	151,000
Total Estimated Construction Cost	1,259,000
Contingencies (30%)	378,000
Engineering, Legal and Administrative Costs (25%)	409,000
Total Project Cost (rounded to nearest $100,000)	2,000,000

Hydraulic Considerations. A second vortex tank can be incorporated into the plant’s hydraulic profile in a manner that would enable it to attain its normally anticipated performance. Furthermore, the existing vortex grit tank would be modified to return its geometry back to the manufacturer’s original design configuration so that its performance would be enhanced. This would be accomplished by filling in the floor of the existing grit tank until the operating depths are reduced to levels that will restore more effective grit removal performance.

SECONDARY TREATMENT ALTERNATIVES

The secondary treatment process at the WRF includes the Orbal oxidation ditches, secondary clarifiers, return activated sludge (RAS) pumping system, and alkalinity feed system. The secondary treatment process provides BOD and TSS removal year-round, as well as biological phosphorus removal (BPR) and nitrification during the dry weather season. Over the years, WRF personnel have modified the operation of the secondary process to optimize BPR. While this change has resulted in overall improved performance and significant reductions in tertiary chemical use, the aerobic treatment capacity (BOD and ammonia removal) of the Orbals has been decreased due to the utilization of a portion of the existing reactors for the creation of the anoxic zone for BPR.

Because of their history of successful operation at the WRF, the Orbals and secondary clarifiers will be retained for use in the future. Replacing these facilities with alternative secondary treatment systems would not be cost effective as capacity would be eliminated then rebuilt. Constructing dissimilar parallel secondary facilities would increase demands on WRF personnel as two distinct systems would have to be operated and maintained. Therefore, this analysis is based on the expansion of the existing system with similar facilities. An exception to this was discussed previously. Due to ongoing reductions in membrane costs, the City should re-evaluate MBRs when the time comes to prepare a preliminary design for the secondary treatment process expansion. MBRs offer the benefit of combined secondary and tertiary treatment.

Existing Secondary Treatment Capacity

The capacity of the existing secondary facilities must be evaluated within the context of both dry weather and wet weather demands. The initial step in this evaluation is to develop and calibrate a computer model of the existing secondary treatment process.

Secondary Process Model. The activated sludge computer model BioWin was used to assess the capacity of the existing secondary treatment facilities. Model calibration is the initial and most important step in a computer simulation of process capacity. Measured values for critical operating and performance parameters for the influent wastewater, Orbals, and secondary effluent are evaluated and summarized. A computer model of the existing secondary treatment process is developed and adjustments are made to influent and biological growth coefficients until the model value for each parameter approximates the measured value. For the purposes of this model calibration, July 2005 operating data was used. Table 7-9 presents the data and calibration summary.

Table 7-9. BioWin Calibration Summary

Item	July 2005	
	Reported Value	Calibrated Model Value
Temperature, F	19.6	**19.6**
Influent flow [(a)], mgd	1.55	**1.55**
Influent BOD5, mg/L	216.6	**216.6**
Influent TSS, mg/L	250.1	**250.1**
Influent Nitrate, mg/L	—	**0**
Influent ammonia, mg/L	18.7	**18.7**
RAS flow, mgd	—	**0.44**
WAS, mgd	—	**0.025**
WAS TSS, mg/L	—	1.1%
WAS TSS, ppd	2,448	2,282
Aeration Basin Mixed Liquor Volatile Suspended Solids Concentration (MLVSS), mg/L	2,567	2,557
AB Solids Retention Time (SRT), days	13.91	14.6
Effluent BOD_5, mg/L	2	1.9
Effluent TSS, mg/L	1.27	2
Effluent Ammonia, mg/L	0.02	0.06
Effluent Phosphorus, mg/L	0.1	0.1
Effluent pH, mg/L	—	7.12

Bold values are model inputs
(a) Model was developed for one Orbal/clarifier train.
— Not available

The predicted values for key parameters compared reasonably well with the reported concentrations.

Dry Weather Process Capacity. The calibrated model was used to simulate the performance of the facility during current average dry weather and maximum month dry weather loading conditions. A state point analysis was performed to verify that the secondary clarifiers were capable of accommodating dry weather solids loading. Table 7-10 presents a summary of the modeling analysis. Figures 7-12 to 7-15 illustrate the Orbal capacity based on different flow and loading conditions, and mixed liquor suspended solids (MLSS) concentrations at a conservatively low wastewater temperature of 16.4 ºC.

Table 7-10. Orbal Capacity based on Modeling Analysis

Loading Condition	MLSS, mg/L	Ammonia Limit, mg/L	Capacity per train	Total Current Capacity
MMDWF and MML	2,500	0.5	1.4 mgd equivalent ADWF	2.8 mgd equivalent ADWF
MMDWF and MML	2,500	3.0	1.9 mgd equivalent ADWF	3.8 mgd equivalent ADWF
MMDWF and MML	3,000	0.5	1.7 mgd equivalent ADWF	3.4 mgd equivalent ADWF
MMDWF and MML	3,000	3.0	2.2 mgd equivalent ADWF	4.4 mgd equivalent ADWF
MMDWF and MML	3,500	0.5	1.9 mgd equivalent ADWF	3.8 mgd equivalent ADWF
MMDWF and MML	3,500	3.0	2.5 mgd equivalent ADWF	5.0 mgd equivalent ADWF
ADWF and MML	3,500	0.5	2.1 mgd ADWF	4.2 mgd ADWF

Figure 7-12. Orbal Capacity during Maximum Month Dry Weather Flow and Loading Conditions at 2500 mg/l of MLSS

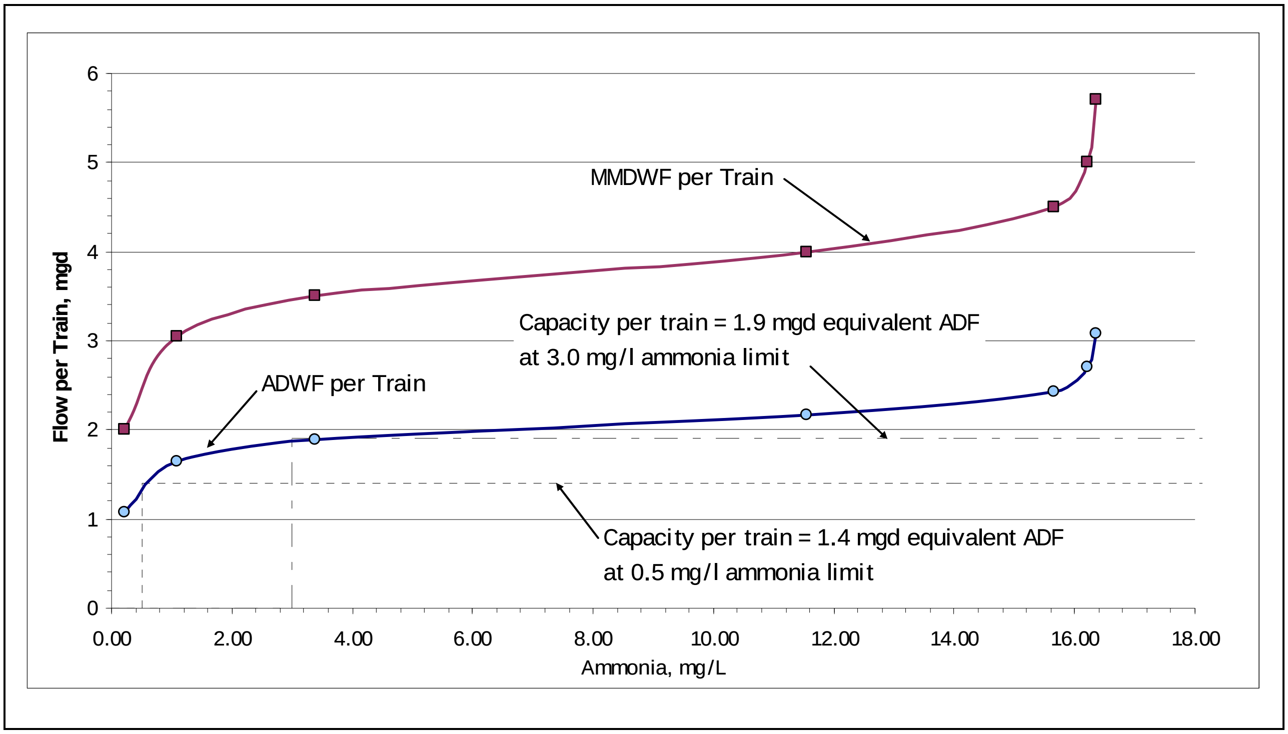


Figure 7-13. Orbal Capacity during Maximum Month Dry Weather Flow and Loading Conditions at 3000 mg/L of MLSS

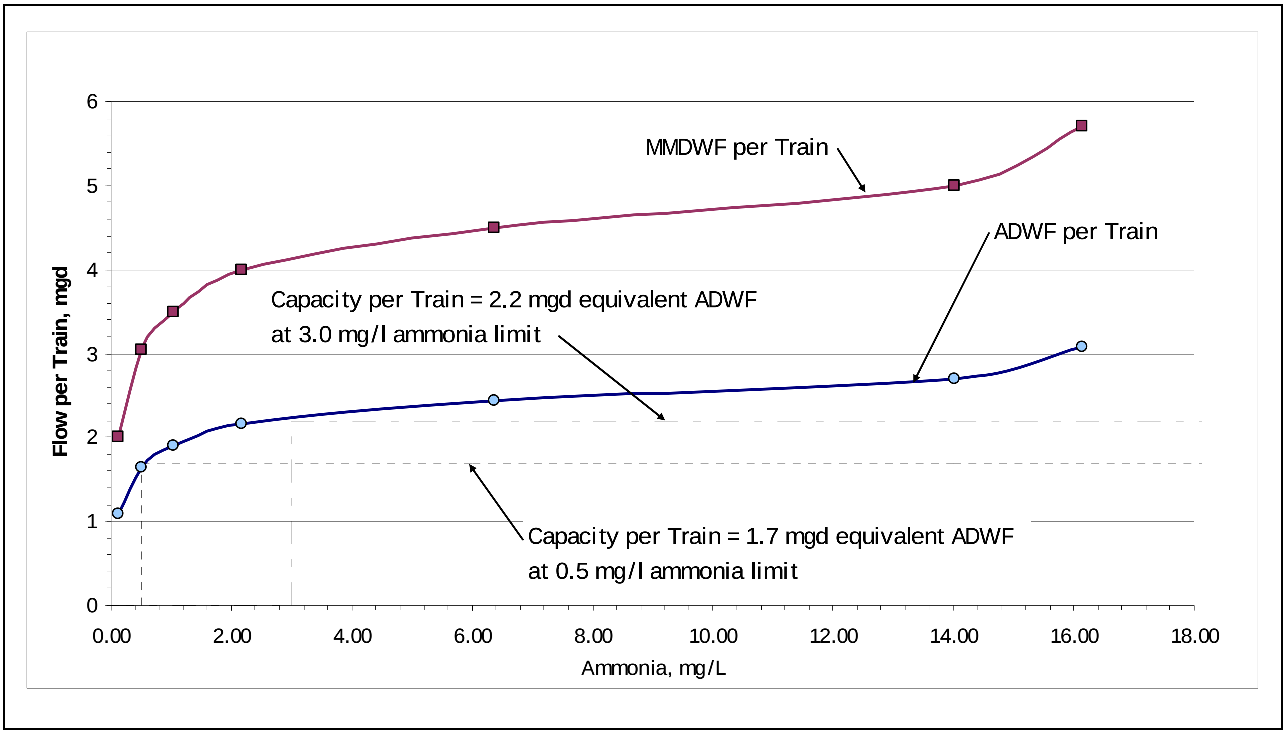


Figure 7-14. Orbal Capacity during Maximum Month Dry Weather Flow and Loading Conditions at 3500 mg/L of MLSS

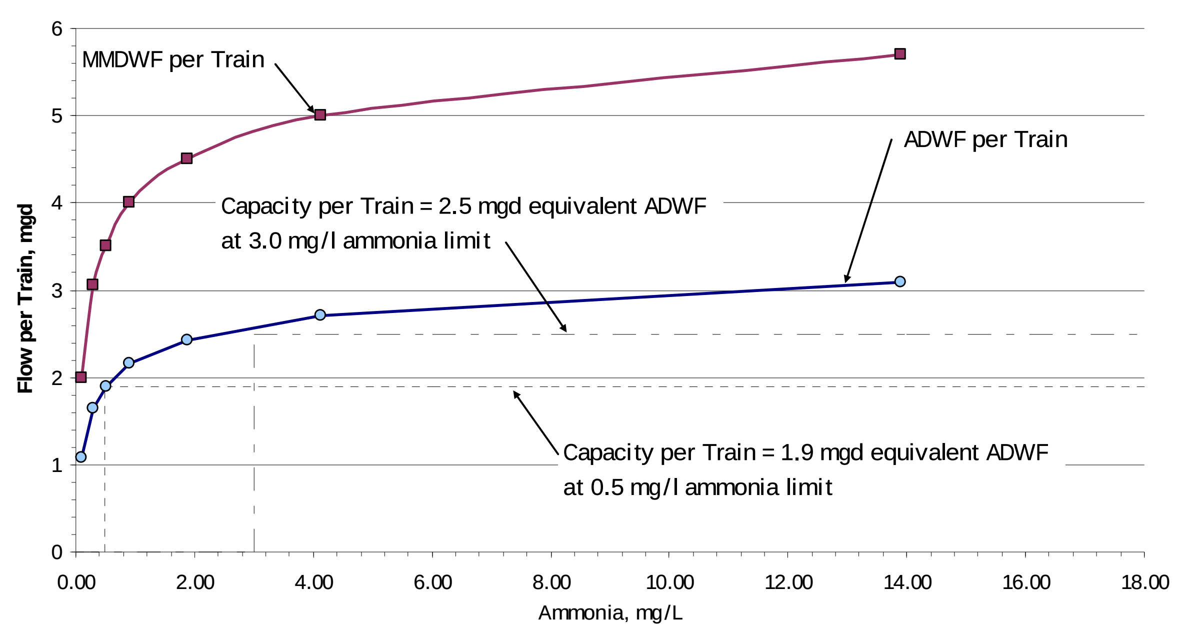
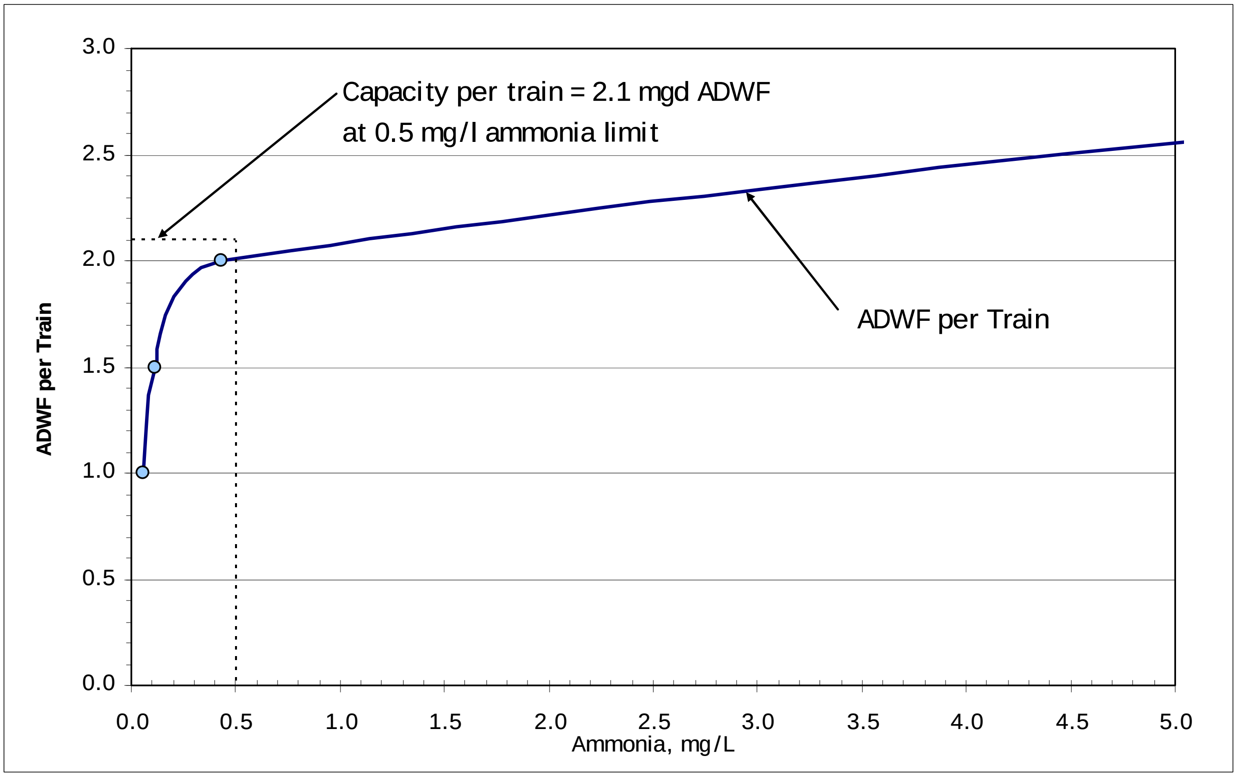


Figure 7-15. Orbal Capacity during Average Dry Weather Flow and Maximum Month Loading Conditions at 3500 mg/L of MLSS

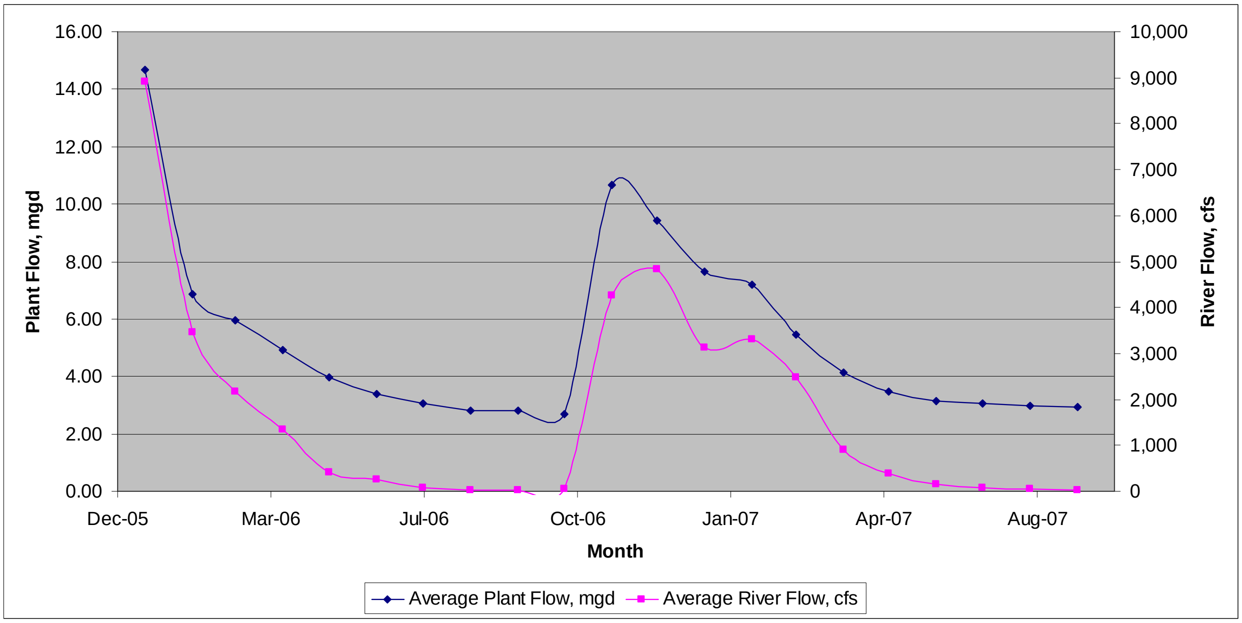


The capacity assessment is complicated by the fact that the WRF's NPDES permit has river-flow-based limits for effluent ammonia. These monthly average limits range from 0.5 mg/L NH3-N when river flows are less than 100 cfs, to 5 mg/L NH3-N when river flows are over 250 cfs. As shown in Figure 7-16, river and WRF flows are closely related. Therefore, when the hydraulic loading at the WRF increases, effluent ammonia limits are relaxed. Consequently, dry weather capacity was viewed from two perspectives:

- Compliance with an effluent ammonia limit of 0.5 mg/L at ADWF and maximum month loading conditions
- Compliance with an effluent ammonia limit of 3 mg/L at MMDWF and maximum month loading conditions

Complying with the ADWF, 0.5 mg/L ammonia limit condition was determined to be controlling (Figures 7-12 through 7-14). The dry weather capacity of the existing secondary treatment process was estimated as 2.1 mgd equivalent ADWF per treatment train (4.2 mgd total). This compares to the estimated current and buildout ADWFs of 3.3 mgd and 6.1 mgd, respectively.

Figure 7-16. Average Plant and River Flow Relationship



Wet Weather Process Capacity. Current operating practice at the WRF is to limit total flow (raw sewage plus RAS) through the secondary treatment process to 28 mgd. This translates into a raw sewage capacity of 22 mgd and a RAS rate of 6 mgd. At higher flow rates, there is a risk of submerging aerator bearings. The existing Orbals are not configured to operate in contact stabilization mode, although this is an option with new systems.

The Orbals are currently the limiting factor in secondary process hydraulic capacity. Without the hydraulic bottleneck they impose, the full RAS capacity of 10.5 mgd could be utilized during peak flow conditions. A state point analysis of the existing clarifiers was performed and is summarized in Table 7-11. With the current RAS pumping rate limitation of 6 mgd that occurs during peak flow conditions, the capacity of the clarifiers, based on their ability to handle the solids loading only, is approximately 9 to 14 mgd each depending on SVI and MLSS concentration. With the removal of this hydraulic limitation, clarifier capacity to handle solids would increase to a capacity range of 12 to 20 mgd each, if the RAS rate was increased to 10.5 mgd. This rating does not consider surface overflow rate limitations, which will ultimately limit clarifier capacity to about 12 mgd each.

For secondary clarifiers receiving “extended aeration” mixed liquors, surface overflow rates should be limited to about 1,000 gpd/SF of clarifier surface area. Based on this criterion, each clarifier should be limited to about 12 mgd at peak flow conditions. This is consistent with the original design criteria for the secondary system.

Another consideration in assessing wet weather capacity is the potential for continued blending during peak flow conditions. The peak flow delivered to the WRF is currently 32 mgd. Approximately 8 to 10 mgd of this bypasses the secondary treatment process and is combined with the secondary effluent just upstream of disinfection. Continuing the practice of effluent blending would reduce the wet weather capacity requirements of the secondary treatment process.

Table 7-11. Clarifier State Point Analysis

Run Number	Description				
	Number of clarifiers	Effluent flow, mgd	RAS flow, mgd	MLSS, g/L	SVI, mL/g (See Note)
1	2	28.5	6	2500	115
2	2	27	6	2500	125
3	2	23	6	3000	115
4	2	21.5	6	3000	125
5	2	18.5	6	3500	115
6	2	17.5	6	3500	125
7	2	40	10.5	2500	115
8	2	38	10.5	2500	125
9	2	31.5	10.5	3000	115
10	2	30	10.5	3000	125
11	2	26	10.5	3500	115
12	2	24	10.5	3500	125

Note: 90th percentile high SVI is 115 mL/g; 95th percentile high SVI is 125 mL/g; rating does not consider surface overflow rate criteria.

Aeration System Capacity. Each Orbal is equipped with four 50-hp drive systems that power eight disk aerators. Some of the drive systems are equipped with variable frequency drives, while others operate at a constant speed. The oxygen supply can be varied by adjusting the number of disks, disk submergence, and rotating speed. WRF personnel have made significant improvements to the oxygen delivery strategy to enhance biological phosphorus removal.

The activated sludge process model BioWin was used to estimate oxygen requirements under a range of conditions. The oxygen requirements were translated into horsepower demands using an estimated aeration system efficiency of 2.5 pounds of oxygen per horsepower per hour, which is somewhat lower than the manufacturer’s claimed efficiency. Estimated oxygen demand and aerator horsepower requirements are summarized in Table 7-12.

As indicated in Table 7-12, the required horsepower for current peak day loading conditions is less than the existing 200-horsepower per-basin capacity. This leaves some reserve capacity available for peak hour loading conditions. Assuming the eventual construction of a third basin, the 200-horsepower per basin capacity would be adequate for buildout conditions.

Table 7-12. Estimated Aeration Requirements

Flow Condition	SOTR (lbs/hr) per Train	Required Horsepower per Train
Current ADWF average annual load (two basins)	161	73
Current ADWF maximum month load (two basins)	208	86
Current ADWF peak day load (two basins)	312	129
Buildout ADWF average annual load (three basins)	187	81
Buildout ADWF maximum month load (three basins)	238	100
Buildout ADWF peak day load (three basins)	356	146

While aeration system capacity is not an issue, the City may want to consider control system improvements to enhance performance and reduce energy use, such as:

- An automated oxygen supply control system.
- Variable frequency drives for all motors.

Capacity Summary. The capacity of the existing secondary treatment facilities are listed in Table 7-13.

Alkalinity Addition

A sodium hydroxide chemical feed system was included in the original plant design for adding alkalinity to the secondary treatment process as needed. It had not been necessary to utilize this system until about two years ago. WRF staff experienced numerous difficulties with the originally provided system and, consequently, experimented with other chemicals. The most successful chemical was liquid lime (calcium hydroxide) and this remains in use. A 2,000-gallon storage tank is used to store the liquid chemical on site. Demands can be as much as 1,000 gallons per week, thereby requiring frequent deliveries.

Although this alternative has proven to be the most successful of the alternatives that have been tried to date, other options are available. The following alternatives have been identified:

1. Retain existing calcium hydroxide system
2. Upgrade calcium hydroxide system
3. Convert to a hydrated lime dry chemical system

Table 7-13. Secondary Capacity Requirements

Item	Current Total Capacity	Buildout Demand	Additional Capacity Required
Overall hydraulic	22 mgd PHF	32 mgd PHF a	10 mgd PHF
Orbals	4.2 mgd ADWF	6.1 mgd ADWF	1.9 mgd ADWF
Secondary clarifiers (dry weather)	17.5 to 28.5 mgd MDDWF	20.0 mgd MDDWF	Up to 2.5 mgd MDDWF
Secondary clarifiers (wet weather)	17.5 to 28.5 mgd PHF	32 mgd PHF a	3.5 to 14.5 mgd PHF
RAS pumping system (dry weather)	10.5 mgd	10.5 mgd	--
RAS pumping system (wet weather)	6 to 10.5 mgd	15 mgd	4.5 to 9 mgd
Aeration system	1,000 lb O2/hr	1,070 lb O2/hr	70 lb O2/hr

(a) Assumes no blending

The feed system will need to have the ability to increase the alkalinity of the water by 50 mg/l. It will also need to be able to feed chemical to the inlet piping of all of the Orbal treatment units or to a common point prior to the splitter structure for the Orbal treatment units.

A thorough evaluation of these alternatives should be undertaken at a preliminary design level to identify all of the considerations that should be made in the final selection. Costs will be based on installation of a hydrated lime dry chemical feed system.

Alternative 1. Construct Third Secondary Treatment Train

This alternative is a continuation of the current WRF design and would consist of the following base elements:

- A third Orbal oxidation ditch.
- A third 120-foot-diameter secondary clarifier.
- Expansion of the RAS pumping system.
- The addition of variable speed drives to the aeration equipment of the existing Orbals.
- A new alkalinity feed system.

The third identical Orbal/clarifier treatment train would operate in parallel with the existing trains. Optional enhancements that the City may want to also consider including as part of this alternative include:

1. Improvements to allow operation in contact/stabilization mode. In contact/stabilization mode, the RAS is aerated in a compartment separate from the main flow stream (the Orbals' outer channel). This mode is often advantageous during peak flow conditions as it allows for a higher solids retention time (SRT) and a lower

clarifier solids loading rate (SLR). Facilities would include a pipe beneath each Orbals' outer channel and gates to direct raw sewage to the desire location. City personnel might consider adding features to allow operation in contact/stabilization mode if peak flows are not reduced to the anticipated extent.

2. Mixed liquor recycle pumping. Mixed liquor recycle pumping would increase denitrification (biological conversion of nitrate to nitrogen gas) in the Orbals. Denitrification can enhance process stability by providing alkalinity recovery and pH control. Low head submersible propeller pumps and piping would convey nitrified mixed liquor from the inner to middle Orbal channels. City personnel may want to add this feature if chemical use for pH control becomes a significant operational expense.
3. Piping improvements to allow continued blended treatment, which includes chemical addition and primary treatment of raw sewage in the existing tertiary clarifiers. This feature would likely only be used in the event a secondary clarifier is out of service during high wet weather flow conditions.

Key considerations associated with this alternative include:

- The need for blending would be eliminated.
- Adequate redundancy would be provided to allow continued successful operation during all but the highest flow and loading conditions.
- Continued operation as multiple parallel trains would be possible.

Design data for this alternative are shown in Table 7-14, while a simplified process flow schematic is provided as Figure 7-17.

Alternative 2. Construct Third Orbal and Wet Weather Upgrades

This alternative recognizes that with the reduction in peak flows accomplished through collection system rehabilitation, the capacity of the existing secondary clarifiers may be adequate. Alternative 2 consists of the following elements:

1. A third Orbal oxidation ditch. The third Orbal is necessary for dry weather nitrification. It would include inlet piping that would enable the tank to operate in the contact/stabilization mode.
2. Piping improvements in the existing Orbal tanks to allow operation in contact/stabilization mode. Operation in contact/stabilization mode would reduce solids loading to the secondary clarifiers.
3. The addition of variable speed drives to the aeration equipment of the existing Orbals.
4. Hydraulic improvements to the existing Orbals.

Table 7-14. Secondary Treatment Alternative 1: Third Secondary Treatment Train - Design Data

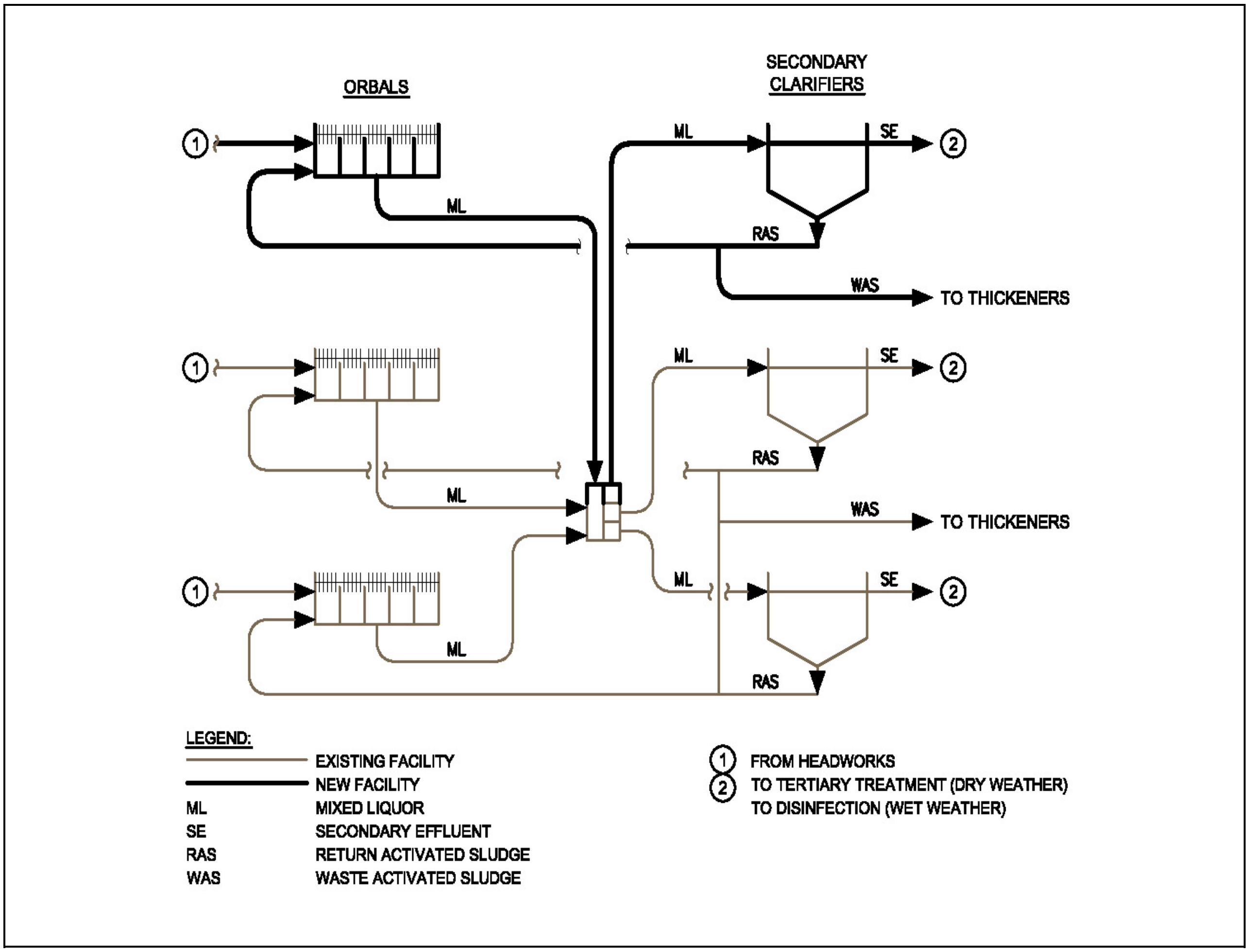
Description	Existing (1)	Buildout
Calcium Hydroxide Feed System (Alkalinity Control)		
Storage Tanks		
Number	1	1
Capacity, ea. Gal	6,500	6,500
Feed Pumps		
Number	2	2
Type	Chemical Metering - Adjustable Speed	Chemical Metering - Adjustable Speed
Capacity, gph	0.1 - 8	0.1 – 8
Aeration Basins (Orbal Oxidation Ditches)		
Number	2	3
Size, each, ft	165 x 137	165 x 137
Sidewater Depth, ft	11.8	11.8
Total Volume, Million Gal	3.1	4.6
Hydraulic Retention Time at ADWF	13.3 hrs	18.1 hrs
Hydraulic Retention Time at AWWF	6.6 hrs	9.2 hrs
Solids Retention Time, days	7	11.5
Design MLSS, mg/L	3000	3000
ADWF Capacity, mgd	4.2 (2)	6.3 (2)
PHF Capacity, mgd	22 (3)	32 (4)
Aeration Equipment		
Type	Surface Disc	Surface Disc
Number per basin	8	8
Capacity per basin, lbs O_2/day (5)	12,000	12,000
Total Connected Horsepower per basin	200	200
Secondary clarifiers		
Type	Suction Arm	Suction Arm
Number	2	3
Diameter, ft	120	120
Sidewater Depth, ft	15.7	15.7
Surface Area, each, SF	11,310	11,310

Table 7-14. Secondary Treatment Alternative 1: Third Secondary Treatment Train - Design Data, cont'd…

Description	Existing (1)	Buildout
Design Overflow Rates, gpd/SF		
ADWF, 1 unit out of service	495	270
AWWF, all units	495	354
MDWWF, all units	951	914
Peak hourly flow, all units	1,060 (3)	943 (4)
Return Sludge Pumps		
Type	Screw Induced Flow Adjustable Speed	Screw Induced Flow Adjustable Speed
Number	4	6
Capacity, each, gpm	900-2,000	900-2,000
Motor HP	15	15
Waste Sludge Pumps		
Type	Screw Induced Flow Adjustable Speed	Screw Induced Flow Adjustable Speed
Number	2	3
Capacity, each, gpm	200-500	200-500
Motor, HP	7.5	7.5
Scum Pumps		
Type	Progressing Cavity Constant Speed	Progressing Cavity Constant Speed
Number	2	3
Capacity, gpm, each	50	50
Motor HP	3	3

1. Original design rating unless otherwise noted.
2. Based on current operating mode for biological phosphorus removal and ability to meet ammonia limits, per process modeling.
3. Hydraulic capacity limited by Orbals and based on operating experience. Balance of PHF blended.
4. Based on 32 mgd PHF, no blending.
5. Existing aeration system capacity based on analysis presented in Table 7-13.

**Figure 7-17. Secondary Treatment Alternative 1:
Third Secondary Treatment Train Process Flow Schematic**



5. Piping improvements to allow primary treatment of blended raw sewage in the tertiary clarifiers. Blended operation would be required during high wet weather flow conditions and potentially during peak dry weather flow conditions when one clarifier is out of service.
6. A new alkalinity feed system

In addition, City personnel may want to consider the addition of recently developed enhancements to improve the performance of the secondary clarifiers during high flow conditions.

Important considerations for this alternative include:

- High clarifier overflow rates during peak flow conditions make reliable performance uncertain. Blending would be used to reduce the clarifier hydraulic loading and maintain acceptable secondary effluent quality.
- Clarifier redundancy would be a significant concern. Taking a clarifier out of service for maintenance or repairs would only be possible during dry weather low flow conditions.

- Blending would continue with increasing frequency to adversely affect disinfection system performance.

Design data and a simplified process flow schematic are provided in Table 7-15 and Figure 7-18, respectively.

Table 7-15. Secondary Treatment Alternative 2:
Third Orbal and Wet Weather Upgrades - Design Data

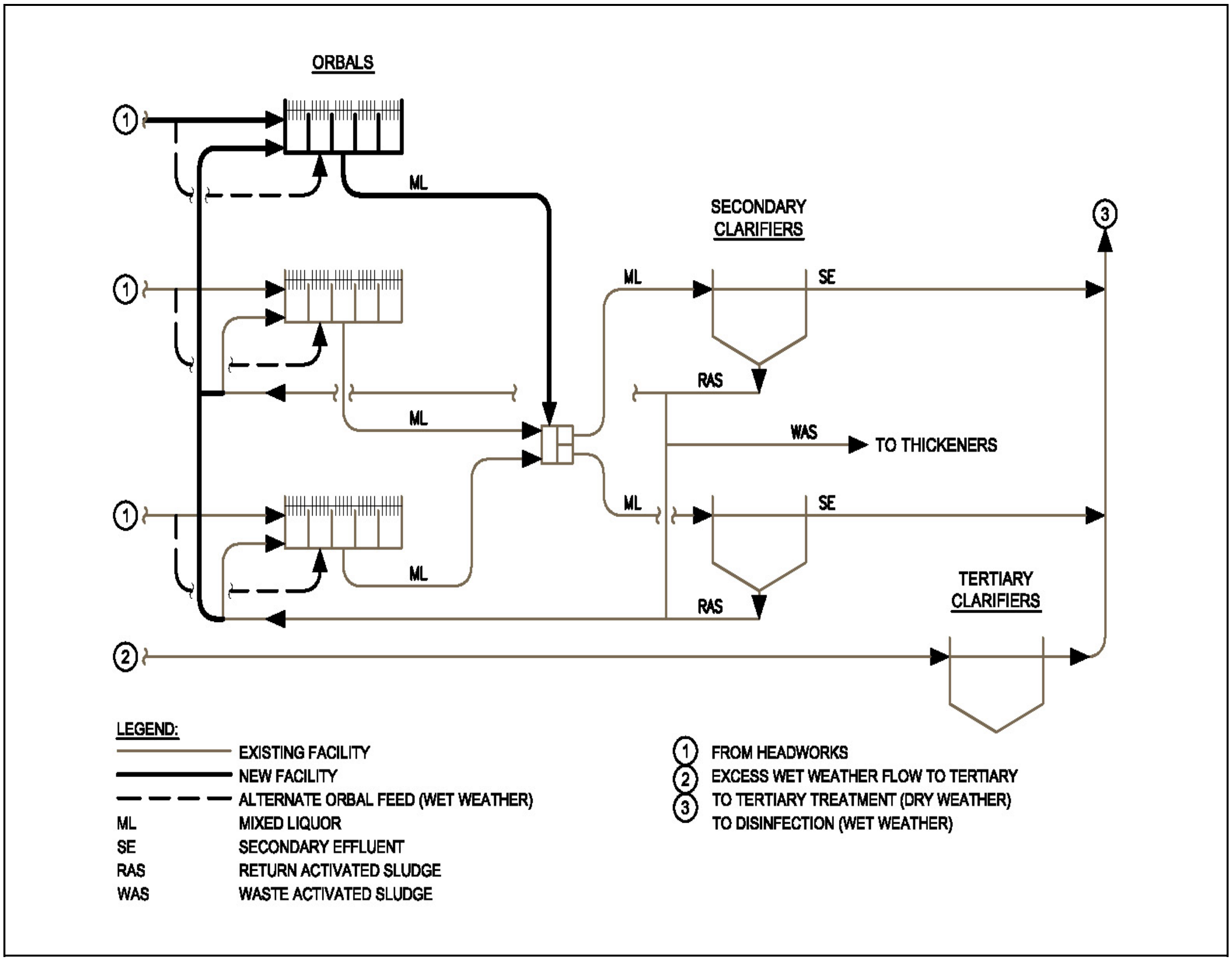
Description	Existing (1)	Buildout
Calcium Hydroxide Feed System (Alkalinity Control)		
Storage Tanks		
Number	1	1
Capacity, ea. Gal	6,500	6,500
Feed Pumps		
Number	2	2
Type	Chemical Metering - Adjustable Speed	Chemical Metering - Adjustable Speed
Capacity, gph	0.1 - 8	0.1 – 8
Aeration Basins (Orbal Oxidation Ditches)		
Number	2	3
Size, each, ft	165 x 137	165 x 137
Sidewater Depth, ft	11.8	11.8
Total Volume, Million Gal	3.1	4.6
Hydraulic Retention Time at ADWF	13.3 hrs	18.1 hrs
Hydraulic Retention Time at AWWF	6.6 hrs	9.2 hrs
Solids Retention Time, days	7	11.5
Design MLSS, mg/L	3000	3000
ADWF Capacity, mgd	4.2 (2)	6.3 (2)
PHF Capacity, mgd	22 (3)	24 (4)
Aeration Equipment		
Type	Surface Disc	Surface Disc
Number per basin	8	8
Capacity per basin, lbs O_2/day (5)	12,000	12,000
Total Connected Horsepower per basin	200	200
Secondary clarifiers		
Type	Suction Arm	Suction Arm

Table 7-15. Secondary Treatment Alternative 2:
Third Orbal and Wet Weather Upgrades - Design Data, Cont'd…

Description	Existing (1)	Buildout
Number	2	2
Diameter, ft	120	120
Sidewater Depth, ft	15.7	15.7
Surface Area, each, SF	11,310	11,310
Design Overflow Rates, gpd/SF		
ADWF, 1 unit out of service	495	539
AWWF, all units	495	531
MDWWF, all units	951	1,060 (4)
Peak hourly flow, all units	1,060 (3)	1,060 (4)
Return Sludge Pumps		
Type	Screw Induced Flow Adjustable Speed	Screw Induced Flow Adjustable Speed
Number	4	4
Capacity, each, gpm	900-2,000	900-2,000
Motor HP	15	15
Waste Sludge Pumps		
Type	Screw Induced Flow Adjustable Speed	Screw Induced Flow Adjustable Speed
Number	2	2
Capacity, each, gpm	200-500	200-500
Motor, HP	7.5	7.5
Scum Pumps		
Type	Progressing Cavity Constant Speed	Progressing Cavity Constant Speed
Number	2	2
Capacity, gpm, each	50	50
Motor HP	3	3

1. Original design rating unless otherwise noted.
2. Based on current operating mode for biological phosphorus removal and ability to meet ammonia limits, per process modeling.
3. Hydraulic capacity limited by Orbals and based on operating experience. Balance of PHF blended.
4. Flow to secondary treatment system constrained by clarifier capacity and capped at 24 mgd. Balance of PHF blended.
5. Existing aeration system capacity based on analysis presented in Table 7-13.

Figure 7-18. Secondary Treatment Alternative 2:
Third Orbal and Wet Weather Upgrades Process Flow Schematic



Evaluation of Secondary Treatment Alternatives

This section compares the two secondary process alternatives based on economic and non-economic factors.

Economic Comparison. Estimated capital project costs for each secondary treatment alternative are compared in Table 7-16.

Table 7-16. Secondary Treatment Alternatives Capital Project Cost Comparison

Description	Capital Project Cost, $1,000	
	Alternative 1: Third Secondary Treatment Train	Alternative 2: Additional Orbal Tank + Wet Weather Modifications
Alkalinity Control System	100	100
Additional Orbal Tank	2,753	2,753
Existing Orbal Tanks Modifications (Hydraulic)	—	150
Secondary Clarifier	1,920	—
RAS/WAS Pump Station	788	—
Tertiary Clarifier Modifications for Wet Weather Treatment	—	200
Electrical/I&C (20%)	1,110	640
Subtotal	6,671	3,843
General Conditions (10%)	670	380
Contractor's Overhead & Profit (15%)	1,000	580
Subtotal	8,341	4,803
Contingencies (30%)	2,500	1,440
Subtotal	10,841	6,243
Engineering & Administration (25%)	2,710	1,560
Total Capital Cost	13,551	7,803

Estimated annual operation and maintenance costs for each secondary treatment alternative are compared in Table 7-17.

Table 7-17. Secondary Treatment Alternatives Annual Operation and Maintenance Cost Comparison

Description	Annual O&M Cost, $1,000	
	Alternative 1: Third Secondary Treatment Train	Alternative 2: Additional Orbal Tank + Wet Weather Modifications
Labor	200	150
Electrical Power	32	30
Maintenance Materials	33	19
Total Annual O&M	265	199

Estimated present worth costs of the secondary treatment alternatives are compared in Table 7-18.

Table 7-18. Secondary Treatment Alternatives Summary Alternative Cost Comparison

Description	Alternative Costs, $1,000	
	Alternative 1: Third Secondary Treatment Train	Alternative 2: Additional Orbal Tank + Wet Weather Modifications
Total Capital Cost	13,551	7,803
Total Annual O&M Cost	265	199
Total Present Worth	16,715	10,179

Non-economic Comparison. The non-economic comparison of the secondary treatment alternatives is summarized in Table 7-19.

Table 7-19. Non-Economic Comparison of Secondary Treatment Alternatives

Evaluation criteria	Alternative 1: Construct Third Secondary Treatment Train	Alternative 2: Third Orbal and Wet Weather Upgrades
O&M considerations	O&M requirements comparable to existing facilities.	O&M requirements comparable to existing facilities. One less clarifier to maintain compared to Alternative 1.
Reliability	Three clarifiers provide additional firm capacity and redundancy	With a secondary clarifier out of service, blended treatment would be required at moderate wet weather flow and potentially during high dry weather flows.
Performance	Blended treatment eliminated except if treatment units are out of service during high wet weather flows.	Probable need to provide blended treatment during high wet weather flow conditions, reducing effluent quality for short periods. Potential need to provide blended treatment during dry weather flows when a clarifier is out of service. Disinfection performance would continue to be impacted during peak flows due to blending.
Flexibility	Ability to operate as parallel trains and as a single process with parallel units. Contact/stabilization not included as part of base project.	Ability to operate as parallel trains lost. Ability to operate in contact/stabilization mode.
Complexity	Process is well understood by WRF personnel. Eliminating the need to perform blended treatment reduces complexity.	Process is well understood by WRF personnel.
Energy use	Slightly higher due to operation of an additional secondary clarifier and RAS pump station.	Energy use comparable to existing facilities

TERTIARY TREATMENT ALTERNATIVES

The tertiary treatment facilities allow the WRF to reliably comply with stringent effluent phosphorus limits during the dry weather season. In addition, the tertiary facilities would be an important component of any potential future effluent reuse program, as they would be necessary for producing Level IV/Class A recycled water. The existing tertiary treatment facilities consist of:

- Tertiary clarifiers
- Chemical sludge pump station
- Chemical feed system
- Filters

It is recognized that the existing filters do not provide efficient total suspended solids removal and have historically demanded significant maintenance. However, overall, the existing tertiary facilities have generally performed adequately, as indicated by consistent compliance with the stringent dry weather effluent limits. This section develops and evaluates the following alternatives for long-term tertiary treatment at the WRF:

1. Expand existing tertiary facilities
2. Construct parallel membrane filtration system
3. Replace existing facilities with membrane filtration system

As discussed in Chapter 8, the existing tertiary facilities provide an excellent foundation for recycled water production. With enhanced disinfection, the existing facilities would be capable of producing the highest-level (Level IV/Class A) recycled water under both the current and future regulations.

Capacity Review

The capacity of the existing tertiary facilities was estimated in Chapter 3. It is worth noting that until 2007, only one tertiary clarifier was placed in service during the dry weather season. So until this time, one tertiary clarifier treated the entire 3.3 mgd ADWF and its associated diurnal and rainfall-induced peaks.

The tertiary system is equipped with flow diversion facilities that allow a portion of the secondary effluent to be routed directly to disinfection during periods of high, rainfall-induced dry weather flows. This strategy has been used successfully by WRF personnel since the WRF was placed in service, and is made possible by the fact that effluent phosphorus limits are relaxed during periods of high river flow. As shown in Figure 7-16, periods of high plant flows are directly related to periods of high river flows.

In assessing the capacity of the existing tertiary facilities, it is important to also consider diurnal peaking. A review of hourly influent flow data during a typical dry weather period shows that the diurnal peak-to-average peaking factor is approximately 1.8:1 (Figure 7-19). Table 7-20 compares buildout dry weather flow conditions. As shown in Table 7-20, the buildout diurnal peak approximates the MMDWF. Therefore, facilities sized for the MMDWF would also accommodate the diurnal peaks experienced during average flow conditions. Diurnal peaks during MMDWF conditions would bypass the tertiary processes, consistent with the current operating practice.

Figure 7-19. Typical Dry Weather Flow Variations at the WRF

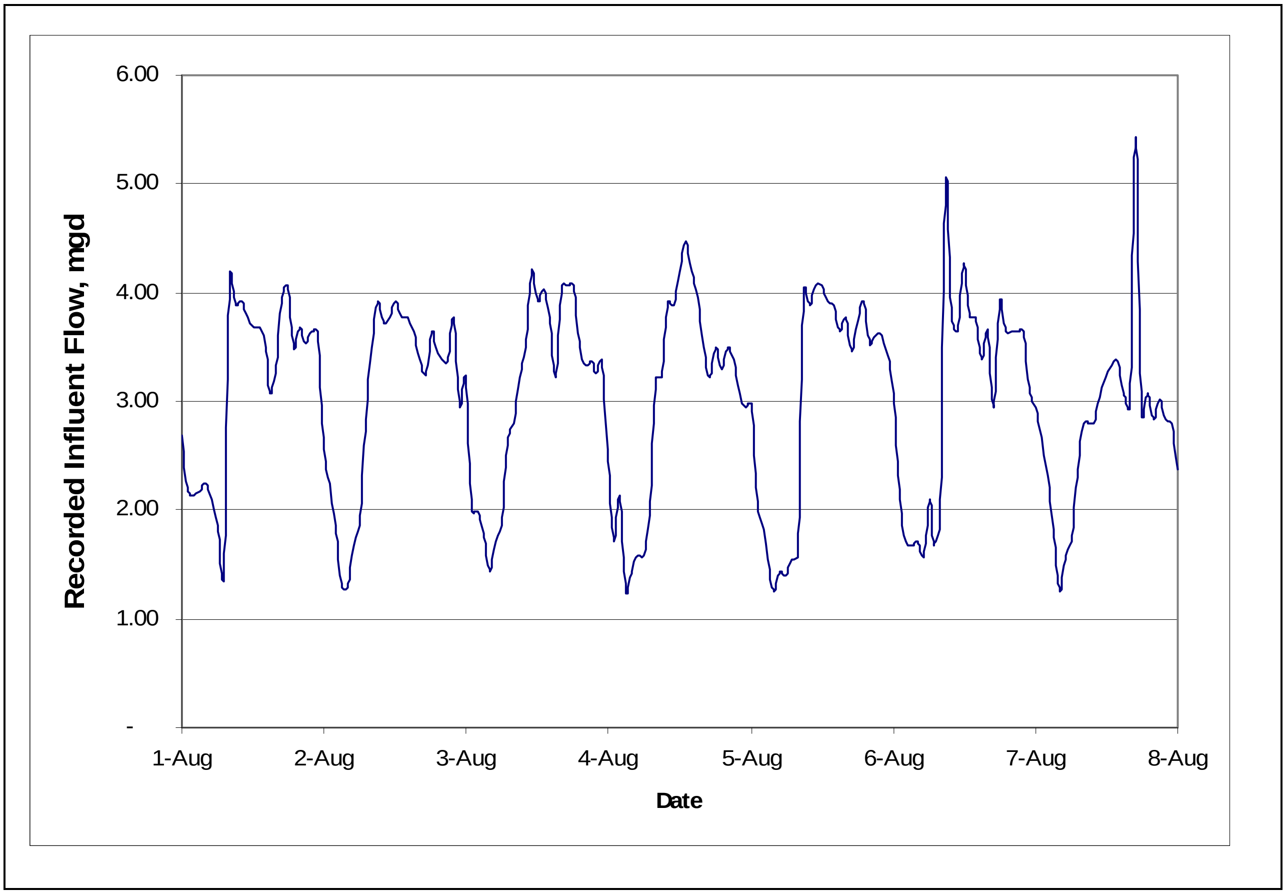


Table 7-20. Buildout Dry Weather Flow Conditions

Buildout Flow Condition	Value
Diurnal peaking factor (peak:average)	1.8
Buildout ADWF, mgd	6.1
Diurnal peak at buildout ADWF, mgd	11.0
Buildout MMDWF, mgd	11.4

The capacity of any filtration system is based on both hydraulic and solids loading criteria. This is an important consideration for tertiary processes that are designed for phosphorus removal. Filters that treat effluent from tertiary clarifiers can be loaded at a higher rate than those which treat secondary effluent with alum floc. Parkson, the manufacturer of the WRF's Dynasand filters, recommends using a design hydraulic loading rate of 5 gpm/sf for tertiary clarifier effluent. However, Parkson recommends limiting hydraulic loading to 4 gpm/sf if secondary effluent with alum floc is filtered directly.

Table 7-21 compares current capacity with buildout flow conditions, and presents capacity requirements for new facilities.

Table 7-21. Tertiary Capacity Requirements

Item	Total Capacity	Buildout Demand	Additional Capacity Required
Tertiary clarifiers	6.2 mgd ADWF	6.1 mgd ADWF	—
Filters sized for tertiary clarifier effluent	7.2 mgd MMDWF	11.4 mgd MMDWF	4.2 mgd MMDWF
Filters sized for direct filtration of secondary effluent/alum floc	5.8 mgd MMDWF	11.4 mgd MMWDF	5.6 mgd MMDWF

Hydraulic Considerations

An understanding of the existing hydraulic conditions and tertiary flow splitting structure are important to developing improvement alternatives. Key considerations include:

- The tertiary flow splitting structure is equipped with a 97-foot-long weir that automatically directs secondary effluent away from the tertiary clarifiers when the flow rate exceeds approximately 10.2 mgd. The flow rate at which this diversion occurs can be reduced by raising the tertiary clarifier gates. Closing these gates completely causes all of the secondary effluent to bypass the tertiary clarifiers.
- Secondary effluent that is automatically diverted away from the tertiary clarifiers is blended with tertiary clarifier effluent in the filter feed channel.
- Tertiary clarifier effluent is split to each filter cell by downward opening gates located in the filter feed channel.
- Based on the WRF's hydraulic profile, approximately 0.5 feet of head is available for splitting flow to the filter cells and future filtration systems. This equates to

approximately 2.2 mgd through each of the six existing 3-foot-wide filter feed gates. Closing all of these gates would result in bypassing the filtration system.

- Approximately 4 feet of head is available for filtration.
- Secondary effluent can be bypassed around the filters via a 5-foot-wide weir gate. This is the normal practice during the wet weather season.

Based on these factors, the following conclusions can be reached:

- Because of the extremely long length of the secondary effluent diversion weir, the flow rate to the tertiary clarifiers is effectively limited to 10.2 mgd.
- Adding a third tertiary clarifier would require an expansion of the tertiary flow splitting structure and installation of a 3-foot weir gate.
- Approximately 0.5 feet of head is available for flow splitting to future filtration facilities. Flow splitting to these future facilities could be accomplished by installing weir(s) with a total length that relates to the existing 18-foot total length by the proportion of flow to be directed to the future facilities.
- To avoid the need for pumping, future filtration facilities would have to require less than approximately 4 feet of head.
- For future filtration systems that require feed pumping, the pump station (and associated flow metering) could serve as the flow split mechanism.
- Adding an actuator to the 5-foot filter bypass gate would provide automation of the bypassing process and allow for accurate control of the flow rate to the filters.

Alternative 1. Expand Existing Tertiary Facilities

In this alternative, the existing tertiary facilities would be retained and similar facilities would be constructed to operate in parallel and increase overall tertiary treatment capacity.

Tertiary Clarifiers. The tertiary clarifiers provide the first step in the chemical phosphorus removal process. Alum is added to the secondary effluent to precipitate phosphorus, which settles in the tertiary clarifiers. In addition, the tertiary clarifiers provide enhanced sedimentation to reduce effluent turbidity and TSS, thereby reducing particulate phosphorus levels.

The tertiary clarifiers are typically placed in service at the start of the dry weather season, and taken out of service at the start of the wet weather season. As discussed previously, a 97-foot-long weir is located such that a portion of the peak dry weather flows automatically bypasses the tertiary clarifiers.

While the total capacity of the existing tertiary clarifiers is adequate for projected buildout conditions, taking one unit out of service for maintenance during low river flows creates concerns with respect to permit compliance. Options for addressing this issue include:

- Construct a third tertiary clarifier

- Size the filtration system such that a portion of the secondary effluent (with alum added) can be filtered directly, bypassing the out-of-service tertiary clarifier.

Because the second option offers the advantage of increased filtration capacity under normal operating conditions, this approach is recommended. Consequently, no additional tertiary clarifiers are included under this alternative.

Chemical Sludge Pumps. The current chemical sludge pumping capacity has proven to be generally adequate. However, re-evaluating capacity needs when the pumps reach the end of their service life should be considered.

Filters. WRF personnel report that the Parkson Dynasand continuous backwash sand filters have performed unsatisfactorily over the years, often providing only about 50 percent TSS removal. While this removal efficiency is less than what would be expected for many more modern filtration systems, it has proven to be adequate for reliable permit compliance. Regardless, because other, potentially more efficient, filtration technologies are available, alternatives will be considered. The following “conventional” technologies are often evaluated for effluent filtration applications:

- Deep bed granular media filters
- Cloth disk filters
- Compressible medium (“Fuzzy”) filters
- Continuous backwash sand filters

These technologies are compared in Table 7-22.

Preliminary hydraulic calculations suggest that both cloth disk and continuous backwash sand filters could be accommodated within the WRF’s existing hydraulic profile without pumping. With these two technologies, it would be necessary to also include flow splitting structure improvements that would control the flow rate to each filter bank.

While compressible medium filters could be incorporated into the hydraulic profile without pumping, their loading rate would be restricted due to limited available head. The reduction in achievable loading rate would decrease the cost effectiveness of this filter type.

It is unlikely that deep bed granular media filters could be added to the tertiary train without the addition of a pump station. While a pump station could be configured to serve the dual functions of pumping and flow splitting, it would clearly add to the cost and complexity of a filter installation.

Filtration technologies are continually evolving. A recent example of this trend is ultrascreens. As more experience is gained with ultrascreens, they may emerge as a viable filtration option. Because of the potential for technological advancements, the City should re-evaluate filtration options as part of the preliminary design process. For the purposes of this report, filtration system costs are based on cloth disk filters.

This alternative does not include a standby tertiary clarifier. The filtration system is sized such that it would be capable of treating the buildout dry weather flows, comprised of approximately half tertiary clarifier effluent and half secondary effluent with alum floc. The capacity of the existing filters has been de-rated accordingly.

Table 7-22. Comparison of Alternative Tertiary Filtration Technologies

	Alternative Filtration Technology			
Evaluation Criteria	Deep Bed Granular Media	Cloth Disk Filter	"Fuzzy" filter (Compressible Medium Filter)	Continuous (granular medium) Upflow Backwash
Backwashing requirements. Water (typically secondary or tertiary effluent) is used for backwashing filtration systems. This water must be recycled back through the WRF for treatment.	High backwash reject ratio (usually more than 8-10 percent). Typically clear water tank for backwash and mudwell for reject water storage required. Air scour system recommended.	Low backwash reject ratio (typically less than 5 percent, 2-3 percent common for normal operating plants). Reduced backwash components and needs (e.g., clear water tank not required).	Low backwash reject ratio (typically less than 5 percent, 2-3 percent common for normal operating plants). Reduced Backwash components and needs (e.g., clear water tank and mudwell not required).	Design allows for backwashing of a small portion of the total filter flow, reducing peak backwash demands (backwash components are minimized but the backwash reject ratio is still high ~ 10 percent which is comparable to other granular type filters)
Operational considerations. Labor demands, flexibility, safety, and complexity are often included in this criterion.	Higher operational demands due to increased backwash requirements	Reduced operational demands compared to deep bed granular media. However, more susceptible to medium blinding during secondary process upsets.	Reduced operational demands compared to deep bed granular media.	Reduced operational demands compared to deep bed granular media.
Ability to direct filter secondary effluent with alum floc. To avoid the need for a new tertiary clarifier, the filtration system should be capable of continued operation when a tertiary clarifier is out of service.	Suitable provided that lower loading rates are used. Alum and polymer required for lower effluent phosphorus requirements as in this application.	Suitable provided that lower loading rates are used. Alum and polymer required for lower effluent phosphorus requirements as in this application.	Experience of this technology for this application is very limited and does not indicate an ability to meet the effluent criteria required.	Suitable provided that lower loading rates are used. Alum and polymer required for lower effluent phosphorus requirements as in this application.

Table 7-22. Comparison of Alternative Tertiary Filtration Technologies, cont'd…

	Alternative Filtration Technology			
Evaluation Criteria	Deep Bed Granular Media	Cloth Disk Filter	"Fuzzy" filter (Compressible Medium Filter)	Continuous (granular medium) Upflow Backwash
Maintenance considerations. Systems that rely on more equipment generally require more maintenance. In addition, systems that inherently restrict maintenance access or utilize equipment with submerged bearings and other components typically demand more labor.	Higher maintenance requirements due to increased backwash requirements and backwash water handling systems.	Lower maintenance demands than deep bed granular media.	Lower maintenance demands than deep bed granular media.	Lower maintenance demands than deep bed granular media.
Reliability/redundancy. Filtration systems are often equipped with a standby filter cell that permits taking a unit out of service for redundancy. Systems utilizing "depth filtration" (such as continuous upflow granular or compressible medium filters) typically provide improved reliability compared to those with "surface filtration", which are more susceptible to blinding.	Depth filtration increases reliability and redundancy. Redundant filtration units are typically used.	Moderate, typically surface filtration does not offer as much redundancy as depth filtration. Redundant filtration units are typically used.	Depth filtration characteristics increase reliability and redundancy. Redundant filtration units are typically used.	Depth filtration characteristics increase reliability and redundancy. Redundant filtration units are typically used.
Media life. Media life and warranties vary significantly between systems. Media replacement represents a significant expense.	Granular media has a typical expected useful life of more than 10-15 years.	Cloth media has a typical expected useful life of 5 to 7 years. Manufacturer warranty is usually 5 to 7 years.	Compressible medium has a typical expected useful life of more than 10 years. Manufacturer warranty is usually 7 to 10 years.	Granular media has a typical expected useful life of more than 10-15 years.
Hydraulic issues. The WRF has limited head available for inclusion of a gravity-fed filtration system. Filtration technologies that have lower head requirements may offer additional flexibility in terms of facility configuration	Moderate head loss. Feed pumping required.	Low head loss. Feed pumping not required.	Relatively high head losses. Ranges from 32 inches for clean media to 80 inches when fully charged with solids. Feed pumping will be required.	Low head loss. Feed pumping not required.

Table 7-22. Comparison of Alternative Tertiary Filtration Technologies, cont'd…

Relative energy use. Filtration alternatives can vary significantly in energy use, which is primarily related to backwashing and head loss.	Higher overall plant energy use; mainly due to high backwash reject ratio and added headloss requirements.	Low relative to deep bed granular media.	Low relative to deep bed granular media.	Higher overall plant energy use; mainly due to high backwash reject ratio
Recycled water production. Systems capable of producing Class A recycled water—preferably with minimal chemical addition—are preferred.	System capable of accommodating production of Class A recycled water.	System capable of accommodating production of Class A recycled water.	System capable of accommodating production of Class A recycled water.	System capable of accommodating production of Class A recycled water.
Competition. Specifying proprietary systems should be avoided if possible. Maximizing competition between manufacturers will reduce equipment costs.	Numerous manufacturers.	Several manufacturers, although designs differ substantially	None. Process is proprietary to Schrieiber Corporation.	Several manufacturers
Relative cost.	Moderate	Low	Low	Moderate
Additional benefits	Extensive operational history	Less space and hydraulic head requirements.	Less space requirements. Can be operated at very high filtration rates (up to 30 gal/min-ft^ - six times greater than cloth or granular filters). Media compressibility offers operational flexibility and optimization.	Extensive operational history at the WRF.

Design data for Alternative 1 are presented in Table 7-23, while a process flow schematic is provided as Figure 7-20.

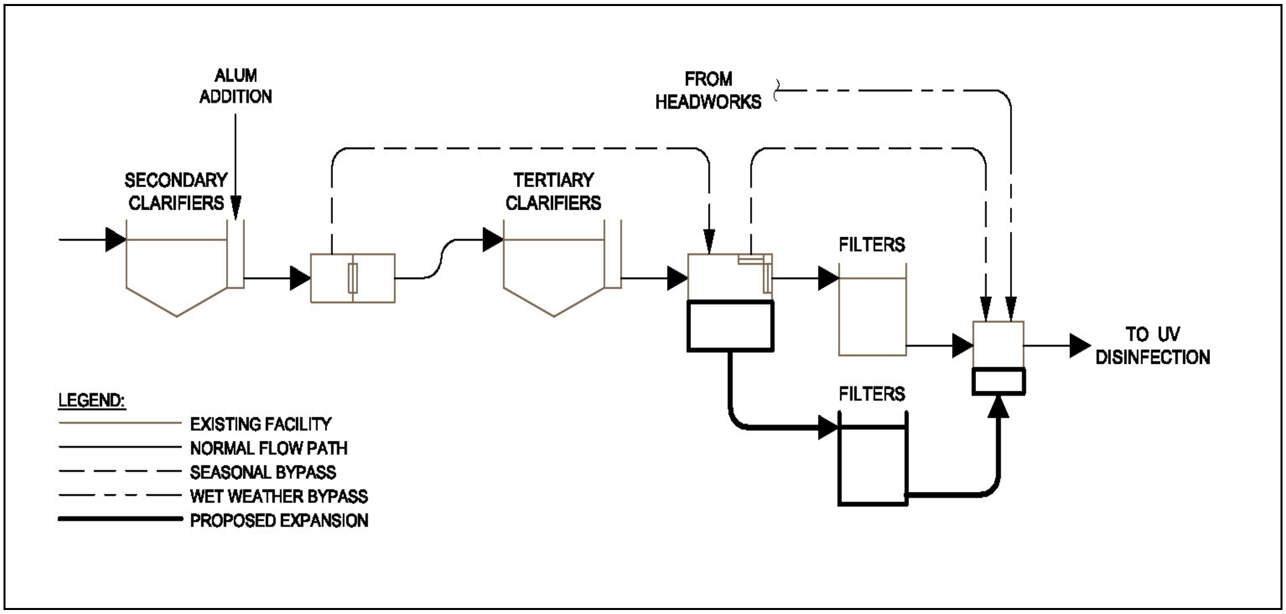
Table 7-23. Design Data for Tertiary Treatment Alternative 1: Expand Existing Filtration System

Description	Value
DESIGN FLOWS	
Average Dry Weather Flow (ADWF)	6.1
Maximum Month Dry Weather Flow (MMDWF)	11.4
DESIGN LOADS	
Phosphorus, lbs/day (mg/L)	100 (2.0)
Tertiary Clarifiers	
Type	Solids Contact
Number	2
Diameter, ft	70
Side Water depth, ft	20
Reactor Detention Time, min	30
Upflow Rate at MMDWF, gpm/SF (gpd/SF)	0.6 (864)
Chemical Sludge Pumps	
Type	Screw Induced Flow Centrifugal
Number	2
Capacity, gpm	150
Motor HP	1.5
Existing Filters	
Type	Continuous Upflow
Number	6
Surface Area, each, sf	200
Basin Geometry	
Length, ft	14.21
Width, ft	17.61
Depth, ft	19.55
Peak Loading Rate, gpm/SF	4.0
Peak Capacity (all units in service), mgd	8.6
Peak Capacity (one unit out of service), mgd	7.2
Air Requirements, scfm/filter module	2.5
Min Backwash Surface Loading Rate, gpm/SF	50

Table 7-23. Design Data for Tertiary Treatment Alternative 1: Expand Existing Filtration System, cont'd…

Description	Value
Filter Expansion	
Peak Flow Capacity Required, mgd	5.6
Type	Cloth media
Number of Cells	2
Disks per Cell	10
Total number of disks	20

Figure 7-20. Flow Schematic for Tertiary Filtration Alternative 1: Expand Existing Filtration System



Alternative 2. Construct Parallel Membrane Filtration System

Under this alternative, the existing tertiary facilities would be retained and operated in parallel with a new membrane filtration system.

Tertiary Clarifiers. The tertiary clarifiers would remain in service, receiving only maintenance improvements and normal equipment replacement.

Chemical Sludge Pumps. The chemical sludge pumps would be replaced as needed

Filters. As with the other existing facilities, the Dynasand filters would remain in service essentially as-is, with equipment and media replacement taking place at normal intervals.

Membrane Filters. A wide range of membrane pore sizes are available, with smaller pore sizes removing increasingly smaller solids. This improved removal is at the expense of higher pressure loss, energy use, and backwashing requirements. Membranes are generally classified based on pore size as follows:

- Microfiltration removes particles larger than 0.5 microns. Microfiltration removes bacteria, cysts, and some viruses. Typical feed pressures are in the range of 25 to 40 psi.
- Ultrafiltration removes particles larger than 0.05 microns. In addition to bacteria and cysts, most viruses are removed. Feed pressures are typically 35 to 50 psi.
- Nanofiltration removes particles larger than 0.001 microns. Large organic molecules and some salts are removed. Feed pressures are 100 to 500 psi.
- Reverse osmosis removes total dissolved solids, hardness, and dissolved carbon compounds, and is used for desalination of sea water. Required feed pressures can reach 1,000 psi.

Microfiltration and ultrafiltration membranes are typically selected for effluent filtration applications unless particularly stringent effluent requirements exist.

Less disinfection energy is required for membrane effluent than for conventional filters due to the membrane's inherent particle removal capabilities. Un-disinfected membrane effluent can often meet numeric bacteria criteria for recycled water. However, DEQ does require some amount of disinfection as a safeguard, and to inactivate viruses.

Experience has shown that certain membrane filter designs are more effective at alum floc removal than others. For example, flat plate designs are more susceptible to blinding when treating secondary effluent with alum floc. Therefore, in order to bypass the tertiary clarifiers and filter secondary effluent directly, only certain membrane filtration system designs should be considered. As membrane systems are rapidly evolving, the City should carefully evaluate the specific options available as part of the preliminary design process.

Membrane filtration systems typically come as packages, equipped with feed pumps, backwash systems, and cleaning systems. The membrane filters would be sized to accommodate dry weather flows that exceed the capacity of the existing tertiary system.

Because of the relatively high pressure requirements, a pump station would be needed to convey secondary effluent through the membrane filtration system. Design data for Alternative 2 are presented in Table 7-24, while a process flow schematic is provided as Figure 7-21.

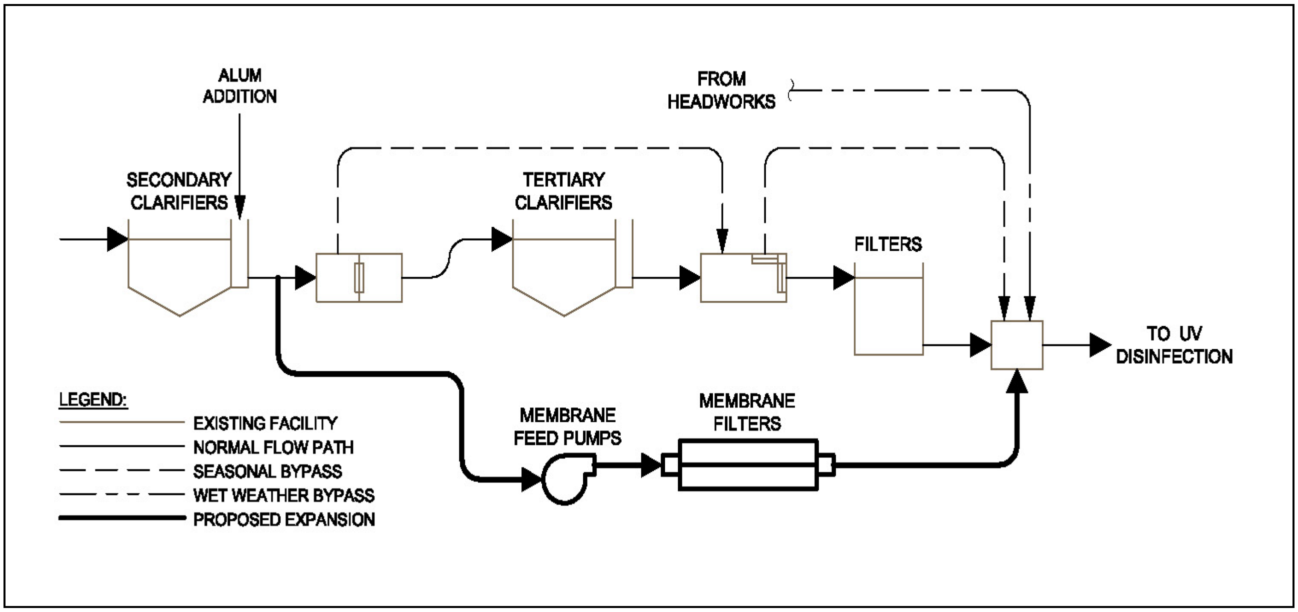
Table 7-24. Design Data for Tertiary Treatment Alternative 2: Membrane Filtration System in Parallel with Existing Filtration System

Description	Value
DESIGN FLOWS	
Average Dry Weather Flow (ADWF)	6.1
Maximum Month Dry Weather Flow (MMDWF)	11.4
DESIGN LOADS	
Phosphorus, lbs/day (mg/L)	100 (2.0)
Tertiary Clarifiers	
Type	Solids Contact
Number	2
Diameter, ft	70
Side Water depth, ft	20
Reactor Detention Time, min	30
Upflow Rate at MMDWF, gpm/SF (gpd/SF)	0.6 (864)
Chemical Sludge Pumps	
Type	Screw Induced Flow Centrifugal
Number	2
Capacity, gpm	150
Motor HP	1.5
Existing Filters	
Type	Continuous Upflow
Number	6
Surface Area, each, sf	200
Basin Geometry	
Length, ft	14.21
Width, ft	17.61
Depth, ft	19.55
Peak Loading Rate, gpm/SF	4.0
Peak Capacity (all units in service), mgd	8.6
Peak Capacity (one unit out of service), mgd	7.2
Air Requirements, scfm/filter module	2.5
Min Backwash Surface Loading Rate, gpm/SF	50
Membrane Filtration Systems	
Production Feed Capacity required, mgd	4.2
Design flux rate, gpd/SF	35.2
Number of racks	2

Table 7-24. Design Data for Tertiary Treatment Alternative 2: Membrane Filtration System in Parallel with Existing Filtration System, cont'd…

Description	Value
Rack dimensions, ft x ft	6 x 25
Membrane housings per rack	36
Membrane elements per housing	4
Total membrane elements	288
Total membrane area, SF	124,128
Raw Water Feed Pumps	
Number (Duty + Standby)	3
Horsepower	130
Backwash Pumps	
Number (Duty + Standby)	2
Horsepower	65

Figure 7-21. Flow Schematic for Tertiary Filtration Alternative 2: Parallel Membrane Filtration System



Alternative 3. Replace Existing Facilities with Membrane Filtration System

Alternative 3 consists of the removing of the existing tertiary treatment facilities and constructing a new membrane filtration system sized to accommodate all dry weather flows. The membrane filtration system would be similar to that described in Alternative 2, suitable for treating secondary effluent and alum floc. The obvious disadvantage of this alternative is financial – existing treatment capacity would be abandoned and then replaced.

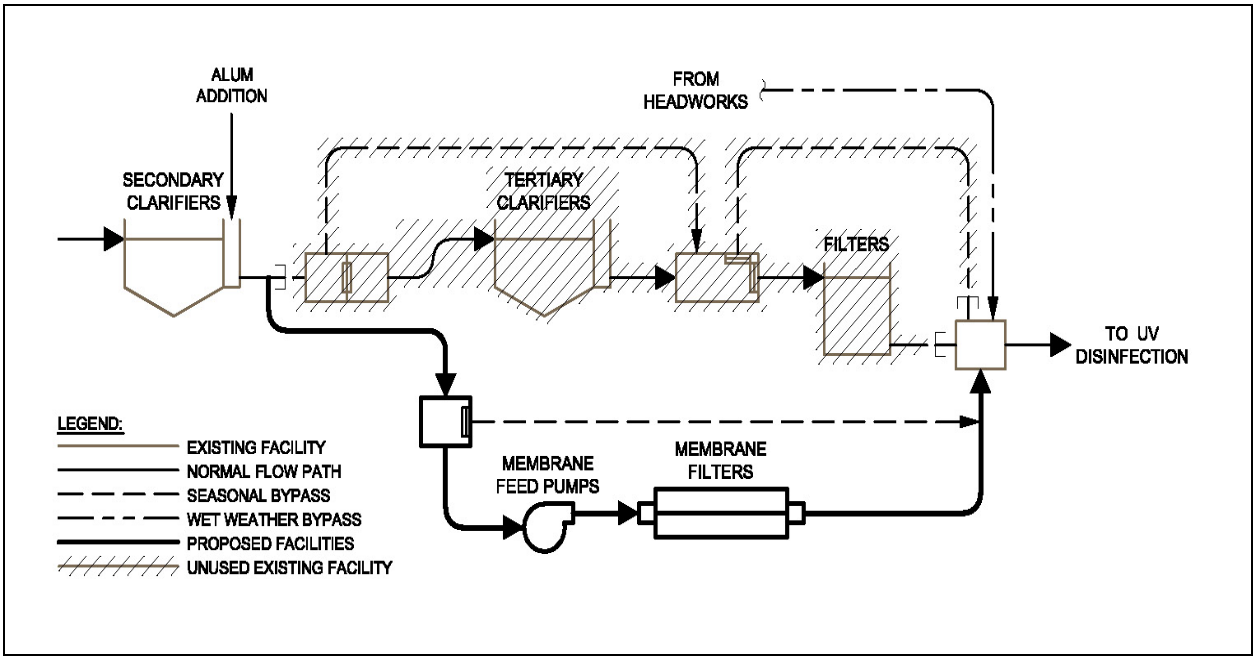
Similar to the existing tertiary system, the membrane filtration system would be configured such that bypassing of dry weather peak flows would be possible.

Design data and a process flow schematic for Alternative 3 are presented in Table 7-25 and Figure 7-22, respectively.

Table 7-25. Design Data for Tertiary Treatment Alternative 3: Replace Existing Filtration System with Membrane Filtration System

Description	Value
DESIGN FLOWS	
Average Day Dry Weather Flow (ADWF)	6.1
Maximum Month Dry Weather Flow (MMDWF)	11.4
DESIGN LOADS	
Phosphorus, lbs/day (mg/L)	100 (2.0)
Existing Filters	
Type	Not Used
Membrane Filtration Systems	
Production Feed Capacity required, mgd	11.4
Design flux rate, gpd/SF	35.6
Number of racks	5
Rack dimensions, ft x ft	6 x 25
Membrane housings per rack	36
Membrane elements per housing	4
Total membrane elements	720
Total membrane area, SF	310,320
Raw Water Feed Pumps	
Number (Duty + Standby)	3
Horsepower	350
Backwash Pumps	
Number (Duty + Standby)	2
Horsepower	400

Figure 7-22. Flow Schematic for Tertiary Filtration Alternative 3: Replace Existing Facilities with a Membrane Filtration System



Evaluation of Tertiary Treatment Alternatives

This section evaluates the tertiary treatment alternatives from economic and non-economic standpoints.

Economic Comparison. A comparison of the estimated capital project costs of the effluent filtration alternatives is presented in the following Table 7-26.

Table 7-26. Tertiary Treatment Alternatives Capital Cost Comparison

Description	Alternative Capital Cost, $1,000		
	Alternative 1: Expand Existing Filtration System	Alternative 2: Parallel Membrane Filtration System	Alternative 3: Existing Filtration Replaced by Membrane Filtration
Tertiary Filter Expansion	913	-	-
Membrane Filtration System	-	3,092	5,943
Electrical/I&C (20%)	180	620	1,190
Subtotal	1,093	3,712	7,133
General Conditions (10%)	110	370	710
Contractor's Overhead & Profit (15%)	160	560	1,070
Subtotal	1,363	4,642	8,913
Contingencies (30%)	410	1,390	2,670
Subtotal	1,773	6,032	11,583
Engineering & Administration (25%)	440	1,510	2,900
Total Capital Cost	2,213	7,542	14,483

A comparison of the estimated annual operation and maintenance costs of the effluent filtration alternatives is presented in the following Table 7-27.

Table 7-27. Tertiary Treatment Alternatives Annual Operation and Maintenance Cost Comparison

Description	Alternative O&M Cost, $1,000		
	Alternative 1: Expand Existing Filtration System	Alternative 2: Parallel Membrane Filtration System	Alternative 3: Existing Filtration Replaced by Membrane Filtration
Labor	100	300	550
Electrical Power	1	16	45
Chemicals	2	10	27
Maintenance Materials	11	23	51
Total Annual O&M	114	349	673

A present worth comparison of the costs of the effluent filtration alternatives is presented in the following Table 7-28.

Table 7-28. Tertiary Treatment Alternatives Present Worth Cost Comparison

Description	Alternative Costs, $1,000		
	Alternative 1: Expand Existing Filtration System	Alternative 2: Parallel Membrane Filtration System	Alternative 3: Existing Filtration Replaced by Membrane Filtration
Total Capital Cost	2,213	7,542	14,483
Total Annual O&M Cost	114	349	673
Total Present Worth	3,574	11,708	22,517

Non-Economic Comparison. The non-economic comparison is summarized in Table 7-29.

Table 7-29. Non-Economic Comparison of Effluent Filtration Alternatives

Evaluation Criteria	Alternative 1: Expand Existing Tertiary Facilities	Alternative 2: Construct Parallel Membrane Filtration System	Alternative 3: Replace Existing Facilities with Membrane Filtration System
Operation and Maintenance Considerations	O&M requirements comparable to existing facilities. Flow splitting to new filters required. Upset conditions can impact filter operations	Two distinct, parallel processes greatly increase O&M requirements. Pump station required. Membrane systems are equipment intensive	Membrane systems are equipment intensive. Pump station required. Membrane systems are equipment intensive
Reliability	WRF personnel have modified the existing filters to enhance reliability	Two distinct process trains would be heavily reliant on numerous pieces of equipment. The two distinct process trains could serve as backups to each other	Membrane systems are very reliant on equipment
Performance	Dynasand filters have not consistently performed well	Membranes provide excellent TSS removal. By blending membrane effluent with current tertiary effluent, overall effluent quality will improve.	Membranes provide excellent TSS removal compared to conventional tertiary processes.
Flexibility	With relatively minor piping and structural modifications, the tertiary clarifiers could provide primary treatment to blended flows during wet weather peak flow conditions.	Having two parallel tertiary processes provides operational flexibility. With relatively minor piping and structural modifications, the tertiary clarifiers could provide primary treatment to blended flows during wet weather peak flow conditions.	Small footprint of membrane system coupled with eliminating the existing tertiary facilities increases available space at the WRF.

Table 7-29. Non-Economic Comparison of Effluent Filtration Alternatives, cont'd…

Evaluation Criteria	Alternative 1: Expand Existing Tertiary Facilities	Alternative 2: Construct Parallel Membrane Filtration System	Alternative 3: Replace Existing Facilities with Membrane Filtration System
Complexity	Existing process is well understood by WRF personnel.	Having two parallel tertiary processes increases complexity. Equipment intensive membrane systems are complex relative to conventional tertiary treatment processes.	Equipment intensive membrane systems are complex relative to conventional tertiary treatment processes.
Energy use	Lowest energy use of any tertiary alternative.	Pumping requirements for membrane system increases energy use.	Pumping requirements for membrane system for all dry weather flow significantly increases energy use.

DISINFECTION ALTERNATIVES

The principle alternative disinfection approach used at municipal wastewater treatment plants is chlorine. The two most common types of chlorine disinfectant are chlorine gas and sodium hypochlorite solution (high strength bleach). However, these alternatives would require both the construction of a chlorine contact tank and the addition of sulfur dioxide or sodium bisulfite to dechlorinate the effluent after disinfection and prior to discharge. Gas based systems (chlorine and/or sulfur dioxide) would also require onerous safety measures and containment systems capable of capturing any of these hazardous gases should a leak occur. Despite the adoption of these measures, these facilities are considered to be more hazardous than either liquid solution based systems or UV. Furthermore, all chlorine based disinfection systems may result in the formation of chlorine byproducts which may result in the formation of toxic compounds in sufficient quantities that the effluent could no longer meet its effluent quality requirements.

Ultraviolet (UV) disinfection systems have been installed in a number of treatment plants in recent years as a means of avoiding the safety issues associated with gas-based systems, the costs of liquid chemical supply, and/or the formation of chlorine byproducts in the effluent. Chlorine is still used in smaller quantities in UV disinfection plants for the production of recycled water used both within and outside of the plant.

The existing WRF effluent disinfection facility utilizes UV technology consisting of 3 parallel channels with 3 banks of low-pressure, low-intensity lamps in each channel. Each bank has 152 individual lamps resulting in a total installed lamp count of 1,368. The number of channels and lamps in service is controlled automatically, based primarily on effluent flow rate.

UV Disinfection Alternatives

Continued use of UV for effluent disinfection is recommended for the WRF’s future effluent disinfection needs. This disinfection method will provide an adequate level of disinfection as needed to continue to meet the effluent disinfection requirements prescribed by the DEQ.

Since the existing UV disinfection system has sufficient capacity for the projected buildout flow conditions at the plant, no modifications are required to meet the effluent disinfection needs at the plant. UV system improvements are therefore not recommended as part of this Master Plan because they are not required to meet current or future requirements.

As a future maintenance and replacement issue, it may be prudent to replace equipment with newer technology. Disinfection alternatives were therefore limited to those that may be considered when the existing equipment nears the end of its useful life.

The following UV disinfection alternatives were identified for the accommodation of projected buildout effluent flow conditions:

- Replace existing equipment with new in-channel UV lamps utilizing current low pressure, high intensity lamp technology and an in-channel lamp cleaning system to reduce the fouling of the lamps during operation.
- Replace the existing facility with a medium pressure, high intensity UV lamp system.

Alternative 1: Replace Existing Equipment. In this alternative, the existing UV disinfection equipment would be replaced with new equipment that utilizes current UV equipment technology. These are similar to the system currently in use at the plant except that the lamps are high-intensity instead of low-intensity and they would be equipped with an in-channel lamp cleaning system to enhance performance operationally and reduce maintenance requirements.

Alternative 2: Replace with a Medium Pressure UV Disinfection System. Provision of a medium pressure high intensity UV disinfection system at the WRF would require the construction of an entirely new disinfection facility as the channel geometry of a medium pressure system is different from the existing in-channel lamp system.

Economic Evaluation of Alternatives. Of the two technologies, only the low pressure lamp system would be cost effective as it would be compatible with the design of the existing UV equipment channels. A changeover to a medium pressure system would require that a new UV disinfection facility be constructed. Furthermore, although medium pressure systems require fewer lamps, they are less efficient so they require more power than low pressure lamp systems. Consequently, they would be both more capital as well as energy intensive than a low pressure high intensity lamp system.

Non-Economic Evaluation of Alternatives. The comparison of non-economic factors of the alternatives for UV disinfection is presented in Table 7-30.

Table 7-30. Non-Economic Comparison of UV Disinfection Alternatives

Evaluation Criteria	Alternative 1: Low Pressure, High Intensity Lamps	Alternative 2: Medium Pressure, High Intensity Lamps
Operation & Maintenance Considerations	More lamps to maintain than with medium pressure systems	Fewer lamps to maintain.
Reliability	Proven technology	Proven technology
Flexibility	Multiple units permit removal of components for maintenance.	Fewer units reduce redundancy.
Complexity	Requires maintenance of monitoring and electrical equipment.	Requires maintenance of monitoring and electrical equipment.
Energy Use	Moderately high	Highest due to lower fraction of lamp output at lethal UV wavelength.

Sodium Hypochlorite System

The existing sodium hypochlorite storage and feed system will be adequate for the projected needs of the treatment plant throughout the master planning period as it is adequate for the chlorination of recycled water used throughout the plant. However, modifications and/or expansions to the system may be needed if large effluent reuse demands are identified in the future.

OTHER PLANT FACILITIES

Outfall

Capacity Requirements. The existing effluent flowmeter and outfall pipeline system has the following capacities:

- Effluent flowmeter: 32.6 mgd
- Outfall pipeline at full flow: 37 mgd.
- Outfall pipeline at surcharged flow: 42 mgd. This can be accomplished by submerging the flume tailwater to the point just below the depth that would begin to affect the accuracy of the flume.

Since all of these capacities are equal to or greater than the projected buildout PHF, no expansion to any of the outfall system components would be required.