Gray & Osborne, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM 20434-7

TO:	BILL HUNTER, P.E., ASSISTANT GENERAL MANAGER/DISTRICT ENGINEER
FROM:	KEITH STEWART, P.E. RUSSELL PORTER, P.E.
DATE:	FEBRUARY 18, 2022
SUBJECT:	SUDDEN VALLEY WTP BACKWASH SYSTEMS ANALYSIS LAKE WHATCOM WATER & SEWER DISTRICT, WHATCOM COUNTY, WASHINGTON G&O #20434.00

INTRODUCTION

In 2019, the Lake Whatcom Water & Sewer District (District) contracted with Gray & Osborne to perform a condition assessment for their existing Sudden Valley Water Treatment Plant (WTP) as part of a larger effort to analyze the District's water treatment facilities in order to prioritize funds for rehabilitation, modification, and/or replacement projects. The goal of the assessment and subsequent analysis is to identify potential improvements for the existing structures and treatment processes in an attempt to maximize treatment efficiency and extend the operational life of these facilities. The reports and technical memoranda generated as part of this assessment project will be used to develop a strategy for prioritizing modifications to the WTP to ensure it can efficiently and cost-effectively provide clean potable water for its existing and projected customers.

This memorandum summarizes the assessment of the existing filter backwash system at the WTP, provides a description of alternative backwash handling and storage methods, and provides analysis and preliminary cost estimates for these alternatives.

Final recommendations for backwash system modifications will be presented in the final alternatives analysis report, which is scheduled to be completed in spring 2021. This final report will consider all of the alternatives and recommendations compiled for each of the treatment systems and will provide a coordinated set of recommendations based on capital costs, District needs, operational costs, and other factors.

1130 Rainier Avenue South, Suite 300 Seattle, Washington 98144 (206) 284-0860 Fax (206) 283-3206

BACKGROUND AND EXISTING FACILITIES

Background

The District operates three Group A water systems – South Shore (DOH 95910), Eagleridge (DOH 08118), and Agate Heights (DOH 52957) – all of which are in and around the shores of Lake Whatcom, which lies southeast of Bellingham in Whatcom County, Washington. The District serves approximately 3,900 residential and commercial water system connections with a residential population of approximately 10,000 people.

The South Shore system is the largest of the three systems and is supplied wholly by water treated at its Sudden Valley Water Treatment Plant. In addition to the WTP, the District also owns and maintains surface water source, storage, and distribution system facilities. The distribution system includes multiple pressure zones, four booster stations, and approximately 2.8 million gallons (MG) of storage in five reservoirs. The District also maintains a secondary intertie with the City of Bellingham Water System (DOH 50600) that is used only during emergency situations.

The existing WTP is a rapid-rate direct filtration plant with a rated capacity of 2.0 million gallons per day (MGD), which is equivalent to approximately 1,400 gallons per minute (gpm), but currently operates at a reduced flow of 1.0 MGD (700 gpm). The maximum allowable water right for this source is 1,526 gpm; however, the equipment and components listed in the alternatives below will be sized to accommodate the WTP's rated flow of 1,400 gpm. This design flow is suitable to serve the projected buildout water demand of 1.3 MGD as listed in the District's 2018 Water System Comprehensive Plan.

The WTP is located at 22 Morning Beach Drive in Bellingham, Washington, and is housed in a partially below-grade concrete building located adjacent to Morning Beach Park. The facility was constructed in 1972 and has undergone several minor improvements since that time but was most recently upgraded in 1992. Two centrifugal raw water pumps pump water from the Lake Whatcom intake to the WTP where alum coagulant is injected. After mixing with coagulant, water enters the flocculation tank before entering the filter distribution trough and the mixed-media filters. Water proceeds through the filters, into the underdrain system, then exits the filter through the filter discharge piping. The filter discharge piping includes injection points for both soda ash (pH adjustment) and chlorine. This piping then directs the filtered water to the below-grade clearwell. Two transfer pumps located in the WTP move water from the clearwell to the chlorine contact basin (CCB), which is a welded steel reservoir located adjacent to the WTP that provides additional chlorine contact time. From the CCB, four finished water pumps pump water to the District's storage reservoirs and distribution system for consumption. Additional information on the filter backwash system – which is the primary subject of this memorandum – is provided below.

Historical WTP Performance

Historically, the plant has performed well and provides high-quality finished water with turbidities of less than 0.1 nephelometric turbidity units (NTU). Raw water is collected from the adjacent Lake Whatcom from an intake located at a depth of approximately 80 feet and approximately 350 feet from the typical shoreline. Lake Whatcom is a large lake that is moderately developed on the northern and western shores but is largely undeveloped on its eastern shore. Raw water quality from the Lake Whatcom source is fairly consistent with turbidity below 1.0 NTU for most of the year. Turbidity increases during the spring and fall runoff season, but typically remains below 5.0 NTU during these periods. Raw water pH is typically between 7.5 and 7.7 and raw water temperature varies between 5 and 8 degrees Celsius.

Filter Backwash System

The WTP utilizes a backwash system to maintain the performance of their mixed-media filter beds. The backwash system consists of four media filters, backwash supply, flow measurement, and waste handling system and each of these components is described in greater detail below.

During normal filter operation, water is distributed evenly to all four filter cells and flows through the filter media and into the respective underdrain chambers. As it passes through the filter media, flocculated sediment and small particles are trapped and removed by the media while filtered water passes into the underdrain system and on through the discharge piping to the clearwell.

As additional particles are adsorbed onto the filter media, the head loss through the filter media and the water level within the filter vessel increases. To remove the adsorbed particles from the filter media, each filter bed is individually backwashed daily prior to filter operation. Table 1 summarizes critical design criteria for the existing filter backwash system and Figure A-1 in Exhibit A shows photographs of the existing equipment. During the backwash of a filter cell, finished water from the distribution system served by the Division 7 Reservoir flows upward through the filter at approximately 1,300 gpm (18.0 gpm/sf) for approximately 9 minutes. At this loading rate, the media bed is fluidized to remove the accumulated sediment particles and the particle-laden backwash water flows into the filter cell waste trough and then to the backwash storage basin. The recently completed WTP Assessment Report (Assessment

Report) produced by Gray & Osborne in 2020 noted that the filters and backwash sequence appear to be performing adequately and do not show a noticeable decrease in performance, filter run times, or rebound after backwashing within the last several years.

TABLE 1

Filter Backwash System Summary

Parameter	Value
Filter Type	Direct Filtration, Rapid-Rate Mixed Media
Filter Area (sf)	288 (4 filters @ 72 sf each)
Fluid Type	Finished Water
Backwash Flow Rate (gpm)	1,300
Backwash Loading Rate (per bed, gpm/sf)	18.0
Backwash Duration (min., per bed)	9–10 [(1)]
Backwash Volume (gal, total)	45,000

(1) Includes 2 minutes of surface wash, 2.5 minutes of surface wash and backwash, and 5 minutes of backwash. Time listed does not include up to 20 minutes of settling, equalization, and/or drainage or up to 15 minutes of filter to waste. Estimated volume for filter to waste is 10,000 to 15,000 gallons.

The backwash flow rate to the filter cells is measured by a Badger® magnetic flow meter installed in 1992 on the backwash supply piping located on the south wall of the WTP. The meter has not been recalibrated since its installation, but according to WTP staff the meter provides consistent performance when compared to previously recorded values. The Assessment Report did note that the existing backwash flow meter is an old model and is likely no longer supported by the manufacturer, which will make it difficult to complete calibration and/or repairs.

After the backwash sequence (including up to 15 minutes for the filter-to-waste cycle) is completed, the filters return to normal operation and water flows through the filters and into the clearwell. According to WTP staff, the entire backwash process for all four filters typically takes 120 to 160 minutes.

Water from the filter backwash process exits the filter vessel via the backwash waste trough and proceeds to a temporary storage basin. The backwash storage basin is located underground between the Main Building and the Finished Water Pump Building, has a volume of approximately 16,000 to 17,000 gallons, and provides flow attenuation for the spent backwash water. Backwash water within the basin is pumped via one of two submersible pumps to a manhole near the Finished Water Pump Building, then flows by gravity to the Afternoon Beach Lift Station. This lift station then pumps the wastewater to the municipal gravity sewer system where water proceeds to the City of Bellingham’s

Post Point Wastewater Treatment Plant (WWTP) for treatment. Overflow from the backwash basin is directed back to Lake Whatcom.

Two backwash pumps are installed within the backwash basin. The larger pump is capable of pumping approximately 400 gpm while the smaller pump is capable of pumping approximately 180 to 200 gpm. Operation of either pump is controlled by a set of level floats within the backwash basin. WTP staff select which pump operates using a manual selector switch within the Main Building, and typically utilize the larger pump during the dry summer months and the smaller pump in the wet winter months. The pumps operate in this fashion so as not to overwhelm the Afternoon Beach Lift Station. The limited capacity of the smaller pump used during winter restricts the speed at which the WTP can complete a backwash sequence because staff must wait for the backwash basin to empty (partially) before backwashing additional filters. This process is cumbersome, time-consuming, and requires visual inspection of the basin during the backwash sequence. It is also noteworthy that the WTP does not maintain any redundant pumps for the backwash basin should either pump fail or be taken offline for maintenance.

The Assessment Report noted that the backwash basin is small and that the current backwash disposal process is expensive as a result of charges incurred while discharging to the municipal sewer system. Although the current backwash procedure provides adequate backwash of the filter vessels, the process is cumbersome for WTP staff and costs for disposal will continue to increase as a result of future sewer discharge rate increases. Backwashing less frequently is one option to reduce operating costs; however, discussions with WTP staff indicate that the current summer filter run time of 12 to 16 hours is the maximum run time possible based on turbidity readings during filter operation. As such, given the current water quality and operational parameters, extending the filter run times by backwashing less frequently, or operating the filters over the course of multiple days, is not feasible.

In order to provide a cost-effective option for backwash waste disposal, reduce operational costs, and provide a convenient and efficient system for WTP staff, the District is interested in investigating alternative methods for spent backwash water handling and disposal. The backwash sequence and components in use at the WTP should have the capacity to handle both current and design flows, sufficient volume for waste handling, provide a convenient and efficient way for WTP staff to backwash all four filters, and should provide redundancy or auxiliary accommodations/connections so that the WTP can remain in operation even if specific components must be taken offline for maintenance or rehabilitation.

To accomplish these goals, we have identified three alternatives that are feasible for the District's WTP operations. The next section describes these three alternatives with variations for backwash waste handling.

ALTERNATIVES ANALYSIS

In this section, three alternatives for backwash waste handling are presented. The alternatives are based around the various discharge locations, and within each alternative there are two options for temporary storage and handling. The alternatives discussed are continued discharge to the municipal sewer system, discharge to Lake Whatcom, or recycling flows back through the treatment system. A general description, specifics about the proposed alternative, impacts to existing buildings and supporting systems, (HVAC, electrical, structural, etc.), advantages/disadvantages, and a cost estimate are provided for each alternative.

Alternative B1 – Discharge to Municipal Sewer

General

This alternative includes continued discharge to the municipal sewer. The alternative is further divided into Options B1A and B1B for both below- and above-grade storage, respectively.

Backwash

In this alternative, all backwash waste would be pumped to the municipal sewer system via the existing Afternoon Beach Lift Station with improvements to optimize operations. The District would continue to pay municipal discharge rates to the City of Bellingham (City).

The District has noted that the current process is expensive and it may be possible to reduce the cost by coordinating with the City to meter the flows to the sewer system during non-peak hours. Typically, municipal sewer systems experience periods of high flows between approximately 6:00 and 9:00 a.m., and again between 5:00 and 10:00 p.m. This is often referred to as a diurnal peak and these peaks typically correspond to times when water system demand is high. Pumping spent backwash water to the sewer system during peak hours further increases the peak flows to the treatment facility, which places additional stress on the wastewater treatment facility equipment. If the District was able to send the backwash waste to the sewer system outside of these windows, it may be possible to negotiate a lower charge which will reduce the overall cost.

Because the existing backwash storage basin is not large enough to contain and store the full volume of a complete backwash sequence (approximately 50,000 gallons), additional storage volume would allow for operational flexibility. This additional storage volume will allow staff to manually initiate the filter backwash sequences during normal working hours, then temporarily store the backwash volume until non-peak discharge hours or would allow them the flexibility to discharge the backwash water at a constant, low flow rate throughout a 24-hour period. It will also allow the staff to sequentially backwash each filter without waiting for the backwash basin to drain to the lift station.

Currently, the WTP staff operate the filters at 700 gpm and backwash each filter once per day prior to operation. To accommodate the full design flow of 1,400 gpm, it is assumed that the WTP staff will need to backwash twice as often to maintain filter performance. Thus, for the design flow of 1,400 gpm it is estimated that 120,000 gallons of storage must be provided. This volume includes two full backwash sequences of 50,000 gallons each plus 20,000 gallons of storage for spare/flexible capacity (20 percent). This storage volume could be provided by new below-grade or above-grade tankage, each of which are described as Options B1A and B1B below.

Both options for additional storage volume are shown on Figure A-2 in Exhibit A. Option B1A is for a new below-grade tank. While a concrete reservoir is one possibility, it is more cost effective to provide detention tank storage similar to those used for stormwater detention. In this alternative, the existing backwash storage basin could be utilized to provide additional attenuation volume, could be abandoned in place and bypassed, or could be removed. Given the added flexibility that this basin could provide, this alternative includes continued use of the existing basin, but modifying the components to include a gravity or pumped drainage to the proposed detention tank. For the purposes of this analysis, it is assumed that the backwash waste will need to be pumped from the existing backwash storage basin to the proposed detention tank, although a more thorough survey and field investigation may show that gravity drainage between the two tanks is feasible. The detention tank would provide below-grade storage and would drain by gravity to a separate submersible pump station – also located below grade. This pump station would accommodate up to three pumps (two duty, one redundant) and would include valves and controls to allow the WTP staff or the programmable logic controller (PLC) to remotely start the pumps based on a timer so that the backwash can be distributed to the lift station during off-peak hours. The detention tank could be made from polyethylene or fiber reinforced plastic (FRP) materials and would consist of prefabricated sections joined in the field. The system includes three access ports to allow for inspection and can accommodate various instruments and floats to provide information on the level within the tank. The tank could be installed within the adjacent land associated with Morning Beach Park. This location would allow access to the tank for WTP staff and still provide an open park setting for use by the general public. Preliminary design criteria for a detention-style tank suitable for this application are provided in Table 2.

Option B1B includes installation of an above-grade concrete storage tank. For this option, the existing below-grade storage basin could be utilized, but instead of pumping to an existing manhole, the pumps would pump backwash water to a new above-grade temporary storage tank located adjacent to the existing CCB. The proposed tank would include inlet piping, a center drain connection for full and complete drainage, access ladder, roof safety railing, level monitoring instrumentation, and access hatches. To ensure that the existing backwash storage basin provides sufficient flexibility and storage to allow WTP staff to sequentially backwash each filter, the existing 200 and 400 gpm pumps should be replaced with larger 600 to 800 gpm submersible pumps. The pumps could be operated with variable frequency drive (VFD) motor starters and discharge from the existing backwash basin would be controlled by adjusting the pump motor speed to maintain the desired flow of 600 to 800 gpm. Gravity discharge from the proposed tank would be controlled by a mechanized butterfly valve and flow meter. The flow meter will measure the flow through the piping and the position of the butterfly valve will be adjusted by the PLC in order to maintain the desired flow to the Afternoon Beach Lift Station.

Design criteria for the proposed above-grade tank are provided in Table 2.

TABLE 2

Alternative B1 Storage Tank Design Criteria

Parameter	Value
New Below-Grade Tank	
Type	Prefabricated (FRP, PE)
Quantity (number of sections)	7
Diameter (ft)	8
Length (ft)	48
Footprint (sf)	7,200
Volume (gal)	123,000
Inlet/Outlet	Pipe Connection
Instrumentation	Ultrasonic Level Sensor High-Alarm Float Switch Duplex Pump Station (floats, ultrasonic level sensor)
New Above-Grade Tank	
Type	Cast-in-Place Concrete, Cylindrical
Diameter (ft)	26
Base Elevation (ft)	342
Overflow Elevation (ft)	377
Volume (gal)	138,000
Volume per Foot (gal/ft)	3,942
Inlet/Outlet	Elevated Inlet Center Drain Connection
Instrumentation	Ultrasonic Level Sensor High-Alarm Float Switch Magnetic Flow Meter Electrically Actuated Butterfly Flow Control Valve

Both Options B1A and B1B will require that any solids accumulated during temporary storage be removed on a regular basis. Based on discussions with WTP staff and our understanding of backwash timing and the backwash storage basin, it is likely that a significant majority (more than 90 percent) of solids are currently discharged to the Afternoon Beach Lift Station. The storage options noted above will provide additional volume and flexibility to retain backwash solids; however, a large portion of these solids should remain suspended and will proceed to the lift station as they do in the current process. Any solids retained within the proposed tank should be removed on a semiregular basis and appropriate access ports and hatches will be provided on the tanks to facilitate this removal. For the purposes of this analysis, it is estimated that solids will need to be removed two times per year and that solids can be removed with a vactor truck, then deposited to the Afternoon Beach Lift Station or directly to the City WWTP. Alternatively, mixing equipment could be added to the tank that would help more solids remain suspended so that they could be pumped to the downstream municipal sewer.

It should be noted that depending on other changes or modifications made by the District to the current disinfection system, it may also be feasible to utilize the existing CCB for temporary backwash waste storage. This would potentially eliminate the need to construct an additional storage tank but would remove the CCB from use for the disinfection system. A final alternatives analysis report proposed as part of this project will be provided separately from this technical memorandum and will combine all of the various options and recommendations for each treatment component. However, each of the recommendations or alternatives presented herein will depend on the full scale of changes desired by the District over the long-term planning process and should always be considered within the full scale of potential changes for the WTP.

Building and Other

No other modifications to the Main Building or Finished Water Pump Building are proposed as part of this alternative. There will be various modifications to the existing Supervisory Control and Data Acquisition (SCADA) system that are required, but these services and modifications will be provided by the District's preferred telemetry and integration service provider.

Site improvements included with this alternative include grading and earthwork required to create a flat and suitable area for the proposed backwash storage tank. Prior to construction of the proposed tank (Option B1B), a thorough geotechnical investigation should be completed. Given the slope of the adjacent terrain, a retaining wall may be required to provide suitable slope stabilization. For the purposes of this investigation, it is assumed that a retaining wall is not required for construction of the new tank and that only basic earthwork and grading are required.

Regardless of which option is selected, modifications to the existing electrical system will be required. For both options (B1A and B1B), the existing backwash basin submersible pumps must be replaced with larger equipment and new flow meters must be installed. Additionally, Option B1B includes the installation of an electrically actuated valve. This additional/new equipment will increase the electrical load on the facility. Additionally, new VFD motor starters are larger than the existing non-VFD starters and may require additional space for new motor control center (MCC) buckets or a reconfiguration of the existing MCCs. For the purposes of this investigation, it is assumed that the existing electrical service to the site is sufficient to accommodate the proposed loads and that a new electrical supply will be sub-fed from the existing Finished

Water Pump Building. A formal electrical analysis should be completed once the size of the proposed electrical loads are defined to confirm this assumption and an assessment of the capacity for the existing MCCs to accept new larger VFD motor starters should be completed.

The new facility will be subject to all applicable stormwater requirements for construction of new structures. The construction of a new tank adjacent to the existing WTP would be subject to the stipulations listed by Whatcom County for the Lake Whatcom Watershed. These requirements will include the need to provide either full infiltration on site or advanced treatment for phosphorous removal. Design of the required stormwater facilities will be provided once the building footprint and paving have been finalized, but a budgetary estimate for the anticipated requirements has been included with the alternative cost estimate included in Exhibit B. In addition, it should be noted that these regulations restrict clearing of the site so that only 35 percent of the existing tree canopy can be cleared.

It is important to note that this alternative will require additional design and coordination with various stakeholders, one of which includes the Sudden Valley Community Association (SVCA). The SVCA owns much of the property adjacent to the WTP and would need to be consulted prior to implementation of any of the alternatives discussed in this memorandum. Furthermore, the District must consider that the property adjacent to the WTP is a public park with waterfront access and use of this public space will likely need to be maintained at all times. Other stakeholders include neighboring residential landowners and utility providers serving the area.

<u>Advantages and Disadvantages</u>

Both Options B1A and B1B maintain the current discharge location and sequence, which is familiar to WTP staff.

One advantage to Option B1A is that the proposed location for construction of the storage tank is open and accessible. One disadvantage to Option B1A is that a new pump station is required, which increases the electrical load to the facility and increases the complexity of the system.

One advantage to Option B1B is that the system could flow by gravity to the existing Afternoon Beach Lift Station. One disadvantage to Option B1B is that it requires construction of a new structure, which will require additional geotechnical investigation and stormwater treatment systems.

Cost Estimate

Option B1A for this alternative is estimated to cost approximately $1,494,000 while Option B1B is estimated to cost approximately $1,022,000. Both of these cost estimates include contingency (25 percent), Washington State sales tax (9.0 percent), and design/project administration (25 percent). A budgetary cost estimate for this alternative is provided in Exhibit B.

Alternative B2 – Discharge to Lake Whatcom

General

This alternative includes revising the existing backwash discharge so that it discharges to Lake Whatcom instead of the municipal sewer system. Similar to Alternative B1, this alternative is further divided into Options B2A and B2B for both below- and above-grade storage, respectively.

Backwash

Discharges to surface water governed by the State of Washington are covered by the National Pollutant Discharge Elimination System (NPDES) Permit which is managed by the Washington State Department of Ecology (Ecology). Ecology maintains a general permit (General Permit) available to all WTPs for discharge of backwash waste and this permit allows WTPs to discharge backwash water to surface water such as Lake Whatcom if they adhere to the requirements listed in the General Permit. The current General Permit is included in Exhibit C, but the key components are summarized below:

- Facilities (WTPs) may discharge to surface water if they provide potable water (more than 35,000 gallons per day) and the discharge is part of a normal operating process (filtration, backwash, etc.).

- Water discharged meets specific maximum requirements for settleable solids, residual chlorine, and pH.

- Facilities must have a valid and current Operation and Maintenance Manual.

- Facilities must complete additional water quality monitoring based on their maximum rate of water production, and must monitor and record these analyses and their results using a web-based monitoring system.

- Provide notice to various stakeholders, including Ecology, in the event that a system disruption or anomaly occurs.

To apply for coverage under the General Permit, the District must complete and sign the application form as well as provide documentation of adherence to all aspects of the General Permit. Conditions for adequate public notice and compliance with all applicable State Environmental Policy Act (SEPA) requirements must also be met. If coverage under the General Permit is granted, the District would need to reapply for coverage every 5 years. This reapplication process is very simple and minimal effort is needed to complete the reapplication process.

Coverage under the General Permit is utilized by many WTPs in Washington State and could potentially reduce the operational costs by reducing the volume sent to the City municipal sewer system.

Discharge limits are highlighted in Section S-2.2 of the General Permit, but include maximum daily limits on settleable solids (0.2 mL/L), total residual chlorine (0.07 mg/L), and pH (9.0). Additional monitoring parameters are listed in Exhibit C (Section S-5.2) and include various inorganic parameters analyzed on a monthly or quarterly basis.

Although no historical data exists for these analytes for the backwash discharge, the WTP staff recently collected samples to estimate potential compliance and treatment required for adherence to the conditions set forth in the General Permit. For this, two 1,000 mL bottles (A and B) were filled every 60 seconds during a backwash cycle (one filter only, Filter 4) on January 26, 2021. These samples were then analyzed by the District (pH, chlorine) as well as a local commercial analytical laboratory (TSS, turbidity). Results of these analyses are shown in Table 3.

TABLE 3

Backwash Discharge Sample Analysis Summary

Sample	Elapsed Time (min) (1)	pH (2)	Total Residual Chlorine (mg/L) (3)	Total Suspended Solids (TSS, mL/L) (4)	Turbidity (NTU) (5)
1	1.0	6.92	0.02	145	36
2	2.0	6.91	0.08	300	70
3	3.0	6.86	0.06	310	90
4	4.0	7.01	0.05	270	39
5	5.0	7.17	0.61	41	9.5
6	6.0	7.24	0.70	19	9.2
7	7.0	7.31	0.81	8	4.8
8	8.0	7.38	0.82	6	1.7

(1) Two-liter sample collected from the backwash waste discharge trough at each time point. One liter used for pH, residual chlorine, TSS, and turbidity samples, and 1 liter used for settleability analysis.
(2) Measured using the District's pH sensor.
(3) Measured using the District's HACH handheld pocket colorimeter.
(4) Measured by Edge Analytical via Method I-3765-85.
(5) Measured by Edge Analytical via SM180.1.

To estimate the settleability of the backwash waste, samples were collected from various time points in the backwash cycle and were allowed to settle. At various times during the settling process, the volume of clear water (supernatant) was measured and recorded. After 24 hours of settling, the supernatant solution was transferred to a separate container, measured for pH and chlorine residual, then submitted to a commercial laboratory for TSS and turbidity analysis. The results of these analyses are provided in Table 4.

TABLE 4

Backwash Discharge Settleability Analysis Summary

Parameter	Clear Volume (mL) (1)		
	Sample 1	**Sample 4**	**Sample 8**
Settling Time (min)			
1	1,000	1,000	1,000
5	920	1,000	1,000
15	920	990	1,000
30	960	980	1,000
60	960	975	1,000
240 (4 hours)	960	975	1,000
480 (8 hours)	960	975	1,000
1,440 (24 hours)	960	975	1,000
Other			
pH (2)	6.92	6.99	7.36
Chlorine Residual (mg/L) (2)	0.07	0.05	0.84
Total Suspended Solids (mL/L) (2)	—	—	—
Turbidity (NTU) (2)	—	—	—

(1) Value listed is the approximate volume of supernatant (clear volume) within the graduated cylinder after the time noted.
(2) Value recorded was measured from sample supernatant after 24 hours of settling time.
(3) Value recorded was measured from sample supernatant after 8 hours of settling time.

The data listed in Table 3 suggest that the proposed backwash discharge to Lake Whatcom would meet permit requirements for pH, but would need additional treatment or accommodations to meet the requirements for residual chlorine and possibly settleable solids. The data in Table 4 suggest that the solids entrained within the backwash water settle rapidly as indicated by the large volume of clear water within the sample and the low rate of change in the clear water volume over a 24-hour period.

Various chemical compounds can be used for dechlorination, most commonly sulfur dioxide gas, sodium metabisulfite, sodium sulfite, calcium thiosulfate, and ascorbic acid. Sulfur dioxide is a hazardous gas similar to chlorine but could be successful at removing chlorine down to the proposed maximum threshold of 0.07 mg/L. Calcium thiosulfate solution is a safer and more user-friendly solution when compared to sodium metabisulfite and sodium sulfite, and does not have safety concerns associated with compressed sulfur dioxide gas. To remove 0.8 mg/L residual chlorine with calcium thiosulfate, which is very conservative given the data in Tables 3 and 4, it is estimated that 9 pounds per day per million gallons per day would be required. Given the potential daily discharge of up to 50,000 gallons, this results in a consumption of up to 1 pound per day. Dechlorination equipment provided with this alternative includes a duplex chemical metering pump system, chemical storage space, and connections to the existing or proposed piping system. This equipment would be housed within a small freestanding building near the backwash storage tank and assumes that the building would be installed on a concrete slab. Sodium thiosulfate is commercially available as a ready-to-use liquid in drums or totes and costs approximately $0.40 per pound.

In addition to dechlorination, the backwash system may require additional treatment or accommodations for reducing and monitoring settleable solids in the discharge water.

To ensure that the discharge requirements listed in the General Permit for settleable solids are met, it is recommended that the District install storage facilities for this alternative. Options and inclusions for these facilities are similar to those described in Alternative B1 (for both below- and above-grade tanks). Some key differences for storage tanks in Alternative B2 are that the tank will be designed to discharge to either Lake Whatcom or the Afternoon Beach Lift Station. During normal operation, backwash supernatant will be pumped to the outfall diffuser within Lake Whatcom; however, the tank will also include accommodations to divert the pumped flow to the lift station during periods where the discharge water quality does not meet the requirements set forth in the NPDES permit. Additionally, monitoring and sampling piping will be provided so the WTP staff can monitor water quality at various locations within the tank and from the discharge stream. Lastly, the tanks will need to be larger to provide sufficient volume to accommodate solids accumulated during the settling process.

Both Options B2A and B2B will require that solids accumulated during storage/settling be removed on a regular basis. Solids retained within the proposed tank should be removed and appropriate access ports and hatches will be provided on the tank to facilitate this removal. It is estimated that solids will need to be removed three to four times per year, and that solids can be removed with a vactor truck, then deposited to the lift station or directly to the City WWTP. Other decanting and/or separation facilities are also feasible if additional separation of solids is desired. Given the data for TSS in Table 3, the average TSS concentration for backwash water is 137 mg/L. If a conservative value of 150 mg/L is combined with an average daily backwash volume of 50,000 gallons (189,270 liters) it is estimated that approximately 22,900 pounds of solids will be generated per year. This weight is equivalent to approximately 68,000 gallons of slurry/sludge if we assume a solids concentration of 4 percent. Table 5 highlights design criteria for the tanks proposed with Alternative B2.

TABLE 5

Alternative B2 Storage Tank Design Criteria

Parameter	Value
New Below-Grade Tank	
Type	Prefabricated (FRP, PE)
Quantity (number of sections)	11
Diameter (ft)	8
Length (ft)	48
Footprint (sf)	14,500
Volume (gal)	193,000
Inlet/Outlet	Pipe Connection
Instrumentation	Ultrasonic Level Sensor High-Alarm Float Switch Duplex Pump Station (floats, ultrasonic level sensor)
New Above-Grade Tank	
Type	Cast-in-Place Concrete, Cylindrical
Diameter (ft)	30
Base Elevation (ft)	342
Overflow Elevation (ft)	382
Volume (gal)	211,400
Volume per Foot (gal/ft)	5,285
Inlet/Outlet	Elevated Inlet Center Drain Connection
Instrumentation	Ultrasonic Level Sensor High-Alarm Float Switch Magnetic Flow Meter Electrically Actuated Butterfly Flow Control Valve

Building and Other

Modifications to the Main Building, Finished Water Pump Building, and associated electrical systems are identical to those described in Alternative B1. Stormwater and land acquisition components are also identical. Proposed facilities for this alternative are shown on Figure A-3 in Exhibit A.

This alternative will include installation of a concrete slab and small building. This building would be located near the storage tank discharge connection, which should provide sufficient reaction time prior to discharge to Lake Whatcom. The new building will house the dechlorination system as well as the backwash discharge monitoring equipment. This alternative will also require construction of an outfall discharge within Lake Whatcom. The discharge should be located at depth (greater than 60 feet) and should be constructed as far away from the WTP intake piping as feasible. The outfall should have a diffuser on the outlet end to reduce the potential for lakebed erosion and should be constructed from ductile iron or high-density polyethylene (HDPE) materials.

Advantages and Disadvantages

One advantage to Option B2A or B2B is that backwash is no longer discharged to the City municipal sewer system. One disadvantage to Option B2A or B2B is that it will require construction within Lake Whatcom, will require additional water quality monitoring, and may require additional treatment for dechlorination and to reduce solids within the discharge. There may also be resistance to discharging a “waste” stream to Lake Whatcom by community members and the general public.

One advantage to Option B2A is that the proposed location for construction of the storage tank is open and accessible. The space would be maintained as a public park and would only be unavailable for use during the active construction period. One disadvantage to Option B2A is that a new pump station is required, which increases the electrical load to the facility and increases the complexity of the system.

One advantage to Option B2B is that a new separate pump station is not required, and the system could conceivably drain by gravity to the Lake Whatcom outfall. One disadvantage to this option is that it requires construction of a new structure, which will require additional geotechnical investigations and stormwater treatment systems.

Cost Estimate

Option B2A for this alternative is estimated to cost approximately $2,126,000 while Option B2B is estimated to cost approximately $1,819,000. Both of these cost estimates include contingency (25 percent), Washington State sales tax (9.0 percent), and design/project administration (25 percent). A budgetary cost estimate for this alternative is provided in Exhibit B.

Alternative B3 – Recycle Backwash Flows to Treatment System

General

This alternative includes revising the backwash handling system so that backwash supernatant can be redirected through the existing treatment equipment. Similar to

Alternative B1, this alternative is further divided into Options B3A and B3B for both below- and above-grade storage, respectively.

Backwash

Prior to 2004, the United States Environmental Protection Agency (EPA) enacted a rule allowing water treatment facilities to recycle spent filter backwash water from a direct filtration plant back through the treatment process and into the distribution system. In 2004, the EPA amended this rule to include more stringent water quality requirements in order to continue this process. The rule is commonly referred to as the Filter Backwash Recycling Rule (FBRR) and is employed by several WTPs in the Pacific Northwest. In this alternative, the WTP would temporarily store backwash waste within a below- or above-grade tank, allow the solids entrained with this water to settle, then reintroduce the supernatant (uppermost clear water layer) back into the treatment process. According to the FBRR, recycled water must be reintroduced so that is undergoes every step of treatment, which in this case means that it must be introduced prior to chemical addition and the existing flocculation tank. Connection at this location is feasible and would require minimal modifications or disruptions to the existing treatment equipment.

There are additional monitoring, recording, and reporting requirements that must be completed for compliance. These requirements include both additional water quality and treatment process parameters and the key components to the existing *FBRR Technical Guidance Manual* are provided in Exhibit D. Additional guidance is available in the 2019 *Water System Design Manual* (Washington State Department of Health) as well from the *10 State Standards Water Treatment Guidance* (2018). In general, the additional monitoring requirements are not significant and would not increase the WTP staff operation and maintenance requirements.

To ensure that the discharge requirements for backwash recycle are met, the District will need to install additional storage/settling facilities to reduce the solids loading to the filters from the recycled flow. Options for providing these additional storage facilities are identical to those described in Alternative B2 for both below- and above-grade facilities. The only difference with this alternative is that the storage tank supernatant will be directed back to the treatment process instead of to the municipal sewer system or to Lake Whatcom. During normal operation, backwash supernatant will drain (or be pumped) to the connection point upstream of the flocculation tank; however, the tank will also include accommodations to drain to the Afternoon Beach Lift Station during periods where the discharge water quality does not meet the requirements set forth in the FBRR. Additionally, monitoring and sampling piping will be provided so the WTP staff can monitor water quality at various locations within the tank and from the discharge stream. Lastly, the maximum percentage of flow that can be recycled during filtration is

10 percent. For the current operational flow of 700 gpm, this equates to a recycle flow of 70 gpm (630 gpm raw water). In order to recycle a typical backwash sequence volume of 42,000 gallons (approximately 85 percent of the total volume), this would require approximately 10 hours of recycle flow – which is feasible given the current filtration and backwash sequences utilized at the WTP. For the full design flow of 1,400 gpm, a recycle flow of 140 gpm (1,260 gpm raw water) is allowed, which will result in a backwash volume pump time of approximately 5 hours.

Additionally, adjustment of disinfection chemicals and/or other chemicals utilized at the WTP (alum, soda ash) may be required during recycle events. This will add complexity and could impact overall water quality.

Both Options B3A and B3B will require that solids accumulated during storage/settling be removed on a regular basis. Solids retained within the proposed tank should be removed and appropriate access ports and hatches will be provided on the tanks to facilitate this removal. For the purposes of this analysis, it is estimated that solids will need to be removed three to four times per year, and that solids can be removed with a vactor truck, then deposited to the Afternoon Beach Lift Station or directly to the City WWTP.

Building and Other

Modifications to the Main Building and associated electrical systems are identical to those described in Alternative B1. Stormwater and land acquisition components are also identical. The proposed facilities for this alternative are shown on Figure A-4 in Exhibit A.

Both Options B3A and B3B will require modification of the existing WTP raw water piping. Although gravity drainage from an above-grade tank (Option B3B) to a new connection point at the WTP is feasible, gravity feed will result in lower flow control and more operator interaction. To provide additional flow control and less operator interaction with the system, both Options B3A and B3B include a small duplex pump station that will pump water from the proposed tank to the raw water connection location. Option B3A includes a new submersible pump station within a below-grade manhole while Option B3B includes centrifugal pumps housed within a small building adjacent to the proposed storage tank. The raw water connection location could be outside the footprint of the Main Building below grade, or piping could be brought within the footprint of the Main Building and be connected above grade just downstream of the existing raw water flow meter. From this connection location, recycled water will continue through the normal treatment process and equipment.

Advantages and Disadvantages

The advantage to Alternative B3 is that it no longer discharges backwash waste to the City municipal sewer system which could potentially reduce operational costs for backwash waste handling. Additionally, the monitoring requirements for Alternative B3 are less intensive than those required to discharge backwash to Lake Whatcom (Alternative B2). Lastly, Alternative B3 would allow a more full and complete utilization of the District's surface water right. One disadvantage is that this alternative will likely require approval from the Washington State Department of Health prior to implementation. Additionally, introduction of backwash recycle water may negatively impact the existing treatment process and/or finished water quality – although it is not likely that these negative impacts would be significant.

One advantage to Option B3A is that the proposed location for construction of the storage tank is open and accessible. The space would be maintained as a public park and would only be unavailable for use during the active construction period. A disadvantage to this alternative is that a new pump station is required, which increases the electrical load to the facility and increases the complexity of the system.

One disadvantage to Option B3B is that it requires construction of a new structure, which will require additional geotechnical investigations and stormwater treatment systems.

Cost Estimate

Option B3A for this alternative is estimated to cost approximately $1,889,000 while Option B3B is estimated to cost approximately $1,564,000. Both of these cost estimates include contingency (25 percent), Washington State sales tax (9.0 percent), and design/project administration (25 percent). A budgetary cost estimate for this alternative is provided in Exhibit B.

SUMMARY

Alternative Summary

Each of the alternatives is briefly described below and Table 6 provides a summary and comparison for the various alternatives.

Alternative B1 – Discharge to the Municipal Sewer System

Under this alternative, the WTP will continue to discharge backwash waste to the municipal sewer system. To potentially reduce costs through off-peak discharge and to help reduce backwash time and improve discharge water quality, this alternative includes two options for additional storage and settling volume. Option B1A includes installation of a new below-grade storage facility, new duplex pump station adjacent to the Main Building, and replacement of the existing backwash discharge pumps. Option B1B includes installation of an above-grade concrete storage tank adjacent to the existing CCB and replacement of the existing backwash storage basin submersible pumps.

Solids handling will be provided by discharging and draining the tank to the municipal sewer several times each year.

Alternative B2 – Discharge to Lake Whatcom

This alternative will direct backwash waste to a new outfall in Lake Whatcom but will maintain a connection to the City's municipal sewer system in the event that spent backwash water does not meet NPDES discharge water quality requirements. The District will apply for coverage under the WTP General Permit for Backwash Discharge as governed by Ecology.

To provide operational flexibility and to help ensure that the water quality stipulations of the General Permit are met, this alternative includes two options for additional storage and settling volume. Option B2A includes installation of a new below-grade storage facility, duplex pump station, and replacement of the existing backwash discharge pumps. Option B2B includes installation of an above-grade concrete storage tank adjacent to the existing CCB, new duplex pump station, and replacement of the existing backwash discharge pumps. Both alternatives include a new building to house the dechlorination and discharge monitoring equipment.

Solids handling will be provided by discharging and draining the tank to the municipal sewer several times each year.

Additional water quality monitoring will be required to ensure that the discharge water meets NPDES discharge requirements.

Alternative B3 – Backwash Recycling

This alternative will direct backwash supernatant back to the existing raw water piping upstream of the existing flocculation tank but will maintain a connection to the City's municipal sewer system in the event that recycle water does not meet water quality requirements. The District will provide information to DOH in compliance with the EPA FBRR.

This alternative includes two options for additional storage and settling volume. Option B3A includes installation of a new below-grade storage facility, duplex recycle pump station, and replacement of the existing backwash discharge pumps. Option B3B includes installation of an above-grade concrete storage tank adjacent to the existing CCB, duplex recycle pump station, and replacement of the existing backwash discharge pumps. For either tank option, supernatant from the storage/settling volume will be pumped to a connection within the Main Building upstream of the existing flocculation tank. This will allow the recycled water stream to flow through the entire treatment process. Both alternatives include a new building to house the backwash recycle pumps and associated electrical and monitoring equipment.

Solids handling will be provided by pumping and draining the tank to the municipal sewer several times each year.

Additional water quality monitoring will be required to ensure that the discharge water meets FBRR discharge requirements.

TABLE 6

Alternatives Summary

Alt. Option	Description	Capital Cost	Advantages	Disadvantages
B1A	Discharge to Municipal Sewer – Below-Grade Tank	$1,494,000	• Familiar process • No additional water quality monitoring required	• Requires additional pump station • Permit and land acquisition
B1B	Discharge to Municipal Sewer – Above-Grade Tank	$1,022,000	• Familiar process • No additional water quality monitoring required	• Permit and land acquisition
B2A	Discharge to Lake Whatcom – Below-Grade Tank	$2,126,000	• Reduces sewer discharge costs	• Requires additional pump station • Additional water quality monitoring required • Increases system complexity • Permit and land acquisition
B2B	Discharge to Lake Whatcom – Above-Grade Tank	$1,819,000	• Reduces sewer discharge costs	• Requires additional pump station • Additional water quality monitoring required • Increases system complexity • Permit and land acquisition
B3A	Backwash Recycle – Below-Grade Tank	$1,889,000	• Less monitoring than Alt. B2 • Greater use of full water right • Reduces sewer discharge costs	• Requires additional pump station • Additional water quality monitoring required • May affect current water quality • Increases system complexity • Permit and land acquisition
B3B	Backwash Recycle – Above-Grade Tank	$1,564,000	• Less monitoring than Alt. B2 • Greater use of full water right • Reduces sewer discharge costs	• Requires additional pump station • Additional water quality monitoring required • May affect current water quality • Increases system complexity • Permit and land acquisition

The current estimated annual cost for discharge to the municipal sewer is approximately $45,000. This was estimated using the monthly billing sheet provided by the District proportioning the calculated backwash flows (50,000 gallons per day) to the total metered flows, then applying this same ratio to the monthly cost. Dividing the capital costs listed in Table 6 by the current estimated annual cost for sewer discharge, the minimum payback period can be calculated. The payback periods for the options listed in Table 6 range between 22 and 40 years and represent the ***minimum*** period since the costs listed in Table 6 do not include additional operational costs for chemicals, electrical, maintenance, etc., which are very difficult to estimate at this point in time. This minimum payback period is relatively high, and as such the District must weigh the value of reducing annual operational costs against the potential increase in system complexity, required monitoring, and the planning and expenditures required to complete Alternative B2 or B3.

Recommendations

It is difficult to provide a backwash system recommendation without considering the other issues that are being considered at the treatment plant. For example, if the District decides to construct a new CCB, then utilizing the existing CCB as a backwash storage and/or recycle tank becomes more favorable as the capital costs to implement this change are less and the minimum payback period decreases. This economy of scale when considering the modifications for the WTP can help drive the decision-making process.

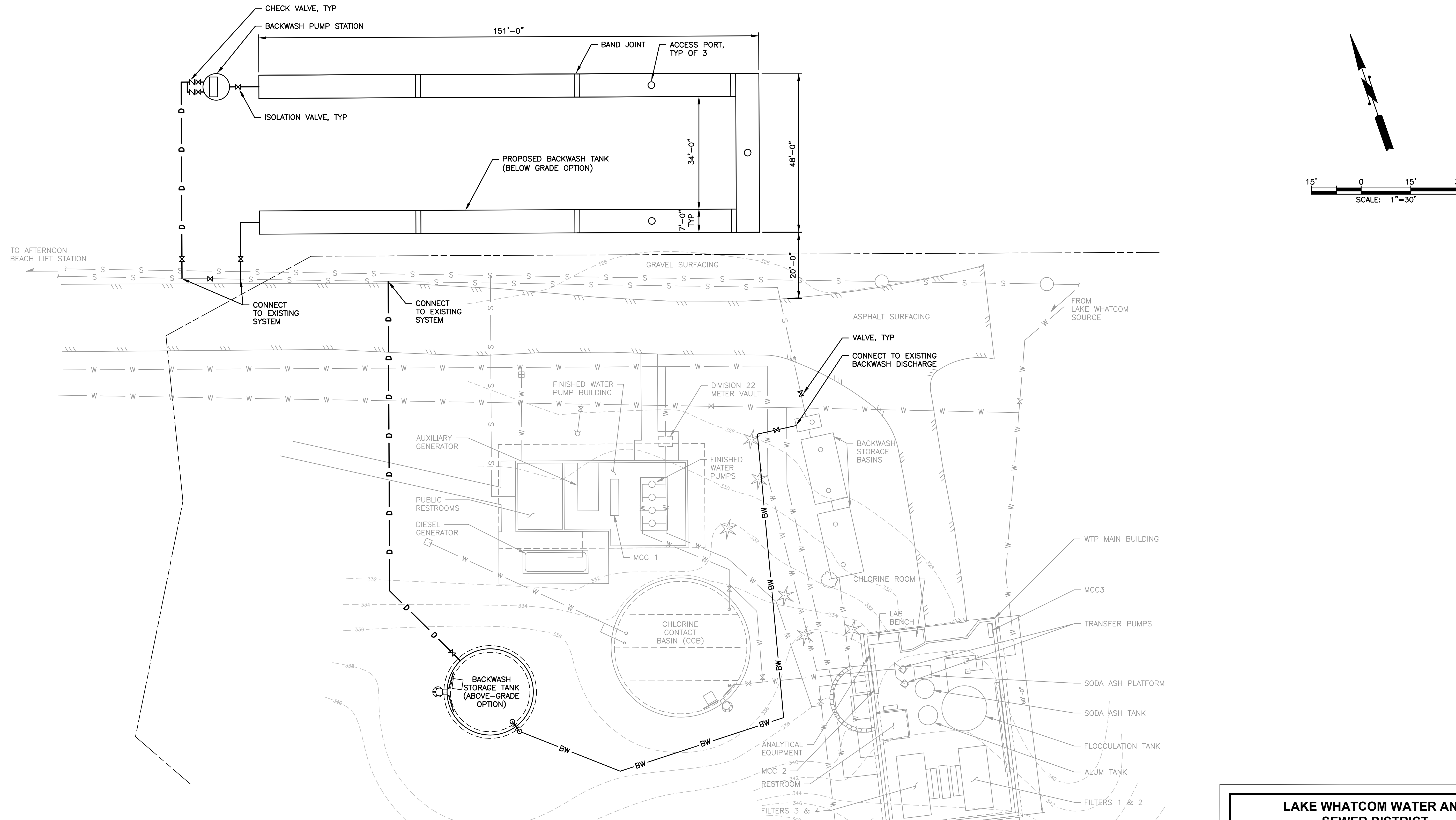
Consequently, the final filtration recommendation will be deferred until the summary report is prepared that contains all of the information in the various technical memoranda to provide an optimized recommendation for the entire filter plant to ensure the District's goal of continuing to provide high-quality treated water for decades to come.

EXHIBIT A

FIGURES

FIGURE A-1

Photographs of Existing Backwash Components



NOTES:

1. THE DEPICTION SHOWN IS SCHEMATIC IN NATURE AND IS INTENDED TO GIVE A GENERAL SCALE OF BUILDING ADDITIONS AND SITE IMPROVEMENTS. THE FINAL DESIGN AND LOCATION OF THE PROPOSED BUILDING WILL BE FINALIZED THROUGH ADDITIONAL DESIGN AND CORRESPONDENCE WITH THE DISTRICT AND THEIR STAFF.

0 1"

ONE INCH AT FULL SCALE.
IF NOT, SCALE ACCORDINGLY

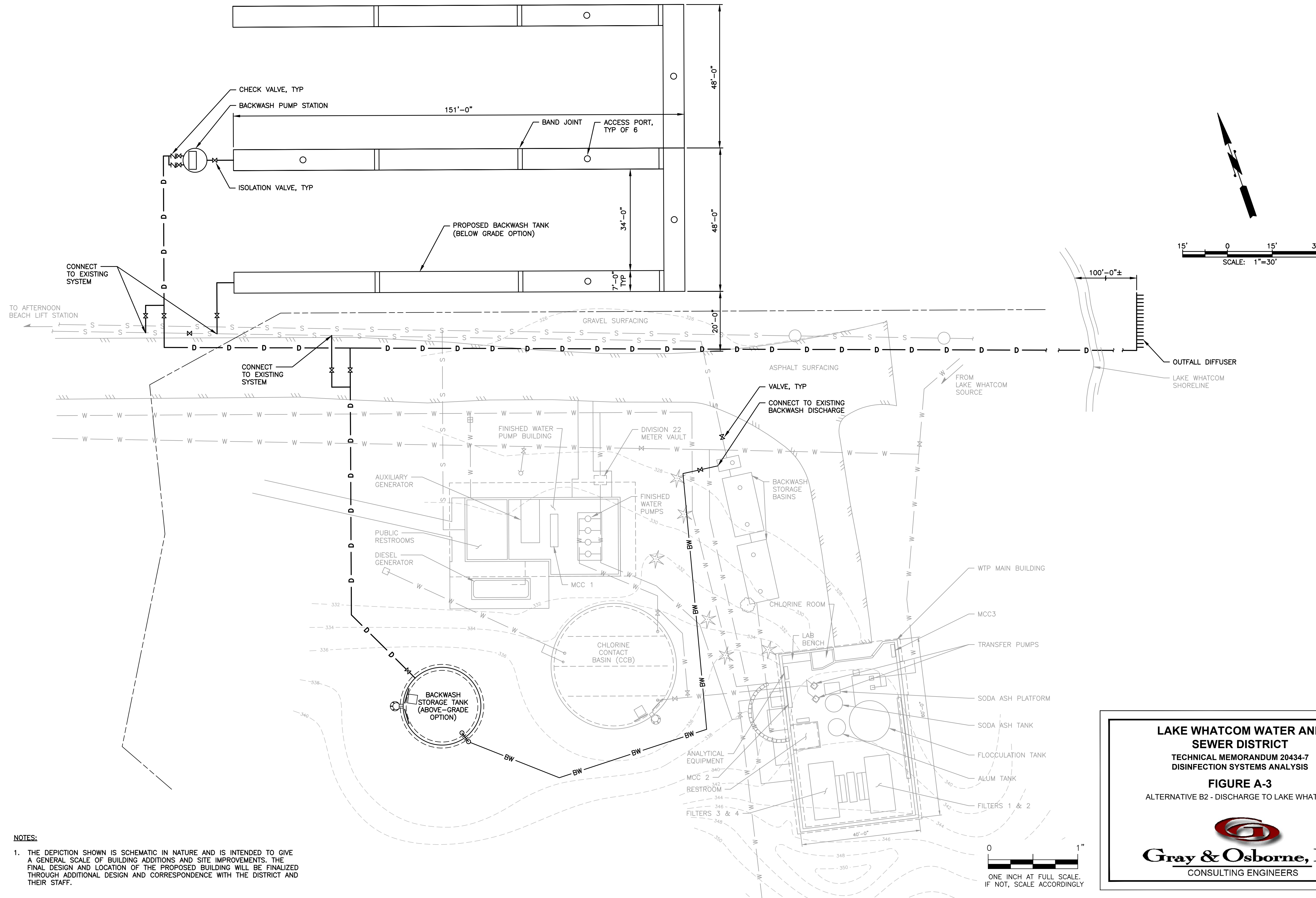
LAKE WHATCOM WATER AND SEWER DISTRICT

TECHNICAL MEMORANDUM 20434-7
DISINFECTION SYSTEMS ANALYSIS

FIGURE A-2

ALTERNATIVE D1 - DISCHARGE TO MUNICIPAL SEWER

Gray & Osborne, Inc.
CONSULTING ENGINEERS



NOTES:

1. THE DEPICTION SHOWN IS SCHEMATIC IN NATURE AND IS INTENDED TO GIVE A GENERAL SCALE OF BUILDING ADDITIONS AND SITE IMPROVEMENTS. THE FINAL DESIGN AND LOCATION OF THE PROPOSED BUILDING WILL BE FINALIZED THROUGH ADDITIONAL DESIGN AND CORRESPONDENCE WITH THE DISTRICT AND THEIR STAFF.

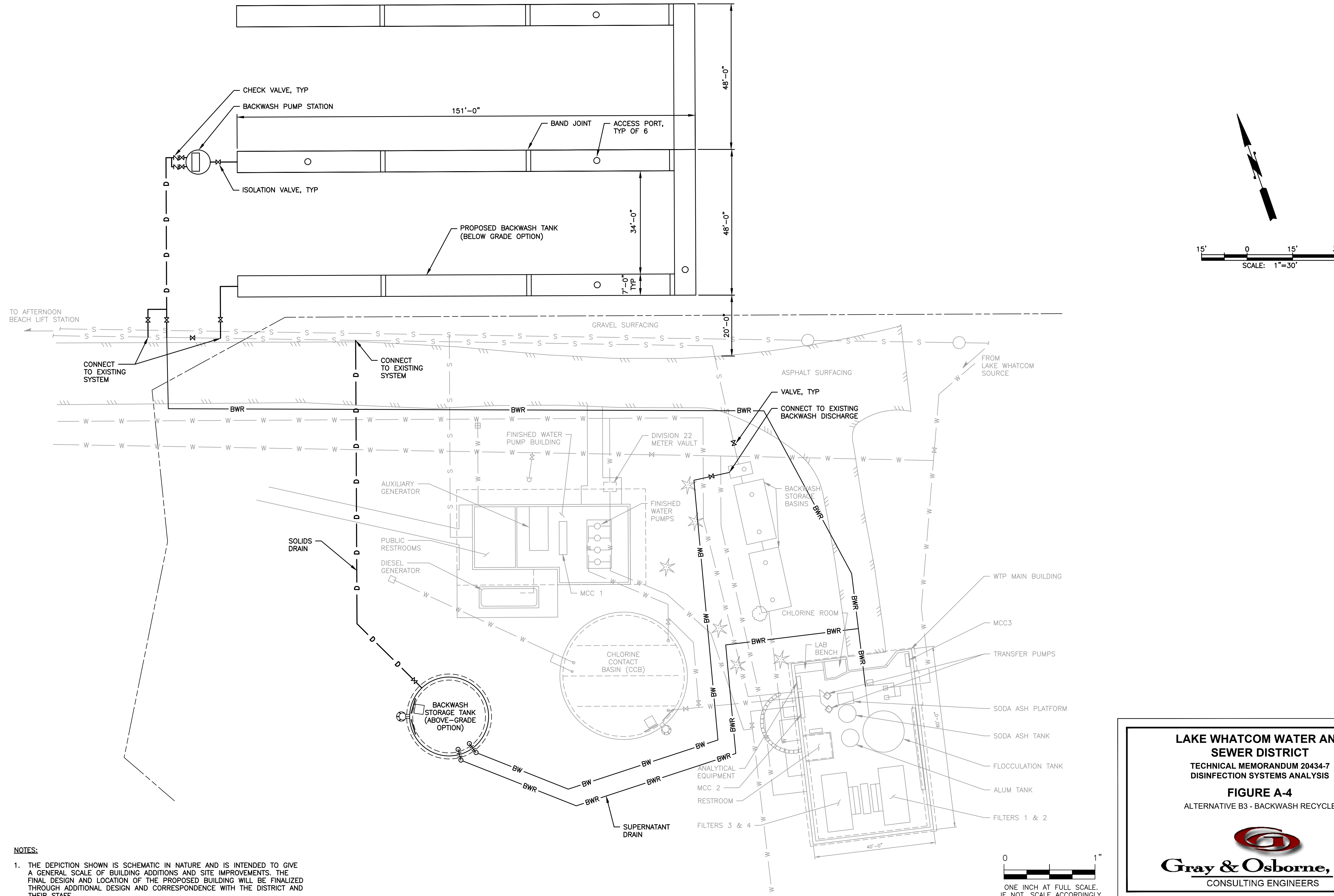
LAKE WHATCOM WATER AND SEWER DISTRICT

TECHNICAL MEMORANDUM 20434-7
DISINFECTION SYSTEMS ANALYSIS

FIGURE A-3

ALTERNATIVE B2 - DISCHARGE TO LAKE WHATCOM

Gray & Osborne, Inc.
CONSULTING ENGINEERS



NOTES:

1. THE DEPICTION SHOWN IS SCHEMATIC IN NATURE AND IS INTENDED TO GIVE A GENERAL SCALE OF BUILDING ADDITIONS AND SITE IMPROVEMENTS. THE FINAL DESIGN AND LOCATION OF THE PROPOSED BUILDING WILL BE FINALIZED THROUGH ADDITIONAL DESIGN AND CORRESPONDENCE WITH THE DISTRICT AND THEIR STAFF.

LAKE WHATCOM WATER AND SEWER DISTRICT

TECHNICAL MEMORANDUM 20434-7
DISINFECTION SYSTEMS ANALYSIS

FIGURE A-4

ALTERNATIVE B3 - BACKWASH RECYCLE

Gray & Osborne, Inc.
CONSULTING ENGINEERS

L:\Lake Whatcom Water and Sewer District\20434.00 Sudden Valley WTP Assessment and Facility Improvements Plan\PLANSET\FIGURES\Figures TM-7 2021-01-19\FIGURE A-4 ALT B3.dwg, 2/25/2021 9:12 AM, PHILIP MARSHALL

EXHIBIT B

RECOMMENDED ALTERNATIVE COST ESTIMATES

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B1 - Option A
Discharge to Municipal Sewer and Construction of New Below Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 72,000	$ 72,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 40,000	$ 40,000
5	Stormwater Improvevments	1	LS	$ 15,000	$ 15,000
6	Site Piping & Appurtenances	1	LS	$ 50,000	$ 50,000
7	120,000 Gallon Storage Tank	1	LS	$ 350,000	$ 350,000
8	Duplex Pump Station	1	LS	$ 120,000	$ 120,000
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Electrical Modifications	1	LS	$ 75,000	$ 75,000
11	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 877,000**
Contingency (25%)	$ 219,300
Subtotal	**$ 1,096,300**
Washington State Sales Tax (9.0%)**	$ 98,700
Subtotal	**$ 1,195,000**
Design and Project Administration (25.0%)***	$ 298,800
TOTAL CONSTRUCTION COST	**$ 1,494,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B1 - Option B
Discharge to Municipal Sewer and Construction of New Above Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 50,000	$ 50,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 60,000	$ 60,000
5	Stormwater Improvevments	1	LS	$ 50,000	$ 50,000
6	Site Piping & Appurtenances	1	LS	$ 35,000	$ 35,000
7	120,000 Gallon Storage Tank	1	LS	$ 200,000	$ 200,000
8	Duplex Pump Station	1	LS	$ -	$ -
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Electrical Modifications	1	LS	$ 50,000	$ 50,000
11	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 600,000**
Contingency (25%)	$ 150,000
Subtotal	**$ 750,000**
Washington State Sales Tax (9.0%)**	$ 67,500
Subtotal	**$ 817,500**
Design and Project Administration (25.0%)***	$ 204,400
TOTAL CONSTRUCTION COST	**$ 1,022,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B2 - Option A
Discharge to Lake Whatcom and Construction of New Below Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 103,000	$ 103,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 40,000	$ 40,000
5	Stormwater Improvevments	1	LS	$ 15,000	$ 15,000
6	Site Piping & Appurtenances	1	LS	$ 100,000	$ 100,000
7	193,000 Gallon Storage Tank	1	LS	$ 500,000	$ 500,000
8	Duplex Pump Station	1	LS	$ 120,000	$ 120,000
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Backwash Treatment and Monitoring	1	LS	$ 100,000	$ 100,000
11	Solids Handling	1	LS	$ 15,000	$ 15,000
12	Electrical Modifications	1	LS	$ 100,000	$ 100,000
13	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 1,248,000**
Contingency (25%)	$ 312,000
Subtotal	**$ 1,560,000**
Washington State Sales Tax (9.0%)**	$ 140,400
Subtotal	**$ 1,700,400**
Design and Project Administration (25.0%)***	$ 425,100
TOTAL CONSTRUCTION COST	**$ 2,126,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B2 - Option B
Discharge to Lake Whatcom and Construction of New Above Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 88,000	$ 88,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 50,000	$ 50,000
5	Stormwater Improvevments	1	LS	$ 50,000	$ 50,000
6	Site Piping & Appurtenances	1	LS	$ 100,000	$ 100,000
7	211,000 Gallon Storage Tank	1	LS	$ 290,000	$ 290,000
8	Duplex Pump Station	1	LS	$ 120,000	$ 120,000
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Backwash Treatment and Monitoring	1	LS	$ 100,000	$ 100,000
11	Solids Handling	1	LS	$ 15,000	$ 15,000
12	Electrical Modifications	1	LS	$ 100,000	$ 100,000
13	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 1,068,000**
Contingency (25%)	$ 267,000
Subtotal	**$ 1,335,000**
Washington State Sales Tax (9.0%)**	$ 120,200
Subtotal	**$ 1,455,200**
Design and Project Administration (25.0%)***	$ 363,800
TOTAL CONSTRUCTION COST	**$ 1,819,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B3 - Option A
Backwash Recycling and Construction of New Below Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 79,000	$ 79,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 40,000	$ 40,000
5	Stormwater Improvevments	1	LS	$ 15,000	$ 15,000
6	Site Piping & Appurtenances	1	LS	$ 55,000	$ 55,000
7	193,000 Gallon Storage Tank	1	LS	$ 500,000	$ 500,000
8	Duplex Pump Station	1	LS	$ 120,000	$ 120,000
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Backwash Treatment and Monitoring	1	LS	$ 30,000	$ 30,000
11	Solids Handling	1	LS	$ 15,000	$ 15,000
12	Electrical Modifications	1	LS	$ 100,000	$ 100,000
13	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 1,109,000**
Contingency (25%)	$ 277,300
Subtotal	**$ 1,386,300**
Washington State Sales Tax (9.0%)**	$ 124,800
Subtotal	**$ 1,511,100**
Design and Project Administration (25.0%)***	$ 377,800
TOTAL CONSTRUCTION COST	**$ 1,889,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

LAKE WHATCOM WATER AND SEWER DISTRICT

SUDDEN VALLEY WTP ASSESSMENT AND ALTERNATIVES ANALYSIS PROJECT
PRELIMINARY COST ESTIMATE

Technical Memorandum 20434-7
Alternative B3 - Option B
Backwash Recycling and Construction of New Above Grade Storage Tank
February 11, 2021
G&O# 20434.00

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 63,000	$ 63,000
2	Minor Change	1	LS	$ 15,000	$ 15,000
3	Erosion / Sedimentation Control	1	LS	$ 10,000	$ 10,000
4	Site Improvements	1	LS	$ 50,000	$ 50,000
5	Stormwater Improvevments	1	LS	$ 50,000	$ 50,000
6	Site Piping & Appurtenances	1	LS	$ 45,000	$ 45,000
7	211,000 Gallon Storage Tank	1	LS	$ 290,000	$ 290,000
8	Duplex Pump Station	1	LS	$ 120,000	$ 120,000
9	Pump Replacement	1	LS	$ 80,000	$ 80,000
10	Backwash Treatment and Monitoring	1	LS	$ 30,000	$ 30,000
11	Solids Handling	1	LS	$ 15,000	$ 15,000
12	Electrical Modifications	1	LS	$ 100,000	$ 100,000
13	Telemetry / SCADA Modifications	1	LS	$ 50,000	$ 50,000

Subtotal*	**$ 918,000**
Contingency (25%)	$ 229,500
Subtotal	**$ 1,147,500**
Washington State Sales Tax (9.0%)**	$ 103,300
Subtotal	**$ 1,250,800**
Design and Project Administration (25.0%)***	$ 312,700
TOTAL CONSTRUCTION COST	**$ 1,564,000**

* Costs listed are in 2020 dollars
** Current sales tax rate is 8.7%.
*** Standard project design and administration fees are 25% of the subtotal including contingency and tax and is provided for planning purposes only.

EXHIBIT C

ECOLOGY WATER TREATMENT PLANT GENERAL PERMIT

Issuance Date: July 17, 2019
Effective Date: September 1, 2019
Expiration Date: August 31, 2024

WATER TREATMENT PLANT GENERAL PERMIT

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
WASTE DISCHARGE GENERAL PERMIT
for
Water Treatment Plants

State of Washington
Department of Ecology
Olympia, Washington 98504-7600

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington

and

The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1251 et seq.

Until this permit expires, is modified, or is revoked, Permittees that have properly obtained coverage under this permit are hereby authorized to discharge in accordance with the Special and General Conditions contained herein.

Heather R. Bartlett
Water Quality Program Manager
Washington State Department of Ecology

This page intentionally left blank

TABLE OF CONTENTS

Page

SUMMARY OF REQUIRED SUBMITTALS III

SPECIAL CONDITIONS 1

S-1 PERMIT COVERAGE 1
S-1.1 Activities, Discharges, and Facilities that Require this Permit 1
S-1.2 Discharges Authorized under this Permit 1
S-1.3 Covered Geographic Area 2
S-1.4 Activities, Discharges, and Facilities that Do Not Require Permit Coverage 2
S-2 LIMITS AND STANDARDS 3
S-2.1 Benchmarks 3
S-2.2 Discharge Limits 3
S-3 PLANNING REQUIREMENTS 4
S-3.1 Operations and Maintenance Manual 4
S-3.2 Solid Waste Control Plan 4
S-3.3 Stormwater Pollution Prevention Plan 5
S-3.4 Other Spill Contingency Plan 6
S-4 OPERATIONAL REQUIREMENTS 6
S-4.1 Operation and Maintenance (O&M) 6
S-4.2 Operational Restrictions 7
S-5 MONITORING REQUIREMENTS 9
S-5.1 Monitoring Objectives 9
S-5.2 Sampling Procedures 9
S-5.3 Analytical Procedures 13
S-5.4 Turbidity 14
S-6 REPORTING AND RECORDKEEPING REQUIREMENTS 14
S-6.1 Permit-Required Submittals 14
S-6.2 Notification Requirements 15
S-6.3 Required Reports 17
S-6.4 Record Retention 19
S-7 PERMIT ADMINISTRATION 19
S-7.1 Application for Coverage 19

GENERAL CONDITIONS 21

G-1 OPERATION AND MAINTENANCE 21
G-1.1 Activities and Discharges Authorized by this Permit 21
G-1.2 Discharges from Activities Not Covered by this Permit 21
G-1.3 Maintaining Compliance if Treatment System Fails 21
G-1.4 Removed Substances 21
G-1.5 Upset 21
G-2 OTHER DUTIES AND RESPONSIBILITIES 22
G-2.1 Additional Monitoring Requirements 22
G-2.2 Compliance with Other Laws and Regulations 22
G-2.3 Duty to Comply with this Permit 22
G-2.4 Duty to Mitigate 22

G-2.5 Duty to Provide Information ... 22
G-2.6 Duty to Reapply ... 23
G-2.7 Notification of Spills and Other Discharges ... 23
G-2.8 Plan Review Required ... 23
G-2.9 Prohibited Discharges ... 23
G-2.10 Reporting Other Information ... 24
G-3 ENFORCEMENT AND PENALTIES ... 24
G-3.1 Enforcement ... 24
G-3.2 Penalties for Tampering ... 24
G-3.3 Penalties for Violating Permit Conditions ... 25
G-3.4 Property Rights ... 25
G-3.5 Right of Inspection and Entry ... 25
G-4 PERMIT MANAGEMENT AND COORDINATION ... 26
G-4.1 Appeal ... 26
G-4.2 Certification and Signature Requirements ... 26
G-4.3 Dates of Coverage under this Permit ... 27
G-4.4 Severability ... 28
G-4.5 Payment of Fees ... 28
G-4.6 Termination of Coverage upon Issuance of an Individual Permit ... 28
G-4.7 Reporting a Cause for Modification or Revocation ... 28
G-4.8 Request to be Excluded from Coverage under this Permit ... 28
G-4.9 Modification, Revocation, and Termination of this General Permit ... 29
G-4.10 Termination of Coverage under this Permit ... 29
G-4.11 Transfer of Permit Coverage ... 30

APPENDIX A. ACRONYMS AND UNITS OF MEASURE ... 1

APPENDIX B. DEFINITIONS ... 1

APPENDIX C. QUESTIONNAIRE ... 1

APPENDIX D. SURVEY QUESTIONS FOR SELECTED WATER TREATMENT PLANTS ... 1

SUMMARY OF REQUIRED SUBMITTALS

Refer to the Special and General Conditions of this permit for additional submittal requirements.

Permit Section	Submittal	Frequency	First Submittal Date
S-6.3.4	Discharge Monitoring Report (DMR) (a)	Monthly	October 15, 2019
S-6.3.1	Questionnaire: Excerpts from Operations, (a) Maintenance, and Planning Documents	Once	January 1, 2020 current Permittees
S-6.3.1	Questionnaire: Excerpts from Operations, (a) Maintenance, and Planning Documents	Once	Within 90 days of coverage for new Permittees
S-6.3.5	DMR with site-specific monitoring data (a)	Quarterly	April 15, 2021 for selected Permittees
S-6.3.6	Survey Regarding Discharge to Ground (a)	Once	February 15, 2022 for selected Permittees
G-2.6	Application for Renewal of Permit Coverage (a)	Once per permit cycle	March 1, 2024
S-6.2.1	Notification of Non-Compliance	As necessary	
S-4.2.1 S-6.2.2	Notification of Planned Bypass	As necessary	
S-6.2.3 G-4.7	Permit Application Supplement or Notification of Significant Change in Process or Discharge	As necessary	
S-6.3.2	Additional Monitoring Results	As necessary	
S-6.3.5	Telephone Notice of Turbidity Greater than 250 NTUs	As necessary	
G-2.7	Notification of Spills or Other Discharges	As necessary	
G-2.10	Other Information	As necessary	
G-4.2	Signature Authorization	As necessary	
G-4.11	Notice of Permit Transfer	As necessary	

Note: The first use of a defined term in the text appears in ***bold italics*** font.

Electronic submittal is required via the Permittee's SecureAccess Washington account at https://secureaccess.wa.gov/ecy/wqwebportal/. More information is available at http://www.ecy.wa.gov/programs/wq/permits/paris/portal.html.

This page intentionally Left Blank

SPECIAL CONDITIONS

S-1 PERMIT COVERAGE

S-1.1 Activities, Discharges, and Facilities that Require this Permit

This ***general permit*** covers all Water Treatment Plants (WTPs) that ***discharge*** backwash ***effluent*** to ***surface water*** and that meet all of the following criteria:

1. Produce potable water or non-potable industrial water (primary treatment/settled water) where the ***treatment*** and distribution of water is the primary function of the ***facility***.
2. Have an ***actual production rate*** equal to or greater than 35,000 gallons per day of treated product water (finished water), as determined on an average monthly basis. The Washington State Department of Ecology (Ecology) reserves the right to determine that ***permit*** coverage is needed for facilities with actual production rates less than 35,000 gallons per day in order to protect ***water quality***.
3. The wastewater discharge is from water treatment filtration processes (filter backwash, ***sedimentation***/pre-sedimentation basin washdown, sedimentation/clarification, or filter-to-***waste***).
4. The water treatment works are not part of a larger, permitted facility, such as a pulp and paper mill.

S-1.2 Discharges Authorized under this Permit

S-1.2.1 Process Wastewater

Beginning on the effective date of this permit, all WTP facilities covered under the *WTP General Permit* effective in September 2014, and that reapplied by March 1, 2019, are authorized to discharge filter backwash water associated with finished water production to ***surface waters of the State,*** subject to the limits identified in this permit. Other WTP facilities that later apply for and obtain coverage under this general permit, have the same authorization to discharge.

S-1.2.2 Non-Routine and Unanticipated Wastewater

Non-routine and unanticipated wastewater consists of process wastewater not identified in Special Condition S-1.2.1 (Process Wastewater), not routinely discharged, and not anticipated at the time of permit application, such as waters used to pressure-test storage tanks or fire water systems, or leaks from drinking water systems.

This permit authorizes non-routine and unanticipated discharges under the following conditions. The ***Permittee*** must characterize the non-routine wastewater for ***pollutants*** and examine the opportunities for reuse. Prior to discharging the non-routine wastewater, the Permittee must obtain approval from Ecology on a case-by-case basis.

Any discharges not specified in Special Condition S-1.2.1 (Process Wastewater) must be addressed in accordance with the terms and conditions of this section.

1. Beginning on the effective date of this permit, prior to any discharge of non-routine and unanticipated wastewater, the Permittee must contact Ecology and provide the following information at a minimum:
   (a) The proposed discharge location.
   (b) The nature of the ***activity*** that will generate the discharge.
   (c) Any alternatives to the discharge, such as reuse, storage, or recycling of the water.
   (d) The total volume of water it expects to discharge.
   (e) The results of the chemical analyses of the water.
   (f) The date of the proposed discharge.
   (g) The expected rate of discharge, in gallons per minute.

2. The Permittee must analyze the wastewater for all parameters with an ***effluent limit*** or ***benchmark*** in this permit as required by Special Condition S-5 (Monitoring Requirements) and must report the results as required by Special Condition S-6 (Reporting and Recordkeeping Requirements), along with any other parameter deemed necessary by Ecology, using the methods and ***quantitation levels*** specified by Ecology.
3. Depending on the nature and extent of pollutants in the wastewater and any opportunities for reuse, Ecology may:
   - Authorize the facility to discharge the wastewater.
   - Require the facility to ***treat*** the wastewater.
   - Require the facility to reuse the wastewater.

   All discharges must comply with the effluent limits established in Special Condition S-2 (Limits and Standards).
4. The discharge may not proceed until Ecology has reviewed the Permittee's request and has authorized the discharge by Administrative Order. Once approved, and if the proposed discharge is to a municipal storm drain, the Permittee must obtain prior approval from the ***municipality*** and notify it when it plans to discharge.

S-1.3 Covered Geographic Area

The geographic area covered by this general permit is the entire State of Washington.

S-1.4 Activities, Discharges, and Facilities that Do Not Require Permit Coverage

Discharges to surface water of wastewaters produced from ion exchange, reverse osmosis, or slow sand filtration water treatment processes do not require coverage under this permit and may require application for an ***individual permit***.

Discharges of wastewater from water treatment filtration processes to ***publicly-owned treatment works*** do not require coverage under this permit.

Discharges of wastewater from water treatment filtration processes to the land do not require coverage under this permit only if that discharged wastewater has no potential, during all weather conditions, to ***runoff*** or overflow into surface water. The operator of a facility that discharges such wastewater to the land must inform the appropriate Ecology Regional Office, identified in Special Condition S-6.2.1 (Notification of Non-Compliance) so that Ecology may determine whether that facility must apply for coverage under an individual State waste discharge permit to ensure that ***waters of the State*** (both underground and surface) are protected from degradation.

Ecology may require facilities that meet the requirements of Special Condition S-1.1 (Activities, Discharges, and Facilities that Require this Permit) but cannot meet the water quality requirements of Special Condition S-2.2 (Discharge Limits) to apply for an individual permit. Such facilities with coverage under this general permit will retain permit coverage until the effective date of the individual permit.

S-2 LIMITS AND STANDARDS

S-2.1 Benchmarks

Special Condition S-5.4 (Turbidity) identifies the ***benchmark*** for the ***turbidity*** of wastewater discharges (not a limit or standard) and explains the Permittee's associated responsibilities.

S-2.2 Discharge Limits

The Permittee must comply with effluent limits for ***settleable solids***, ***pH***, and ***total residual chlorine*** shown in the table below.

EFFLUENT LIMITS			
Parameter	**Effective Term**	**Average Monthly Discharge Limit (a)**	**Maximum Daily Discharge Limit (b)**
Settleable Solids	Sept 2019 – Aug 2024	0.1 mL/L	0.2 mL/L
Total Residual Chlorine	Sept 2019 – Aug 2024	Not applicable	0.07 mg/L
Parameter	**Effective Term**	**Daily Minimum**	**Daily Maximum**
pH (c)	Sept 2019 – Aug 2024	6.0 S.U.	9.0 S.U.

(a) The ***average monthly discharge limit*** is defined as the greatest average of ***daily discharges*** allowed for a calendar month, calculated as the sum of all the daily discharges measured during a calendar month divided by the number of daily discharges measured during that month. Where only one sample is measured in a month, its value may not exceed the ***monthly average***.

(b) The maximum daily ***discharge limit*** is defined as the greatest daily discharge allowed during a calendar day. Except for pH, if a parameter is measured more than once within a single calendar day, the daily discharge is the arithmetic average of the values from that single day.

(c) The averaging of pH values is not allowed.

S-2.3 Impaired Waterbodies and TMDL Requirements

The Permittee must comply with any applicable ***total maximum daily load*** (TMDL) determination that is completed and accepted by the U.S. Environmental Protection Agency (EPA) as of either the effective date of this permit or the effective date of facility coverage under this permit, whichever is later.

If the Permittee discharges pH, settleable solids, or total residual chlorine pollutants to a waterbody listed as impaired for any of those pollutants per the ***303(d) list*** approved by the U.S. EPA on July 22, 2016, the Permittee must monitor for the listed pollutant(s) unless it demonstrates that the listed pollutant(s) is not present in its discharge. The applicable listing of impairment is the listing that is final as of the effective date of this permit or the effective date of facility coverage under this permit, whichever is later.

1. A new facility may not cause or contribute to an exceedance of the listed pollutant(s).
2. An existing facility that has the potential to cause or contribute to impairment of a listed waterbody must demonstrate that its discharge will cause no increase in the pollutant(s) of concern, identify steps that it can take to reduce the discharge of those pollutant(s), and incrementally implement those steps. Ecology will either set the schedule for meeting this requirement with an administrative order or require an individual permit for the facility.

S-3 PLANNING REQUIREMENTS

S-3.1 Operations and Maintenance Manual

The Permittee must prepare an ***Operations*** and ***Maintenance*** (O&M) manual in accordance with WAC 246-290 Parts 2 and 5. The O&M manual must identify the main water treatment processes employed by the facility and document the procedures for operating and maintaining the wastewater treatment and discharge systems (e.g., the filter backwash systems). At a minimum the O&M manual must include:

1. Maintenance schedule and procedures for treatment and discharge systems.
2. Monitoring necessary to assure proper functioning of treatment and discharge systems.
3. Emergency shut down and containment procedures in the event of uncontrolled discharge due to plant maintenance activities, severe ***stormwater*** events, start-ups or shut-downs, or other causes.

The Permittee must update the O&M manual as necessary to reflect changes in the water treatment processes and procedures and must keep the manual on ***site*** (as an electronic or hard-copy document) and available for inspection by Ecology.

S-3.2 Solid Waste Control Plan

The Permittee must maintain a solid waste ***control*** plan. The plan must include, at a minimum, a description of the ***solid waste***, identification of the source of the solid waste, the generation rate of the solid waste, and identification of the disposal methods of the solid waste. The plan must comply with any applicable requirements of the jurisdictional health department and any local requirements for a solid waste permit. The Permittee must update the plan as necessary to reflect changes in solid waste handling and disposal and keep the plan on site (as an electronic or hard-copy document) and available for inspection by Ecology.

S-3.3 Stormwater Pollution Prevention Plan

Not every WTP needs a ***Stormwater Pollution Prevention Plan*** (SWPPP). However, Permittees that discharge "***stormwater associated with industrial activity***" (See definitions in Appendix B.) from their sites to surface water or to a separate stormwater sewer system must prepare a SWPPP. New facilities must complete or implement all ***Best Management Practices (BMPs)*** prior to producing the authorized discharge. Existing facilities must implement ***operational*** or ***source control BMPs*** within the first 6 months following the effective date of this permit and complete ***treatment BMPs***, if required, within the first year following the effective date of this permit.

1. The SWPPP must include the following:
   - (a) Assessment and description of existing and potential pollutant sources.
   - (b) Description of the operational BMPs.
   - (c) Description of selected source-control BMPs.
   - (d) When necessary, a description of the ***erosion*** and ***sediment*** control BMPs.
   - (e) When necessary, a description of the treatment BMPs.
   - (f) Implementation schedule.
2. The descriptions of BMPs must include the following:
   - (a) ***Operational Source Control BMPs*****:** Operational BMPs are common to all facilities and include at the minimum:
     - i. *Responsible Party:* Identification by name or position the ***person*** responsible for stormwater management.
     - ii. *Good Housekeeping:* Listing of ongoing maintenance and cleanup activities, as appropriate, of areas that may contribute pollutants to stormwater discharges.
     - iii. *Preventive Maintenance:* Schedule for inspection and maintenance of the stormwater drainage and treatment systems (if any) and plant equipment and systems that could fail and result in contamination of stormwater.
   - (b) ***Structural Source Control BMPs*****:** Source control BMPs eliminate or minimize the exposure of stormwater to pollutants.
   - (c) **Treatment BMPs:** Treatment BMPs reduce the amount of pollutants in stormwater and maintain compliance with water quality standards.
   - (d) ***Erosion and Sediment Control BMPs*****:** Erosion and sediment control BMPs prevent soil erosion. The SWPPP must identify the locations on site with the potential for soil erosion that could contaminate stormwater.

The Permittee must update the SWPPP as necessary to reflect changes in potential pollutant sources and BMPs and must keep the plan on site (as an electronic or hard-copy document) and available for inspection by Ecology.

S-3.4 Other Spill Contingency Plan

The Permittee must have, maintain, and implement a spill plan for preventing the accidental release of pollutants to State waters and for minimizing damages if such a spill occurs. At a minimum, the plan must include the following:

1. Documentation of the procedures the Permittee will employ for the prevention, containment, and control of spills or unplanned discharges of the following:
   (a) Oil and petroleum products.
   (b) Materials which, when spilled or otherwise released into the environment, are designated ***dangerous waste*** or extremely ***hazardous waste*** by the procedures set forth in WAC 173-303-070.
   (c) Other materials that may become pollutants or cause ***pollution*** upon reaching waters of the State, such as untreated hyper-chlorinated water.
2. A description of the reporting system that will alert responsible managers and legal authorities in the event of a spill.
3. A description of the preventive measures and facilities that prevent, contain, or treat spills (including an overall facility plot showing drainage patterns).
4. A list of all oil and chemicals used, processed, or stored at the facility that may be spilled into State waters.

For the purpose of meeting this requirement, plans and manuals, or portions thereof, required by 33 CFR 154; 40 CFR 109; 40 CFR 110; 40 CFR Part 112; the Federal Oil Pollution Act of 1990, Chapter 173-181; and contingency plans required by Chapter 173-303 WAC may be included by reference as long as they are available on site.

The Permittee must review the plan at least annually and update it as necessary. The reviewer must initial and date the plan and note any updates to the plan to keep it current. This plan must be kept on site (as an electronic or hard-copy document) and be available for inspection by Ecology.

S-4 OPERATIONAL REQUIREMENTS

S-4.1 Operation and Maintenance (O&M)

The Permittee must at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed to achieve compliance with this permit. Proper O&M includes adequate laboratory controls; any maintenance activities that will produce a wastewater discharge to or through the filter backwash wastewater treatment area (e.g., settling basin); all sampling procedures, notifications, and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems that the Permittee installs only when their operation is necessary to achieve compliance with this permit.

S-4.2 Operational Restrictions

S-4.2.1 Bypass Prohibition and Procedures

Fully effective operation of treatment systems is required at all times. Although this generally requires the use of all portions of an existing treatment system, in some cases maintenance necessary to ensure effective operation may require bypassing portions of a system. Where such a bypass will not cause an exceedance of effluent limits or water quality standards, the bypass may occur without notification to Ecology. However, where the Permittee undertakes a bypass for reasons other than ***essential maintenance***, or where a bypass would cause exceedance of an effluent limit or water quality standard, the Permittee may undertake a bypass only in accordance with the provisions of this section.

This permit prohibits all ***bypasses***, except (a) When the bypass is for essential maintenance, as authorized in Item 1, below, or (b) When Ecology has approved an anticipated bypass following the procedures in Item 2, below.

1. Bypass for Essential Maintenance without the Potential to Cause Violation of Permit Limits or Conditions

   This permit allows bypasses for essential maintenance of the treatment system when necessary to ensure effective operation of the system. The Permittee may bypass the treatment system for essential maintenance only if doing so does not cause a violation of an effluent limit. The Permittee is not required to notify Ecology when bypassing for essential maintenance. However, the Permittee must comply with the monitoring requirements specified in Special Condition S-5 (Monitoring Requirements).

2. Anticipated Bypasses for Non-Essential Maintenance

   This permit prohibits any anticipated bypass that is not approved through the following process. Ecology may approve an anticipated bypass under the conditions listed below.

   (a) If a bypass is for non-essential maintenance, the Permittee must notify Ecology, if possible, at least ten days before the planned date of bypass. The notice must contain:

   - A description of the bypass and the reason the bypass is necessary.
   - An analysis of all known alternatives which would eliminate, reduce, or mitigate the potential impacts from the proposed bypass.
   - A cost-effectiveness analysis of alternatives.
   - The minimum and maximum duration of bypass under each alternative.
   - A recommendation as to the preferred alternative for conducting the bypass.
   - The projected date of bypass initiation.
   - A statement of compliance with SEPA.
   - A request for modification of water quality standards as provided for in WAC 173-201A-410, if an exceedance of any water quality standard is anticipated.
   - Details of the steps taken or planned to reduce, eliminate, and prevent recurrence of the bypass.

(b) For probable construction bypasses, the Permittee must notify Ecology of the need to bypass as early in the planning process as possible. The Permittee must consider the analysis required above during the project planning and design process. The project-specific engineering report as well as the plans and specifications must include details of probable construction bypasses to the extent practical. In cases where the Permittee determines the probable need to bypass early, the Permittee must continue to analyze conditions up to and including the construction period in an effort to minimize or eliminate the bypass.

(c) Ecology will determine if the Permittee has met the conditions of Items (a) and (b) above and consider the following prior to issuing a determination letter, an administrative order, or a permit modification as appropriate for an anticipated bypass:

- If the Permittee planned and scheduled the bypass to minimize adverse effects on the public and the environment.
- If the bypass is unavoidable to prevent loss of life, personal injury, or ***severe property damage***.
- If feasible alternatives to the bypass exist, such as:
  - The use of auxiliary treatment facilities.
  - Retention of untreated wastes.
  - Stopping production.
  - Maintenance during normal periods of equipment downtime, but not if the Permittee should have installed adequate backup equipment in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance.
  - Transport of untreated wastes to another treatment facility.

S-4.2.2 Application of Chemicals

The addition of excessive quantities of treatment chemicals to the wastewater is prohibited. The use of treatment chemicals that will result in a water quality violation in the ***receiving water*** is prohibited.

Non-Pesticidal Use
Any addition of chemicals to treat the wastewater (discharge) must comply with manufacturers' recommendations and be administered only at a rate appropriate for treatment.

Pesticidal Use
Any addition of chemicals to treat the wastewater (discharge) must comply with the relevant Federal Insecticide, Fungicide, and Rodenticide Act label.

S-4.2.3 Solid Waste Management

The Permittee must handle and dispose of all solid waste in such a manner as to prevent its entry into waters of the State, either ***groundwater*** or surface water. The Permittee must follow its Solid Waste Control Plan, as described in Special Condition S-3.2 (Solid Waste Control Plan).

S-4.2.4 Spill Prevention and Control

The Permittee must prevent or control pollutant discharges from site runoff, spillage and leaks, sludge and waste disposal, and materials handling and storage. The Permittee must follow its SWPPP, as described in Special Condition S-3.3 (Stormwater Pollution Prevention Plan), and its Spill Prevention and Control Plan, as described in Special Condition S-3.4 (Other Spill Contingency Plan).

S-5 MONITORING REQUIREMENTS

S-5.1 Monitoring Objectives

Samples and measurements taken to meet the requirements of this permit shall be ***representative*** of the volume and nature of the monitored discharge or pollutant, including representative sampling of any unusual discharge or discharge condition, including bypasses, ***upsets***, and maintenance-related conditions affecting effluent quality. Monitoring must occur at intervals sufficiently frequent to yield data that reasonably characterize the nature of the monitored discharge or pollutant.

Ecology may require by administrative order monitoring of intake water, influent to treatment facilities, internal waste streams, and/or receiving waters to verify compliance with net ***discharge limits*** or removal requirements, to verify the maintenance of proper waste treatment or control practices, or to determine the effects of the discharge on the waters and sediments of the State.

S-5.2 Sampling Procedures

S-5.2.1 Event Criteria, Frequency, and Timing

Permittees must monitor the wastewater (discharge) in accordance with the testing schedule appropriate for their facilities, based on the ***design maximum production capacity*** of product water (drinking and industrial water) and the source of the raw source water (surface water or groundwater). For the purpose of determining whether the source of raw water is surface water or groundwater, Ecology will use the same classification method as the Washington State Department of Health (DoH), which additionally specifies a third source of raw water: "***groundwater under the direct influence of surface water***" (GWI). Ecology will consider GWI the same as surface water unless the DoH designates a specific source at a particular WTP as groundwater.

WTP facilities are divided into two monitoring groups as follows:

- **Group 1:** Facilities designed to produce less than 4 million gallons per day (gpd) ***or*** use only groundwater for their source water. Group 1 facilities must follow Testing Schedule A below.
- **Group 2:** Facilities designed to produce 4 million gallons per day or more ***and*** treat surface water or GWI. Group 2 facilities must follow Testing Schedule B below.

	< 4 Million gpd	**≥ 4 Million gpd**
Surface Water / GWI	Group 1	Group 2
Groundwater	Group 1	Group 1

Testing Schedule A: Monitoring Methods and Frequency for Group 1 WTP Facilities

Parameter	Analytical Method (Accuracy)	Detection Limit (a)	Quantitation Level (b)	Sampling Frequency	Sample Type
Settleable Solids	SM 2540 F – Imhoff Cone (±0.1 mL/L or ±1.0%)	0.1 mL/L	0.1 mL/L	Monthly	Grab
pH	SM 4500-H^+ B – Meter (±0.02 standard units)	NA	NA	Monthly	Grab
Total Residual Chlorine	SM 4500 Cl G – Photometer (±0.01 mg/L)	0.01 mg/L	0.02 mg/L	Monthly	Grab
Turbidity	EPA 180.1 – Nephelometric (±0.5 NTU ±1.0%)	0.1 NTU	0.5 NTU	Monthly	Grab
Chloride (c)	SM 4500 B/C/D/E – Titration (±1 mg/L)	0.2 mg/L	1.0 mg/L	Quarterly 2021 Only	Grab
Total Dissolved Solids (c)	SM 2540 C – Gravimetric (±10 mg/L)	10 mg/L	20 mg/L	Quarterly 2021 Only	Grab
Total Iron (c)	EPA 200.7 – ICP/MS (±50 ug/L)	12 ug/L	50 ug/L	Quarterly 2021 Only	Grab
Dissolved Iron (c)	EPA 200.7 – ICP/MS (±50 ug/L)	12 ug/L	50 ug/L	Quarterly 2021 Only	Grab
Total Manganese (c)	EPA 200.8 – ICP/MS (+0.5 ug/L)	0.1 ug/L	0.5 ug/L	Quarterly 2021 Only	Grab
Dissolved Manganese (c)	EPA 200.8 – ICP/MS (+0.5 ug/L)	0.1 ug/L	0.5 ug/L	Quarterly 2021 Only	Grab
Total Daily Volume of Discharge	Meter or Estimate (±30 gallons)	10 gallons per event	10 gallons per event	Daily	NA
Total Daily Number of Discharge Events	Count	Count	Count	Daily	NA

Testing Schedule B: Monitoring Methods and Frequency for Group 2 WTP Facilities

Parameter	Analytical Method (Accuracy)	Detection Limit (a)	Quantitation Level (b)	Sampling Frequency	Sample Type
Settleable Solids	SM 2540 F – Imhoff Cone (±0.1 mL/L or ±1.0%)	0.1 mL/L	0.1 mL/L	Weekly	Grab
pH	SM 4500-H^+ B – Meter (±0.02 standard units)	NA	NA	Weekly	Grab
Total Residual Chlorine	SM 4500 Cl G – Photometer (±0.01 mg/L)	0.01 mg/L	0.02 mg/L	Weekly	Grab
Turbidity	EPA 180.1 – Nephelometric (±0.5 NTU ±1.0%)	0.1 NTU	0.5 NTU	Weekly	Grab

Testing Schedule B: Monitoring Methods and Frequency for Group 2 WTP Facilities

Parameter	Analytical Method (Accuracy)	Detection Limit (a)	Quantitation Level (b)	Sampling Frequency	Sample Type
Chloride (c)	SM 4500 B/C/D/E – Titration (±1 mg/L)	0.2 mg/L	1.0 mg/L	Quarterly 2021 Only	Grab
Total Dissolved Solids (c)	SM 2540 C – Gravimetric (±10 mg/L)	10 mg/L	20 mg/L	Quarterly 2021 Only	Grab
Total Iron (c)	EPA 200.7 – ICP/MS (±50 ug/L)	12 ug/L	50 ug/L	Quarterly 2021 Only	Grab
Dissolved Iron (c)	EPA 200.7 – ICP/MS (±50 ug/L)	12 ug/L	50 ug/L	Quarterly 2021 Only	Grab
Total Manganese (c)	EPA 200.8 – ICP/MS (+0.5 ug/L)	0.1 ug/L	0.5 ug/L	Quarterly 2021 Only	Grab
Dissolved Manganese (c)	EPA 200.8 – ICP/MS (+0.5 ug/L)	0.1 ug/L	0.5 ug/L	Quarterly 2021 Only	Grab
Total Daily Volume of Discharge	Meter or Estimate (±30 gallons)	10 gallons per event	10 gallons per event	Daily	NA
Total Daily Number of Discharge Events	Count	Count	Count	Daily	NA

Analytical methods are from "Guidelines Establishing Test Procedures for the Analysis of Pollutants," 40 CFR Part 136, Revised August 2017.

(a) **Detection Limit** (also known as ***method detection limit*** or MDL):
The minimum concentration of an analyte that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure given in 40 CFR Part 136, Appendix B.

(b) **Quantitation Level** (also known as minimum level of quantitation, practical quantitation limit, or PQL):
- (1) The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. It is equivalent to the concentration of the lowest calibration standard, assuming that the laboratory has used all method-specified sample weights, volumes, and clean-up procedures. The quantitation level is calculated by multiplying the method detection limit by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10^n, where n is an integer. (64 FR 30417)
- (2) The smallest detectable concentration of an analyte greater than the method detection limit where the accuracy (precision & bias) achieves the objectives of the intended purpose. (*Report of the Federal Advisory Committee on Detection and Quantitation Approaches and Uses in **Clean Water Act** Programs*, Submitted to the U.S. EPA December 2007.)

(c) Only those Permittees required to complete the Survey regarding discharge to ground, in accordance with Special Condition S-6.3.6, must analyze wastewater for this parameter.

GWI = Groundwater under the direct influence of surface water.
gpd = Gallons per day.
mg/L = Milligrams per liter.
ug/L = Micrograms per liter.
mL/L = Milliliters per liter.
NA = Not applicable.
NTU = Nephelometric turbidity unit.

The first monitoring period begins on the effective date of this permit.

Monitoring for chloride, total dissolved solids, total and dissolved iron, and total and dissolved manganese (secondary pollutants) is required only four times during the calendar year 2021, i.e., once each quarter: Jan-Mar, Apr-June, July-Sept, and Oct-Dec. Permittees must collect and analyze two samples each quarter for the six secondary pollutants. One of the samples must be from the same monitoring point as normally monitored, which is the ***outfall*** where treated filter backwash wastewater discharges to surface water. The other sample must be ***untreated*** filter backwash wastewater from a location between its creation at the filtration system where backwashing occurs and its entry into the treatment area, e.g., settling basin. Condition S-5.2.3 contains a schematic illustration of the sampling locations.

Based on the results of secondary ***contaminant*** monitoring, Ecology may modify this or a future permit by adding monitoring requirements for some or all of the secondary pollutants. Additionally, Ecology may change the activities, discharges, and facilities that require coverage under this permit, or may require certain Permittees to apply for an individual permit.

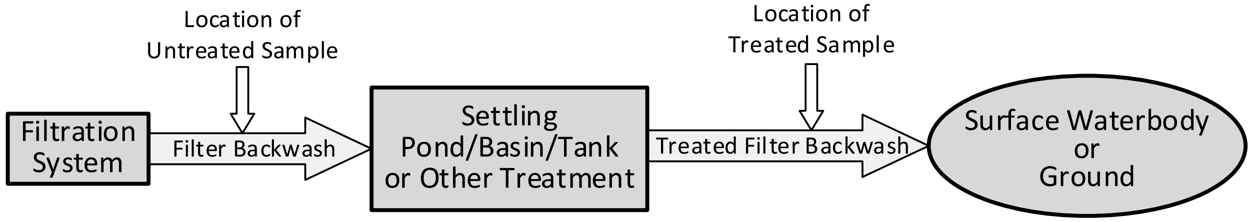
S-5.2.2 Field Documentation

For each measurement or sample taken, the Permittee must record the following information:

1. The date, exact place, method, and time of sampling or measurement.
2. The individual who performed the sampling or measurement.
3. The dates the analyses were performed.
4. The individual who performed the analyses.
5. The analytical techniques or methods used.
6. The results of all measurements and analyses.

S-5.2.3 Location

The Permittee must conduct all monitoring of treated filter backwash wastewater as close to the point of discharge to surface water (end of pipe) as is reasonably possible. The location for special purpose sampling of ***untreated*** filter backwash wastewater should be downstream of and as close as is reasonably possible to the filtering system undergoing backwash (at or prior to its entry into the treatment area as described in Section S-5.2.1). The illustration below provides a conceptual model of the wastewater handling system and shows where sampling for secondary pollutants in untreated wastewater is to occur.



S-5.2.4 Sampling Methods

Sampling methods used to meet the monitoring requirements specified in this permit must conform to the latest revision of the "Guidelines Establishing Test Procedures for the Analysis of Pollutants" contained in 40 CFR Part 136, (or as applicable in 40 CFR subchapters N [Parts 400-471] or O [Parts 501-503]) unless otherwise specified in this permit. Ecology may specify alternative methods only for parameters without limits or without a U.S. EPA-approved test method in 40 CFR Part 136. Sampling must yield samples representative of the wastewater discharged by the Permittee.

S-5.3 Analytical Procedures

S-5.3.1 Laboratory Accreditation

All monitoring data required by Ecology must be prepared by a laboratory registered or accredited under the provisions of Chapter 173-50 WAC, "Accreditation of Environmental Laboratories." Flow, temperature, settleable solids, specific conductance, pH, turbidity, and internal process control parameters are exempt from this requirement, except that specific conductance, pH, and turbidity must be accredited if the laboratory must otherwise be registered or accredited. An accredited laboratory must provide all ***chlorine*** and secondary pollutant data.

S-5.3.2 Laboratory Documentation

All laboratory reports providing monitoring data must include the following information: sampling date, sample location, date of analysis, parameter name, CAS number, analytical method/number, ***method detection limit*** (MDL), laboratory reporting limit or practical quantitation level (PQL), reporting units, and concentration detected. Analytical results from samples sent to a contract laboratory must also include information on the chain of custody, QA/QC results, and documentation of accreditation for each parameter.

S-5.3.3 Laboratory Methods

The Permittee must analyze all wastewater samples for the parameters and using the methods, MDLs, and PQLs specified in Special Conditions S-5.2.1 (Event Criteria, Frequency, and Timing) and S-5.2.4 (Sampling Methods) unless:

- Another permit condition specifies other methods, MDLs, or PQLs; ***or***
- The method used produces measureable results in the sample, and the U.S. EPA has listed it as an EPA-approved method in 40 CFR Part 136.

The analyses must also include any other parameter deemed necessary by Ecology. If the Permittee uses an alternative method, not specified in the permit and allowed as above, it must report the test method, MDL, and PQL on the ***discharge monitoring report (DMR)*** or other required report. If the Permittee is unable to obtain the required MDL or PQL in its effluent due to matrix effects, the Permittee must submit a matrix-specific MDL and PQL to Ecology along with appropriate laboratory documentation.

S-5.4 Turbidity

The benchmark for turbidity in discharges of treated wastewater from backwashing of water treatment filtration systems is 25 Nephelometric turbidity units (NTUs).

If during scheduled monitoring of treated backwash effluent, the Permittee finds the turbidity to exceed 25 NTU, the Permittee must take either of the following ***actions*** as appropriate.

- If the measured turbidity was in the range of 26 to 250 NTUs, the Permittee must review facility operations, determine the likely cause of the benchmark exceedance, modify operations to prevent a reoccurrence of the exceedance, update the relevant planning document(s) as needed, and preserve documentation of the exceedance and corrective action within 10 ***calendar days*** of the date the discharge exceeded the benchmark.
- If the measured turbidity exceeded 250 NTUs, the Permittee must:
  1) First, immediately take action to stop, contain, and clean up the unauthorized discharge, and minimize any adverse impacts to waters of the State.
  2) Second, telephone a report of the incident to the appropriate Ecology Region Emergency Response Tracking System (ERTS) and the regional permit administrator. Contact information is provided in Special Condition S-6.2.1.
  3) Third, review facility operations, determine the likely cause of the benchmark exceedance, modify operations to prevent a reoccurrence of the exceedance, update the relevant planning document(s) as needed, and preserve documentation of the exceedance and corrective action within 10 calendar days of the date the discharge exceeded the benchmark.

S-5.5 Supporting Documentation

The Permittee must maintain supporting documentation for all field and laboratory measurements and any calculations used to determine the total daily volume of discharges and total daily number of discharge events.

S-6 REPORTING AND RECORDKEEPING REQUIREMENTS

S-6.1 Permit-Required Submittals

Unless otherwise specified in this permit, the Permittee must use the on-line "Water Quality Permitting Portal" at http://www.ecy.wa.gov/programs/wq/permits/paris/portal.html to submit all permit-required reports by the specified due dates. Where another condition of this permit requires submission of hardcopy paper documentation, the Permittee must ensure that the submission is postmarked or received by Ecology no later than the specified due date. The Permittee must submit hardcopy paper documentation to the water quality permit coordinator at the appropriate address provided in Special Condition S-6.2.1 (Notification of Non-Compliance).

S-6.2 Notification Requirements

S-6.2.1 Notification of Non-Compliance

In the event that the Permittee fails to comply with any of the terms and conditions of this permit, or in the event of a spill or other discharge not authorized by this permit, such that the resulting non-compliance may threaten human health or the environment, the Permittee must:

1. Immediately take action to stop, contain, and cleanup unauthorized discharges and otherwise stop the non-compliance, correct the problem, and minimize any adverse impacts to waters of the State.
2. Immediately notify Ecology of a spill by calling the appropriate regional Emergency Response Tracking System (ERTS) phone number and the regional permit administrator. The phone numbers are provided below:

Ecology Central Regional Office Water Quality Program 1250 West Alder Street Union Gap, WA 98903-0009 509-575-2490 TDY: 711 or 1-800-833-6341	**Counties** Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, and Yakima
Ecology Eastern Regional Office Water Quality Program 4601 North Monroe Spokane, WA 99205-1295 509-329-3400 TDY: 711 or 1-800-833-6341	**Counties** Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, and Whitman
Ecology Northwest Regional Office Water Quality Program 3190 - 160th Avenue SE Bellevue, WA 98008-5452 (425) 649-7000 TDY: 711 or 1-800-833-6341	**Counties** Island, King, Kitsap, San Juan, Skagit, Snohomish, and Whatcom
Ecology Southwest Regional Office Water Quality Program 300 Desmond Drive SE Lacey, WA 98503 360-407-6300 TDY: 711 or 1-800-833-6341	**Counties** Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Lewis, Mason, Pacific, Pierce, Skamania, Thurston, and Wahkiakum

3. Notify the Ecology regional permit administrator of any other non-compliance, including any unanticipated bypass and/or upset that exceeds any effluent limit in the permit, orally within 24 hours from the time the Permittee becomes aware of the non-compliance.
4. If applicable, repeat the sampling and analysis that identified the non-compliance, and submit the results to Ecology within 5 days of becoming aware of the non-compliance.

5. Submit a detailed written report to Ecology at the appropriate address provided in Step 2 above within 5 days of the time the Permittee becomes aware of the non-compliance. The report must include all of the following information, at a minimum:
   (a) A description of the nature and cause of the non-compliance, including the quantity and quality of any unauthorized discharges.
   (b) The period of non-compliance, including the beginning and ending dates and times of the non-compliance, or if the Permittee has not yet corrected the non-compliance, the anticipated date and time when the Permittee will return to compliance.
   (c) The results of any additional sampling and analyses.
   (d) A description of the corrective action taken or planned by the Permittee.
   (e) Steps the Permittee has taken or plans to take to reduce, eliminate, and prevent a recurrence of the non-compliance.
   (f) Any other pertinent information.
6. Ecology may temporarily waive the written report required in Step 5, above, on a case-by-case basis upon written request if it has received a timely oral report, but in no case for more than 30 days after the Permittee becomes aware of the non-compliance.

Reportable failures of compliance include, but are not limited to:

1. Any bypass that exceeds any effluent limit in this permit.
2. Any upset that exceeds any effluent limit in this permit.
3. Any exceedance of a maximum ***daily discharge limit*** for any of the pollutants listed in Special Condition S-2 (Limits and Standards).

Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with any of the terms and conditions of this permit or from any resulting liability for failure to comply.

S-6.2.2 Notification of an Anticipated Bypass

The requirements for notifying Ecology of an intended bypass are identified in Special Condition S-4.2.1 (Bypass Prohibition and Procedures).

S-6.2.3 Notification of a Change in Covered Activities

The Permittee must report to Ecology any facility expansion, production increase, or significant process modification that may cause a new or increased discharge of pollutants that may cause either an exceedance of an effluent limit or a discharge beyond that reported in the original ***application for coverage***. This report must be in the form of a new application or a supplement to the original application.

Significant process changes include a ***substantially*** increased discharge of pollutants or a change in the nature of the discharge of pollutants, including:

- A wastewater discharge increase of 25% more than the previous permit covered;

- A new source of raw water that requires different treatment processes, consequently altering the characteristics of the discharged wastewater; or
- A change or addition of treatment to remove a substance not previously removed, consequently altering the characteristics of the discharged wastewater.

S-6.3 Required Reports

S-6.3.1 Questionnaire: Excerpts from Operations, Maintenance, and Planning Documents

At least once during every 5-year permit term, the Permittee must provide to Ecology certain information from its Operations and Maintenance Manual, Solid Waste Control Plan, Stormwater Pollution Prevention Plan, and any other spill contingency plan. The Permittee must provide this information by (a) 90 days after its coverage under this permit begins, or (b) January 1, 2020, whichever is later; and whenever that information changes due to updates of any of these plans. Appendix C contains a blank "Questionnaire" for the required information. An electronic version of the Questionnaire is available on the Ecology Water Treatment Plant website, (https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Water-treatment-plants).

If the Permittee wishes, rather than completing the entire Questionnaire, they may provide:

- Electronic versions of the entirety of some or all of its operations, maintenance, and planning documents, ***and***
- Simplified responses in the Questionnaire, itself. These simplified responses must include the specific page, table, or figure numbers in the submitted document(s) where Ecology can readily find the requested detailed information.

S-6.3.2 Additional Monitoring by Permittee

If the Permittee monitors any pollutant more frequently than required by Special Condition S-5 (Monitoring Requirements) of this permit, then the Permittee must include the results of such monitoring in the calculation and reporting of the data submitted in the Permittee's discharge monitoring report.

S-6.3.3 Bypasses

The Permittee must report bypasses to Ecology as described in Special Condition S-4.2.1 (Bypass Prohibition and Procedures).

S-6.3.4 Discharge Monitoring Report (DMR)

The Permittee must submit a DMR each calendar month, whether or not a discharge occurred. If the facility did not discharge during a given monitoring period, the Permittee must submit a completed DMR with "No Discharge" entered as the DMR Reporting Code. Submission of DMRs must be completed by no later than the 15th day of the month following the completed monitoring period.

Permittees must sign up for and submit monitoring data through the Ecology WebDMR program via the Permittee's SecureAccess Washington account, which is accessible at https://secureaccess.wa.gov/ecy/wqwebportal/. More information is available at the "Water Quality Permitting Portal" at http://www.ecy.wa.gov/programs/wq/permits/paris/portal.html and at "About WQWebDMR" at http://www.ecy.wa.gov/programs/wq/permits/paris/webdmr.html.

Permittees unable to submit electronically (e.g., those who do not have an Internet connection) must contact the Ecology Water Treatment Plant permit administrator at the locations provided in Special Condition S-6.2.1 (Notification of Non-Compliance) to request a waiver and obtain instructions on how to obtain a hardcopy paper DMR. Permittees with waivers must submit hardcopy paper DMRs to be received by Ecology no later than the 15th day of the month following the completed monitoring period.

All DMRs must contain the following information:

1. Include data for each of the parameters for which monitoring is required by Special Condition S-5 (Monitoring Requirements) and as required by the DMR entry screen or hardcopy paper form. Report a value for each day sampling occurred and for the monthly values.
2. If the Permittee did not discharge wastewater during a given monitoring period, enter the "No Discharge" reporting code.
3. Record onto the DMR those analytical values reported as "less than the detection limit" by entering "<" followed by the numeric value of the ***detection limit*** (e.g., < 2.0). If the method used did not achieve the detection limit or quantitation level identified in Special Condition S-5.2.1 (Event Criteria, Frequency, and Timing), report the actual detection limit and quantitation level in the DMR comments section or other location provided.
4. Report the analytical test method actually used in the DMR comments section or other location provided if the laboratory used an alternate method not specified in the permit and as allowed in Special Condition S-5.2.1 (Event Criteria, Frequency, and Timing).
5. Calculate average and total values (unless otherwise specified in the permit) using:
   (a) For all quantitative results measured at levels equal to or greater than the agency-required detection limit value: The reported numeric value.
   (b) For results reported at less than the detection limit numerically (e.g., <0.01 mg/L or not detected ***with*** a specified detection limit value): One-half the reported detection limit value.
   (c) For results reported as less than the detection limit non-numerically (e.g., ND or not detected) and ***without*** a specified detection limit value,
      i. If the same parameter was detected in another sample from the same monitoring point for the reporting period: One-half the detection limit value reported for the other sample.
      ii. If the same parameter was not detected in another sample from the same monitoring point for the reporting period: Zero.
6. Submit an electronic copy of the laboratory report as an attachment using the link for "About WQWebDMR" or as a paper copy along with the hardcopy paper DMR form. Laboratory reports must include a record of the chain of custody, QA/QC results, and documentation of accreditation for each parameter.

S-6.3.5 Exceedance of Turbidity Benchmark

Whenever monitoring that has been performed in accordance with Special Condition S-5 finds that the effluent turbidity exceeded 250 NTUs, the Permittee must telephone a report of the incident to the appropriate Ecology Region Emergency Response Tracking System (ERTS) and the regional permit administrator. Their contact information is provided in Condition S-6.2.1. Special Condition S-5.4 identifies additional requirements for documentation.

S-6.3.6 Survey Regarding Discharge to Ground

Shortly after Ecology receives the Permittee's Notice of Intent (NOI) and its responses to the planning documents questionnaire (see Special Condition S-6.3.1), Ecology will inform the Permittee whether it must complete and submit a survey regarding discharges to ground (Survey). Some of the requested information includes as-built engineering drawings of the filter backwash wastewater settling tanks and constructed settling, storage, and infiltration basins and ponds (Question 4). Appendix D lists the questions in the Survey, and the Ecology Water Treatment Plant website, (https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Water-treatment-plants), will provide guidance for completing the Survey. Survey participants must submit the entire completed Survey to Ecology no later than February 15, 2022.

S-6.4 Record Retention

The Permittee must retain records of all monitoring information resulting from any monitoring activity required as a condition of the application for or as a condition of coverage under this permit for a minimum of 5 years following the specified expiration date of this permit. Such information must include all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit. The Permittee must extend this period of retention during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by Ecology.

The Permittee must keep a copy of this permit (electronic or paper) at the facility and make it available upon request to Ecology inspectors.

S-7 PERMIT ADMINISTRATION

S-7.1 Application for Coverage

S-7.1.1 Who May Apply for Coverage

New facilities, or facilities currently operating without permit coverage, that qualify under Special Condition S-1 (Permit Coverage) must apply for coverage under this general permit.

S-7.1.2 How to Obtain Coverage

An applicant must submit to Ecology a completed and signed application for coverage (an electronic notice of intent, or eNOI), specifically prescribed by Ecology for this general permit, available for example via the Ecology webpage: https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Water-treatment-plants. All such applications for coverage must be submitted within 180 days prior to commencement of the activity which may result in the discharge of any pollutant to waters of the State.

All applications for coverage under this permit must:

1. Contain sufficient information necessary for adequate program implementation;
2. Contain the legal name and address of the owner or operator, the facility name and address, type of facility and discharges, and the receiving waterbodies;
3. Bear a certification of correctness;
4. Be signed by a responsible person, as identified in General Condition G-4.2 (Certification and Signature Requirements); ***and***
5. Include any other information that Ecology deems relevant.

S-7.1.3 Public Notice

All new applicants for this permit and any existing Permittee that plans a significant process change, as described in Special Condition S-6.2.3 (Notification of a Change in Covered Activities), must cause notice to be circulated within the geographical area of the proposed discharge and certify this fact to Ecology. Such notice must:

1. Be published twice, with at least a 1-week interval between, in the newspaper of greatest general circulation within the county in which the discharge is proposed to occur;
2. Be circulated by any other method as Ecology may direct; ***and***
3. Contain, at a minimum, the following:
   (a) The name, address, and location of the facility requesting coverage under this permit;
   (b) The applicant's activities or operations that result in a discharge;
   (c) The name of the general permit under which coverage is requested; ***and***
   (d) The following statement: "Any person desiring to present their views to Ecology regarding this application may do so in writing, within 30 days of the last date of publication of this notice. Comments should be submitted to Ecology. Any person interested in Ecology's action on this application may notify Ecology of their interest within 30 days of the last date of publication of this notice."

S-7.1.4 Proof of Compliance with SEPA

All new applicants must submit to Ecology, along with an application for coverage, proof and certification that their facility has met all applicable requirements of the ***State Environmental Policy Act*** (SEPA) under Chapter 197-11 WAC.

GENERAL CONDITIONS

G-1 OPERATION AND MAINTENANCE

G-1.1 Activities and Discharges Authorized by this Permit

All activities and discharges authorized by this permit must be consistent with the terms and conditions of this permit. The Permittee is at all times responsible for continuous compliance with the terms and conditions of this permit. The discharge of any pollutant more frequently than or at a concentration or amount in excess of that authorized by this permit constitutes a violation of the terms and conditions of this permit.

G-1.2 Discharges from Activities Not Covered by this Permit

The discharge of pollutants resulting from activities not covered under this permit for which the ***discharger*** has requested coverage is a violation of this permit.

G-1.3 Maintaining Compliance if Treatment System Fails

The Permittee, in order to maintain compliance with this permit, must control production and all discharges such that, in the event of reduction, loss, failure, or bypass of any portion of the treatment system, the Permittee maintains compliance with this permit until the treatment system is fully restored or an alternate method of treatment is provided. This requirement applies in the situation where, among other things, the primary source of power of the treatment system is reduced, lost, or fails.

G-1.4 Removed Substances

The Permittee must not allow collected screenings, grit, solids, sludges, or other pollutants removed in the course of treatment or control of the wastewater and/or stormwater covered by this permit to be resuspended or reintroduced to the storm sewer system or to waters of the State.

G-1.5 Upset

An upset is an exceptional incident in which an unintentional and temporary non-compliance with ***technology-based permit effluent limits*** occurs due to factors beyond the reasonable control of the Permittee. An upset does not include non-compliance to the extent caused by operational error, improperly designed treatment facilities, inadequate storage or treatment facilities, lack of preventive maintenance, or careless or improper operation.

An upset constitutes an affirmative defense to an action brought for non-compliance with such technology-based permit effluent limits if the requirements of this paragraph are met. No determination made during administrative review of claims that non-compliance was caused by upset, and before an action for non-compliance, is a final administrative action, subject to judicial review. A Permittee who wishes to establish the affirmative defense of upset must demonstrate, through properly signed contemporaneous operating logs or other relevant evidence, that:

1. An upset occurred, and that the Permittee can identify the cause(s) of the upset;

2. The permitted facility was being properly operated at the time of the upset;
3. The Permittee submitted notice of the upset as required in Special Condition S-6 (Reporting and Recordkeeping Requirements) of this permit; ***and***
4. The Permittee complied with any remedial measures required under this permit.

In any enforcement proceeding, the Permittee seeking to establish the occurrence of an upset has the burden of proof.

G-2 OTHER DUTIES AND RESPONSIBILITIES

G-2.1 Additional Monitoring Requirements

Ecology may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G-2.2 Compliance with Other Laws and Regulations

Nothing in this permit excuses the Permittee from any requirement for compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

The Permittee must comply with effluent standards and prohibitions for ***toxic*** pollutants established under Section 307(a) of the ***Clean Water Act***, the Resource Conservation and Recovery Act (Public Law 95.190), the Hazardous Waste Management Act (Chapter 70.105 RCW), the Solid Waste Management–Reduction and Recycling Act (Chapter 70.95 RCW), and all other applicable requirements of 40 CFR 122.41 and 122.42 within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G-2.3 Duty to Comply with this Permit

The Permittee must comply with all Conditions of this permit. Any permit non-compliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; permit termination, revocation and reissuance, or modification; or denial of an application for renewal of coverage.

G-2.4 Duty to Mitigate

The Permittee must take all reasonable steps to minimize or prevent any discharge, use, or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

G-2.5 Duty to Provide Information

The Permittee must provide to Ecology, within a reasonable time, all information that Ecology may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee must also provide to Ecology, upon request, copies of records required to be kept by this permit.

G-2.6 Duty to Reapply

If the Permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the Permittee must reapply for coverage under this permit (or under an individual permit) at least 180 days prior to the specified expiration date of this permit. An expired general permit and coverage under the general permit continue in force and effect until Ecology issues a new general permit (or a new individual permit) or until Ecology cancels the general permit. Coverage under this permit continues for only those Permittees who reapply for coverage in a timely manner.

G-2.7 Notification of Spills and Other Discharges

If the Permittee has knowledge of a discharge or spill that could constitute a threat to human health, welfare, or the environment, the Permittee must:

1. Take appropriate action to correct or minimize the threat to human health, welfare, and the environment.
2. Notify the Ecology regional office and other appropriate spill response authorities immediately, but in no case later than within 24 hours of obtaining that knowledge.
3. Immediately report spills or other discharges which might cause bacterial contamination of marine waters to the Ecology regional office and to the Department of Health, Shellfish Program.
4. Immediately report spills or discharges of oils or hazardous substances to the Ecology regional office and to the Washington Emergency Management Division.

The relevant 24-hour phone numbers are:

- Department of Ecology Northwest Regional Office (425) 649-7000
- Department of Ecology Southwest Regional Office (360) 407-6300
- Department of Ecology Central Regional Office (509) 575-2490
- Department of Ecology Eastern Regional Office (509) 329-3400
- Washington Emergency Management Division (800) 258-5990
- Department of Health Shellfish Program (360) 789-8962

G-2.8 Plan Review Required

Prior to constructing or modifying any wastewater control facilities, the Permittee must provide all engineering reports and detailed plans and specifications to Ecology for approval in accordance with Chapter 173-240 WAC. Submission of engineering reports, plans, and specifications must occur in accordance with a ***compliance schedule*** issued by Ecology or at least 30 days before the time approval is desired. Construction and operation of the facilities must occur in accordance with the approved plans.

G-2.9 Prohibited Discharges

Discharge of pollutants by the Permittee to waters of the State are prohibited except as authorized through coverage under this permit.

This permit does not authorize any person to discharge any of the following:

1. Any radiological, chemical, or biological warfare agent or high-level radioactive waste into waters of the State.
2. Any pollutants that the Secretary of the Army acting through the Chief, Corps of Engineers, finds would substantially impair anchorage and navigation.
3. Any pollutant that the U.S. EPA, not having waived its right to object pursuant to Section 402(e) of the Clean Water Act, has objected to in writing pursuant to Section 402(d) of the Clean Water Act.
4. Any pollutant in conflict with plans or amendment thereto approved pursuant to Section 208(b) of the Clean Water Act.
5. Any pollutant subject to a toxic pollutant discharge prohibition under Section 307 of the Clean Water Act.
6. Any dangerous waste, as defined in the dangerous waste regulations, Chapter 173-303 WAC, into a subsurface disposal system, such as a ***well*** or drainfield.

G-2.10 Reporting Other Information

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to Ecology, the Permittee must promptly submit such facts or information.

G-3 ENFORCEMENT AND PENALTIES

G-3.1 Enforcement

Ecology, with the assistance of the attorney general, may sue in courts of competent ***jurisdiction*** to enjoin any threatened or continuing violation of this permit or the Conditions thereof without the necessity of a prior revocation of coverage under this permit. Any violation of the terms and conditions of this permit, the state Water Pollution Control Act, or the federal Clean Water Act are subject to the enforcement sanctions, direct and indirect, as provided for in WAC 173-226-250.

G-3.2 Penalties for Tampering

Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, by imprisonment for not more than 2 years per violation, or by both fine and imprisonment. If a conviction of a person is for a violation committed after a first conviction of such person under this Condition, punishment shall be a fine of not more than $20,000 per day of violation, by imprisonment of not more than 4 years, or by both fine and imprisonment.

Any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or non-compliance, shall, upon conviction, be punished by a fine of not more than $10,000 per violation, by imprisonment for not more than 6 months per violation, or by both fine and imprisonment.

G-3.3 Penalties for Violating Permit Conditions

Any person who is found guilty of willfully violating the terms and conditions of this permit is guilty of a crime and, upon conviction thereof, may be punished by a fine of up to $10,000 and costs of prosecution, by imprisonment, or by both fine and imprisonment, in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of this permit may incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to $10,000 for every such violation. Each and every such violation is a separate and distinct offense, and in the case of a continuing violation, every day's continuance may be deemed a separate and distinct violation.

G-3.4 Property Rights

This permit does not convey any property rights of any sort, or any exclusive privilege.

G-3.5 Right of Inspection and Entry

The Permittee must allow Ecology or its authorized representative, upon the presentation of credentials and such other documents as may be required by law, at reasonable times, for the purpose of inspecting and investigating; (a) Conditions relating to the pollution or the possible pollution of any waters of the State, or (b) Actual or suspected violations of water quality standards, effluent standards or limits, or the terms and conditions of this permit:

1. To enter upon the premises, public or private, in which an effluent source or discharge is located or where any records must be kept under the terms and conditions of this permit.
2. To have access to and to copy at reasonable cost any records that must be kept under the terms and conditions of this permit.
3. To investigate, inspect, or monitor any facility, operation, or practice regulated by or required under this permit, including:
   (a) Postings.
   (b) Collection, control, treatment, pollution management, and discharge facilities.
   (c) Monitoring equipment or methods.
4. To sample or monitor any discharge, internal waste stream, substances, or parameters at any location, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act.

“Reasonable times” includes regular business hours and any other times when Ecology suspects the occurrence or evidence of a violation requiring immediate inspection.

G-4 PERMIT MANAGEMENT AND COORDINATION

G-4.1 Appeal

Any person may appeal the terms and conditions of this general permit, as they apply to the appropriate class of dischargers, within 30 days of issuance of this general permit, in accordance with Chapter 43.21B RCW and Chapter 173-226 WAC.

Any person may appeal the terms and conditions of this general permit, as they apply to an individual discharger, within 30 days of the effective date of coverage of that discharger, in accordance with Chapter 43.21B RCW. Consideration of an appeal of general permit coverage of an individual discharger is limited to the general permit's applicability or inapplicability to that individual discharger.

The appeal of general permit coverage of an individual discharger does not affect any other dischargers covered under this general permit. If the terms and conditions of this general permit are found to be inapplicable to any individual discharger(s), the matter shall be remanded to Ecology for consideration of issuance of an individual permit or permits.

G-4.2 Certification and Signature Requirements

The Permittee must sign and certify as correct all applications, reports, or information that it provides to Ecology. The person who provides such signature and certification must be any of the following:

1. In the case of corporations, a responsible corporate officer who may be:
   (a) A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function or any other person who performs similar policy- or decision-making functions for the corporation; ***or***
   (b) The manager of one or more manufacturing, production, or operating facilities, provided:
      i. The manager is authorized to make management decisions which govern the operation of the permitted facility or activity, including having the explicit or implicit duties of making major capital investment recommendations and initiating and directing other comprehensive measures to assure long-term environmental compliance with environmental laws and regulations;
      ii. The manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; ***and***
      iii. Authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.
2. In the case of a partnership, a general partner.
3. In the case of a sole proprietorship, the proprietor.
4. In the case of a municipal, state, or other public facility or activity, either a principal executive officer or ranking elected official.
5. A duly authorized representative of a person identified among items 1 through 4 of this Condition. A person is a duly authorized representative only if:

(a) A person identified among items 1 through 4 of this Condition makes the authorization in writing and submits it to Ecology; ***and***

(b) The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity or a position having overall responsibility for environmental matters for the Permittee. A duly authorized representative may thus be either a named individual or any individual occupying a named position.

If an authorization under item 5 of this Condition is no longer accurate because a different individual or position has responsibility for the overall operation of the facility or activity, the Permittee must provide to Ecology a new authorization satisfying the requirements of this Condition prior to or together with any applications, reports, or information to be signed by an authorized representative.

Any person signing a document under this Condition must make the following certification:

> *"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."*

G-4.3 Dates of Coverage under this Permit

Starting on the date that Ecology receives a Notice of Intent application for permit coverage, Ecology has 30 days to inform the applicant whether or not the application is complete. If the applicant has submitted a complete NOI, and Ecology does not respond to the applicant within those 30 days, permit coverage automatically commences on the later of the following, as applicable:

1. For Permittees already covered under the expiring general permit who met all renewal requirements (WAC 173-226-220 (2) and (3)), the effective date of this general permit. Ecology sends all such Permittees a new coverage letter after the reissuance of the general permit.
2. For new applicants without current coverage under the general permit:
    a. The date specified on the coverage letter that Ecology sends to the applicant.
    b. The 31st day following Ecology's receipt of the applicant's completed Notice of Intent application for coverage (61st day following the publication date of the second public notice per WAC 173-226-130 (5)).

When a Permittee has made a timely and sufficient application for the renewal of coverage under this permit prior to its expiration, this permit remains in effect and enforceable until Ecology:

1. Denies the application;
2. Issues a replacement permit; ***or***
3. Cancels the expired permit.

Coverage under an expired general permit for Permittees who fail to submit a timely and sufficient application expires on the expiration date of the general permit.

G-4.4 Severability

The provisions of this permit are severable, and if any provision of this permit, or application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances and the remainder of this permit are not affected thereby.

G-4.5 Payment of Fees

The Permittee must provide payment of fees associated with this permit as assessed by Ecology pursuant to Chapter 173-224 WAC until the permit is either terminated or revoked.

G-4.6 Termination of Coverage upon Issuance of an Individual Permit

When an NPDES waste discharge individual permit is issued to a discharger otherwise subject to this general permit, the applicability of this general permit to that Permittee is automatically terminated on the effective date of the individual permit.

G-4.7 Reporting a Cause for Modification or Revocation

The Permittee must provide a new application or information supplemental to the previous application whenever:

1. The Permittee anticipates a significant change to the permitted activity or in the quantity or type of discharge authorized by this permit; ***or***
2. The Permittee knows, or has reason to believe, that any activity has occurred or will occur which would constitute cause for modification or revocation pursuant to 40 CFR 122.62.

A significant change includes, but is not limited to, any facility expansion, production increase, or process modification that would change the nature or increase the quantity of pollutants discharged such as to cause either non-compliance with effluent limits or discharges beyond those reported in the previous application for coverage. The Permittee must provide its plans, supplemental information, or new application for coverage to Ecology at least 60 days prior to any proposed changes. This reporting to Ecology does not relieve the Permittee of the duty to comply with the existing permit until it is modified or reissued.

G-4.8 Request to be Excluded from Coverage under this Permit

Any discharger authorized by this general permit may request to be excluded from coverage under this general permit by applying for an individual permit. Such discharger must provide to Ecology an application as described in WAC 173-216-070 or WAC 173-220-040, whichever is applicable, with reasons supporting the request for exclusion from coverage under this permit. These reasons must fully document how an individual permit will apply to the applicant in a way that this general permit cannot.

Ecology may require the applicant to provide information to support the request for exclusion from coverage under this general permit. Ecology will either issue an individual permit or deny the request with a statement explaining the reason for the denial.

G-4.9 Modification, Revocation, and Termination of this General Permit

Ecology may modify, revoke and reissue, or terminate this permit during its term for cause in accordance with the provisions of Chapter 173-226 WAC. Grounds for modification, revocation and reissuance, or termination include, but are not limited to, any of the following:

1. A change in the technology or practices for control or abatement of pollutants applicable to the category of dischargers covered under this permit.
2. Promulgation of effluent limit standards or guidelines pursuant to the Clean Water Act or Chapter 90.48 RCW for the category of dischargers covered under this permit.
3. Approval by Ecology of a water quality management plan containing requirements applicable to the category of dischargers covered under this permit.
4. Receipt of information that indicates that cumulative effects on the environment from dischargers covered under this permit are unacceptable.
5. Establishment by the U.S. Environmental Protection Agency of a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) under Section 307(a) of the Clean Water Act for a toxic pollutant which is more stringent than any limit upon such pollutant in this permit.

In the event that a material change occurs in the condition of the waters of the State, Ecology may, by appropriate order, modify permit Conditions or specify additional Conditions in permits previously issued.

The filing of a request by the Permittee for a permit modification, revocation and reissuance, or termination, or of a notification of planned changes or anticipated non-compliance does not stay any permit Condition.

G-4.10 Termination of Coverage under this Permit

Ecology may revoke coverage for any discharger under this permit for cause in accordance with Chapter 173-226 WAC. The discharger has 30 days during which to respond to any notification from Ecology of termination of coverage under this permit before coverage under this permit is automatically revoked. Cases where coverage may be terminated include, but are not limited to, any of the following:

1. Violation of any term or condition of this permit.
2. Failure or refusal of the Permittee to comply with an interim or final requirement contained in this permit or submitted as part of its application for coverage under this permit.
3. Misrepresentation or failure to disclose fully all relevant facts when applying for and obtaining coverage under this permit.
4. A material change in the quantity or type of waste disposed or in any other condition that requires either a temporary or permanent reduction or elimination of the permitted discharge.
5. A determination that the permitted activity endangers human health or the environment or contributes to a water quality standard violation.
6. Incorporation of an approved local ***pretreatment*** program into a municipality's permit.

7. Failure of the Permittee to satisfy the public notice requirements of WAC 173-226-130(5) when applicable.
8. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090 and General Condition G-3.5 (Right of Inspection and Entry).
9. Nonpayment of permit fees or penalties assessed pursuant to RCW 90.48.465 and Chapter 173-224 WAC.

Ecology may require any discharger, whether or not already covered under this general permit, to apply for and obtain coverage under an individual permit or another more appropriate general permit.

Permittees whose coverage has been revoked for cause according to WAC 173-226-240 may request temporary coverage under this permit during the time an individual permit is being developed, provided that the request is made within 90 days from the time of revocation and is submitted along with a complete individual permit application.

G-4.11 Transfer of Permit Coverage

Coverage under this permit is not transferable to any person except after notice to Ecology.

In the event of any change in control or ownership of the facility or activity from which the authorized discharge emanates, the Permittee must notify the succeeding owner or controller of the existence of this permit by letter, and provide a copy of that letter to Ecology.

A Permittee may transfer coverage under this permit to a succeeding owner or operator of the facility or activity producing the discharge, including owners or operators of lots or parcels within a common plan of development or sale, by:

1. Preparing a written agreement, signed by both the current Permittee and the new discharger, that specifies the proposed date of the transfer of coverage, responsibility, and liability for this permit; ***and***
2. Submitting to Ecology a copy of that written and signed agreement at least 30 days prior to the proposed transfer date; ***and***

Provided that:

Ecology does not notify the current Permittee and the new discharger by the proposed transfer date of its intent to modify, to revoke and reissue, or to terminate permit coverage. If Ecology does not notify the current Permittee and the new discharger, the transfer of permit coverage is effective on the date specified in the written agreement between the current Permittee and the new discharger.

When a current Permittee of a construction stormwater discharge site transfers control or ownership of a portion of that permitted site to another person, the current Permittee must also submit an updated application for coverage to Ecology indicating the acreage remaining after the transfer.

Upon consent of the Permittee, Ecology may transfer coverage under this permit to a succeeding Permittee by a minor modification in accordance with 40 CFR 122.63(d) to identify the new Permittee and incorporate such other requirements as Ecology may deem necessary.

This page intentionally left blank

APPENDIX A. ACRONYMS AND UNITS OF MEASURE

Acronym	Meaning
AKART	All known, available, and reasonable methods of prevention, control, and treatment
BMP	Best management practice
CAS	Chemical Abstract Service
CFR	Code of Federal Regulations
DoH	Washington State Department of Health
DMR	Discharge monitoring report
Ecology	Washington State Department of Ecology
eNOI	Electronic notice of intent
EPA	Environmental Protection Agency
ERTS	Emergency Response Tracking System
GWI	Groundwater under the direct influence of surface water
MDL	Method detection limit
ND	Not detected
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and maintenance
PQL	Practical quantitation level
QA/QC	Quality assurance and quality control
RCW	Revised Code of Washington State
SEPA	State Environmental Policy Act, RCW 43.21C
SOP	Standard operating procedures
SWPPP	Stormwater pollution prevention plan
TMDL	Total maximum daily load
U.S.	United States
USC	United States Code
WAC	Washington Administrative Code
WTP	Water Treatment Plant

Unit of Measure	Meaning
gpd	Gallons per day
ug/L	Micrograms per liter
mg/L	Milligrams per liter
mL/L	Milliliters per liter
NTU	Nephelometric turbidity units
S.U.	Standard units

APPENDIX B. DEFINITIONS

303(d) List
The list of waterbodies in Washington State that do not meet the water quality standards specified in Chapter 173-201A WAC. The Washington State Department of Ecology (Ecology) prepares and the U.S. Environmental Protection Agency approves this list periodically (every 2 years). The list is posted on the Ecology web site at https://apps.ecology.wa.gov/approvedwqa/ApprovedSearch.aspx.

Action
Any human project or activity.

Activity
A discernible set of related actions or processes conducted within a facility, operation, or site that may cause a discharge of pollutants. Examples include, but are not limited to, construction; manufacturing; production or use of raw materials, products, or wastes; transportation; and cleanup or treatment of machinery, structures, land, or water.

Actual production rate
For the Water Treatment Plant General Permit, the amount of finished water that a treatment facility actually produces on any given day. To calculate the value of the actual production rate on an average monthly basis, add the value of each daily production rate during a calendar month, and divide the sum by the total number of days in the month.

Adaptive Management
A structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously meets one or more resource management objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is a tool which should be used not only to change a system, but also to learn about the system. Since adaptive management is based on a learning process, it improves long-run management outcomes. The challenge in using the adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge.

All Known, Available, and Reasonable methods of prevention, control, and Treatment (AKART)
A technology-based approach of decision making for limiting pollutants from discharges. AKART represents the most current methodology for preventing, controlling, and abating pollution that can be installed or used at a reasonable cost.

Application for coverage
A formal request for coverage under this general permit using the paper or electronic form developed by the Washington State Department of Ecology for that purpose.

Average monthly discharge limit
The greatest average of daily discharges allowed for a calendar month. To calculate the value of the actual average monthly discharge for comparison with the limit, add the value of each daily discharge

measured during a calendar month, and divide this sum by the total number of daily discharges measured.

Background
The biological, chemical, physical, and radiological conditions that exist in the absence of any influences from outside an area potentially influenced by a specific activity.

Benchmark
A pollutant concentration used as a threshold, below which a pollutant is unlikely to cause a water quality violation, and above which it may. Benchmark values are not water quality standards and not numeric effluent limits – they are indicator values. Often when a pollutant concentration exceeds a benchmark, some active response may be necessary, i.e., ***adaptive management***.

Best Management Practice (BMP)
Activity, prohibition, maintenance procedure, or other physical, structural, and/or managerial practice to prevent or reduce pollution of and other adverse impacts to the waters of Washington State. BMPs include treatment systems, operating schedules and procedures, and practices used singularly or in combination to control plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage. BMPs may be further categorized as operational, source control, erosion and sediment control, and treatment BMPs.

Bypass
The diversion of stormwater or a wastestream from any portion of a treatment facility. A bypass may be intentional or unintentional.

Calendar Day
A period of 24 consecutive hours starting at 12:01 A.M. and ending at the following 12:00 P.M. (midnight).

Carcinogen
Any substance or agent that produces or tends to produce cancer in humans. The term carcinogen applies to substances on the U.S. Environmental Protection Agency lists of A (known human) and B (probable human) carcinogens, and any substance which causes a significant increased incidence of benign or malignant tumors in a single, well conducted animal bioassay, consistent with the weight of evidence approach specified in the U.S. Environmental Protection Agency Guidelines for Carcinogenic Risk Assessment.

Chlorine
A chemical used to disinfect wastewaters of pathogens harmful to human health. Chlorine is extremely toxic to aquatic life.

Clean Water Act (CWA)
The primary federal law in the United States governing water pollution and that includes goals for eliminating releases of large amounts of toxic substances into water, eliminating additional water pollution by 1985, and ensuring that surface waters will meet standards necessary for human sports and recreation by 1983. (Federal Water Pollution Control Act, Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, 97-117, and 100-4; USC 1251, et seq.)

Color
The optical density at the visual wavelength of maximum absorption, relative to distilled water. One hundred percent transmittance is equivalent to zero optical density. The analytical procedure for measuring this parameter is typically Standard Methods for the Examination of Water and Wastewater, Method 204.

Completed Notice of Intent application for permit coverage (Completed application)
A permit application form received by Ecology for which: (1) The applicant has filled out all applicable form fields with the correct information and had the application signed and certified by an individual who meets the requirements of WAC 173-226-200 (3); (2) The applicant has completed the publication of the required public notice for its application (WAC 173-226-130 (5)); and (3) The 30-day public comment period (which starts on the publication date of the second public notice) has ended (WAC 173-226-200 (2)).

Compliance schedule
A schedule of remedial measures that includes an enforceable sequence of actions or operations leading to compliance with an effluent or other limit, prohibition, or standard.

Contaminant
Any biological, chemical, physical, or radiological substance that does not occur naturally in a given environmental medium or that occurs at concentrations greater than those in the natural or ***background*** conditions.

Control

1. To direct, oversee, supervise, manage, perform, or give instruction about any decision, action, or operation of the specific facility, site, field, wastestream, or other object "under control."
2. The partial removal or complete eradication of native plants, non-native non-noxious plants, algae, noxious or quarantine-list weeds, or other nonnative invasive ***organisms*** from a waterbody. The purpose of control activities may be to protect some of the beneficial uses of a waterbody, such as swimming, boating, water skiing, fishing access, etc. The goal may be to maintain some native aquatic vegetation for habitat, while accomplishing some removal for beneficial use protection. Control activities may include the application of chemical(s) to all or part of a waterbody.

Conveyance
A mechanism for transporting water, wastewater, or stormwater from one location to another location, including, but not limited to, gutters, ditches, pipes, and/or channels.

Daily discharge
The amount of a pollutant discharged during any 24-hour period that reasonably represents a calendar day for purposes of sampling. For pollutants with limits expressed in units of mass, the daily discharge is calculated as the total mass of the pollutant discharged during the day. For pollutants with limits expressed in other units of measurement, the daily discharge is calculated as the average measurement of the pollutant throughout the day.

Dangerous waste
Any discarded, useless, unwanted, or abandoned nonradioactive substances, including but not limited to certain pesticides, or any residues or containers of such substances which are disposed of in such quantity

or concentration as to pose a substantial present or potential hazard to human health, wildlife, or the environment because such wastes or constituents or combinations of such wastes: (1) Have short-lived, toxic properties that may cause death, injury, or illness or have mutagenic, teratogenic, or ***carcinogenic*** properties; or (2) Are corrosive, explosive, flammable, or may generate pressure through decomposition or other means. The exact definition of dangerous waste is provided at WAC 173-303-040.

Design maximum production capacity
The amount of finished water that a water treatment facility is designed to produce at peak output and 24-hour production.

Detection limit
The minimum observed result such that the lower 100(1- α) percent confidence limit of the result is greater than the mean of the method blanks.

Detention
The temporary collection of water into a storage device or pond, with the subsequent release of that water either at a rate slower than the collection rate or after a specified time period has passed since the time of collection. The purposes of detention include, but are not limited to, improving the quality of the water released and reducing or smoothing the mass flow rate of its discharge over time.

Detention pond
Man-made structure constructed specifically to collect and manage stormwater. Detention ponds are generally dry until a significant storm event and subsequently gradually release the accumulated stormwater through an outlet.

Dilution factor (DF)
A measure of the amount of mixing of effluent and receiving water that occurs at the ***mixing zone*** boundary, expressed as the inverse of the effluent fraction. For example, a dilution factor of 16 means that, assuming complete mixing at the mixing zone boundary, the effluent comprises 6.25 percent by volume, and the receiving water comprises 93.75 percent by volume of the mixture of effluent and receiving water [DF = 1/(6.25/100) = 16].

Discharge (the noun form is the same as Effluent)
To release or add material to waters of the State, including via surface runoff.

Discharge limit (same as Effluent limit)
Any restriction, including schedules of compliance, established by the local government, the Washington State Department of Ecology, or the U.S. Environmental Protection Agency on quantities, rates, and/or concentrations of biological, chemical, physical, radiological, and/or other characteristics of material discharged into any site including, but not limited to, waters of the State of Washington.

Discharge Monitoring Report (DMR)
A report submitted periodically (usually monthly or quarterly) by a Permittee to the Washington State Department of Ecology that provides the results of effluent monitoring tests conducted by or on the behalf of the Permittee.

Discharger
An owner or operator of any facility, operation, or activity subject to regulation under Chapter 90.48 of the Revised Code of Washington State or the federal Clean Water Act.

Domestic wastewater
Waste and wastewater containing human wastes, including kitchen, bath, and laundry wastes from residences, buildings, industrial establishments, or other places, together with such groundwater infiltration or surface waters as may be present.

Effluent (same as the noun form of Discharge)
Material (usually an aqueous liquid) released to waters of the State, including via surface runoff.

Effluent limit (same as Discharge limit)
Any restriction, including schedules of compliance, established by the local government, the Washington State Department of Ecology, or the U.S. Environmental Protection Agency on quantities, rates, and/or concentrations of biological, chemical, physical, radiological, and/or other characteristics of material discharged into any site including, but not limited to, waters of the State of Washington.

Entity
Any person or organization, including, but not limited to, cities, counties, municipalities, Indian tribes, public utility districts, public health districts, port authorities, mosquito control districts, special purpose districts, irrigation districts, state and local agencies, companies, firms, corporations, partnerships, associations, consortia, joint ventures, estates, industries, commercial pesticide applicators, licensed pesticide applicators, and any other commercial, private, public, governmental, or non-governmental organizations, or their legal representatives, agents, or assignees.

Erosion
The detachment and movement of soil or rock fragments and the wearing away of the land surface by precipitation, running water, ice, wind, or other geological agents, including processes such as gravitational creep.

Erosion and Sediment Control Best Management Practice (ESC BMP)
Best management practice (BMP) intended to prevent erosion, sedimentation, or the release of sediment-laden water from the site. Examples include preserving natural vegetation, seeding, mulching and matting, and installation of plastic covering, filter fences, sediment traps, or ponds. (synonymous with stabilization and structural BMP)

Essential Maintenance
Maintenance required to ensure the proper and successful operation of the subject structure, equipment, mechanism, or facility. Examples of essential maintenance are: (1) Frequent cleaning of oily materials from an in-line pH sensor that controls whether or not an episodic discharge occurs; (2) Removal of accumulated sediment and trash from a catch basin prior to the basin becoming so filled that it no longer functions as intended; and (3) Testing and replacing emergency batteries that would provide, in the event of a regional power outage, electrical power to critical operations central to the purpose of the facility.

Facility (same as Operation)
The physical premises (including the land and appurtenances thereto) owned or operated by a Permittee from which wastewater or stormwater is discharged subject to regulation under the ***National Pollutant Discharge Elimination System*** program.

General permit
A single permit that covers multiple characteristically similar dischargers of a ***point source*** category within a designated geographical area, in lieu of many individual permits that are specifically tailored and issued separately to each discharger.

Groundwater (same as Underground water)
The water located in a ***saturated zone*** or stratum beneath the surface of the land or below a surface waterbody. Groundwater is a water of the State and includes ***interflow***, which is a type of perched water, and water in all other saturated soil pore spaces and rock interstices, whether perched, seasonal, or artificial. Although ***underground water*** within the ***vadose zone*** (unsaturated zone) also is a type of groundwater, the Washington State groundwater quality standards do not specifically protect soil pore water or soil moisture located in the vadose zone.

Groundwater under the direct influence of surface water (GWI)
Any water beneath the surface of the ground with: (a) Significant occurrence of insects or other microorganisms, algae, or large-diameter pathogens such as *Giardia lamblia*; or (b) Significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. GWI is groundwater located close enough to nearby surface water to receive direct surface water recharge. Potential sources of GWI include all infiltration galleries, Ranney wells, springs, and wells less than 50 feet deep located within 200 feet of surface water. Identifying a potential GWI to be an actual GWI requires either: (a) Determination of a hydraulic connection between the groundwater and the surface water; or (b) Demonstration through water quality monitoring of a correlation between groundwater and surface water measurements.

Hazardous waste
That waste designated by 40 CFR Part 261, and regulated by the U.S. Environmental Protection Agency.

Individual permit
A permit that covers only a single point source, discharger, or facility.

Interflow
Underground water derived directly from rainfall or snowmelt that percolates into the shallow soil, travels a relatively short distance laterally through the soil near the land surface, and subsequently seeps either: (1) Back onto the land surface where it may evaporate, mix with runoff, or discharge to a surface waterbody, or (2) Below the surface into a surface waterbody. The presence and amount of interflow is a function of the soil system depth, permeability, and water-holding capacity.

Jurisdiction
1. The practical authority granted to a formally constituted legal body to deal with and make pronouncements on legal matters and, by implication, to administer justice within a defined area of responsibility.

2. The geographical area or subject-matter to which such practical authority applies.

Load Allocation (LA)
Within the context of a total maximum daily load, that portion of the ***loading capacity*** of a pollutant entering a waterbody attributed to: (1) Existing or future ***nonpoint sources*** of pollution (i.e., all sources not covered by a National Pollutant Discharge Elimination System permit); and (2) Natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. LA does not include reserves for future growth or a margin of safety.

Loading capacity
The greatest amount of pollutant that a waterbody can receive and still meet water quality standards.

Maintenance
Activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing. Maintenance includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include replacement of dysfunctional facilities, including cases where environmental permits require replacing an existing structure with a different structure, as long as the functioning characteristics of the original structure are not changed. One example is the repair of a deteriorating paved walkway along the top of the berm enclosing a settling pond that otherwise is fully functional with no overtopping or leaks to the ground surface. Maintenance of WTP settling ponds includes periodic assessment to ensure ongoing proper operation, removal of built-up pollutants (e.g., sediments), replacement of spent or failing treatment media, and other actions taken to prevent or correct degraded performance.

Method Detection Limit (MDL)
Minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte. The MDL (or simply "detection limit") is the smallest measured amount or concentration of analyte in a sample that gives rise to a Type I error tolerance of alpha under the null hypothesis that the true amount or concentration of analyte in the sample is equal to that of a blank. (The alternative hypothesis is that the true amount or concentration of analyte is greater than that of a blank).

Mixing zone
That portion of a waterbody adjacent to an effluent discharge point where mixing dilutes the effluent with the receiving water. The water within this zone need not meet numeric water quality criteria, but must allow passage of aquatic organisms and not upset the ecological balance of the receiving water. The permit specifies the mixing area or volume fraction of the receiving water surrounding the discharge point.

Monthly average
The sum of all daily measurements obtained during a calendar month divided by the number of days measured during that month (arithmetic mean).

Municipality
A political unit incorporated for local self-government, such as a city, town, borough, county, parish, district, association, or other public body (including an intermunicipal agency of two or more of the foregoing entities) created by or pursuant to state law; an authorized Indian tribe or tribal organization;

or a designated and approved management agency under Section 208 of the Clean Water Act. Municipalities include special districts created under state law, such as a water district, sewer district, sanitary district, utility district, drainage district, or similar ***entity***.

National Pollutant Discharge Elimination System (NPDES)
The federal wastewater permitting system for discharges of pollutants from point sources to the navigable ***waters of the United States*** authorized under Section 402 of the Clean Water Act. The U.S. Environmental Protection Agency has authorized the State of Washington to issue and administer NPDES permits for non-federal point sources within the State.

Nonpoint source
A source from which pollutants may enter waters of the State that is not readily discernible, such as any dispersed land-based or water-based activities including, but not limited to, atmospheric deposition; surface water runoff from agricultural lands, urban areas, or forest lands; subsurface or underground sources; or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System program.

Operation (same as Facility)
The physical premises (including the land and appurtenances thereto) owned or operated by a Permittee from which wastewater or stormwater is discharged subject to regulation under the National Pollutant Discharge Elimination System program.

Operational Source Control Best Management Practice (Operational source control BMP)
The schedule of activities, prohibition of practices, maintenance procedures, employee training, good housekeeping, and other managerial best management practices to prevent or reduce the pollution of waters of the State.

Organism
Any individual life form: an animal, plant, fungus, protistan, or moneran.

Outfall
The location of a point source where a discharge leaves a facility, site, or municipal separate storm sewer system and flows into waters of the State. Outfalls do not include open ***conveyances*** connecting two municipal separate storm sewers; or pipes, tunnels, or other conveyances which connect segments of the same stream or other waters of the State and are used to convey waters of the State (e.g., culverts).

Permit
An authorization, license, or equivalent control document issued by a formally constituted legal body, such as the Washington State Department of Ecology, to a facility, activity, or entity to treat, store, dispose, or discharge materials or wastes, specifying the waste treatment and control requirements and waste discharge conditions. Unless the context requires differently, "permit" refers to individual and general permits authorized under the National Pollutant Discharge Elimination System program.

Permittee
The entity who receives notice of coverage under this general permit.

Person
Any individual or organization, including, but not limited to, cities, counties, municipalities, Indian tribes, public utility districts, public health districts, port authorities, mosquito control districts, special purpose districts, irrigation districts, state and local agencies, companies, firms, corporations, partnerships, associations, consortia, joint ventures, estates, industries, commercial pesticide applicators, licensed pesticide applicators, and any other commercial, private, public, governmental, or non-governmental organizations, or their legal representatives, agents, or assignees.

pH
A measure of the acidity or alkalinity of water. A pH of 7.0 is defined as neutral. Large variations above or below 7.0 are harmful to most aquatic life. Mathematically, pH is the negative logarithm of the activity of the hydronium ion (often expressed as the negative logarithm of the molar concentration of the hydrogen ion). The analytical procedure for determining this amount is typically Standard Methods for the Examination of Water and Wastewater, Method 423.

Point source
Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters of the State, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft. Point source does not include agricultural stormwater discharges and return flows from irrigated agriculture. See 40 CFR 122.3 for exclusions.

Pollutant (in water)
Any discharged substance or pathogenic organism that would: (1) Alter the biological, chemical, physical, radiological, or thermal properties of any water of the State, or (2) Would be likely to create a nuisance or render such water harmful, detrimental, or injurious (a) to the public health, safety, or welfare, (b) to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (c) to any animal or plant life, either terrestrial or aquatic, either directly from the environment or indirectly by ingestion through the food chain.

Pollutants may include, but are not limited to, the following: solid waste, incinerator residue, garbage, sewage, sewage sludge, filter backwash, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, dredged spoil, rock, sand, cellar dirt, and other industrial, municipal, and agricultural wastes.

Pollutant does not mean: (1) Sewage from marine vessels or a discharge incidental to the normal operation of a vessel of the Armed Forces, within the meaning of Section 312 of the Clean Water Act (CWA); (2) Dredged or fill material discharged in accordance with a permit issued under Section 404 of the CWA; or (3) Water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well, if that well is approved by authority of the Washington State Department of Ecology (Ecology), and if Ecology determines that such injection or disposal will not result in the degradation of groundwater or surface water resources.

Pollution (of water)
The man-made or man-induced contamination or other alteration of the biological, chemical, physical, or radiological properties of any water of the State, including change in temperature, taste, odor, ***color***, or turbidity of the water; or such discharge of any solid, liquid, gaseous, or other substance into any water

of the State that will, or is likely to, create a nuisance or render such water harmful, detrimental, or injurious to: (1) The public health, safety, or welfare; (2) Domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses; or (3) Any animal or plant life, either terrestrial or aquatic, either directly from the environment or indirectly by ingestion through the food chain.

Pretreatment
The reduction of the amount or concentration of pollutants, elimination of pollutants, or alteration of the nature of pollutant properties to a less harmful state prior to or in lieu of discharging wastewater to a treatment plant. This reduction or alteration may be obtained by biological, chemical, or physical processes, by process changes, or by other means, except by diluting the pollutants.

Publicly-owned treatment works (POTW)

1. A sewage treatment plant and its collection system that is owned by a municipality, the State of Washington, or the federal government. A POTW includes the sewers, pipes and other conveyances that convey wastewater to the treatment plant, and any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature.
2. The municipality or other entity that has jurisdiction over the indirect discharges to and the discharges from the treatment works.

Quantitation level (QL)
The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. The QL is equivalent to the concentration of the lowest calibration standard, assuming that all method-specified sample weights, volumes, and cleanup procedures have been employed. The QL may be calculated by multiplying the method detection limit (MDL) by 3.18 and rounding the result to the number nearest to (1, 2, or 5) x 10n, where n is an integer.

Receiving water
The waterbody at the point of discharge, whether that discharge is through a point source or via sheet flow. If the discharge is to a stormwater conveyance system, either surface or subsurface, the receiving water is the waterbody to which the stormwater conveyance system discharges. Systems designed for groundwater drainage, redirecting stream natural flows, or conveyance of irrigation water/return flows that coincidentally convey stormwater, are considered the receiving water. Receiving waters may also be groundwater to which surface runoff is directed by infiltration.

Representative (sample)
A sample that yields data that accurately characterizes the nature of a discharge or other sampled matrix for the parameters of concern. A representative sample should account for the factors that contribute to the variability of the parameters, such as the quantity of the discharge, the date and time of the sampling event, and whether the particular sampling location or associated physical events may affect the material sampled. Combining grab samples collected from multiple outfalls from a designated area of the facility during a certain time range to create a flow-weighted composite sample may be required to obtain a representative sample.

A random sample may not be a representative sample. Representative sampling schemes should vary based on the population distribution and variability. For a relatively constant discharge, a grab sample is representative. For a discharge that varies greatly over time or space, a grab sample would likely not be representative.

Runoff
Water derived directly from rainfall or snowmelt that travels across the land surface and discharges: (1) To waterbodies either directly or through a constructed collection and conveyance system, or (2) To the subsurface through a constructed collection and conveyance system.

Sanitary sewer
A sewer designed to convey ***domestic wastewater***.

Saturated zone
The subsurficial zone in which all soil pore spaces and rock interstices are completely filled with groundwater. Saturated zones include aquifers, whether or not they produce a significant yield, areas of perched groundwater, and interflow.

Sediment
The fragmented material that originates from the weathering and erosion of rocks, unconsolidated deposits, or unpaved yards; and is suspended in, transported by, or deposited by water.

Sedimentation
The deposition or formation of sediment.

Settleable solids
The material that settles out of suspension within a certain timespan measured volumetrically. The analytical procedure for determining this amount is typically Standard Methods for the Examination of Water and Wastewater, Method 209E.

Severe property damage
Substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to exist. Severe property damage does not include economic loss caused by delays in production.

Site
1. The land or water area where any facility, operation, or activity is physically located or conducted, including any adjacent land or buffer areas used in connection with such facility, operation, or activity.
2. The land or water area receiving any effluent discharged from any facility, operation, or activity.

Solid waste
All putrescible, nonputrescible, solid, and semisolid waste. Examples of solid waste are: garbage, rubbish, ashes, industrial wastes, swill, demolition and construction wastes, abandoned vehicles or parts thereof, discarded commodities, sludge from wastewater treatment plants and septic tanks, woodwaste, contaminated soils, contaminated dredged material, dangerous waste, and problem wastes.

Source Control Best Management Practice (Source control BMP)
Best management practice intended to prevent or reduce the release of pollutants. Two types of source control BMPs exist: (1) Structural, which include physical, structural, or mechanical devices or

facilities (e.g., roofs covering storage and working areas); and (2) Operational, which include management of activities that are sources of pollutants (e.g., directing wash water and similar discharges to the ***sanitary sewer*** or a dead-end sump).

State
The State of Washington.

State Environmental Policy Act (SEPA)
The Washington State law intended to prevent or eliminate damage to the environment that requires State and local agencies to consider the likely environmental consequences of development proposals prior to their approval (Chapter 43.21C RCW, as implemented through Chapter 197-11 WAC).

Stormwater
Water derived directly from rainfall or snowmelt that either: (1) Travels across the land surface and discharges to waterbodies either directly or through a collection and conveyance system; or (2) Percolates into the shallow soil, travels laterally through the soil near the land surface, and subsequently seeps back onto the land surface where it mixes with runoff or discharges to a surface waterbody. (Same as Runoff plus Interflow)

Stormwater associated with industrial activity
Stormwater discharged from any conveyance that: (1) Is used for collecting and conveying stormwater; and (2) Drains stormwater from manufacturing, processing, or raw materials storage areas at an industrial facility. (See 40 CFR 122.26(b)(14).)

Stormwater Pollution Prevention Plan (SWPPP)
The written plan that describes the measures to be employed at a facility to identify, prevent, and control the contamination of point source discharges of stormwater.

Structural Source Control Best Management Practice (Structural source control BMP)
Physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. Examples of structural source control BMPs typically include:
(1) Enclosing and/or covering the pollutant source (building or other enclosure, a roof over storage and working areas, temporary tarp, etc.); and (2) Segregating the pollutant source to prevent run-on of stormwater, and to direct only contaminated or potentially contaminated stormwater to appropriate treatment BMPs.

Substantial
Of considerable size, quality, value, degree, amount, extent, or importance.

Surface water
Lakes, rivers, ponds, streams, inland waters, ***wetlands***, marine waters, estuaries, and all other fresh or brackish waters and water courses, plus drainages to those waterbodies. Surface waters do not include hatchery ponds, raceways, pollution abatement ponds, and wetlands constructed solely for wastewater treatment.

Surface waters of the State of Washington
All waters within the geographic boundaries of the State of Washington defined as “waters of the United States” in 40 CFR 122.2, and all waters defined as “waters of the State” in RCW 90.48.020 excluding

underground waters. These include lakes, rivers, ponds, streams, inland waters, wetlands, marine waters, estuaries, and all other fresh or brackish waters and water courses, within the jurisdiction of the State of Washington, plus drainages to those waterbodies. Surface waters of the State do not include hatchery ponds, raceways, pollution abatement ponds, and wetlands constructed solely for wastewater treatment.

Technology-based effluent limit
A permit limit that is based on the ability of a treatment method to reduce the amount (e.g., concentration) of a pollutant.

Total maximum daily load (TMDL)

1. An estimate of the maximum amount of a pollutant that a specific impaired waterbody or waterbody segment can receive in a day and still be protective of its designated beneficial uses, i.e., meet water quality standards. The TMDL must incorporate seasonal variation, include a margin of safety, and account for all of the point and nonpoint sources that contributed to the impairment of the specific waterbody.

2. A water cleanup plan and a mechanism for establishing water quality-based controls on all point and nonpoint sources of pollutants within a watershed basin, sub-basin, or hydrographic segment associated with a specific impaired waterbody. Percentages of the TMDL of a single pollutant are allocated to the various pollutant sources as waste ***load allocations*** for point sources and load allocations for nonpoint sources and background. A TMDL becomes effective after the U.S. Environmental Protection Agency has reviewed and approved it.

Total residual chlorine
The amount of chlorine remaining in water or wastewater, which is equivalent to the sum of the combined residual chlorine (non-reactive) and the free residual chlorine (reactive). The analytical procedure for determining this amount is typically Standard Methods for the Examination of Water and Wastewater, Method 408.

Toxic
Causing death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in any organism or its offspring upon exposure, ingestion, inhalation, or assimilation.

Treat

1. To apply an algaecide, herbicide, or other control product to the water, vegetation, or soil to control or kill algae, vegetation, insects, or some other pest or target species, or to remove or inactivate bioavailable phosphorus.

2. To remove a pollutant from wastewater or to perform some other manipulation of wastewater to reduce or control the adverse effects of a pollutant therein.

Treatment

1. The application of an algaecide, herbicide, or other control product to the water, vegetation, or soil to control or kill algae, vegetation, insects, or some other pest or target species, or to remove or inactivate bioavailable phosphorus.

2. The removal of a pollutant from wastewater or some other manipulation of wastewater to reduce or control the adverse effects of a pollutant therein.

Treatment Best Management Practice (Treatment BMP)
Best management practice intended to remove pollutants from wastewater, such as ***detention ponds***, oil/water separators, biofiltration, and constructed wetlands.

Turbidity
The optical property of water that causes light to be scattered and absorbed rather than transmitted in a straight line. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Turbidity is a measure of water clarity using a calibrated turbidimeter according to the analytical procedure described typically by Standard Methods for the Examination of Water and Wastewater, Method 214A.

Underground water (same as Groundwater)
The water located in a saturated zone or stratum beneath the surface of the land or below a surface waterbody. Groundwater is a water of the State and includes interflow, which is a type of perched water, and water in all other saturated soil pore spaces and rock interstices, whether perched, seasonal, or artificial. Although underground water within the vadose zone (unsaturated zone) also is a type of groundwater, the Washington State groundwater quality standards do not specifically protect soil pore water or soil moisture located in the vadose zone.

Upset
An exceptional incident in which an unintentional and temporary non-compliance with technology-based, permit effluent limits occurs due to factors beyond the reasonable control of the Permittee. An upset does not include non-compliance to the extent caused by operational error, improperly designed treatment facilities, inadequate storage or treatment facilities, lack of preventive maintenance, or careless or improper operation.

Vadose zone
The subsurficial zone where soil pore spaces and rock interstices are typically occupied at least partially by air. The vadose zone may extend from the surface of the ground down to the top of the water table, i.e., the top of the saturated zone, whether perched or not.

Waste
Any discarded, abandoned, unwanted, or unrecovered material, except the following are not waste materials for the purposes of this permit: (1) Discharges into the ground or groundwater of return flow, unaltered except for temperature, from a groundwater heat pump used for space heating or cooling, provided that such discharges do not have significant potential, either individually, or collectively, to affect groundwater quality or uses; and (2) Discharges of stormwater that are not contaminated or potentially contaminated by industrial or commercial sources.

Water Quality (WQ)
The biological, chemical, physical, and radiological characteristics of water, usually with respect to its suitability for a particular purpose.

Water quality-based effluent limit
A limit on the concentration of an effluent parameter that is intended to prevent the concentration of that parameter from exceeding its water quality criterion after it is discharged into a receiving water. The limit may include a dilution factor if ***all known, available, and reasonable methods of prevention, control, and treatment*** have been accomplished and other restrictions are met.

Waters of the State of Washington
All waters within the geographic boundaries of the State of Washington defined as "waters of the United States" in 40 CFR 122.2, and all waters defined as "waters of the State" in RCW 90.48.020. These waters of the State include lakes, rivers, ponds, streams, inland waters, wetlands, marine waters, estuaries, underground waters, and all other fresh or brackish waters and water courses within the jurisdiction of the State of Washington, plus drainages to those waters.

Waters of the United States
All waters within the geographic boundaries of the State of Washington defined as "waters of the United States" in 40 CFR 122.

Well
A bored, drilled, or driven shaft, or dug hole whose depth is greater than the largest surface dimension.

Wetland
Any area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Jurisdictional wetlands are wetlands that have been identified as such by local, state, or federal agencies. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands.

APPENDIX C. QUESTIONNAIRE: EXCERPTS FROM OPERATIONS, MAINTENANCE, AND PLANNING DOCUMENTS

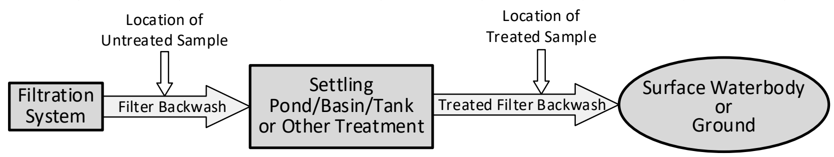
Questionnaire: Excerpts from Operations, Maintenance, and Planning Documents

For the Water Treatment Plant General Permit

Section S-3 Planning Requirements

Type in the required information; Copy and Paste the relevant portions of the facility O&M Manual and Solid Waste Control, Stormwater Pollution Prevention, and Spill Contingency Plans; or upload the existing documents and explain on this form where the required information is located within those documents, e.g., by page numbers.

Facility Name:		**Permit Number:**	
Completed by:		**Date:**	
Email Address:		**Phone:**	



Provide in-house SOPs and schedules for operating, maintaining, and periodic cleaning and servicing of the filter backwash system:

Approximate frequency of **filter backwashing** (number of backwash events/month):

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

Approximate average volume of **untreated filter backwash wastewater** generated from each backwash event (gals/backwash event):

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

Provide the methods used to dechlorinate the filter backwash wastewater prior to discharging it to surface water or the ground:

Provide a list of the oils and chemicals used, processed, or stored on site, and that may be a source of pollutants to any waters of the State. Identify how and where these materials are used and processed, in part by showing their locations on the Site Plan.

Provide in-house SOPs for sampling and analyses of the monitoring parameters required by this permit:

Approximate frequency of discharges from the **filter backwash wastewater treatment area** (number of discharges/month):

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

Approximate average volume of **treated filter backwash wastewater** discharged from each event (gallons/discharge event)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

Page 1 of 3

Questionnaire: Excerpts from Operations, Maintenance, and Planning Documents

For the Water Treatment Plant General Permit

Section S-3 Planning Requirements

Provide a list of the solid wastes generated on site, the sources and locations where generated, their chemical compositions, and their final dispositions. Show on the accompanying Site Plan the locations where solid wastes are temporarily stored or finally disposed on site. If applicable, identify the contractor who removes solid wastes from the site for final disposal off site.

Approximate amount of solid waste generated monthly (pounds/month):

Waste	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

Provide the emergency shut-down and containment procedures for responses to unexpected discharges or spills, severe weather, and unexpected or major maintenance activities, where releases of pollutants to waters of the State may occur. Describe the emergency notification procedures for alerting responsible managers and local pollution control authorities, and list the names and phone numbers of the facility emergency contacts.

Identify and describe the best management practices (BMPs) employed to control existing and potential sources of pollutants, including contaminated stormwater runoff and spills of petroleum and other chemicals. BMPs must explicitly address operational source control, structural source control, treatment, and erosion and sediment control. (See the permit for any definitions.)

Supporting attachments must include both a **Site Plan** and a **Facility Schematic**.

The **Site Plan** must be drawn to scale and show the following elements:

(a) Approximate scale bar.
(b) North arrow.
(c) Source of the base map.
(d) Complete property line or boundary of the site.
(e) All significant structures, chemical and fuel storage areas, and secondary containment structures.
(f) All filter backwash wastewater settling tanks and constructed settling, storage, and infiltration basins and ponds (Ponds).
(g) Surficial drainage patterns, such as the distinct on-site stormwater catchment areas.
(h) All pipelines, both above and underground, that convey water treatment wastewater.
(i) All outfalls to each surface waterbody that may receive discharged treated wastewater.
(j) All outfalls to each infiltration-to-ground area that may receive discharged treated wastewater.
(k) Complete boundary of each infiltration-to-ground area.

The **Facility Schematic** must show the following elements and be accompanied by the text described below:

(a) All tanks, piping, valving, and in-line monitoring and control systems that comprise the filtration system for producing potable or industrial water.
(b) All tanks, piping, valving, and in-line monitoring and control systems related to the generation, treatment, and disposal of filter backflush wastewater.
(c) Text that briefly describes the raw water source(s), treatment process(es), generation of filter backwash wastewater, treatment of that wastewater, and discharge of the treated wastewater, including seasonal variations.

Questionnaire: Excerpts from Operations, Maintenance, and Planning Documents

For the Water Treatment Plant General Permit

Section S-3 Planning Requirements

Submit this completed report, Site Plan, Facility Schematic, and any other supporting information to the Department of Ecology electronically via your SecureAccess Washington account at https://secureaccess.wa.gov/ecy/wqwebportal/. More information is available at the "Water Quality Permitting Portal" at http://www.ecy.wa.gov/programs/wq/permits/paris/portal.html.

I certify under penalty of law that this completed Questionnaire and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information hereby submitted. Based on my inquiry of the person or persons who are responsible for environmental management and pollution control at my facility and who were directly responsible for gathering the information and attachments, this completed Questionnaire is, to the best of my knowledge and belief, true, accurate, complete, and in full compliance with Permit Condition S-6. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

____________________________ ____________________

Printed Name* Title

____________________________ ____________________

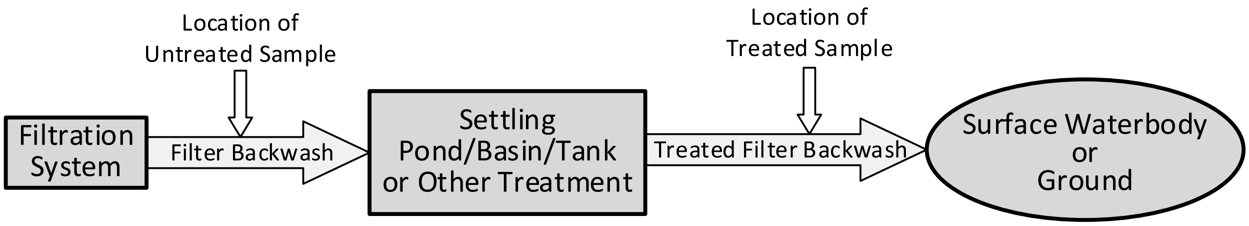
Signature* Date Signed

* The person signing this certification must do so in accordance with Permit Condition G-4.2.

Page 3 of 3

APPENDIX D. SURVEY QUESTIONS FOR SELECTED WATER TREATMENT PLANTS

Answer questions in the spaces provided, and attach the specified documentation.



1. Permit Number:
2. Water Treatment Plant Name:
3. Your Name:
   Your phone number:
   Your email address:
4. Attach as-built engineering drawings of the filter backwash wastewater settling tanks and constructed settling, storage, and infiltration basins and ponds (Ponds), including:
   (a) Horizontal and vertical dimensions.
   (b) Maximum capacity.
   (c) Construction materials of the bottom and sides, including the liner material, if any.
   (d) Shortest horizontal distance between each Pond and the nearest surface waterbody, including that waterbody's name.
   (e) Shortest horizontal distance between each infiltration-to-ground area and the nearest surface waterbody, including that waterbody's name.
   (f) Estimated rates of discharge (average, maximum, and minimum) in units of gallons per minute to the Ponds ***and*** to the surface waterbody or ground.
5. Provide maintenance procedures for the Ponds, including:
   (a) Method of excavating accumulated solids.
   (b) Management of on-site storage and disposal areas.
   (c) The stage at which accumulated solids, if any, are permanently removed from the site.
6. Provide GPS-determined latitude and longitude to at least 5 decimal places of each outfall to each surface waterbody and infiltration-to-ground area.

EXHIBIT D

EPA FILTER BACKWASH RECYCLE RULE

United States Environmental Protection Agency
Office of Water (4606)
EPA 816-F-01-019
June 2001
www.epa.gov/safewater

EPA

Filter Backwash Recycling Rule: A Quick Reference Guide

Overview of the Rule

Title	Filter Backwash Recycling Rule (FBRR) 66 FR 31086, June 8, 2001, Vol. 66, No. 111
Purpose	Improve public health protection by assessing and changing, where needed, recycle practices for improved contaminant control, particularly microbial contaminants.
General Description	The FBRR requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.
Utilities Covered	Applies to public water systems that use surface water or ground water under the direct influence of surface water, practice conventional or direct filtration, and recycle spent filter backwash, thickener supernatant, or liquids from dewatering processes.

Public Health Benefits

Implementation of FBRR will result in . . .	‣ Reduction in risk of illness from microbial pathogens in drinking water, particularly *Cryptosporidium*.
Estimated impacts of the FBRR include . . .	‣ FBRR will apply to an estimated 4,650 systems serving 35 million Americans. ‣ Fewer than 400 systems are expected to require capital improvements. ‣ Annualized capital costs incurred by public water systems associated with recycle modifications are estimated to be $5.8 million. ‣ Mean annual cost per household is estimated to be less than $1.70 for 99 percent of the affected households and between $1.70 and $100 for the remaining one percent of affected households.

Conventional and Direct Filtration

- Conventional filtration, as defined in 40 CFR 141.2, is a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal. Conventional filtration is the most common type of filtration.
- Direct filtration, as defined in 40 CFR 141.2, is a series of processes including coagulation and filtration, but excluding sedimentation, and resulting in substantial particulate removal. Typically, direct filtration can be used only with high-quality raw water that has low levels of turbidity and suspended solids.

Recycle Flows

- **<u>Spent Filter Backwash Water</u> - A stream containing particles that are dislodged from filter media when water is forced back through a filter (backwashed) to clean the filter.**
- **<u>Thickener Supernatant</u> - A stream containing the decant from a sedimentation basin, clarifier or other unit that is used to treat water, solids, or semi-solids from the primary treatment processes.**
- **<u>Liquids From Dewatering Processes</u> - A stream containing liquids generated from a unit used to concentrate solids for disposal.**

Critical Deadlines and Requirements

For Drinking Water Systems

December 8, 2003	**Submit recycle notification to the state.**
June 8, 2004	**Return recycle flows through the processes of a system's existing conventional or direct filtration system or an alternate recycle location approved by the state (a 2-year extension is available for systems making capital improvements to modify recycle location).** **Collect recycle flow information and retain on file.**
June 8, 2006	**Complete all capital improvements associated with relocating recycle return location (if necessary).**

For States

June 8, 2003	**States submit FBRR primacy revision application to EPA (triggers interim primacy).**
June 8, 2005	**Primacy extension deadline - all states with an extension must submit primacy revision applications to EPA.**

What does a recycle notification include?

- **Plant schematic showing origin of recycle flows, how recycle flows are conveyed, and return location of recycle flows.**
- **Typical recycle flows (gpm), highest observed plant flow experienced in the previous year (gpm), and design flow for the treatment plant (gpm).**
- **State-approved plant operating capacity (if applicable).**

What recycle flow information does a system need to collect and retain on file?

- **Copy of recycle notification and information submitted to the state.**
- **List of all recycle flows and frequency with which they are returned.**
- **Average and maximum backwash flow rates through filters, and average and maximum duration of filter backwash process (in minutes).**
- **Typical filter run length and written summary of how filter run length is determined.**
- **Type of treatment provided for recycle flows.**
- **Data on the physical dimension of the equalization and/or treatment units, typical and maximum hydraulic loading rates, types of treatment chemicals used, average dose, frequency of use, and frequency at which solids are removed, if applicable.**

For additional information on the FBRR

Call the Safe Drinking Water Hotline at 1-800-426-4791; visit the EPA web site at www.epa.gov/safewater; or contact your state drinking water representative.

Additional material is available at www.epa.gov/safewater/filterbackwash.html.

United States
Environmental Protection
Agency

Filter Backwash Recycling Rule

Technical Guidance Manual

Office of Ground Water and Drinking Water (4606M)
EPA 816-R-02-014
www.epa.gov/safewater
December 2002

Printed on Recycled Paper

This document provides public water systems and States with Environmental Protection Agency's (EPA's) current technical and policy recommendations for complying with the Filter Backwash Recycling Rule (FBRR). The statutory provisions and EPA regulations described in this document contain legally binding requirements. This document is not a regulation itself, nor does it change or substitute for those provisions and regulations. Thus, it does not impose legally binding requirements on EPA, States, or public water systems. This guidance does not confer legal rights or impose legal obligations upon any member of the public.

While EPA has made every effort to ensure the accuracy of the discussion in this guidance, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling.

The general description provided here may not apply to a particular situation based upon the circumstances. Interested parties are free to raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation. EPA and other decisionmakers retain the discretion to adopt approaches on a case-by-case basis that differ from those described in this guidance where appropriate.

Mention of trade names or commercial products does not constitute endorsement or recommendation for their use.

This is a living document and may be revised periodically without public notice. EPA welcomes public input on this document at any time.

Acknowledgements

The Environmental Protection Agency gratefully acknowledges the individual contribution of the following:

Mr. Jerry Biberstine, National Rural Water Association
Dr. David Cornwell, Environmental Engineering & Technology, Inc.
*Mr. Rich Haberman, Department of Health Services, Southern California Branch
Mr. David Hartman, Department of Water Works, City of Cincinnati
Mr. Peter Keenan, American Water Works Service Company, Inc.
Dr. Sun Liang, Metropolitan Water District of Southern California
Mr. Allen Roberson, American Water Works Association
*Mr. Jack Schulze, Texas Natural Resource Conservation Commission
Dr. John Tobiason, University of Massachusetts, Department of Civil and Environmental Engineering
Mr. Steve Via, American Water Works Association
*Mr. John Wroblewski, Pennsylvania Department of Environmental Protection

* Participation supported by Association of State Drinking Water Administrators.

CONTENTS

1. Introduction....1
   - 1.1 Overview....1
   - 1.2 FBRR Components....1
   - 1.3 FBRR Objective....4
   - 1.4 Outline of the Document....5
   - 1.5 Additional Information....6

Part I

2. Regulated Recycle Streams....9
   - 2.1 Introduction....9
   - 2.2 Treatment Processes and Origins of Recycle Streams....9
     - 2.2.1 Conventional Treatment Plants....10
     - 2.2.2 Direct Filtration Plants....11
   - 2.3 Recycle Flows Regulated by the FBRR....12
     - 2.3.1 Spent Filter Backwash....12
     - 2.3.2 Thickener Supernatant....13
     - 2.3.3 Liquids from Dewatering Processes....13
   - 2.4 Reference....14

3. Reporting Requirements....15
   - 3.1 Introduction....15
   - 3.2 Recycle Notification....15
     - 3.2.1 Plant Schematic....17
     - 3.2.2 Flow Information....19
     - 3.2.3 Recycle Notification Form....20

4. Recycle Return Location....23
   - 4.1 Introduction....23
   - 4.2 Timeline for Compliance....24

5. Recordkeeping Requirements....29
   - 5.1 Introduction....29
   - 5.2 Required Recordkeeping Information....31
     - 5.2.1 Recycle Notification....31
     - 5.2.2 Recycle Flows....31
     - 5.2.3 Backwash Information....32
     - 5.2.4 Filter Run Length and Termination of Filter Run....33
     - 5.2.5 Recycle Stream Treatment....33
     - 5.2.6 Equalization and Treatment Information....33

Part II

6. Part II Overview....39

7. Recycle Streams 41
7.1 Introduction 41
7.2 Spent Filter Backwash Water 42
7.2.1 Frequency and Quantity 42
7.2.2 Quality 43
7.3 Thickener Supernatant 44
7.3.1 Frequency and Quantity 45
7.3.2 Quality 45
7.4 Liquids From Dewatering Processes 46
7.4.1 Quantity and Quality 46
7.5 Non-Regulated Recycle Streams 49
7.6 References 50

8. Operational Considerations and Modifications 51
8.1 Introduction 51
8.2 Adjust Chemical Feed Practices During Recycle Events 51
8.3 Return Recycle Stream(s) to Presedimentation Basin 53
8.4 Control Raw Water Flow or Recycle Return Flow 53
8.5 Reduce the Amount of Generated Spent Filter Backwash 53
8.5.1 Air Scour with Backwash 54
8.5.2 Surface Wash with Backwash 54
8.5.3 Reduce the Length of Backwash 55
8.5.4 Increase Filter Run Times 55
8.6 Reduce the Amount of Filter-to-Waste 56
8.7 References 58

9. Equalization 59
9.1 Introduction 59
9.2 Advantages 61
9.3 Disadvantages 63
9.4 Costs 64
9.5 Evaluating Equalization 64
9.6 References 68

10. Treatment of Recycle Streams 69
10.1 Introduction 69
10.2 Advantages 70
10.3 Disadvantages 71
10.4 Costs 71
10.5 Recommended Design Goals 71
10.5.1 Ten State Standards 71
10.5.2 California 71
10.5.3 Maryland 72
10.5.4 Ohio 72
10.5.5 Cornwell and Lee (1993) 72
10.5.6 United Kingdom Water Industry Research (UKWIR) (1998) 72

10.6 Evaluating Treatment 73
10.7 Treatment Options 77
10.7.1 Sedimentation 77
10.7.2 Microsand-Assisted Sedimentation 85
10.7.3 Dissolved-Air Flotation 85
10.7.4 Granular Bed Filtration 87
10.7.5 Membrane Filtration 89
10.7.6 Disinfection 92
10.8 Comparison of Treatment Options 93
10.9 References 95

Appendices

Appendix A. Glossary
Appendix B. Worksheets
Appendix C. Reporting Example for 3.0 MGD Plant
Appendix D. Reporting Example for 20 MGD Plant
Appendix E. Reporting Example for 48 MGD Plant
Appendix F. Characteristics of Spent Filter Backwash Water
Appendix G. Characteristics of Thickener Supernatant
Appendix H. Characteristics of Liquids from Dewatering Processes

Figures

Figure 1-1. Filter Backwash Recycling Rule Provisions 2
Figure 1-2. FBRR- Rule Requirements and Implementation Timeline.........................3

Figure 2-1. Example Conventional Filtration System With Recycle 10
Figure 2-2. Example Direct Filtration System With Recycle.....................................11

Figure 3-1. FBRR Provisions- Reporting Requirements 16
Figure 3-2. Example Plant Schematic for Recycle Notification.................................17
Figure 3-3. Example Hand-drawn Plant Schematic for Recycle Notification.............18

Figure 4-1. Examples of Recycle Return Locations 24
Figure 4-2. FBRR Provisions- Recycle Return Location 26

Figure 5-1. FBRR Provisions- Recordkeeping Requirements....................................30
Figure 5-2. Example of Recycle Flow Frequency Recordkeeping Information (No Equalization or Treatment of Recycle Streams Provided) 31
Figure 5-3. Example of Recycle Flow Frequency Information (Equalization and/or Treatment Provided) 32

Figure 7-1. Lagoons Used to Settle Solids...45
Figure 7-2. Sludge Drying Bed..47
Figure 7-3. Monofill Used for Dewatering Residuals 47

Figure 9-1. Example of Equalizing Recycle Streams 60
Figure 9-2. Existing Layout of James E. Quarles Water Treatment Plant...................66
Figure 9-3. Proposed Improvements for Recycle Streams at the James E. Quarles Water Treatment Plant...67

Figure 10-1. Crown Water Treatment Plant – Existing 76
Figure 10-2. Crown Water Treatment Plant – Proposed...76
Figure 10-3. General Sedimentation Process for Treatment of Recycle Stream 77
Figure 10-4. Circular Radial-flow Clarifier 79
Figure 10-5. Lagoon Process for Recycle Streams...80
Figure 10-6. Typical Plate Settler Design..81
Figure 10-7. Microsand-Assisted Sedimentation Process for Recycle Streams 85
Figure 10-8. Dissolved-Air Flotation Process for Recycle Streams 86
Figure 10-9. Granular Bed Filtration Process for Recycle Streams............................88
Figure 10-10. Membrane Treatment Process for Recycle Streams 90

Figure C-1. Schematic for a 3.0 MGD Plant 117
Figure D-1. Schematic for a 20 MGD Plant 126
Figure E-1. Schematic for a 48 MGD Plant..136
Figure F-1. Mianus Water Treatment Plant 147
Figure F-2. Kanawha Valley Water Treatment Plant 149

Figure F-3. Swimming River Water Treatment Plant 149
Figure F-4. New Castle Water Treatment Plant 150
Figure G-1. Mianus Water Treatment Plant 157
Figure G-2. Swimming River Water Treatment Plant...157
Figure G-3. New Castle Water Treatment Plant..158
Figure H-1. Mianus Water Treatment Plant 165
Figure H-2. New Castle Water Treatment Plant..165

Tables

Table 4-1. Recycle Return Location Compliance Schedule.......................................25
Table 7-1. Commonly Produced Non-Regulated Residual Streams 49
Table 10-1. Results of AWWA FAX Survey on Systems that Recycle.....................69
Table 10-2. Spent Filter Backwash Turbidity and Particle Log Reductions by Treatment Type...94
Table F-1. Comparison of Plant Influent to Spent Filter Backwash.........................145
Table F-2. Comparison of Raw Water to Spent Filter Backwash 146
Table F-3. Comparison of Plant Influent to Spent Filter Backwash Exiting the Backwash Holding Tank..148
Table G-1. Comparison of Plant Influent to Sludge and Thickener Supernatant 156
Table G-2. Lagoon Decant Data 158
Table H-1. Characteristics of Dewatered Plant Residuals.......................................163
Table H-2. Pressate Quality in Comparison to Influent Water.................................164

ABBREVIATIONS

List of abbreviations and acronyms used in this document:

ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
CADD	Computer Aided Drafting and Design
CFR	Code of Federal Regulations
CT	The Residual Concentration of Disinfectant (mg/l) Multiplied by the Contact Time (minutes)
DAF	Dissolved-Air Floatation
DBP	Disinfection By-Products
DE	Diatomaceous Earth
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
FBRR	Filter Backwash Recycling Rule
FR	Federal Register
gal	gallons
gpd	gallons per day
gpm	gallons per minute
gpm/ft^2	gallons per minute per square foot
GWUDI	Groundwater Under Direct Influence of Surface Water
HAA5	Haloacetic Acids (monochloroacetic, dichloroacetic, trichloroacetic, monobromoacetic, and dibromoacetic acids)
hrs	Hours
IESWTR	Interim Enhanced Surface Water Treatment Rule
Kgal	Thousand Gallons
LT1ESWTR	Long-Term 1 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MF	Microfiltration
MG	Million Gallons

mg/L	milligrams per liter
MGD	Million Gallons per Day
m/h	meters per hour
M/R	Monitoring/Reporting
NOM	Natural Organic Matter
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
PN	Public Notification
PWS	Public Water System
PWSID	Public Water System Identification
SOP	Standard Operating Procedure
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TT	Treatment Technique
TTHM	Total Trihalomethanes
TTHMFP	Total Trihalomethanes Formation Potential
UF	Ultrafiltration
UV_{254}	Ultraviolet absorbance at 254 nanometers
WTP	Water Treatment Plant
X log removal	Reduction to $1/10^x$ of original concentration
μ or μm	Micron (10^-6 meter)
μg/L	Micrograms per liter

1. INTRODUCTION

1.1 OVERVIEW

The Filter Backwash Recycling Rule (FBRR) establishes regulatory provisions governing the way that certain recycle streams are handled within the treatment processes of conventional and direct filtration water treatment systems. The FBRR also establishes reporting and recordkeeping requirements for recycle practices that will allow States and EPA to better evaluate the impact of recycle practices on overall treatment plant performance. The FBRR published in the Federal Register (66 FR 31086, June 8, 2001) presents the specific regulatory requirements that must be met by affected systems. Figure 1-1 contains a flowchart that presents the FBRR requirements. Figure 1-2 contains a timeline with the key dates for both States and systems. This document has been developed to provide operators with the practical guidance and relevant information to assist them in complying with the FBRR provisions. It outlines detailed methods for complying with each portion of the FBRR, and provides other useful information regarding recycle practices and filter backwashing not specifically required by the FBRR.

1.2 FBRR COMPONENTS

The FBRR applies to public water systems (PWSs) that meet **all** of the following three criteria (40 CFR 141.76(a)):

- System is a Subpart H system (i.e., uses surface water or ground water under the direct influence of surface water);
- System treats water by conventional or direct filtration processes; and,
- System recycles one or more of the following: spent filter backwash water, thickener supernatant or liquids from dewatering processes. Chapter 2 provides more information on regulated recycle streams.

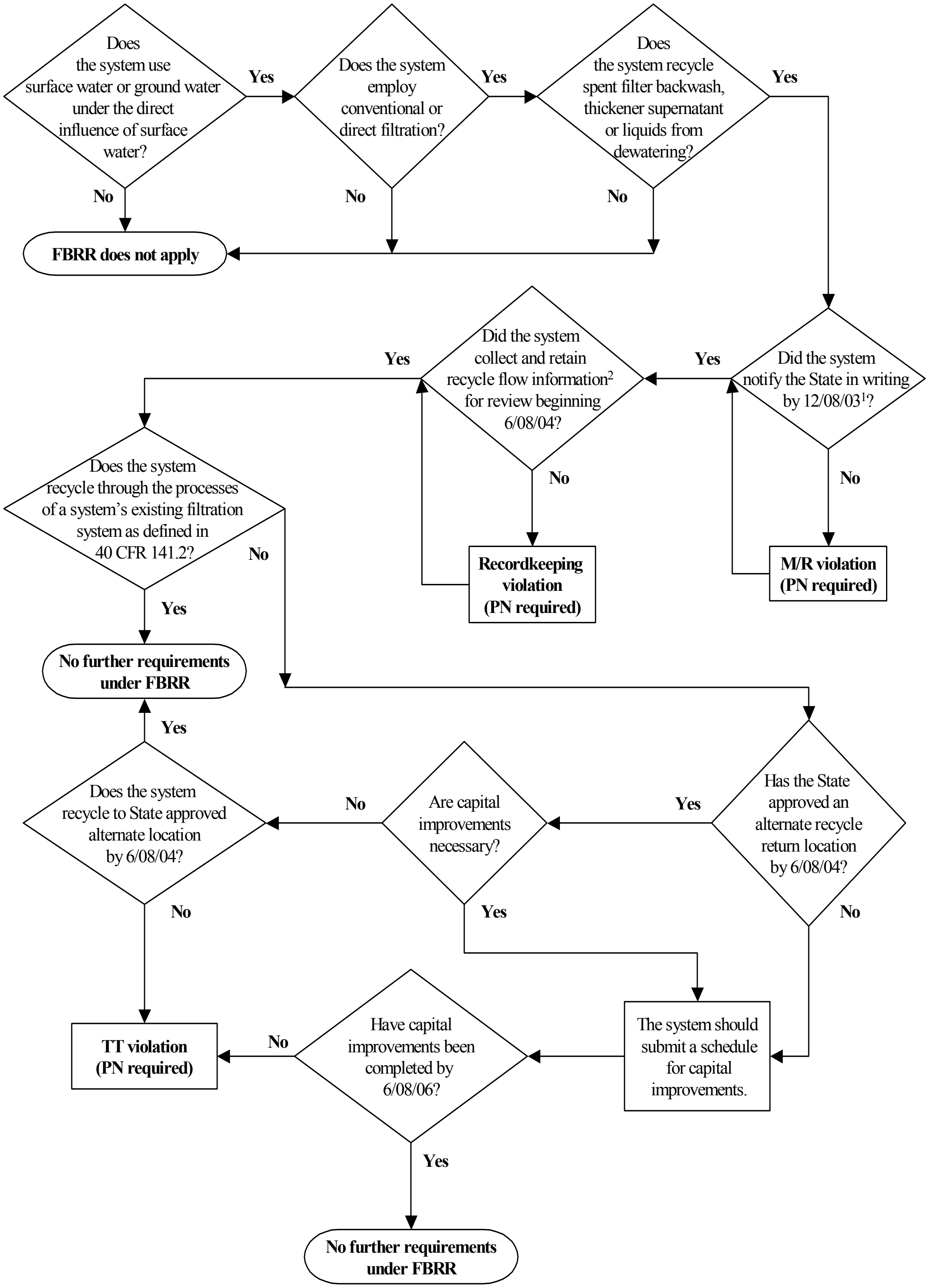
Conventional filtration, as defined in 40 CFR 141.2, is a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal.

Direct filtration, as defined in 40 CFR 141.2, is a series of processes including coagulation and filtration, but excluding sedimentation, and resulting in substantial particulate removal.

The FBRR consists of three distinct components:

- Reporting (40 CFR 141.76(b)): The FBRR requires a system to notify the State about its recycle practices if the system is a Subpart H system, a conventional or direct filtration plant, and recycles one or more of the regulated recycle streams.

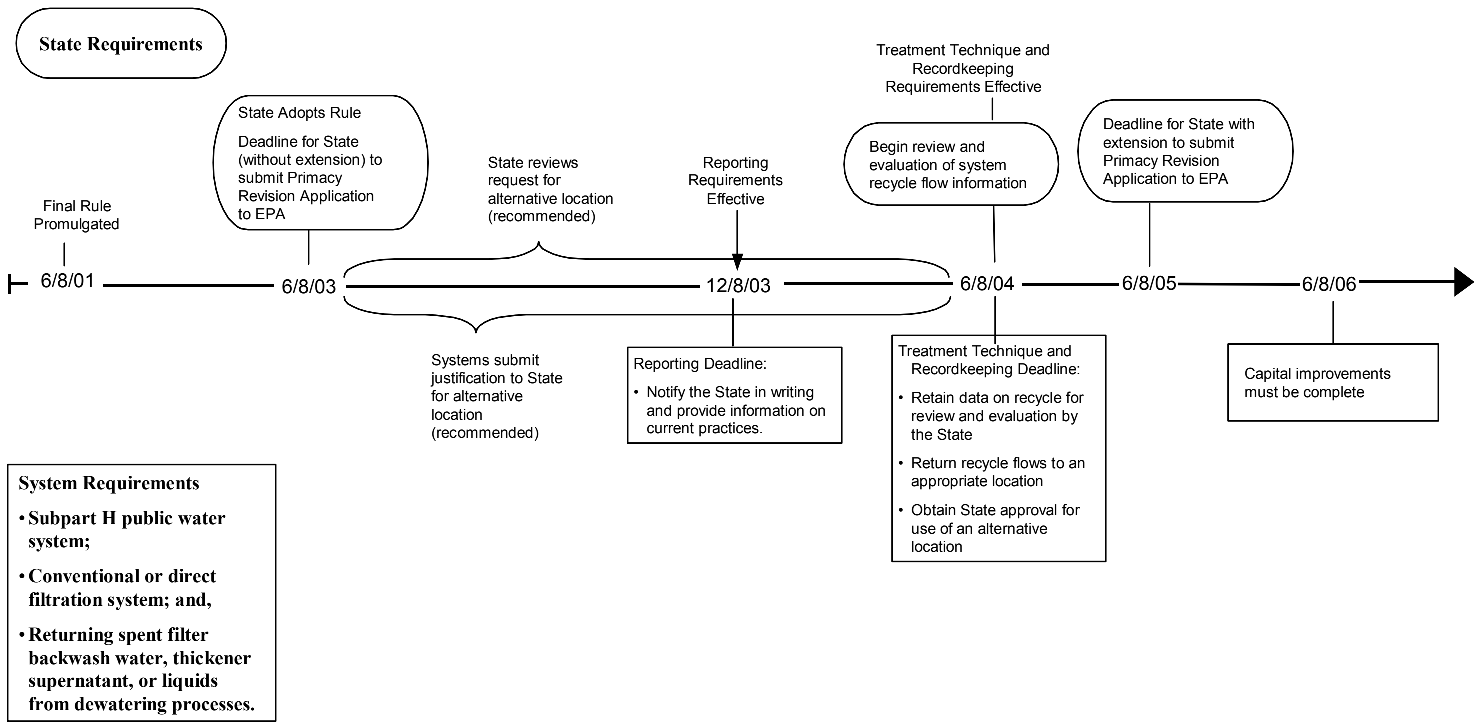
Figure 1-1. Filter Backwash Recycling Rule Provisions



1. Notification includes information specified in 40 CFR 141.76 (b) (1) and (2)
2. Recycle flow information is specified in 40 CFR 141.76 (d) (1) through (6)

Figure 1-2. Filter Backwash Recycling Rule

Rule Requirements and Implementation Timeline



Systems must notify the State by December 8, 2003. Reporting requirements are contained in Chapter 3.

- Recycle Return Location (40 CFR 141.76(c)): The FBRR requires spent filter backwash, thickener supernatant, or liquids from dewatering processes to be returned through all the processes of a system's existing conventional or direct filtration system (if the system practices recycle), as defined in 40 CFR 141.2. Systems can receive State approval to recycle at an alternate location. Details of the recycle return location requirements are discussed in Chapter 4.

- Recordkeeping (40 CFR 141.76(d)): The FBRR also includes recordkeeping requirements related to recycling procedures. Systems must collect and retain certain recycle information beginning June 8, 2004. Recordkeeping requirements are presented in Chapter 5.

If systems are unsure if the rule applies to them, they should contact their State office or Primacy Agency.

1.3 FBRR OBJECTIVE

The objective of the FBRR is to improve the control of microbial pathogens, particularly *Cryptosporidium,* in public drinking water systems by helping to ensure that recycle practices do not compromise the ability of treatment plants to produce safe drinking water. Recycle streams have the potential to contain higher concentrations of *Cryptosporidium* oocysts than source water streams and could therefore introduce additional *Cryptosporidium* oocysts into the treatment process. An increase in the concentration of *Cryptosporidium* oocysts in the treatment process may increase the risk of *Cryptosporidium* oocysts in finished water and threaten public health. *Cryptosporidium* oocysts are of concern because they are not easily inactivated by commonly used disinfectants, such as chlorine (sedimentation and filtration are the main barriers for removal of *Cryptosporidium*).

What is *Cryptosporidium*?

Cryptosporidium is an intestinal parasite that can be passed through a water treatment plant and into the drinking water supply. Infection can cause gastrointestinal illness, lasting up to two weeks, and may even be life threatening for people with weakened immune systems. Several outbreaks of cryptosporidiosis have been traced to *Cryptosporidium* in drinking water. The worst outbreaks occurred in Milwaukee in 1993 when more than 400,000 people fell ill with flu-like symptoms. *Cryptosporidium* is difficult to treat (inactivate) because it is resistant to most disinfectants used by water treatment systems. Consequently, other treatment processes, such as sedimentation and filtration, must be effective in removing *Cryptosporidium* oocysts from raw water and recycle streams.

1.4 OUTLINE OF THE DOCUMENT

This guidance manual is divided into two parts. Part I addresses issues specifically related to the FBRR regulatory requirements. It is designed to guide systems through the requirements for regulatory compliance with the FBRR. To make this process as straightforward as possible, EPA has developed flowcharts and worksheets that can be used as a reference during assessment of relevant filter backwash issues.

Part II provides guidance on recycle management options and operational considerations that may assist systems in understanding recycle processes. It addresses issues that are important to the effective management of potential recycle streams, but **are not specifically required by the FBRR regulations**. While compliance with the regulatory requirements is important for all affected systems, there are additional non-regulatory issues comprising the full scope of management of potential recycle streams. By addressing this broader range of recycling issues, systems will be able to develop strategies to achieve and maintain optimal overall treatment plant performance. This guidance manual should be a useful tool for any public water supply operator interested in improving plant performance, and not just those affected by the FBRR provisions.

Part I of the guidance is organized into four chapters and presents rule requirements:

> ***Chapter 2. Regulated Recycle Streams:*** This chapter identifies the three regulated recycle streams and discusses the sources of recycle streams with respect to conventional and direct filtration processes.
>
> ***Chapter 3. Reporting Requirements:*** This chapter contains information on the reporting requirements for systems.
>
> ***Chapter 4. Recycle Return Location:*** This chapter presents the requirements for recycle return location to ensure compliance with the FBRR. This chapter also presents issues associated with recycling to a location that does not take advantage of the entire treatment train.
>
> ***Chapter 5. Recordkeeping Requirements:*** This chapter presents recordkeeping requirements for systems and provides a detailed description of the data collection components of the FBRR.

Part II of the document is organized as follows and is strictly guidance for systems:

> ***Chapter 6. Part II Overview:*** This chapter discusses the purpose of Part II and how to evaluate collected data on recycle practices.
>
> ***Chapter 7. Recycle Streams:*** This chapter describes different recycle streams (regulated and non-regulated) and characteristics of recycle streams.

Chapter 8. Operational Considerations and Modifications: This chapter presents information on how to modify the main treatment train process or better manage recycle streams to minimize the impacts of recycle streams on finished water.

Chapter 9. Equalization: This chapter describes equalization of recycle streams and discusses the advantages and disadvantages of equalization. Case studies are presented.

Chapter 10. Treatment of Recycle Streams: This chapter describes the concept of treatment and discusses the advantages and disadvantages of treating recycle streams. This chapter also describes specific treatment options and issues associated with each treatment option. Case studies are presented.

Appendix A – Glossary
Appendix B – Worksheets
Appendix C – Reporting Example for 3.0 MGD Plant
Appendix D – Reporting Example for 20 MGD Plant
Appendix E – Reporting Example for 48 MGD Plant
Appendix F – Characteristics of Spent Filter Backwash
Appendix G – Characteristics of Thickener Supernatant
Appendix H – Characteristics of Liquids from Dewatering Processes

1.5 ADDITIONAL INFORMATION

A rule summary (eight pages long) and quick-reference guide (two pages) are available on the FBRR and provide a brief summary of the rule requirements. The implementation guide developed for States is also available. These documents can be obtained from your State office or on EPA's website (www.epa.gov/safewater/filterbackwash.html). You can also contact the Safe Drinking Water Hotline at 1-800-426-4791 for general information or visit the EPA Office of Ground Water and Drinking Water website (www.epa.gov/safewater).

PART I

2. REGULATED RECYCLE STREAMS

2.1 INTRODUCTION

> ***Rule Reference:***
> **40 CFR 141.76 (a)**
>
> **(a)** ***Applicability.*** All subpart H systems that employ conventional filtration or direct filtration treatment and that recycle spent filter backwash water, thickener supernatant, or liquids from dewatering processes must meet the requirements in paragraphs (b) through (d) of this section.

The prime objective of the FBRR is to ensure an adequate level of public health protection by minimizing the risk associated with *Cryptosporidium* in recycle flows. Under the Interim Enhanced Surface Water Treatment Rule (IESWTR) and Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) provisions, all surface water and ground water under the direct influence of surface water systems are required to achieve at least 2-log removal of *Cryptosporidium*. The recycling of spent filter backwash water and other recycle streams could impact treatment processes and finished water quality. Recycle streams may affect treatment processes due to hydraulic surges or high concentrations of contaminants in the recycle stream. The FBRR regulates three recycle streams: spent filter backwash water, thickener supernatant, and liquids from dewatering processes. These three recycle streams have the potential to adversely impact finished water quality because they may occur in sufficient volumes to create unmanageable hydraulic surges and may contain elevated concentrations of *Cryptosporidium* oocysts and other microbial and chemical contaminants.

2.2 TREATMENT PROCESSES AND ORIGINS OF RECYCLE STREAMS

> ***Regulated Recycle Streams***
> Spent filter backwash water
> Thickener supernatant
> Liquids from dewatering processes
>
> ***Unregulated Residual Streams (not all-inclusive)***
> Filter-to-waste
> Membrane concentrate
> Ion exchange regenerate
> Sludge
> Diatomaceous earth slurry

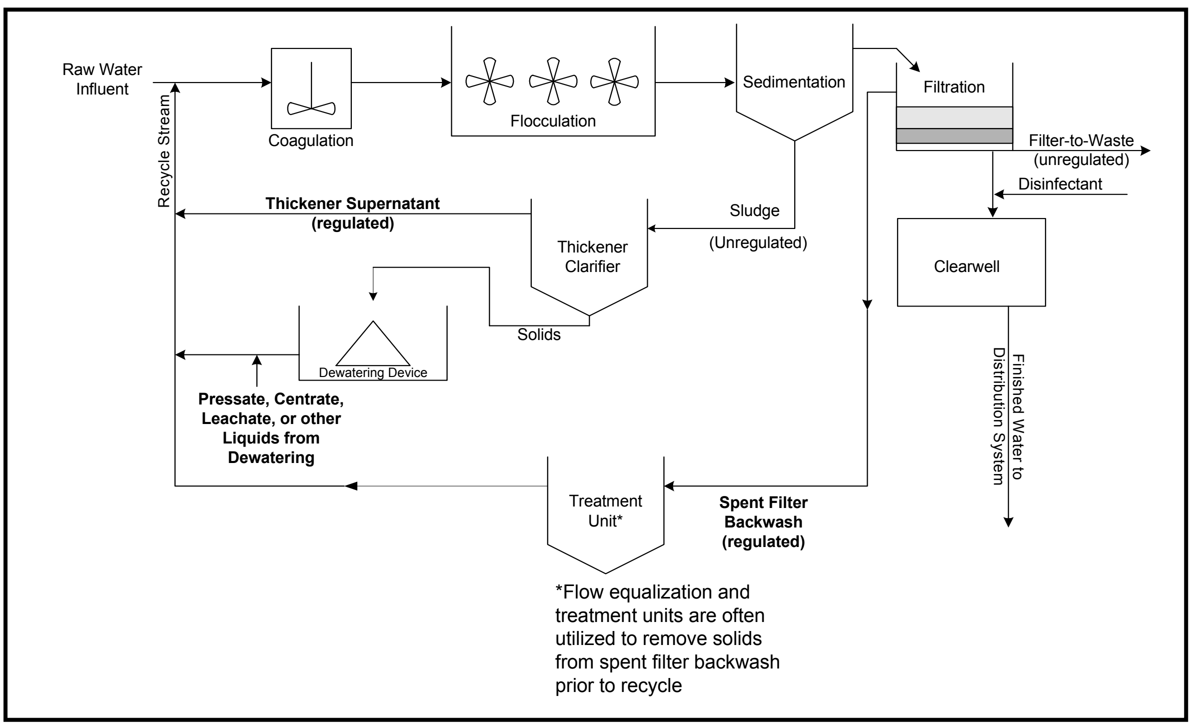
The FBRR applies to conventional and direct filtration systems that recycle spent filter backwash water, thickener supernatant, or liquids from dewatering processes. While conventional and direct filtration systems have the potential to create other unregulated recycle streams, such as filter-to-waste flows, only the three aforementioned recycle streams are regulated by the FBRR. The following sections provide a general background on conventional and direct filtration treatment processes and the origin of recycle streams. Although there are several variations of conventional and direct filtration processes, only the basic configurations will be presented here. More detailed information on recycle stream origins is contained in Chapter 7.

2.2.1 Conventional Treatment Plants

Conventional treatment plants, by definition (40 CFR 141.2), employ the following four unit processes: coagulation, flocculation, sedimentation, and filtration. The coagulation and rapid mix process usually has a short reaction time and is followed by the flocculation process. The flocculation process forms floc, which then settle in the sedimentation basin. Periodically, accumulated solids from sedimentation basins are removed. Solids can either be disposed to the sanitary sewer, discharged to a sewer or surface water (this option requires a discharge permit), or thickened and possibly dewatered, with ultimate disposal to a landfill or land-application. Particles not removed by coagulation, flocculation, and sedimentation are typically removed by the filters. Figure 2-1 shows a typical conventional treatment system.

In a conventional plant, flows that may be recycled include: spent filter backwash (regulated), gravity thickener supernatant from sedimentation solids (regulated), dewatering liquids (regulated), and filter-to-waste (not regulated). The potential recycle stream origin locations are shown in Figure 2-1.

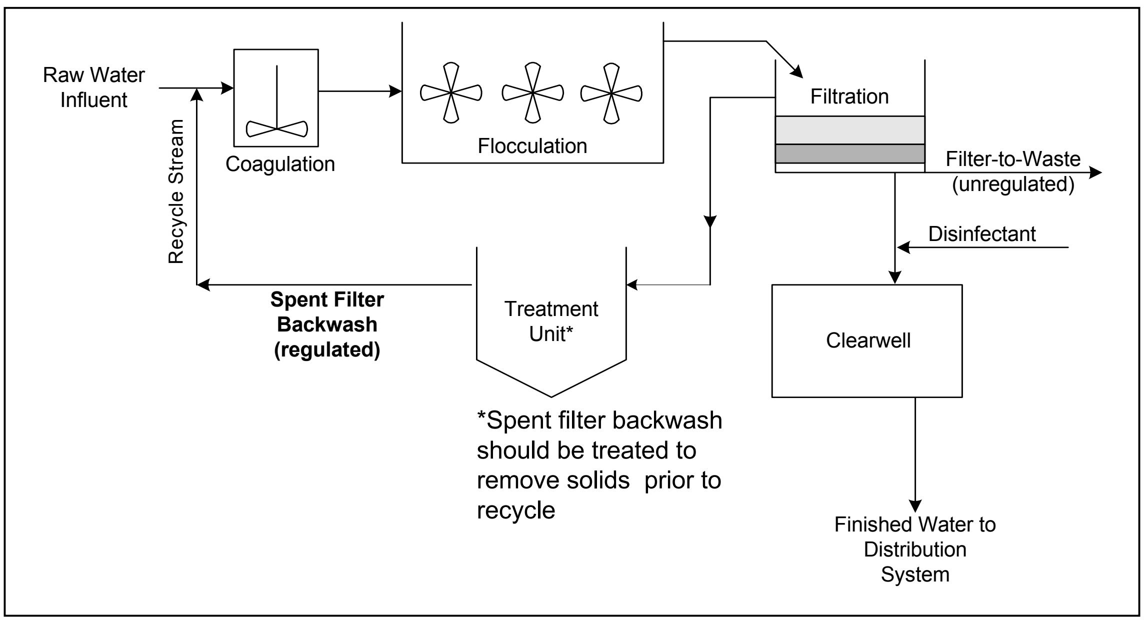
Figure 2-1. Example Conventional Filtration System with Recycle



2.2.2 Direct Filtration Plants

Direct filtration treatment omits the sedimentation process but is otherwise similar to conventional filtration treatment. Water in the treatment train goes directly from coagulation/flocculation to filtration, where solids are removed (see Figure 2-2). Hence, direct filtration systems do not produce sedimentation solids or clarification residuals during primary processes. Although the raw water turbidity of direct filtration plants is usually lower than most conventional plants, the solids loading to the filters may be higher because of the absence of the sedimentation process prior to filtration. If spent filter backwash is not treated prior to recycle, solids loading onto the filters will increase over time because there is no other way for solids to be removed from the treatment train. Therefore, solids are typically removed from recycle streams prior to being returned to the primary treatment train/plant headworks.

Figure 2-2. Example Direct Filtration System with Recycle



2.3 RECYCLE FLOWS REGULATED BY THE FBRR

Many different types of residual streams may be recycled at drinking water treatment plants. EPA originally identified twelve recycle streams for study in the proposed rule. Based on *Cryptosporidium* occurrence data and possible effects on finished water, three recycle streams were selected for regulation by the FBRR. These recycle streams are:

- Spent filter backwash water;
- Thickener supernatant (sometimes referred to as sludge thickener supernatant); and,
- Liquids from dewatering processes.

These three recycle streams are described in more detail in the following sections. Process solids recycled from clarification units are not regulated by the FBRR. However, if softening systems or contact clarification systems recycle any of the regulated flows (spent filter backwash, thickener supernatant, or liquids from dewatering processes), then these systems must comply with the requirements of the FBRR.

2.3.1 Spent Filter Backwash

A filter during backwash

Spent filter backwash is generated when water is forced through the filter, counter to the flow direction used during treatment operations. This action cleans the media by dislodging accumulated particles, including microorganisms, captured by the filter media. Consequently, the resulting spent filter backwash contains particles trapped in the filter during treatment operations, including particles produced from coagulation and pathogens such as *Cryptosporidium.* The practice of recycling may reintroduce these particles into the treatment process. Spent filter backwash water typically averages 3% to 6% of total plant production (McGuire, 1997). However, on an instantaneous basis, the spent filter backwash flows could be as high as 60% (or higher in some instances) of the plant flow. More information on spent filter backwash water characteristics is available in Chapter 7.

Spent filter backwash can be recycled with or without treatment or flow equalization.

2.3.2 Thickener Supernatant

Thickener supernatant is the decanted clear water that exits a sludge thickening basin after gravity settling. Some plants recycle the supernatant from the thickener. Depending on whether the thickener is operated in a batch mode or a continuous mode, the supernatant can be recycled to the plant intermittently or continuously.

Some plants combine the flows from several plant processes prior to thickening. The flow entering gravity thickeners primarily consist of sedimentation basin sludge but can also include spent filter backwash and flows from dewatering devices. Factors affecting the quantity of thickener supernatant produced include:

- The raw water quality;
- The quantity of residuals produced (dependant upon the raw water quality, coagulation scheme, and the sludge collection/removal efficiency);
- The level of treatment provided to thickener influent flows; and,
- The volume of the spent filter backwash (if spent filter backwash is discharged to the thickener).

More information on thickener supernatant is contained in Chapter 7.

2.3.3 Liquids from Dewatering Processes

The liquids removed from sludge, by mechanical or other means, are referred to as liquids from dewatering processes. In mechanical dewatering processes, drinking water plants often use belt presses, centrifuges, filter presses, vacuum presses, and other similar sludge-concentrating equipment. Sludge can also be dewatered in a sludge drying bed, lagoon, or monofill (sludge-only landfill). Sludges are dewatered in order to reduce their volume, which facilitates handling and disposal. The volume of the dewatering liquid depends on the volume and solids content of the thickened sludge fed to the dewatering devices. Recycle flows from dewatering devices are produced at low rates and unlikely to cause a plant to exceed operating capacity. However, the dewatering liquid may contain *Cryptosporidium* oocysts because it is derived from solids that may hold high concentrations of oocysts. More information on liquids from dewatering processes is contained in Chapter 7.

2.4 REFERENCE

McGuire, M. J. 1997. (Draft) Issue Paper on Waste Stream Recycle and Filter-to-Waste in Water Treatment Plants. Prepared for an American Water Works Association (AWWA) Technical Work Group.

3. REPORTING REQUIREMENTS

3.1 INTRODUCTION

The FBRR has specific reporting requirements. Systems must submit the required information to the State by December 8, 2003 (see Figure 3-1). This information is known as the Recycle Notification and can provide useful data for evaluating system recycle practices. A worksheet has been developed to assist systems with reporting the required information (Recycle Notification form in Appendix B). A completed example of this worksheet is included at the end of this chapter. Systems will want to check with their State to make sure the reporting format is acceptable. Examples that may be useful when completing the forms are presented in Appendices C, D, and E.

3.2 RECYCLE NOTIFICATION

Each system that uses conventional or direct filtration and recycles spent filter backwash water, thickener supernatant, or liquids from dewatering processes must provide the State with the following written information by December 8, 2003:

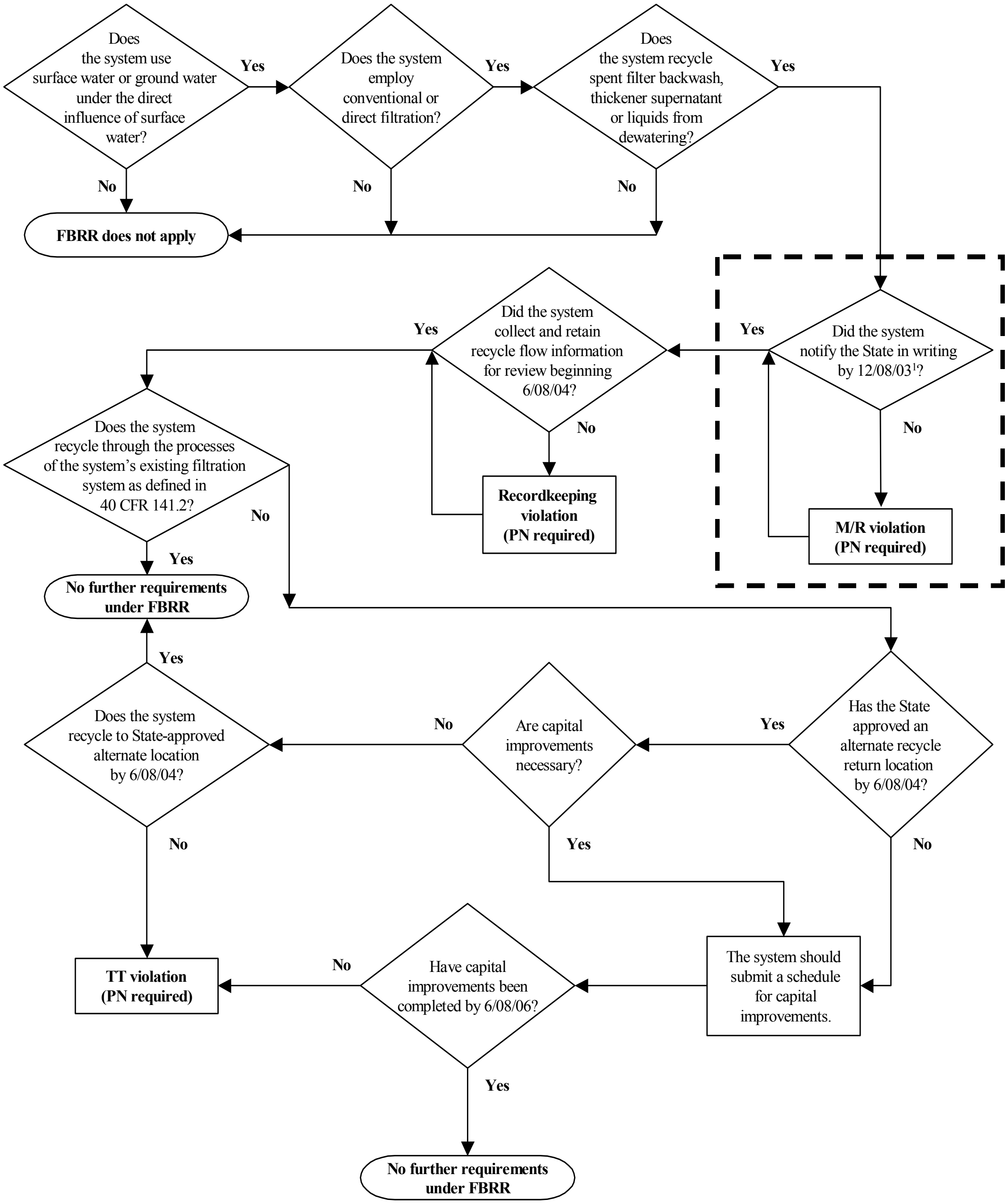
- A plant schematic showing the origin of all recycle streams, the hydraulic conveyance used to transport the recycle streams, and the location where the recycled streams enter the treatment process.
- Typical recycle flow, highest observed plant flow experienced in the previous year, and design flow for the treatment plant. All flows must be reported in gallons per minute (gpm).
- The State-approved operating capacity for the plant, if the State has made such a determination.

> ***Rule Reference:***
> **40 CFR 141.76 (b)**
>
> **(b)** ***Reporting***. A system must notify the State in writing by December 8, 2003, if the system recycles spent filter backwash water, thickener supernatant, or liquids from dewatering processes. This notification must include, at a minimum, the information specified in paragraphs (b)(1) and (2) of this section.

The submitted data will be evaluated by the State to determine whether the system's current recycle return location is acceptable or if the system must make modifications. A system that fails to submit this information to the State commits a monitoring/reporting violation, which requires Tier 3 public notification. Failure to notify the public within one year of the violation is a violation of the Public Notification Rule.

The Recycle Notification form (provided in Appendix B and included as an example at the end of this chapter) can be used for the Recycle Notification, if the form is accepted by the State. Systems are required to keep a copy of the Recycle Notification and all other information submitted to the State. Systems that use, or plan to use, an alternate recycle return location may want to request approval for the alternate recycle location when submitting the Recycle Notification to the State. All alternate recycle return locations must be approved by the State by June 8, 2004. Chapter 4 provides more information on the required recycle return location.

Figure 3-1. Filter Backwash Recycling Rule Provisions- Reporting Requirements



1. Notification includes information specified in 40 CFR 141.76 (b) (1) and (2). 40 CFR 141.76 (b)(1) requires a plant schematic showing the origin of all recycle flows, the hydraulic conveyance used to transport them, and the recycle return location.
40 CFR 141.76 (b)(2) requires typical recycle flow (in gpm), highest observed plant flow for previous year (in gpm), treatment plant design flow (in gpm), and State-approved operating capacity (if a State determination has been made).

3.2.1 Plant Schematic

The plant schematic may take a variety of formats, such as Computer Aided Drafting and Design (CADD), Power Point, neatly hand-drawn figures, copy of an existing plant schematic, or other formats acceptable to the State. The contents of the schematic are more important than its format. The schematic must clearly show the following:

- Origin of all recycle streams;
- Method of transporting recycle streams, including conduits, pipes, pumps, valves, and flow controllers; and,
- Location of re-entry for recycled stream to the treatment process.

If the recycle streams undergo equalization or treatment prior to re-entering the main treatment train, this information should also be displayed in the schematic. Figures 3-2 and 3-3 are examples of acceptable schematics.

Figure 3-2. Example Plant Schematic for Recycle Notification

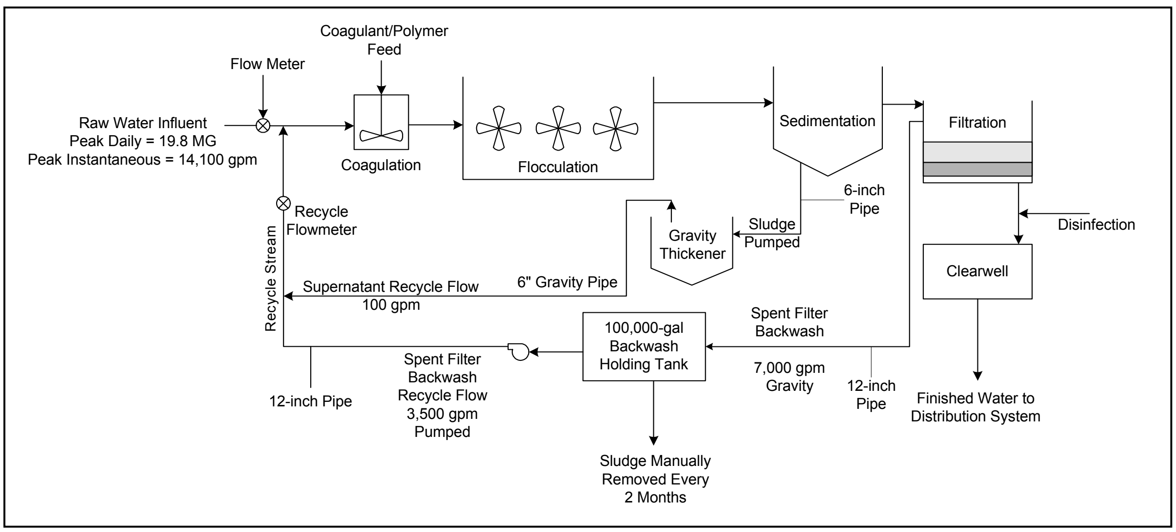
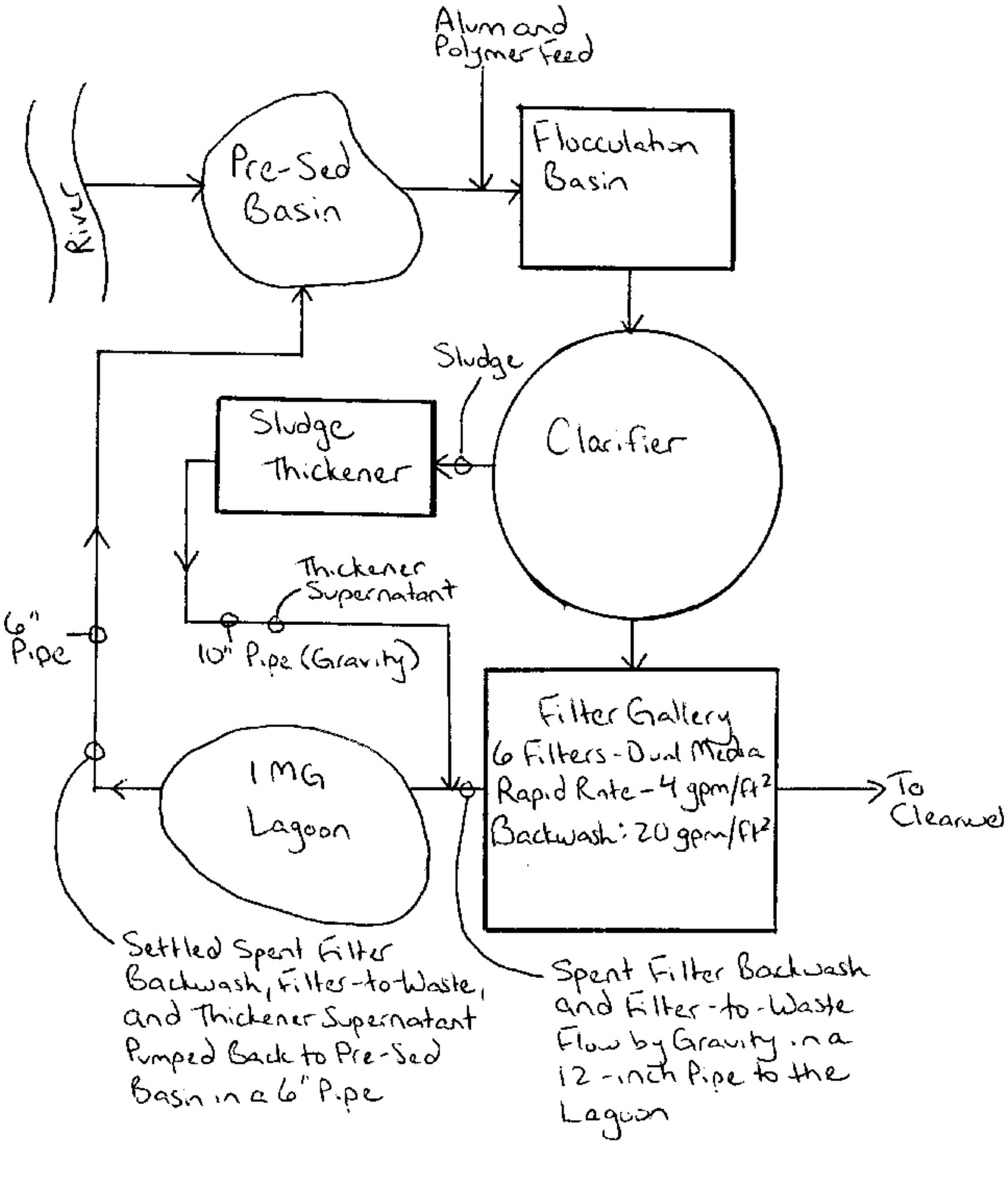


Figure 3-3 Example Hand-drawn Plant Schematic for Recycle Notification



3.2.2 Flow Information

Under the FBRR, four types of flow information are required to be reported to the State:

- Typical recycle flow (in gpm);
- Highest observed plant flow experienced in the previous year (in gpm);
- Design flow for the treatment plant (in gpm); and,
- State-approved operating capacity (if available).

The State can evaluate this information to determine if recycle practices create design flow exceedances or exceedances of the State-approved operating capacity.

Typical Recycle Flow

The typical recycle flow must be reported to the State. This value must include all recycle flows covered by this rule (spent filter backwash, thickener supernatant and liquids from dewatering processes) that are returned to the treatment train. Some States may regulate additional recycle streams and may require these to be reported as well. Methods for determining recycle flows include:

- Metering at one location or individually;
- Estimating based on backwash rates or basin overflow rates;
- Estimating from pump records, if pumps are used;
- Estimating from hydraulic conveyance capacity of the conduit; or,
- Estimating by drop in water surface elevation in a tank.

Appendices C, D, and E provide examples of how to determine the typical recycle flow. The recycle flow must be reported to the State in gpm.

Highest Observed Plant Flow in the Previous Year

To determine the highest observed plant flow experienced in the previous year, a review of plant monitoring records should be conducted. The flow should be measured at a point that accurately captures the total amount of water passing through the treatment system at a given time, including raw water and recycle flows. Locations for measuring this flow may include:

- Flowmeters at the plant inlet that record both raw water and recycle flow. In some plants, these flows may be measured separately or the flowmeter may be located such that both flows are recorded simultaneously.

- Flow into the clearwell (if representative of plant influent flow, such as in a small system). This flow may be obtained from pumping records, metered, or estimated. Measuring the flow exiting the clearwell may not provide an accurate plant flow if clearwell water is used for backwashing filters or other plant processes or if the distribution pump rate varies from the raw water rate.

- Raw water and recycle pump records (if pumps are used).

The important point to remember is that both raw water and recycle flows should be included in determining the highest observed plant flow for the previous year. The Recycle Notification form (in Appendix B) can be used to report flow information to the State. A completed example of this form is included at the end of this chapter. Systems will want to check with their State first to make sure this reporting form is acceptable.

Examples in Appendices C, D, and E provide guidelines for identifying the highest observed plant flow. Some plants may operate in a manner such that the highest observed raw water flow will not coincide with the highest observed recycle flow. Also, the highest observed raw water flow may not represent the highest observed plant flow if recycle flows are significant (see example in Appendix C for an illustration of a situation where the highest observed plant flow occurred when recycle flows were being returned at a significant rate). The highest observed plant flow must be reported in gpm.

Design Flow

The design flow for the treatment plant does not require measurement and should be available from design documents, facility plans, or operation and maintenance manuals. The design flow must be reported to the State in gpm.

State-Approved Operating Capacity

If the State has determined and approved an operating capacity for a system, the system must provide this information as part of the Recycle Notification. Systems may want to contact the State to verify if they have a State-approved operating capacity.

3.2.3 Recycle Notification Form

The Recycle Notification form in Appendix B can be used for the Recycle Notification to the State, if the form is acceptable to the State. A completed example of this form is shown on the next page (also found in Appendix C). Other examples illustrating how to complete this form can be found in Appendices C, D, and E.

FILTER BACKWASH RECYCLING RULE
RECYCLE NOTIFICATION FORM

SYSTEM NAME _Example 3.0 MGD Plant_______________________________

PWSID ___________________________________ **DATE** __Dec 1, 2003___________

Check with your State or Primacy Agency to make sure this form is acceptable.

Does your system use conventional or direct filtration? __Yes (conventional)________________
Does your system recycle spent filter backwash water, thickener supernatant, or liquids from dewatering processes? __Yes (spent filter backwash)___________________________________
If you answered yes to both questions, please report the following:

1. What is the typical recycle flow (in gpm)?___1,500 gpm______________________________
2. What was the highest observed plant flow for the system in the previous year (in gpm)?
   ___2,500 gpm____
3. What is the design flow for the treatment plant (in gpm)? __2,080 gpm__________________
4. Has the State determined a maximum operating capacity for the plant? If so, what is it? __2,080 gpm____
5. Please include a plant schematic that shows:
   - the origin of **all** recycle flows (spent filter backwash, thickener supernatant, liquids from dewatering processes, and any other);
   - the location where **all** recycle flows re-enter the treatment plant process; and
   - the hydraulic conveyance used to transport **all** recycle flows.

Comments: ___The highest observed plant flow of 2,500 gpm exceeds State-approved operating capacity.____

____

---

6. Are you requesting an alternate recycle location? __________Yes ____X_____ No
An alternate recycle location is one that does not incorporate all treatment processes of a conventional filtration plant (coagulation, flocculation, sedimentation, and filtration) or direct filtration plant (coagulation, flocculation, and filtration). The State or Primacy Agency must approve the recycle location by June 8, 2004. Please contact your State or Primacy Agency on what additional information may be needed.

Comments: ____

____

4. RECYCLE RETURN LOCATION

4.1 INTRODUCTION

> ***Rule Reference:***
> **40 CFR 141.76 (c)**
>
> **(c)** ***Treatment technique requirement***. Any system that recycles spent filter backwash water, thickener supernatant, or liquids from dewatering processes must return these flows through the processes of a system's existing conventional or direct filtration system as defined in 40 CFR 141.2 or at an alternate location approved by the State by June 8, 2004. If capital improvements are required to modify the recycle location to meet this requirement, all capital improvements must be completed no later than June 8, 2006.

To ensure at least 2-log removal of *Cryptosporidium*, regulated recycle streams must be introduced at a location where the flow passes through the treatment processes of the system's existing conventional or direct filtration system or at an alternate location approved by the State (see Figure 4-1). The preamble of the FBRR cites eight studies on conventional and direct filtration systems that demonstrate 2-log *Cryptosporidium* removal. The 2-log *Cryptosporidium* removal was achieved in those studies when:

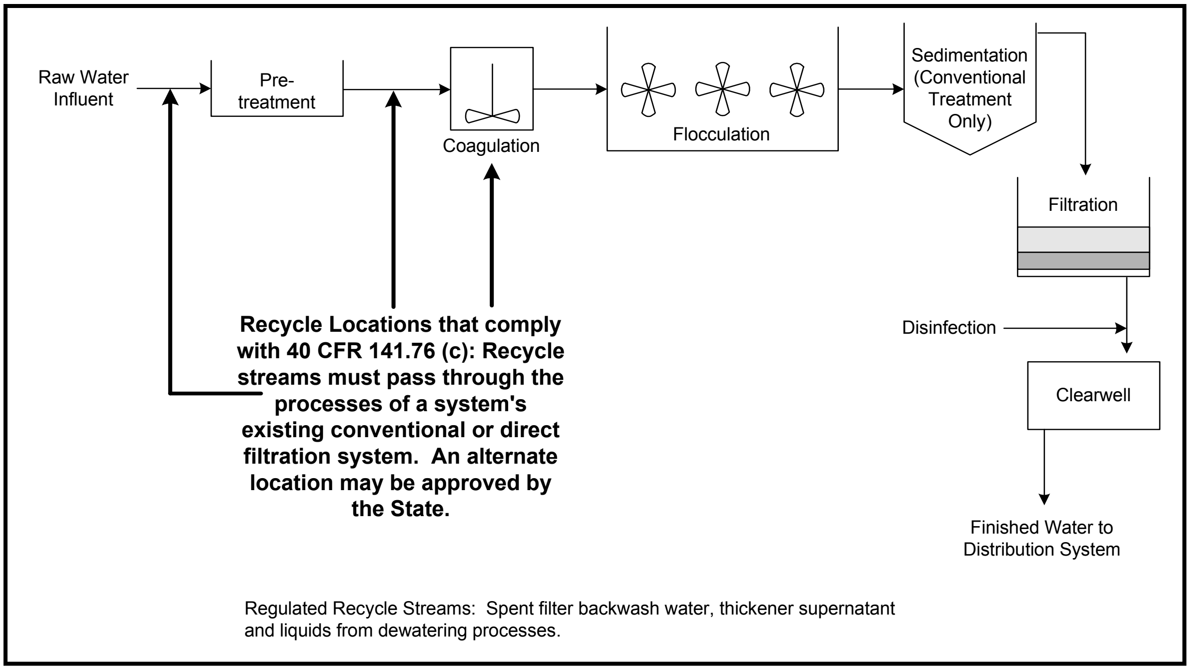
- Coagulation, flocculation, sedimentation (in conventional filtration only), and filtration were employed; and,
- The turbidity limits in the finished water as specified in the IESWTR and LT1ESWTR were met.

To obtain the 2-log *Cryptosporidium* removal, the FBRR requires recycle streams to pass through all conventional (coagulation, flocculation, sedimentation, and filtration) or direct (coagulation, flocculation, and filtration) filtration processes to receive optimum treatment.

An existing system may have a recycle location that does not incorporate all conventional or direct filtration treatment processes. The concerns associated with these recycle locations are:

- The return of the recycle stream after the point of primary coagulant addition may disrupt the chemistry of the treatment process and may impair treatment performance.
- If the recycle stream is not treated through coagulation and flocculation, oocysts and other contaminants could pass through the filters. Sedimentation and filtration are the main barriers to *Cryptosporidium* since it is resistant to certain disinfectants (primarily chlorine and chloramines) and proper coagulation and flocculation are necessary for optimum filter performance.
- The 2-log *Cryptosporidium* removal may not be achieved if the recycle stream does not pass through all treatment processes in a conventional or direct filtration system.

Figure 4-1. Examples of Recycle Return Locations



Treatment plants that return recycle streams to an alternate location (i.e., a location other than shown in Figure 4-1) in order to maintain optimal treatment performance may apply to the State to recycle at an alternate location. If the system has questions regarding the required recycle return location, they should contact the State or Primacy Agency.

4.2 TIMELINE FOR COMPLIANCE

A timeline for recycle location compliance is presented in Table 4-1. It presents several compliance scenarios and deadlines for submitting information or completing activities. Figure 4-2 contains a flowchart for recycle return location compliance. For a timeline of all rule requirements and deadlines, see Figure 1-2 in Chapter 1.

If a system currently recycles to a location that allows the recycle stream to be processed through the treatment processes of the existing conventional or direct filtration system, the system is not required to make any changes to the recycle return location. However, the system must comply with all reporting and recordkeeping requirements of the FBRR, as presented in Chapters 3 and 5.

If a system currently recycles to a location in the treatment process that does not allow the recycle stream to pass through the treatment processes of the system's existing conventional or direct filtration processes, the system may submit a request to the State for approval of this alternate recycle location. The checklist on page 27 may be useful when evaluating an alternate recycle return location. The State must approve or deny such a request by June 8,

2004. Systems may want to consider submitting an alternate return location request with the Recycle Notification information due on December 8, 2003 (see Chapter 3 for details).

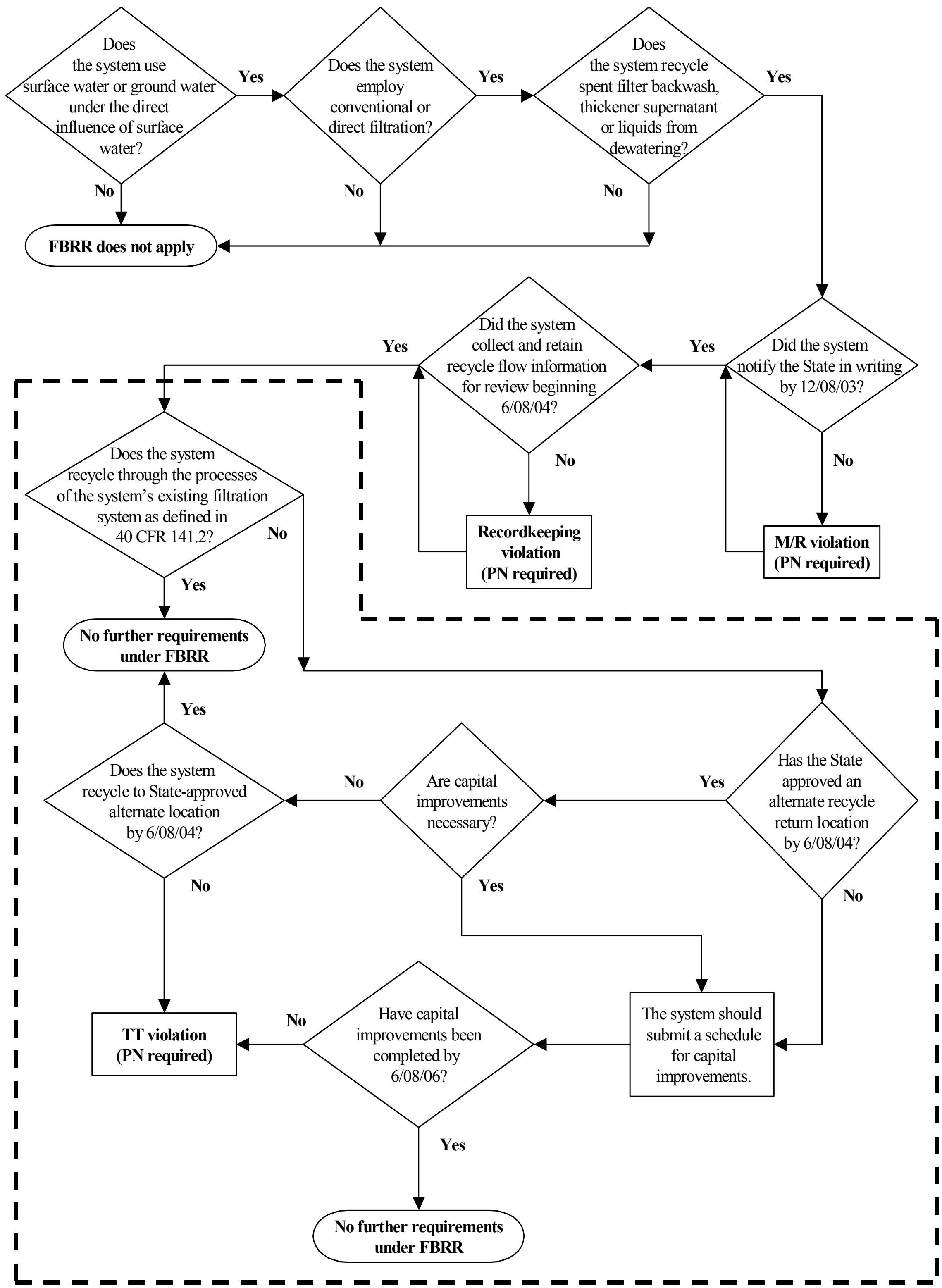
If the State does not approve the alternate location and capital improvements are needed to relocate the recycle return point, or if the State approves an alternate recycle location that requires capital improvements, the system must complete the necessary capital improvements by June 8, 2006.

If the system decides to relocate the existing recycle return point so that recycle is returned through all processes of the system's existing conventional or direct filtration treatment train (as defined in 40 CFR 141.2), capital improvements must be completed no later than June 8, 2006.

Table 4-1 Recycle Return Location Compliance Schedule

If:	The System Must:	By:
No capital improvements are necessary and the system is not seeking approval for an alternate location . . .	meet only the reporting and record-keeping requirements of the FBRR . . .	See Chapters 3 and 5.
The system is planning to request state approval for use of an alternate location . . .	receive approval from the State . . .	June 8, 2004.
The system is planning to request State approval for use of an alternate location AND capital improvements are necessary . . .	receive approval from the State for alternate recycle return location . . .	June 8, 2004; and,
	complete all improvements . . .	June 8, 2006.
Capital improvements are necessary to relocate the point of recycle return . . .	complete all improvements . . .	June 8, 2006.

Figure 4-2. Filter Backwash Recycling Rule Provisions- Recycle Return Location



<u>Systems seeking approval of an alternate recycle return location should consider submitting:</u>

T A written request explaining the reason and/or rationale for using the alternate recycle location (such as if the plant requires recycle to an alternate location to maintain optimal finished water quality, or other reason), including an explanation of why the alternate recycle location would not or does not cause a negative impact upon the finished water quality.

T A plant schematic identifying the alternate recycle location (which may be the schematic required in 40 CFR 141.76(b) if the alternate location is currently used).

T Demonstration of compliance with IESWTR/LT1ESWTR turbidity limits through submission of combined filter effluent and/or individual filter effluent data.

T A description of the type of treatment(s) applied to the recycle stream (if any).

T A comparison of plant influent water quality to the recycle stream water quality. Data for comparison may include, but are not limited to:

- Turbidity;
- Cysts and oocysts;
- Cyst and oocyst-sized particles;
- Iron and/or manganese;
- Disinfection Byproduct (DBP) levels;
- Level of organic matter (TOC, DOC, UV_{254}); and,
- pH.

T Information on sedimentation performance (as evidenced by settled water turbidity as related to recycle practices).

T Design and monitoring data for the alternate recycle location.

T Information on the current loading rates of unit processes, and the impact to the loading rates caused by the alternate location.

T Information on flow control during recycle.

T An analysis of other impacts that the alternate location may have on finished water quality.

5. RECORDKEEPING REQUIREMENTS

5.1 INTRODUCTION

Rule Reference:
40 CFR 141.76 (d)

(d) ***Recordkeeping.*** The system must collect and retain on file recycle flow information specified in paragraphs (d)(1) through (6) of this section for review and evaluation by the State beginning June 8, 2004.

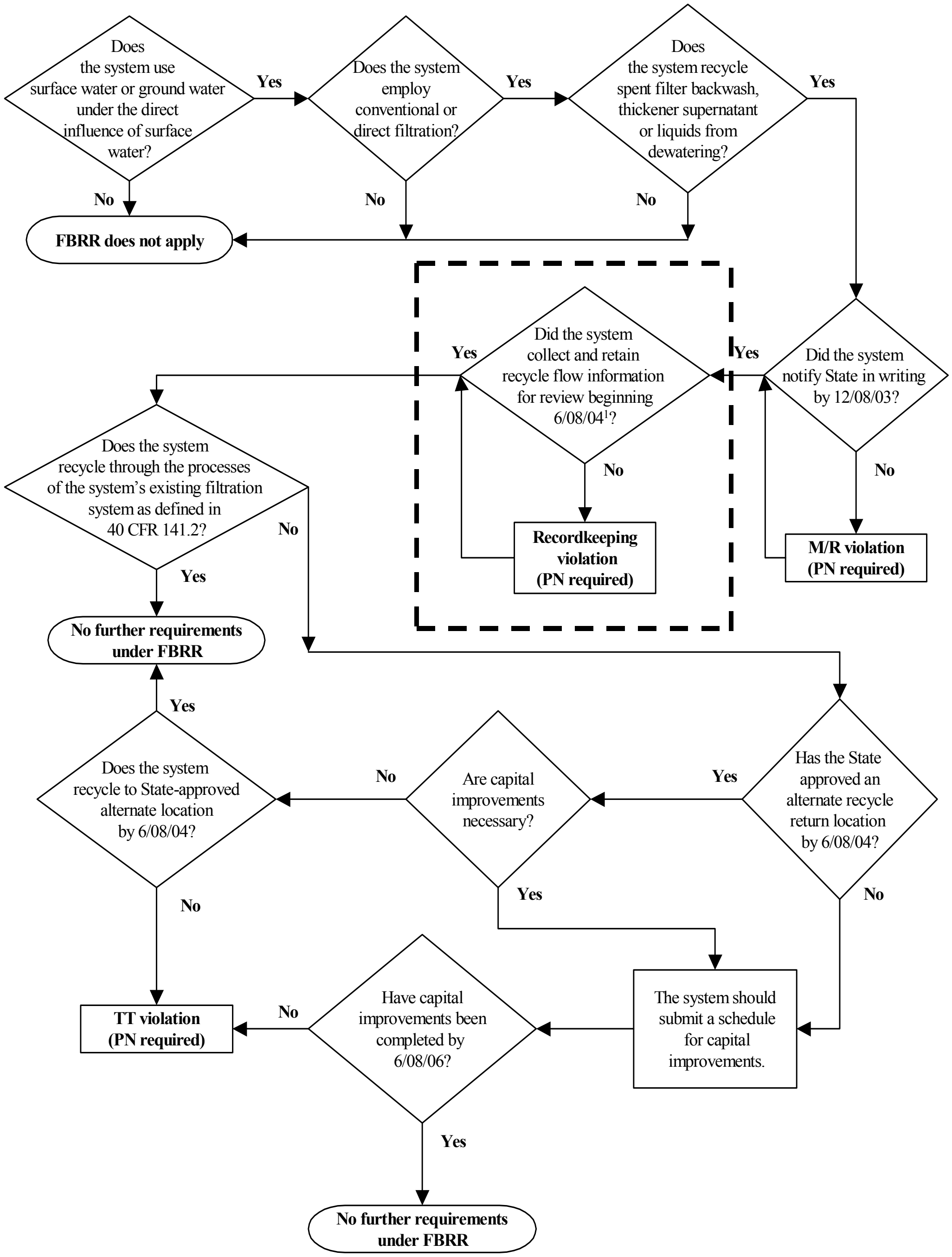
The FBRR has specific recordkeeping requirements in addition to the reporting requirements (see Chapter 3) and recycle return location requirements (see Chapter 4).

For FBRR compliance, a system must collect and retain the following information for review and evaluation by the State beginning June 8, 2004 (see Figure 5-1):

- A copy of the Recycle Notification (see Chapter 3);
- A list of all recycle flows and the frequency at which they are returned;
- Average and maximum backwash flow rates through the filters and the average and maximum duration of the filter backwash process, in minutes;
- Typical filter run length and a written summary of how filter run length is determined (e.g., headloss, turbidity, time, etc.);
- If applicable, the type of treatment provided for the recycle stream before it re-enters the conventional or direct filtration process; and,
- If applicable, data about the physical dimensions of the equalization and/or treatment units, typical and maximum hydraulic loading rates, types of treatment chemicals used, average dose of chemicals, frequency of chemical addition, and frequency of solids removal.

With the exception of the Recycle Notification, systems are not required to submit this information unless requested to do so by the State. However, all of the information must be made available by the system for State review during sanitary surveys, Comprehensive Performance Evaluations, or other inspections or activities. After the State reviews this information, a system may be required to modify its recycling practices or undertake other activities. Failure to comply with the recordkeeping requirements is a recordkeeping violation, which requires Tier 3 public notification. Failure to notify the public of the violation within the appropriate time frame is a public notification violation. The worksheet in Appendix B (Recordkeeping Form) can be used for collecting data (if this form is acceptable to the State). A completed example of this form is included at the end of this chapter. Appendices C, D, and E contain examples that may be helpful when completing the forms.

Figure 5-1. Filter Backwash Recycling Rule Provisions- Recordkeeping Requirements



1. System must collect and retain the following information: a copy of the Recycle Notification; a list of all recycle flows and the frequency with which they are returned; average and maximum backwash flow rates through the filters and the average and maximum durations of the filter backwash process, in minutes; typical filter run length and a written summary of how filter run length is determined (e.g. headloss, turbidity, time, etc.); if applicable, the type of treatment provided for the recycle flow before it re-enters the conventional or direct filtration process; if applicable, data about the physical dimensions of the equalization or treatment units, typical and maximum hydraulic loading rates, type of treatment chemicals used, average dose of chemicals, frequency of chemical addition, and frequency of solids removal.

5.2 REQUIRED RECORDKEEPING INFORMATION

The following sections provide information on the required recordkeeping information the system must collect. Systems should consult the State on frequency of data collection. The State could require a system to collect data as operating conditions change, such as on a seasonal basis.

5.2.1 Recycle Notification

Systems must maintain a copy of all information that is submitted to the State, as described in Chapter 3.

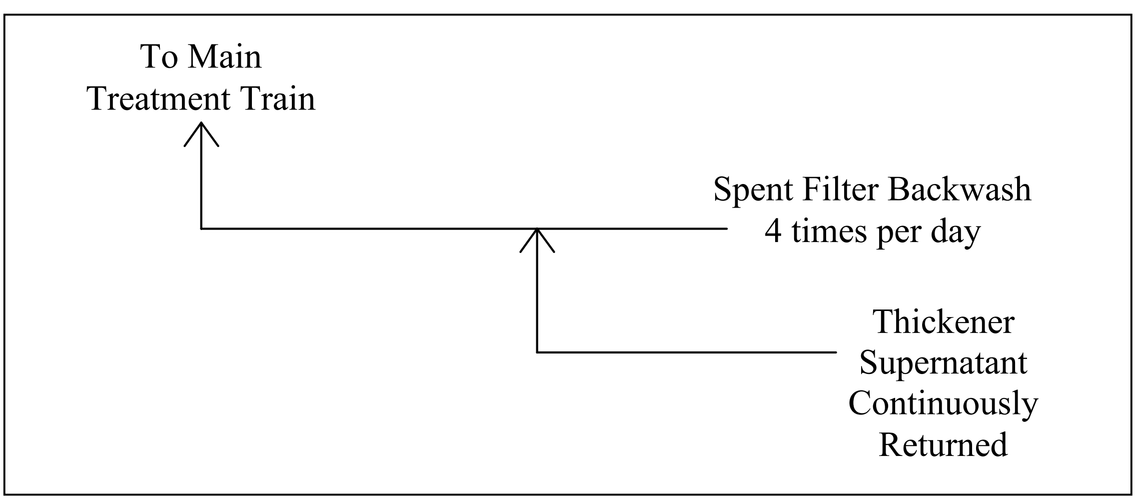
5.2.2 Recycle Flows

The system must retain a list of all recycle flows (regulated and non-regulated) and the frequency of return of each flow. Recycle streams are often generated at varying frequencies and flow rates. It is important to recognize that the rate at which each recycle stream is generated may differ from the rate at which these flows are returned to the treatment train if equalization and/or treatment of recycle streams is provided. The FBRR requires systems to record the frequency at which recycle flows are returned. If allowed by the State, the Recordkeeping Form can be used to record recycle flow information (see Appendix B). A completed example of this form is included at the end of this chapter. Examples in Appendices C, D, and E provide examples of ways to collect recycle flow information.

<u>Recycle without Treatment or Equalization</u>

If recycle streams are returned to the main treatment train without equalization and/or treatment, then the system must record the frequency at which the flows are returned to the main treatment train (see Figure 5-2).

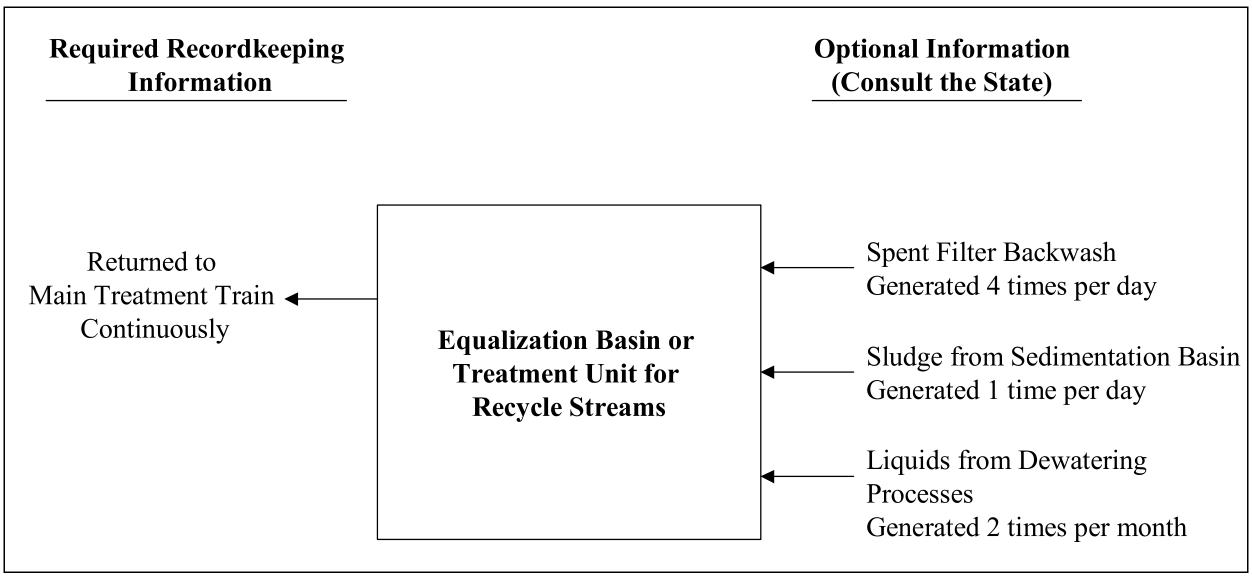
Figure 5-2. Example of Recycle Flow Frequency Recordkeeping Information (No Equalization or Treatment of Recycle Streams Provided)



Recycle with Treatment and/or Equalization

If recycle streams are discharged to an equalization basin or treatment unit, then the frequency at which these flows are returned to the main treatment train must be recorded. States may want systems to also record the frequency at which recycle flows are generated if equalization and/or treatment is provided to the recycle flows. Knowing the frequency at which recycle flows are generated and returned will assist systems and States in assessing recycle practices. Figure 5-3 provides a schematic that illustrates the required information that systems must record and some of the types of optional information States could request.

Figure 5-3. Example of Recycle Flow Frequency Information (Equalization and/or Treatment Provided)



5.2.3 Backwash Information

Systems must collect the following backwash information for the filter(s):

- Average backwash flow rate through the filter;
- Average duration of filter backwash;
- Maximum backwash flow rate through the filter; and,
- Maximum duration of filter backwash.

Filters tend to be backwashed in a highly regulated and well-monitored manner. The plant records should be specific about the filter backwash process. Some systems may not vary the backwash rate throughout the backwash process, so that the average and maximum backwash rates are the same. Other systems may vary the backwash rate throughout the backwash process. For instance, a system may use air scour or surface wash in addition to backwashing. The average and maximum backwash rates are different in this case because of the varying backwash rate. Also, some systems may vary the backwash rates seasonally based on changing water temperature or system loading rates. States may require systems to collect backwash information for different operating conditions. Systems should check with the State to determine the frequency of data collection. Backwash flow rates can be reported based on metered values, rise-rate tests, pump records, or other means.

The Recordkeeping Form in Appendix B can be used to record backwash information. A completed example of this form is included at the end of this chapter. Examples in Appendices C, D, and E illustrate how backwash information can be collected and recorded.

5.2.4 Filter Run Length and Termination of Filter Run

Systems must provide to the State the typical filter run length (typical time that a filter is operated before it is backwashed). The filter run length is the sum of the time that the filter is operating between backwashes. As water passes through, a filter becomes clogged with particles that eventually could begin to compromise the treatment ability of the filter. Systems may have different methods for determining typical filter run length.

Systems must maintain a written summary of the methods used to determine the run time along with the typical filter run time. If turbidity, head loss, or filter effluent turbidity thresholds are used to determine the filter run time, these thresholds should be provided. If the filter run is terminated based on a pre-determined time established by the system or other means, this determination should also be noted.

The Recordkeeping Form in Appendix B can be used to record this information. A completed example of this form is included at the end of this chapter. Examples in Appendices C, D, and E provide an example of how to report the information.

5.2.5 Recycle Stream Treatment

If a system treats or equalizes its recycle streams, then information about these processes must be included in records maintained for the FBRR. The system must record information on the type of treatment that is provided.

5.2.6 Equalization and Treatment Information

If equalization or treatment of the recycle stream is provided, systems must collect the following information on the units:

- Physical dimensions of the equalization and/or treatment units. A sketch of the unit with dimensions may be helpful. This information will be used to determine the capacity of the unit;

- Typical and maximum hydraulic loading rates. This could include generated rates for each recycle stream (see Figure 5-3);

- Type of treatment chemical(s) used, if the recycle stream is chemically treated. It may be useful to note whether the chemical is introduced to the recycle stream prior to entering the unit or directly into the unit;

- Average dose rate of the treatment chemical and frequency of chemical use must be provided; and,

- Frequency of solids removal. Solids removal is important because solids can reduce the equalization/treatment capability of the unit by occupying a significant volume in the unit. Systems will need to record the frequency of solids removal (for example, once a month).

The Recordkeeping Form in Appendix B can be used to record this information. A completed example of this form is included at the end of this chapter. Examples in Appendices D and E illustrate how this information can be collected and recorded.

FILTER BACKWASH RECYCLING RULE RECORDKEEPING FORM

SYSTEM NAME __Example 3.0 MGD Plant___________________________
PWSID ___________________________________ **Operating Period**[1] _Jun 2003-Jun 2004

Check with your State or Primacy Agency to make sure this form is acceptable.

Type of Recycle Stream	Frequency at which flow is returned[2]
Spent Filter Backwash	4 times/day returned to main treatment train
Thickener Supernatant	
Liquids from Dewatering Process	
Other	
Other	

Filter Information	Filter Number[3]			
	1-8, all filters the same			
Average Duration of Backwash (in minutes)	15 minutes			
Maximum Duration of Backwash (in minutes)	15 minutes			
Average Backwash Flow[4] (in gpm)	1,500 gpm			
Maximum Backwash Flow[4] (in gpm)	1,500 gpm			
Run Length Time of Filter[5] (include units)	48 hrs			
Criteria for Terminating Filter Run[6]	Time, unless individual filter turbidity exceeds 0.2 NTU.			

Is treatment or equalization provided for recycle flows? __________Yes ____X_____ No
If yes, complete the following table.

Type of Treatment Provided		
Physical Dimensions of Unit		
Typical Hydraulic Loading Rate		
Maximum Hydraulic Loading Rate		
Type of Chemical Used		
Average Dose of Chemical (mg/L)		
Frequency of Chemical Addition		
Frequency of Solids Removal		

See instructions on back.

Instructions

1. Note the operating period for the information provided. Check with your State or Primacy Agency for required operating period.

2. The frequency at which the recycle stream is returned can be described as continuous, once a day, or as another frequency.

3. Fill out all information for each of your filters. If some or all filters are operated the same, note the appropriate filter numbers.

4. The backwash flow is obtained by multiplying filter surface area (in ft^2) by backwash rate (gpm/ft^2). Use the average backwash rate to get the average flow and the maximum backwash rate to get the maximum flow. If the flow is varied throughout the backwash process, then the average can be computed on a time-weighted basis as follows:

$$\frac{(\text{Backwash Rate 1 X Duration 1}) + (\text{Backwash Rate 2 X Duration 2}) + \ldots}{\text{Duration 1} + \text{Duration 2} + \ldots}$$

5. The filter run length time is the sum of the time that the filter is producing water between backwashes.

6. Describe how run length time is determined. For example, is the run length based on head loss across the filter, turbidity levels of filter effluent, a predetermined amount of time, or another method?

PART II

6. PART II OVERVIEW

Water treatment systems typically recycle residual streams for one or both of the following reasons:

- Water resources are limited, such as in the arid southwest, and the system may not be able to access additional water. Therefore, certain residual streams (such as spent filter backwash) are recycled to maximize production.

- Recycling of residual streams may be more cost-effective than disposal, such as discharge to a storm sewer or sanitary sewer. Therefore, the system recycles the residual stream.

For those systems regulated by the FBRR, specific reporting, recycle return location, and recordkeeping requirements apply (as described in Chapters 3, 4, and 5). States will most likely evaluate the information collected and submitted by systems and decide if recycle practices are impacting finished water quality. If the State identifies problems with recycle practices or the recycle return location, then States and systems should revise or alter main treatment plant processes and/or recycle practices to minimize impacts on finished water. For instance, an exceedance of turbidity limits may be linked to recycle practices. Part II of this document provides information on how States and systems can evaluate recycle practices, recycle stream characteristics, and alternatives to consider to minimize the impacts of recycle practices on treatment plant performance and in particular, finished water quality. **States and systems should note that the information presented in Part II is provided as an additional resource and is not required by the FBRR. In some instances the information is very site specific. Therefore, if systems are considering modifying their treatment process or recycle practices, the State should be consulted prior to any modification.**

Part II contains the following chapters:

- ***Chapter 7. Recycle Streams:*** This chapter describes different recycle streams (regulated and non-regulated) and characteristics of recycle streams.

- ***Chapter 8. Operational Considerations and Modifications:*** This chapter presents information on how to modify the main treatment train process or better manage recycle streams to minimize the impacts of recycle streams on finished water.

- ***Chapter 9. Equalization:*** This chapter describes equalization of recycle streams and discusses the advantages and disadvantages of equalization. Case studies are presented.

- ***Chapter 10. Treatment of Recycle Streams:*** This chapter describes the concept of treatment and discusses the advantages and disadvantages of treating recycle streams. This chapter also describes specific treatment options and the issues associated with each treatment option. Case studies are presented.

States and systems can also refer to the references listed at the end of each chapter and AWWA's *Self Assessment of Recycle Practices* (2002) for more detailed information on a specific case study or evaluation of recycle practices.

7. RECYCLE STREAMS

7.1 INTRODUCTION

Water treatment plants throughout the United States recycle or reintroduce a variety of residual streams back into their treatment plants. Some of these flows may contain *Cryptosporidium* oocysts and other contaminants, while others may be quite harmless. As indicated elsewhere in this document, only three recycle streams (spent filter backwash water, thickener supernatant, and liquids from dewatering processes) are regulated by the FBRR. (Note: The FBRR only applies to conventional and direct filtration systems that recycle one or more of the regulated recycle streams.) These streams are regulated because they are the recycle streams most likely to contain *Cryptosporidium* oocysts (and other contaminants) and may represent a large percentage of overall plant production. Spent filter backwash water data indicates that both *Cryptosporidium* and *Giardia* cysts can occur in greater concentrations than raw water concentrations. Thickener supernatant and liquids from dewatering processes both result from sludge that may contain elevated *Cryptosporidium* and *Giardia* cyst concentrations in comparison to raw water concentrations. Data show that microbial contaminants, in addition to other contaminants, can be released from the sludge into the recycle stream if the sludge is not properly settled, treated, and/or removed. In addition to contaminants, the volume and/or flow rates of the recycle stream are also of concern. Two of the regulated streams- spent filter backwash water and thickener supernatant- can be produced at sufficient rates to create hydraulic surges or cause a water treatment plant to exceed operating capacity.

Regulated Recycle Streams
- Spent filter backwash water
- Thickener supernatant
- Liquids from dewatering processes

Unregulated Residual Streams (not all-inclusive)
- Filter-to-waste
- Membrane concentrate
- Ion exchange regenerate
- Sludge
- Diatomaceous earth slurry

In addition to the regulated recycle streams, water treatment plants produce other streams that, as of yet, are not regulated. Examples of typical unregulated streams are filter-to-waste, membrane concentrate, ion exchange regenerate, and sludge. These streams were not regulated in the FBRR because of one or more of the following:

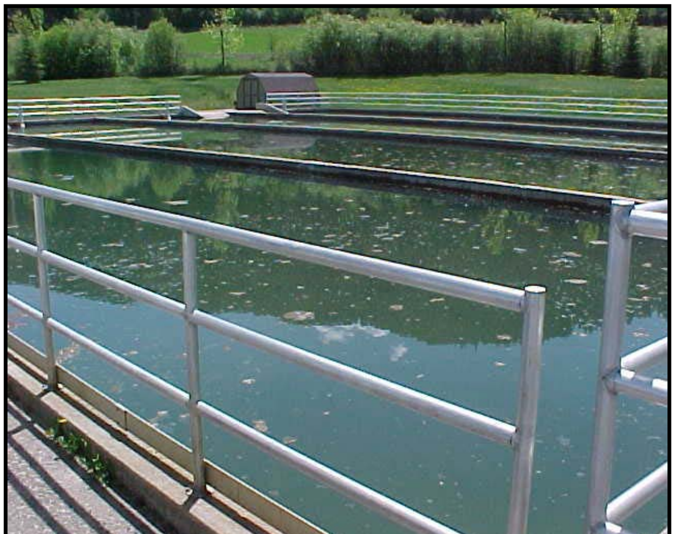
- The quality of the stream was of high quality and probably would not adversely impact overall treatment plant efficiency (such as filter-to-waste);
- The stream was of such small volume that the chance of hydraulic surge was minimal (such as waste flows from turbidimeters); or,
- The stream was not typically recycled due to the quality of the stream (such as ion exchange regenerate).

This chapter provides a discussion of each of the regulated recycle streams and a brief discussion of some recycle streams not regulated by the FBRR.

7.2 SPENT FILTER BACKWASH WATER

Filter backwashing is an integral part of treatment plant operation. Filters are typically cleaned by flushing them with water in the reverse direction to normal flow. The water flow must have sufficient force to separate particles from the filter media, so a greater than normal flow is used. The resulting water, which carries particles flushed from the filters including microbes (such as *Cryptosporidium*), raw water particles, and particles from the coagulation process, is called waste or spent filter backwash water. The backwash period generally lasts for 10-25 minutes at a rate of approximately 15 to 20 gpm/ft^2, and produces a significant volume of spent filter backwash. Of all the processes that produce residual streams, filter backwash typically produces the largest volume of water and at the highest rate.

7.2.1 Frequency and Quantity



This backwash holding basin is used to allow settling of spent filter backwash.

Filter runs generally last between 24 and 72 hours in length, but vary from plant to plant. Filters are taken off-line for backwashing based on time (hours of filter run time), turbidity and/or particle counts in filter effluent, head loss across the filter, or other system-specific methods. A typical backwashing operation lasts for 10-25 minutes with maximum rates of 15 to 20 gpm/ft^2, but the backwash rate varies for each plant and filter type. Since a high water flow is used, a large volume of spent filter backwash water is produced in a relatively short amount of time. Some plants only produce spent filter backwash sporadically (small plants), but larger plants with numerous filters may produce it continuously as filters are rotated for backwashing. Medium and small plants typically produce spent filter backwash as an intermittent stream in large volumes over a short time span. The return of the spent filter backwash to the main treatment train without treatment or equalization is known as direct recycle. Direct recycle could result in the plant exceeding its operating capacity or experiencing hydraulic disruptions if the raw water flow is not properly managed during recycle.

Spent filter backwash can comprise 2% to 10% of the total plant production, but on the average accounts for 2.5% of average plant production (Environmental Engineering and

Technology, 1999). Recycled spent filter backwash can represent a significant percentage of plant instantaneous flow during recycle events, particularly if no equalization is provided. High recycle flows can result in hydraulic surges and possibly upset treatment plant performance. For instance, the spent filter backwash scenario presented in the example in Appendix C illustrates that the spent filter backwash recycle volume constitutes 4% of the total plant production, but during periods of recycle it constitutes 60% of the plant instantaneous flow.

7.2.2 Quality

The quality of spent filter backwash varies from plant to plant. Spent filter backwash quality has been analyzed in several studies. One research project funded by the American Water Works Association Research Foundation (AWWARF) surveyed 25 representative water treatment plants to compare the differences in microbial, physical, and chemical water quality of raw waters to untreated spent filter backwash (Cornwell et al., 2001). Of the 146 raw water samples collected, *Giardia* and *Cryptosporidium* were detected in 30% and 11% of samples, respectively. The observed geometric mean levels of *Giardia* and *Cryptosporidium* in the raw water samples for the detections were 89 and 108/100 L, respectively. For the 148 spent filter backwash samples, 8% and 5% were positive for *Giardia* and *Cryptosporidium*, respectively. The geometric mean levels of *Giardia* and *Cryptosporidium* in the spent filter backwash samples with detections were 203 and 175/100 L, respectively. All of the data were collected by means of the immunofluorescence assay method. Concentrations of *Giardia* and *Cryptosporidium* in spent filter backwash were observed to be approximately 16 and 21 times higher than corresponding raw water samples, respectively, after adjusting for recovery efficiency. Infectious *Cryptosporidium* was observed in six raw water samples (4.9%) and nine spent filter backwash samples (7.4%). Other water quality parameters were also sampled, including dissolved organic carbon (DOC), TTHMs, HAA5s, and metals. DOC and zinc concentrations showed a three-fold increase and TTHMs had a 92-fold increase in concentration in spent filter backwash when compared to raw water samples after chemical addition. Appendix F has additional information on contaminants in spent filter backwash.

This newly constructed lagoon will be used to equalize and settle spent filter backwash prior to recycling.

Kawamura (2000) indicates that spent filter backwash water from a conventional treatment plant generally has a turbidity of 150 to 250 NTU. Other data shows a range from 7 to 148 NTU for spent filter backwash turbidity from conventional treatment plants (HDR, 1997). Data from another study (Cornwell and Lee, 1993) showed that turbidity during backwash at one plant varied between 0.57 and 97 NTU (See Table F-1, Appendix F). A study by Tobiason et al.,

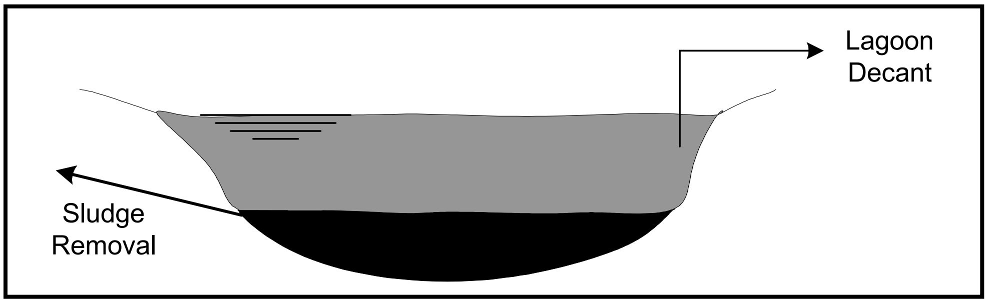
(1999) found high peak turbidity levels of 150 to 400 NTU that fell to 1 to 7 NTU at later stages of recycle. The peak turbidity levels were associated with the settling of solids in the backwash storage tank after the flow of spent filter backwash water into the tank ended. The variability of the spent filter backwash turbidity is due to the variability of raw water, upstream treatment processes, filter design and operation, and backwashing practices. For example, the amount of solids trapped in a filter will be highly dependent upon the amount of solids in the raw water, the amount and type of coagulant used, whether lime softening is used (as it can add greatly to the solids load), and the efficiency of the sedimentation unit process (in conventional treatment systems). The quality of the spent filter backwash water also depends on the volume of backwash water used. The more water used, the more diluted the spent backwash water will become (HDR, 1997).

Other contaminants contained in the spent filter backwash can impact plant performance and finished water. TOC, aluminum, manganese, and iron concentrations in the spent filter backwash can be higher than those found in both the raw water and raw water after chemical addition. In a study by Levesque, et al., (1999) a facility with flow equalization but no solids removal had peak grab sample concentrations of 143 mg/L TOC, 158 mg/L total aluminum, and 1.23 mg/L total manganese. These contaminants are typically more of a concern when thickener supernatant is recycled in combination with the spent filter backwash (HDR, 1997). Total suspended solids (TSS) may also be a concern. TSS in the spent filter backwash varies between plants and during the backwash cycle. A study by Bashaw et al., (2000) indicated that TSS was very high, with a peak of approximately 300 mg/L and an average TSS of 71 mg/L, during the first three minutes of backwash. Another study by Myers et al., (2000) showed an average TSS of backwash water of 300 mg/L. A study by Tobiason et al., (1999) found high peak levels of 600 to 7,000 mg/L TSS in recycled spent filter backwash water. These peak levels were associated with the settling of solids in the backwash storage tank after the flow of spent filter backwash water into the tank ended. The recycled spent filter backwash from a backwash holding tank may have lower TSS values since solids are settled in the holding tank. However, if the backwash holding tank is mixed, no solids removal will occur and TSS could be high in the recycle stream.

7.3 THICKENER SUPERNATANT

Thickener supernatant results from gravity thickening of solids. In the gravity thickener unit, solids in the water stream settle out as a result of gravity. Gravity-thickeners can consist of clarifiers, sedimentation basins, backwash holding tanks, lagoons, and other similar units. After settling, the clarified water or decant that exits the unit is called thickener supernatant (see Figure 7-1). The sludge at the bottom of the sedimentation basin and other sludge-holding units could contain elevated levels of microbial (such as *Cryptosporidium* and *Giardia* cysts), organic, and inorganic contaminants as compared to the raw water. These contaminants can remain in the supernatant if the sludge is not properly settled, treated, and/or removed. The supernatant should be removed from the thickener unit in a manner such that the settled solids are not disturbed to minimize contamination issues.

Figure 7-1. Lagoon Used to Settle Solids



7.3.1 Frequency and Quantity

Thickener supernatant can be recycled continuously or intermittently. The frequency of thickener supernatant recycling depends on the quantity of sludge that is produced and thickener supernatant recycle practices. Thickener supernatant is often combined with other plant flows (such as spent filter backwash, filter-to-waste, or liquids from dewatering processes).

Approximately 65% to 75% or more of the sludge generated at a treatment facility settles out in sedimentation basins at a conventional alum coagulant plant. Generally, the sludge is 0.05% to 3% solids and the remainder is water. Sludge volumes are typically 0.1% to 3% of the plant flow (Environmental Engineering and Technology, 1999). The volume of sedimentation basin sludge supernatant is dependent on sludge production, sludge solids content, and method of thickener operation. Sludge production is a function of plant production, raw water suspended solids, plant process (such as lime softening), coagulant type and coagulant dose. The quantity of sedimentation basin thickener supernatant is approximately 75% to 90% of the original volume of sedimentation basin sludge produced (Environmental Engineering and Technology, 1999). The volume of lagoon decant depends on the volume of influent waste streams, concentration of solids in the waste stream, loading duration and frequency, drainage rates, overflow rates, and evaporation rates (Environmental Engineering and Technology, 1999).

7.3.2 Quality

Contaminant concentrations in thickener supernatant depend on the raw water characteristics, thickener design, thickener loading rate, and the type and amount of coagulant added.

Data for *Giardia* and *Cryptosporidium* in untreated sedimentation basin sludge showed concentrations of 3,000 to 5,000 cysts/100 L in a plant with two sampling points (Environmental Engineering and Technology, 1999). In another study, the *Giardia* concentration was 40 cysts/L and the *Cryptosporidium* concentration was 80 cysts/L in the sludge (Cornwell and Lee, 1993). The same study indicated that recycling the supernatant did not impact finished water quality. More detailed influent water, sludge, and supernatant data can be found in Table G-1, Appendix G, Characteristics of Thickener Supernatant.

Residual characteristics in lagoon decant are altered due to treatment in the lagoon and storage. Anaerobic conditions may occur, promoting the release of some metals from solid state to dissolved form. This may also occur for organics, and could result in taste and odor problems. However, anaerobic biological decomposition may reduce virus, parasite, or pathogenic microbial concentrations. Data on lagoon decant characteristics are presented in Table G-2, Appendix G.

A study by Hoehn, et al., (1987) reported significant release of manganese, iron, and TOC from sludges held in manually cleaned, anaerobic sedimentation basins (sedimentation basins that receive sludge and act as gravity thickeners). The study also concluded that sludge stored in lagoons can also be expected to degrade the overlying water, a consideration when recycling thickener supernatant.

Another study confirmed Hoehn's observations that manually-cleaned sedimentation basins caused more manganese to be released than mechanically cleaned basins (Cornwell and Lee, 1993). As the sludge accumulated in a manually cleaned basin, manganese levels in the clarified water gradually increased. Generally, if solids were removed from the waste stream prior to recycle, TTHM formation potential and TOC in the recycle stream was no higher than in the raw water.

7.4 LIQUIDS FROM DEWATERING PROCESSES

Some filtration plants prepare waste solids (sludge) for disposal by concentrating solids and removing excess water, which reduces the volume of waste that must be disposed. The sludge typically comes from sedimentation basins, clarifiers, backwash holding tanks, or other units, and contains only 1% to 2% solids. Removing liquids from these waste solids can concentrate the sludge up to 50% solids (Kawamura, 2000). The liquids that are removed are referred to as liquids from dewatering processes.

Liquids from dewatering can be produced from a lagoon or sludge drying bed as decant and underflow, from monofill as leachate, or from mechanical dewatering devices as pressate, filtrate, or centrate. If recycled, these liquids are subject to the FBRR.

7.4.1 Quantity and Quality

Liquids from dewatering processes can be of reduced quality since they consist of water extracted from thickened sludge. Most of the *Cryptosporidium* oocysts that are removed from raw water by treatment are concentrated, first as sludge in the sedimentation basin, clarifier, or other treatment processes. They can be settled a second time in a gravity thickener and then dewatered. The recycle stream created by the dewatering process typically has a smaller volume than spent filter backwash, but its size depends on the volume of sludge produced in the plant, and on the solids content of the sludge. Most plants will produce a small, intermittent stream as a result of the dewatering process.

Non-mechanically Dewatered Sludge Recycle Streams

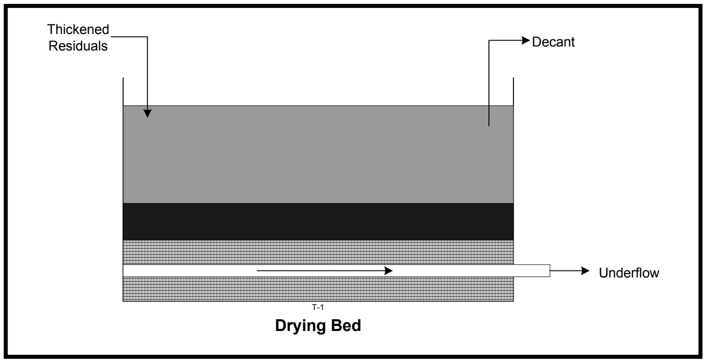


Figure 7-2. Sludge Drying Bed

Sludge drying beds, lagoons, and monofills can be used as non-mechanical processes to dewater sludge. Each of these dewatering processes creates a waste stream. Sludge drying beds are used for dewatering sludge through draining, percolation, decanting, and evaporation (see Figure 7-2). The quantity of decant and underflow depends on the volume of sludge applied to a bed, the sludge solids content, loading duration and frequency, and drainage and evaporation rates. The underflow and decant account for 50% to 75% of applied volume. If a thickener is not used, the underflow and decant volume would be in the range of 0.3% to 0.4% of plant production based on average sludge volumes reported elsewhere (Environmental Engineering and Technology, 1999). No published data exists that demonstrates the potential impact of recycling sludge drying bed decant and underflow. See Appendix H, Table H-1, for data on sludge drying bed underflow. Lagoons can be designed and operated in a manner similar to a sludge drying bed for dewatering.

Monofill (sludge-only landfill) is available in some States as a means of disposal of dewatered plant residuals from a water treatment plant. Water percolates through the monofill and is a potential recycle stream if it is collected by an underdrain (see Figure 7-3). The quantity of monofill leachate is dependent on the quantity and quality of dewatered residuals and the quantity of rainfall entering the monofill. The rate of seepage through the monofill is a function of sludge permeability and hydraulic gradient (Environmental Engineering and Technology, 1999). Three sets of pilot data from a study are presented in Table H-1, Appendix H. The leachate was generated by constructing pilot-scale monofills using two alum sludges and one ferric sludge. Although none of the metals concentrations shown in Table H-1 exceed primary MCLs, dissolved iron and manganese concentrations for a few of the data sets exceeded secondary MCLs. Metals and pH are typically the constituents of concern in leachate.

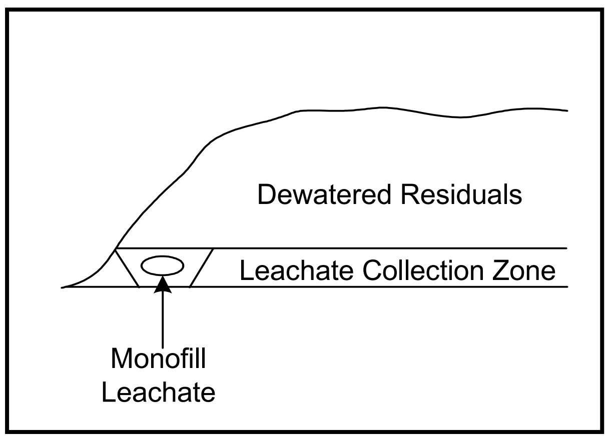


Figure 7-3. Monofill used for Dewatering Residuals

Mechanically Dewatered Sludge Recycle Streams

The conveyer is used to transport sludge from the centrifuge (background) after dewatering.

Water treatment plant residuals can also be dewatered by mechanical means, such as a centrifuge or belt filter press. The quantity depends on the volume and solids content of the thickened residuals feed. If the sedimentation basin average sludge flow is 0.6% of plant production, the dewatering device concentrate flow may be approximately 0.1% to 0.2% of plant flow. Belt filter presses and centrifuges, particularly at smaller facilities, are typically operated for only 8 to 12 hour shifts per day, often only five days per week. Operating routines would also affect potential recycle rates (Environmental Engineering and Technology, 1999). Data presented in Table H-2, Appendix H, shows that turbidity, TOC, and TTHMs can be high in liquids from mechanically dewatered sludge. Both total and dissolved aluminum and manganese concentrations may also be high. Elevated aluminum is expected to be present in waste streams of water plants practicing alum coagulation, and release of significant levels of manganese from residuals has been demonstrated. No published data exists on the potential impacts of recycling mechanical dewatering device concentrates. Plants generally dilute the dewatered residuals stream with other recycle streams prior to return to the main treatment train. The concentrates may often undergo further settling when put into thickeners prior to recycle.

7.5 NON-REGULATED RECYCLE STREAMS

The FBRR only regulates spent filter backwash water, thickener supernatant, and liquids from dewatering processes at conventional and direct filtration systems. However, other residual streams are produced at treatment plants. Table 7-1 provides a summary of some common residual streams produced by water treatment plants.

Table 7-1. Commonly Produced Non-Regulated Residual Streams

Residual Stream	Description
Filter-to-Waste	Generated by filters when the filter is placed back on-line after backwashing and prior to discharging to the clearwell. Typically of high quality since the stream has been treated by all treatment processes. Typically 0.5% of total amount of filtered water and second largest potential waste stream (after spent filter backwash) generated at a plant (HDR, 1997). Can be recycled or disposed.
Membrane Concentrate Reject Stream	Generated when the source water is passed through the membrane for treatment. Either returned back through the membrane for treatment or disposed (discharged to surface water, sanitary sewer, or land-applied).
Ion Exchange Residual Streams	Generated when the resins are regenerated, rinsed, or backwashed. Quality may be of concern if recycled.
Sludge from Softening Plants and Contact Clarifiers	Solids generated in the sedimentation basin or contact clarifiers. Recycled as an intrinsic part of the treatment process.
Slow Sand Filter-to-Waste	Generated over 1 to 2 days during the slow sand filter ripening period. Quality and volume may be of concern if recycled.
Diatomaceous Earth (DE) slurry	Generated when the DE filter is cleaned. Consists of filter medium and particles removed from the source water. Quality and volume may be of concern if recycled.
Minor Streams	Streams that result due to spills, laboratory analyses, washdown of plant facilities, and leaks. Typically of small volume, but quality may be a concern if recycled. AWWA's *Self-Assessment of Recycle Practices* (2002) provides more information on minor streams.

7.6 REFERENCES

AWWA. 2002. Self Assessment of Recycle Practices. Denver, CO.

AWWA/ASCE. 1998. *Water Treatment Plant Design*. Third Edition. McGraw Hill. New York, NY.

Bashaw, W., T. Ginn, and R. Thomson. 2000. Design for Reclaiming Filter Backwash Water at the James E. Quarles Water Treatment Plant. Proceedings from AWWA 2000 Annual Conference. Denver, CO.

Cornwell, D., C. Vandermeyden, and G. Dillow. 1992. Landfilling of Water Treatment Plant Coagulant Sludges. AWWARF. Denver, CO.

Cornwell, D., M. MacPhee, N. McTigue, H. Arora, G. DiGiovanni, M. LeChevallier, and J. Taylor. 2001. Treatment Options for *Giardia*, *Cryptosporidium*, and Other Contaminants in Recycled Backwash Water. AWWARF. Denver, CO.

Cornwell, D., and R. Lee. 1993. Recycle Stream Effects on Water Treatment. AWWARF Report #90624. Denver, CO.

Environmental Engineering and Technology. 1999. Background Papers on Potential Recycle Streams in Drinking Water Treatment Plants. AWWA.

HDR. 1997. Draft EPA Guidance Manual – Recycle of Spent Filter Backwash Water and Other Waste Streams, Filter-to-Waste, and Uncovered Finished Reservoirs.

Hoehn, R.C., J.T. Novak, and W.T. Cumbie. 1987. Effects of Storage and Preoxidation on Sludge and Water Quality. AWWA Journal, Vol. 9, No. 6.

Kawamura, S. 2000. *Integrated Design and Operation of Water Treatment Facilities.* Second Edition. John Wiley & Sons, Inc. New York, NY.

Levesque, B.R., J.E. Tobiason, W. Parmenter, and J.K. Edswald. 1999. Filter Backwash Recycle: Quality Characteristics and Impacts on Treatment. Proceedings from AWWA 1999 Annual Conference. Denver, CO.

Myers, T., J. Skadsen, and L. Sanford. 2000. Coping with Filter Backwash Recycle in Water Treatment. Proceedings from AWWA 2000 Annual Conference. Denver, CO.

Tobiason, J.E., B.R. Levesque, J.K. Edzwald, G.S. Kaminski, H.J. Dunn, and P.B. Galant. 1999. Water Quality Impacts of Filter Backwash Recycle. Proceedings from AWWA 1999 Water Quality Technology Conference. Tampa, FL.

8. OPERATIONAL CONSIDERATIONS AND MODIFICATIONS

8.1 INTRODUCTION

As States and systems evaluate recycle practices, there are operational considerations and modifications that can be employed by water systems to minimize the impacts that the recycle of process flows and backwashing practices have on treatment. They all may not be appropriate for any given system; however, they have been proven appropriate in site specific situations. Operational considerations that systems may investigate include the following:

- Adjust chemical feed practices in the main treatment train during recycle events;
- Return recycle stream(s) to presedimentation basin;
- Control raw water or recycle stream flow to avoid unmanageable hydraulic surges;
- Reduce the amount of spent filter backwash generated through backwash modifications or increased filter run times;
- Reduce the filter-to-waste volume if filter-to-waste flows are recycled; and,
- Equalize (see Chapter 9) and/or treat (see Chapter 10) recycle stream(s) prior to returning stream(s) to the main treatment train.

While these operational considerations and modifications are not required by the FBRR, they are practices that can help systems optimize treatment and minimize the impact of recycle on treatment plant performance. Modifications can be implemented with or without pretreatment and/or equalization of the recycle stream. In addition, system modifications may or may not involve capital improvements at the plant. **Each operational consideration and modification is site-specific and pilot- or full-scale testing is recommended prior to modifying plant operations. Also, the State should be consulted prior to modifying any processes.** The operational considerations and modifications presented in this section are not all-inclusive.

8.2 ADJUST CHEMICAL FEED PRACTICES DURING RECYCLE EVENTS

Jar Testing References

- Draft LT1ESWTR Turbidity Provisions Technical Guidance Manual (under development by EPA)
- Operational Control of Coagulation and Filtration Processes, AWWA M37, 1992 [Denver, CO] (available from AWWA)

Some plants have successfully tracked influent changes by streaming current readings, zeta potential readings, or other means and adjusted the chemical feed rate and type accordingly during recycle events. Jar testing prior to any modifications will be important to identify the type and amount of chemicals that perform best when recycle streams are introduced to the plant. Most systems will want to develop a Standard Operating Procedure (SOP) to assist operators with proper chemical feed operations during recycle events. Also, maintaining the recycle stream flow at a certain percentage of the total plant flow may be essential to properly implement this operational modification without major plant upsets. Equalization of the recycle stream may be necessary to maintain the target recycle percentage (see Chapter 9). The case studies presented in this section illustrate successes and concerns with modifying chemical feed practices during recycle events.

Case Study- Success with chemical feed modifications (Moss, 2000)

The Salt Lake City Public Utilities Department (SLCPUD) noticed an increase in particle counts and decrease in streaming current values during spent filter backwash recycle events. Operators were able to adjust coagulant feed rates to compensate for influent water quality variations such that finished water was not effected during recycle. In addition, SLCPUD fed polymer (high charge anionic polymer) to the spent filter backwash clarifier to increase sedimentation of the spent filter backwash prior to recycling.

Case Study- Issues with chemical feed modifications (Goldgrabe-Brewen, 1994)

A study of three plants in northern California reported coagulant underdosing when a streaming current detector was used in coagulant dosage control mode. Positively charged particles contained in the spent filter backwash caused the streaming current monitor reading to increase, resulting in chemical underdosing. This same study also demonstrated that using polymer exclusively for coagulation had negative impacts on clarification when the recycle percentage exceeded five percent of the total raw water treated.

This option may be complicated due to residual chemicals contained in the recycle stream and the intermittent nature of some recycle streams. These residuals can cause a fluctuation of chemical demands at the head of the plant when mixed with raw water. Also, determining the appropriate chemical dose may be difficult, as presented in the case studies. A polymer feed system may need to be installed for successful treatment if one does not already exist. EPA estimates the cost of installing a polymer feed system on a 1.8 MGD plant was $8,900 in capital costs and $4,000 in operation and maintenance costs (EPA, 2000).

8.3 RETURN RECYCLE STREAM(S) TO PRESEDIMENTATION BASIN

If presedimentation basins are available, the recycle stream can be returned to the presedimentation basin prior to coagulation. Additional settling prior to the main treatment train may reduce particle loading onto the filters. Another added benefit of discharging recycle streams to a presedimentation basin, if configured to avoid short-circuiting, is the mixing that will occur with the raw water. A more consistent influent water quality to the plant allows for more uniform chemical feed operations and overall improved treatment plant efficiency. A disadvantage with this operational consideration is that more frequent sediment/solids removal will be required.

8.4 CONTROL RAW WATER FLOW OR RECYCLE RETURN FLOW

Systems should be careful to avoid unmanageable hydraulic surges or plant capacity exceedances during recycle events. Two options systems may want to consider to avoid unmanageable hydraulic surges or plant capacity exceedances are:

- Control raw water flow during recycle events such that the raw water flow plus recycle flow will not create a hydraulic surge or plant capacity exceedance.

- Control the rate of return of recycle flows by providing equalization of recycle streams (see Chapter 9).

Maintaining the recycle flow at or below 10 percent of the plant influent (raw water flow plus recycle flow) should be sufficient (SPHEM, 1992; Kawamura, 2000; Cornwell and Lee, 1994). The appropriate recycle flow percentage will vary from system to system depending on site specific water quality and treatment conditions.

8.5 REDUCE THE AMOUNT OF GENERATED SPENT FILTER BACKWASH

Several options are available for reducing the amount of generated spent filter backwash, including:

- Using air scour or surface wash to supplement the backwash process;

- Determining the minimum backwash duration necessary to produce optimum filtered water; and,

- Increasing filter run times and decreasing the frequency of backwashes.

Systems should be careful, when modifying backwash practices, to monitor the resulting impact on filtered water quality. Modifying backwash practices can affect filtered water turbidity (causing either increases or decreases in turbidity) and systems must maintain compliance with all filter effluent turbidity standards. The LT1ESWTR Turbidity Provisions Technical Guidance Manual has additional information on filter assessments and backwash practices (under development by EPA).

8.5.1 Air Scour with Backwash

Air scour can be used in conjunction with backwash and in some instances has been shown to provide better cleaning than water-only backwash, and saves on backwash water. A water works in southern Nevada that upgraded to an air/water backwash system was able to reduce its backwash water volume by 500 million gallons per year (Logsdon et al., 2000).

The process can consist of three scenarios (AWWA, 1999):

- **Air scour alone before backwash.** This process is recommended for fine sand, dual media, and triple media filters.
- **Simultaneous air scour and backwash during rising water level but before overflow.** Air scour and backwash can be done simultaneously, with air scour terminating before overflow. This process is recommended for fine sand, dual media, triple media, and coarse monomedium anthracite.
- **Simultaneous air scour and water backwash during overflow.** This process consists of air scour with water backwash throughout the overflow period. This process is recommended for coarse monomedium sand or anthracite filters. Special baffled overflow troughs are essential for anthracite filters to prevent loss of anthracite.

The use of air scour in the backwash process may allow a reduction in the backwash rate and duration, producing less spent filter backwash.

8.5.2 Surface Wash with Backwash


A surface wash arm.

Surface wash systems inject jets of water from orifices located about 1 to 2 inches above the surface of the fixed bed. Surface wash jets are operated for 1 to 2 minutes before the upflow wash and usually are continued during most of the upflow wash. Surface wash is terminated 2 or 3 minutes before overflow to prevent media loss. Surface wash may allow the time of backwash to be decreased and result in less generated spent filter backwash. EPA estimates that the cost of installing a surface wash system at a 1.8 MGD plant was $159,400 in capital costs and $5,700 in operation and maintenance costs (EPA, 2000).

8.5.3 Reduce the Length of Backwash

Under some conditions, it may be possible to reduce the time of backwash and still comply with turbidity standards. In fact, backwashing for too long can be detrimental to the media and filter performance. Backwashing should typically be terminated when the filter backwash turbidity is between 10 and 15 NTU (Kawamura, 2000); however, the optimum filter backwash turbidity value will vary from system to system. Full-scale tests are necessary to determine the backwash duration that minimizes the filter ripening time when the filter is placed back on-line and results in the optimum filtered water quality.

> ***Case Study (Myers, et al., 2000)***
> The Ann Arbor Water Treatment Plant (WTP) (50 MGD lime softening plant) evaluated four backwash durations: 5, 8, 10, and 15 minutes. Particle counts were measured in the subsequent filter run for each backwash duration. The results indicated the 8- or 10-minute backwash duration produced the best particle removal for their system configuration in the subsequent filter run. Eight minutes produced the lowest particles in the first hour and 10 minutes produced the lowest particles over the filter run. A backwash duration of 8 minutes was selected, resulting in approximately 20% reduction in backwash volume as opposed to a 10-minute backwash duration.

8.5.4 Increase Filter Run Times

Evaluating an increase in the filter run time may be worthwhile and can result in a significant reduction in generated spent filter backwash volume over time. **Caution should be exercised so as not to compromise finished water by operating a filter to or past the point of breakthrough.** Chemical feed practices can also be modified to optimize coagulation, flocculation, and sedimentation, resulting in increased filter run times.

> ***Case Study (Myers, et al., 2000)***
>
> Pilot and full-scale tests were conducted on extending filter run times at the Ann Arbor WTP (50 MGD lime softening plant). The addition of a fine garnet layer to the filters allowed the filter run times to be increased from 75 hours to 96 hours. Headloss in all the extended filter runs did not exceed three feet. Extending the filter runs resulted in a 30% decrease in backwash volume and also eliminated about 700 filter backwashes per year, simplifying operations and reducing costs.

8.6 REDUCE THE AMOUNT OF FILTER-TO-WASTE

If filter-to-waste flows are recycled, several options exist to reduce this particular stream. Although this stream is not regulated by the FBRR, systems may be concerned about its potential for causing hydraulic surge. Such systems may consider terminating the filter-to-waste process when the filtered water turbidity level reaches a predetermined level, as opposed to terminating the filter-to-waste process after a preset time. For example, some systems may filter-to-waste for a preset time limit of 15 minutes on all filters during initial filter start-up. Systems may want to re-evaluate the filter-to-waste procedure. Evaluation of filter-to-waste practices may reveal that desired turbidity or particle count levels in the filtered water may be achieved prior to the preset time limit.

Another option is to reduce the filter ripening period, which will in turn reduce the filter-to-waste volume. The following practices have been demonstrated in certain systems to decrease the initial turbidity spike that occurs when a filter is placed back on-line:

- **Delayed start.** The delayed start consists of letting the filter rest for a period of time between backwashing and placing the filter back into service. This option may not be possible during peak flow periods, but is a good option to consider for reducing initial turbidity spikes.

- **Slow start.** The slow start is a technique that involves a gradual increase of flow to the filter until the desired hydraulic loading rate is achieved. Again, this option can potentially reduce initial turbidity spikes but may require modification of the system to properly control the flow to the filter.

- **Add a coagulant or polymer during the backwash process.** Some studies have shown that coagulants added to the backwash water during the later stages of the backwash process could accelerate the filter ripening process (Hess et al., 2000).

- **Add polymer during initial start-up of filter.** A polymer can be fed to the filter influent during the initial start-up period to enhance initial filtration performance. Polymer feed is then terminated once the filter has reached optimal performance. Systems should be careful when adding polymer during initial filter start-up. Polymer addition can create mud balls and other problems in the filter.

Systems should exercise caution when modifying filter-to-waste practices. Systems will need to verify that their filter-to-waste practices maintain compliance with finished water turbidity standards.

Case Study (Carmichael, Lewis, and Aquino, 1998)

The Milwaukee Water Works compared filter performance for three different scenarios:

- Backwash with no polymer addition;
- Backwash with cationic polymer (Cat-Floc T) added to the backwash water; and,
- Adding cationic polymer to the filter influent water for the last hour of a filter run and then adding it again during the first hour of the following run.

The strategy of adding polymer to the filter influent water both before and after backwash at a dosage of 0.4 mg/L controlled the initial spike better than adding polymer to the backwash water. Filter performance was measured based on particle counting. Full-scale practice has been modified to include the addition of a slug dose (0.4 mg/L) of undiluted cationic polymer in the filter box in front of the influent valve as the settled water flows into the filter box after the influent valve is opened. Then during the first hour of the filter run, polymer is fed at a dose of 0.4 mg/L. Polymer is no longer fed in the last hour of a filter run before backwash, as this did not improve filter performance.

8.7 REFERENCES

AWWA. 1999. *Water Quality and Treatment*. Fifth Edition. McGraw Hill, Inc. New York, NY.

Carmichael, G., C.M. Lewis, and M. A. Aquino. 1998. Enhanced Treatment Plant Optimization and Microbiological Source Water Study. Draft final report to EPA.

Cornwell, D.A., and R.G. Lee. 1994. Waste Stream Recycling: Its Effect on Water Quality. Journal AWWA. 86(11) p 50-63.

Goldgrabe-Brewen, J. 1994. Impact of Recycle Streams on Water Quality. AWWA Proceedings.

Hess, A., et al. 2000. An International Survey of Filter O&M Practices. Proceedings from the AWWA Annual Conference. Denver, CO.

Kawamura, S. 2000. *Integrated Design and Operations of Water Treatment Facilities*. Second Edition. John Wiley & Sons, Inc. New York, NY.

Logsdon, G. S., A. F. Hess, M. J. Chipps, and A. J. Rachwal. 2000. Filter Backwash Water Processing Practices. Proceedings from the AWWA Annual Conference. Denver, CO.

Moss, Linda. 2000. Backwash Water Return Effects: Evaluation and Mitigation. Proceedings from the AWWA Water Quality Technology Conference. Salt Lake City, UT.

Myers, T., J. Skadsen, and L. Sanford. 2000. Coping with Filter Backwash Recycle in Water Treatment. Proceedings from the AWWA 2000 Annual Conference. Denver, CO.

SPHEM (Great Lakes- Upper Mississippi River Board State Public Health and Environment Managers). 1997. Recommended Standards for Water Works ("Ten State Standards"). Health Education Services. Albany, NY.

U.S. EPA. February 2000. Cost and Technology Document for the Proposed Long Term 1 Enhanced Surface Water Treatment Rule and Filter Backwash Rule. Office of Ground Water and DrinkingWater.

9. EQUALIZATION

9.1 INTRODUCTION

Water treatment plants are designed to treat up to a specific flow rate and water is typically introduced to the plant via pumps at a controlled rate. When additional flows during recycle events are introduced, the recycle stream may cause one or more of the following:

- The plant exceeds the design capacity. Recycle streams (spent filter backwash water in particular) can be generated rapidly and in large volumes, and have the potential to cause a plant to exceed its design capacity.

- Hydraulic surge. The introduction of recycle streams can cause the flow to the plant to increase suddenly, which can disrupt treatment processes.

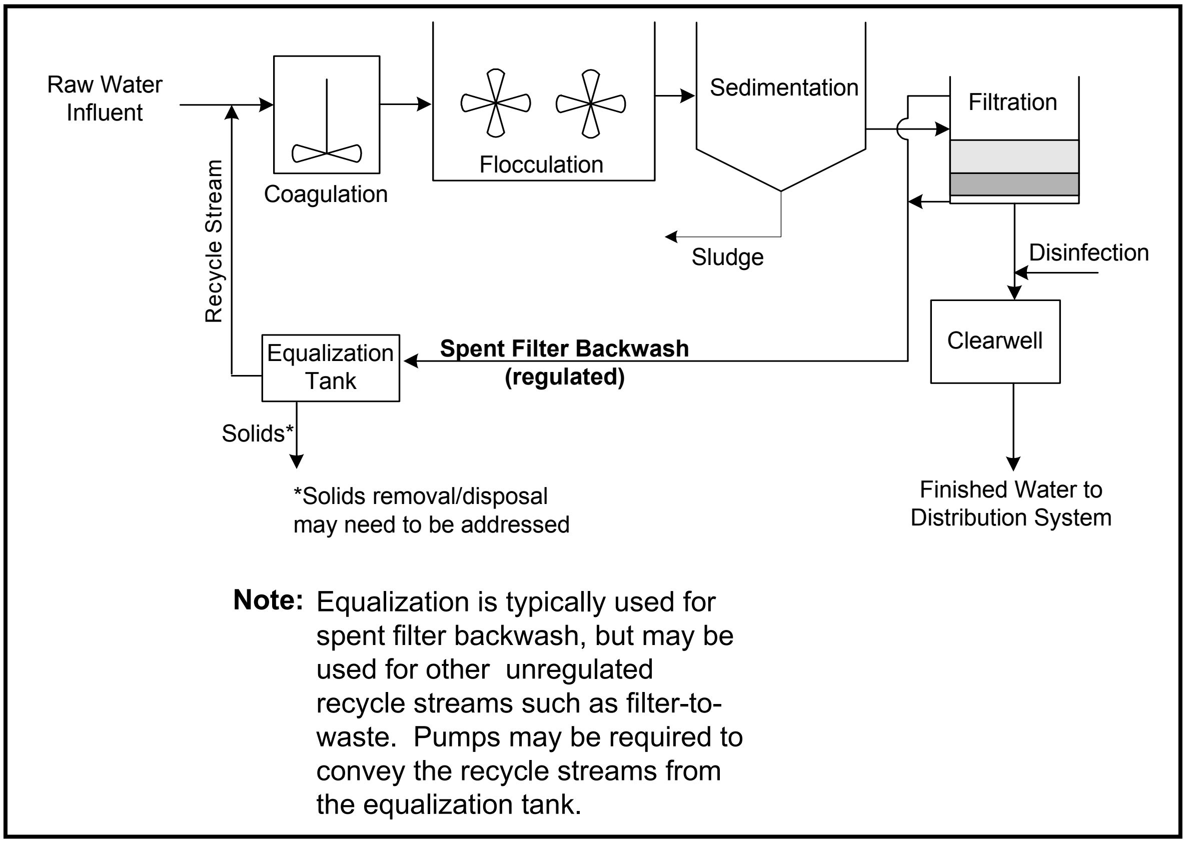
- The influent water quality is significantly altered by the recycle stream. The potential exists for recycle streams to contain higher concentrations of contaminants, particularly pathogens, than the raw water. Also, the chemistry of the recycle stream may influence water quality such that the overall treatment efficiency of the plant may be affected.

Equalization of recycle streams can be provided to help reduce the impacts of recycle streams on plant processes. Equalization consists of providing storage or detention of the recycle stream and returning the recycle stream at a rate different than the generated rate. For instance, spent filter backwash is generated at a particular plant at a rate of 2,000 gpm. Equalization is provided in a spent filter backwash holding tank, and the holding is operated such that the spent filter backwash is returned at a rate of 500 gpm. Figure 9-1 provides a schematic for equalization of spent filter backwash. With equalization, flows can be returned at a rate less than the generated flow rate. Equalization of recycle streams can be provided by basins similar to sedimentation basins, lagoons, or other similar units. The case studies presented in this chapter provide information on equalization tank design considerations.

When determining the rate of return from the equalization basin, the rule of thumb has been to maintain the recycle flow at or below 10% of the plant flow (SPHEM 1997; Kawamura, 2000; Cornwell and Lee, 1994). However, the actual percentage varies from plant to plant and systems need to evaluate the percentage of recycle stream that creates the minimal impacts on finished water. In addition, a continuous recycle return flow (as opposed to intermittent recycle return flow) has been recommended for optimum plant performance (McGuire, 1997; Petersen and Calhoun, 1995).

This chapter discusses the advantages and disadvantages of equalization and methods for assessing the impacts of equalization or lack of equalization at a system. Two case studies are presented later in this chapter to provide real-life scenarios and concerns.

Figure 9-1. Example of Equalizing Recycle Streams



9.2 ADVANTAGES

Benefits of Equalization

- ✓ Minimize hydraulic surge
- ✓ Better flow pacing of chemicals
- ✓ Subsequent recycle stream treatment processes may be downsized

Flow equalization provides hydraulic stabilization that can help to maintain optimal finished water quality. Equalization of recycle streams can provide the following benefits:

- Minimize hydraulic surges and the possibility of hydraulic overload of sedimentation basins, filters, and other treatment units. Settled water quality has been shown to deteriorate as surface-loading rates of the sedimentation basin increase (AWWA, 1999). Hydraulic overload can compromise overall treatment plant efficiency and removal of pathogens and other contaminants. Hydraulic surges can also result in a plant exceeding its design or State-approved capacity. Equalization can help eliminate the situation where clarification and filtration operating rates may be exceeded at precisely the time recycle streams may be returning large numbers of oocysts to the treatment process. Example 9-1 illustrates a situation where direct recycle practices resulted in a plant exceedance and other plant process impacts.

- Allow better flow pacing of chemicals at the head of the treatment plant when the flow is more consistent. Recycle streams vary with quality as the stream is produced. For instance, spent filter backwash typically contains more particles during the beginning of filter backwash than at the end of the backwash process. Equalization can allow the spent filter backwash to be mixed (if mixing is provided in the equalization basin) and of a more consistent quality, in addition to controlling the flow. A more consistent recycle stream, both in quantity and quality, will allow for consistent chemical feed operation.

- Equalization can allow a reduction in the size of a recycle stream treatment unit (if provided) by reducing the peak recycle stream flow.

Equalization basins can be operated such that settling of particles can occur. Chapter 10 has more information on treatment through sedimentation.

Example 9-1. Evaluating Recycle Practices

Note: The following example is intended to illustrate how a system or State could evaluate recycle practices and resulting modifications. This example is not intended to establish plant operation or modification criteria.

Using the example and information for the 3.0 MGD plant presented in Appendix C, recycle practices were evaluated. Following is a quick summary of the plant information:

- Plant design flow: 3.0 MGD (2,080 gpm);
- Observed Peak Plant Influent: 2,500 gpm, consisting of 1,000 gpm raw water flow and 1,500 gpm spent filter backwash recycle flow; and,
- Typical Recycle Flow: 1,500 gpm- This flow represents spent filter backwash. Backwash is conducted at a rate of 15 gpm/ft^2 and each filter has a surface are of 100 ft^2. Filters are backwashed individually, four filters per night. Filters were backwashed for a duration of 15 minutes.

To evaluate their recycle practices, the system determined the percent of peak plant influent flow that was recycle flow on an instantaneous basis:

$$\%\ \text{Recycle flow} = \frac{\text{Recycle Flow}}{\text{Total Plant Flow}} = \frac{1{,}500\ \text{gpm}}{2{,}500\ \text{gpm}} = 60\%$$

The percent recycle flow on an instantaneous basis of 60% was rather high. Also, the peak plant influent flow of 2,500 gpm exceeds the plant design flow of 2,080 gpm. Further evaluation of plant flows during recycle indicated the design flow was typically exceeded during recycle events. The sedimentation basin and filters were both subjected to hydraulic surges during recycle. Turbidity and particle counts in the finished water were recorded at 30-second intervals as another means of evaluating impact of recycle practices. The results indicated substantial increases in both turbidity and particle counts during recycle events as opposed to periods where recycle was not occurring.

The system decided to install a lagoon to provide equalization. The lagoon was sized for two backwash volumes plus adequate freeboard. The lagoon was operated such that recycle flows were reduced from 1,500 gpm under direct recycle practices to 500 gpm. The lagoon was allowed to fill completely during backwash (15 minutes) to allow mixing and then pumped back to the plant before the next backwash commenced.

9.3 DISADVANTAGES

Few disadvantages are associated with flow equalization, however, as with any water treatment plant improvement, costs are a consideration. Multiple or redundant facilities may be required for adequate operation. Should the equalization basin not be operated on a continuous basis or operation suspended for an extended time (2 to 3 days), sludge may form in the bottom and be subsequently discharged to the plant influent. Sludge can taint the equalized flow, create objectionable tastes and odors, and carry other undesirable substances in the recycle stream. Another disadvantage is the required amount of space needed to accommodate the equalization basin.

Case Study (Myers, et al., 2000)
Four alternatives for handling spent filter backwash at the Ann Arbor WTP (50 MGD lime softening plant) were evaluated:

- Discharge to a storm sewer (equalization required to meet discharge permit flow requirements);
- Discharge to a sanitary sewer (equalization required by receiving wastewater plant);
- Discharge to a lime sludge lagoon; and,
- Equalization with recycle.

The system evaluated all four alternatives for feasibility, flexibility, and cost-effectiveness. For this particular plant, equalization with recycle in conjunction with discharge to the lime sludge lagoon was the most feasible and cost-effective option. Discharge to the lime sludge lagoon was recommended to be included as a back-up and added operational flexibility.

The conceptual equalization basin design included an equalization basin with a capacity of at least two backwash volumes and variable speed pumps to maintain the recycle flow between 5% and 10% of the raw water flow. Equalization of recycle provided the following benefits for the Ann Arbor WTP:

- Reduced the possibility of plant capacity exceedance during recycle;
- Reduced hydraulic surge through the plant, resulting in better settling and particle removal through the filters; and,
- Allowed for more consistent chemical feed, which resulted in more consistent water quality.

The conceptual design also included a recommendation that the equalization basin allow for future chemical addition if treatment becomes necessary in the future.

9.4 COSTS

Costs are associated with both the construction and operation and maintenance (O&M) of equalization basins. EPA developed a range of costs as part of the FBRR making process. Capital costs associated with equalization basins for design recycle flows into the equalization basins of 0.59 MGD and 83.59 MGD were $317,000 per MGD and $14,360 per MGD, respectively. O&M costs associated with equalization basins for design flows of 0.59 MGD and 83.59 MGD were $11,000 per MGD and $130 per MGD, respectively (EPA, 2000).

9.5 EVALUATING EQUALIZATION

Evaluating existing equalization or evaluating the need for equalization is an important step in examining the effects of recycle practices on a system, particularly when a plant is out of compliance (for example, unable to meet current turbidity standards). In order to evaluate if equalization improvements would be beneficial, the following information and plant performance data should be assessed:

- Evaluate the data collected on recycle practices, as discussed in Chapters 3, 4, and 5. Systems may want to examine frequency of recycle streams, recycle stream flow rates, backwash practices, and other information. Systems may be able to determine that plant capacity and individual treatment unit process loading rates are exceeded during recycle events. The system should then evaluate the impact to finished water quality as a result of recycle practices.

- Evaluate loading rates to treatment units (specifically clarifiers, sedimentation basins, and filters) during recycle events. Compare the loading rates during recycle events to the design loading rates. In order to ensure finished water quality meets all standards, the design loading rates should rarely be exceeded.

- Examine turbidity and/or particle count levels in finished water during recycle events. If turbidity and particle counts increase during recycle events, equalization may be one option to reduce these impacts (see Example 9-1).

- Examine daily operation information and assess the chemical feed practices during recycle events. If the system must modify chemical feed practices during recycle events, equalization may allow a more consistent chemical feed practice.

Again, equalization can allow the recycle stream to be returned at a more controlled rate and at a more consistent quality. As the system evaluates equalization, treatment options may also be considered. Chapters 10 provides more information on treatment for recycle streams. If treatment is not installed at the time the equalization units are installed, the system may want to allow room in the design for future treatment.

Case Study (Bashaw, et al., 2000)

The James E. Quarles WTP is a 64 MGD conventional filtration treatment plant located in Marietta, Georgia. The recycle practices were evaluated as part of the expansion process (upgrade to a capacity of 96 MGD) and recycle stream equalization and treatment alternatives were investigated. As seen in Figure 9-2, the existing system recycles spent filter backwash, thickener supernatant, filtrate, and filter-to-waste. All recycle streams are treated in a clarifier, equalized in a recycle tank, and then recycled to the raw water reservoir.

Four alternatives were evaluated for the recycle streams:

1. Adding polymer to flocculate the solids in the spent filter backwash water before settling. Jar tests were conducted to determine the type and dose of polymer needed.

2. Equalizing backwash flows and thickener overflows prior to settling. Flows to the clarifier during backwash were 2.7 times the average flow to the clarifier. Equalization would provide a consistent flow to the backwash clarifier for better detention and treatment. Also, the suspended solids in the spent filter backwash varied greatly over the backwash cycle. With mixing the full backwash flow volume in the equalization tank, a more uniform concentration of solids is obtained. The added benefit of mixing is that the polymer feed rate could be maintained at a more uniform rate.

3. Discharge filter-to-waste flows downstream of the clarifier. Since filter-to-waste contains almost no solids, little treatment is accomplished in the clarifier. By-passing the clarifier reduces the loading to the clarifier and provides better detention and treatment (removal of solids) of spent filter backwash flow.

4. Provide additional treatment after the clarifier.

The following options were selected for final design and are presented in Figure 9-3:

- Two new equalization tanks will be installed to receive spent filter backwash and thickener supernatant. The equalization tanks were designed to accommodate two backwash volumes plus thickener overflows. Each tank will be equipped with submersible mixers for blending contents and with vertical, mixed flow transfer pumps that will discharge to a flocculation tank.

- The discharge piping from the equalization tanks will be equipped with polymer feed injection capabilities.

- A two-stage flocculation tank will be installed downstream of the equalization tanks and will provide 10 minutes of detention time at peak flow rate.

- Filter-to-waste flows will be discharged downstream of the clarifier.

- The existing clarifier capacity will not be modified due to the elimination of filter-to-waste flows and longer filter runs (to be achieved with deep-bed filters that will be installed as part of the plant upgrades). The clarifier will be able to provide 4.2 hours of detention time.

- Treatment of the flow exiting the clarifier was not included as part of the final design, but the final design allows for installation of treatment if needed in the future.

Figure 9-2. Existing Layout of James E. Quarles Water Treatment Plant

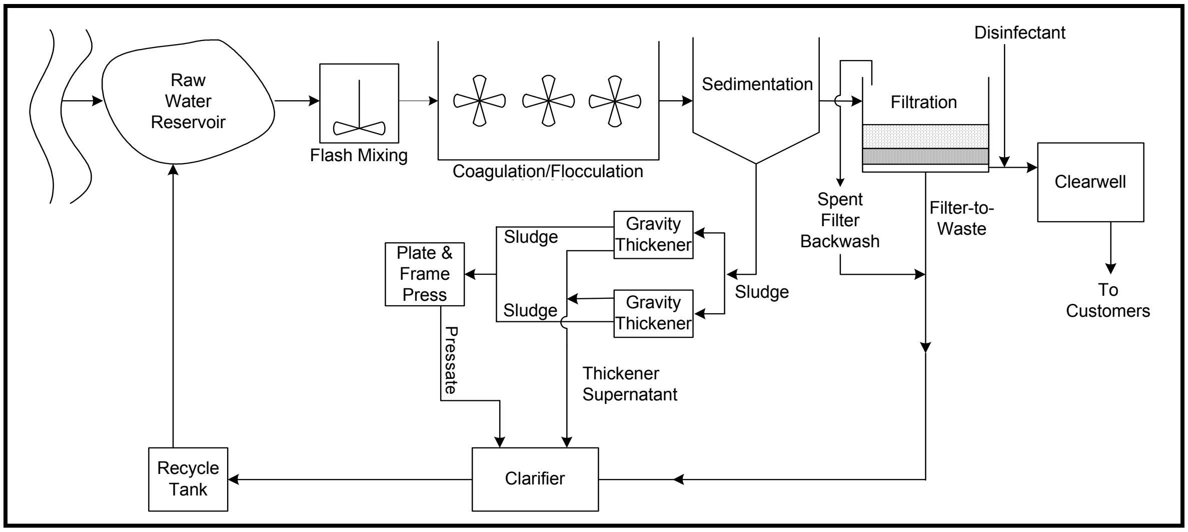
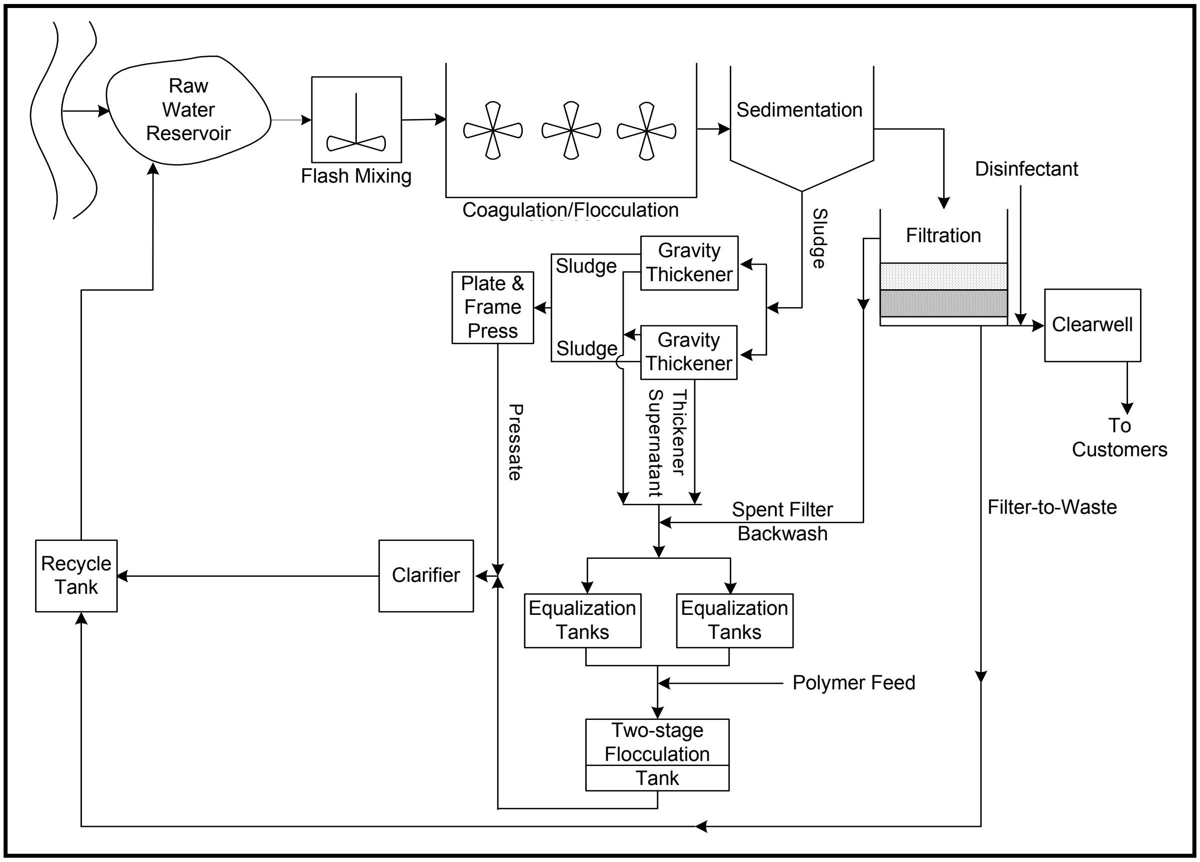


Figure 9-3. Proposed Improvements for Recycle Streams at the James E. Quarles Water Treatment Plant



9.6 REFERENCES

AWWA. 1999. *Water Quality and Treatment- Fifth Edition*. McGraw Hill, Inc. New York, NY.

Bashaw, W., T. Ginn, and R. Thomson. 2000. Design for Reclaiming Filter Backwash Water at the James E. Quarles Water Treatment Plant. Proceedings from the AWWA Annual Conference. Denver, CO.

Cornwell, D.A., and R.G. Lee. 1994. Waste Stream Recycling: Its Effect on Water Quality. Journal AWWA. 86(11) p50-63.

Kawamura, S. 2000. *Integrated Design of Water Treatment Facilities- Second Edition*. John Wiley & Sons, Inc. New York.

McGuire, M.J. 1997. (Draft) Issue Paper on Waste Stream Recycle and Filter-to-waste in Water Treatment Plants. Prepared for AWWA Technical Work Group.

Myers, T., J. Skadsen, and L. Sanford. 2000. Coping with Filter Backwash Recycle in Water Treatment. Proceedings from AWWA Annual Conference. Denver, CO.

Petersen, D. W., and B. Calhoun. 1995. Do You Recycle? Results of AWWA's Recycle Practices Survey. AWWA Annual Conference.

SPEHM (Great Lakes- Upper Mississippi River Board State Public Health and Environmental Managers). 1997. Recommended Standards for Water Works ("Ten State Standards"). Health Education Services. Albany, NY.

U.S. EPA. February, 2000. Cost and Technology Document for the Proposed Long Term 1 Enhanced Surface Water Treatment Rule and Filter Backwash Recycling Rule. Office of Ground Water and Drinking Water.

10. TREATMENT OF RECYCLE STREAMS

10.1 INTRODUCTION

Residual streams are often high in particulates, solids, and other contaminants. It may be necessary to treat residual streams prior to recycling so finished water quality is not compromised. An AWWA FAX survey taken in 1998 found that the majority of systems that recycle (approximately 70%) treat and/or equalize the stream prior to its return to the main treatment train (AWWA, 1998). The most common type of treatment is sedimentation. See Table 10-1 for the results of the AWWA FAX survey.

The FBRR does not require treatment of recycle streams beyond returning flows through the processes of a system's existing conventional or direction filtration system. However, EPA recognizes that additional treatment of recycle streams may be appropriate to reduce risks of microbial contamination and optimize the operational performance of the system. As systems and States begin to evaluate recycle practices, they may decide that treatment of recycle streams or modifications to existing recycle stream treatment processes is warranted.

Table 10-1. Results of AWWA FAX Survey on Systems that Recycle

TREATMENT TYPE	PERCENTAGE OF SYSTEMS
No Treatment	30
Sedimentation	38
Equalization	14
Sedimentation and Equalization	10
Lagoon	3
Other	5

Some systems may decide that recycle of residual streams is not cost-effective and may elect to dispose of residual streams. Disposal of residual streams may need to meet requirements under other Federal and State statutes and regulations. Some options that may be available include:

- Discharge to the sanitary sewer;
- Discharge to a surface or ground water body; or,
- Irrigation/land application.

Systems should check with their State and EPA regional offices to determine what restrictions or permit requirements apply to any of these disposal options. This document will not cover disposal options.

This chapter presents a description of recycle stream treatment concepts, the advantages and disadvantages associated with treatment, guidelines for treatment, methods for assessing existing recycle stream treatment or the need for treatment, and a brief description of different treatment options. Case studies are also provided that give examples of different recycle stream treatment options.

10.2 ADVANTAGES

Treatment processes for recycle streams that are properly designed and operated can reduce levels of *Cryptosporidium* and *Giardia*, contaminants of concern in recycle streams. Treatment processes can also be designed and operated to remove other contaminants, such as solids, particulates, DBP precursors, TOC, aluminum, iron, and manganese. These contaminants can create aesthetic and health issues in the finished water if not removed from recycle streams. Other benefits of treatment are as follows:

- Treatment of recycle streams may be cheaper and less time- intensive for the operator than modifying main treatment train processes during recycle events. Because both quantity and quality of plant influent change during recycle events, operators may need to modify chemical feed processes and other main treatment plant processes to ensure that finished water quality is not compromised. Treatment of recycle streams can allow more consistent operation of the main treatment train processes.

- Treatment of recycle streams can reduce particle loading on sedimentation basins (in conventional filtration plants) and filters in the main treatment train, thus possibly extending the useful life of these units.

<u>Benefits of Treating Recycle Streams</u>

- ✓ Removal of contaminants, particularly *Cryptosporidium* and *Giardia.*
- ✓ Allows more consistent operation of main treatment train, resulting in saved money and operator time.
- ✓ May extend useful life of sedimentation basins and filters in main treatment train.

It may be necessary to equalize flow in addition to providing treatment to control the recycle stream flow. The use of equalization may also reduce the size of the treatment unit required to handle the recycle flow.

10.3 DISADVANTAGES

There are some disadvantages associated with treatment of recycle streams. As with any other treatment plant improvement, more equipment requires more maintenance. Again, when compared to other residual management options (such as disposal), the O & M of treatment units may be a more cost-effective option.

10.4 COSTS

The costs will vary depending on the type of treatment, flows, level of treatment, and other site-specific issues. However, treatment may be cheaper than other alternatives (such as discharge to a surface water body or wastewater treatment plant). EPA estimated a sedimentation basin with polymer feed and tube settlers to have a capital cost of $228,000 and $1,560,000 for design loading rates to the sedimentation basin of 0.022 MGD and 19.87 MGD, respectively (EPA, 2000). Annual operation and maintenance costs were estimated to be $4,600 and $34,700 for design loading rates to the sedimentation basin of 0.022 MGD and 19.87 MGD, respectively (EPA, 2000).

10.5 RECOMMENDED DESIGN GOALS

The FBRR does not provide specific requirements for treatment. Some States and professionals have developed treatment guidelines that are presented for consideration in the following sections. Systems should check with their State on specific treatment requirements or guidelines when considering treatment for recycle streams.

10.5.1 Ten States Standards

The Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers, (or Ten States Standards) (SPHEM, 1997), recommend that spent filter backwash be returned at a rate less than 10% of the raw water flow entering the plant. Spent filter backwash should not be recycled when raw water contains excessive algae, when finished water taste and odor problems occur, or when trihalomethane levels in the distribution system exceed allowable levels.

10.5.2 California

California recommends that treatment plants establish an operational goal for turbidity of less than 2.0 NTU for recycled spent filter backwash and other recycle streams. If this turbidity limit cannot be achieved, the system should treat the recycle stream to a quality equal to the average raw water quality. In addition, new facilities should remove 80% of solids before recycle and the recycle flow should be less than 10% of the plant flow.

10.5.3 Maryland

Maryland has a policy for both new and existing surface water treatment plants. New surface water plants should provide treatment for recycle streams. Existing systems can continue to recycle under the following controlled circumstances:

- The recycle ratio should be less than 5%;
- A minimum of two hours of polymer-enhanced sedimentation should be provided; and,
- Sedimentation should be provided with very low, continuous overflow rates (0.3 gpm/ft^2).

10.5.4 Ohio

Ohio recommends recycle streams be treated prior to their return to the main treatment train. In addition, the recycle flow should be less than 10% of the plant flow.

10.5.5 Cornwell and Lee (1993)

Based on an evaluation of eight systems, Cornwell and Lee (1993) made the following observations which may minimize impacts on finished water quality:

- Equalization should be provided so that recycle is continuous rather than intermittent.
- The recycle stream should be properly treated for cyst removal with an 80 percent treatment efficiency.
- Overflow rates from the backwash water clarifier should be less than 0.07 gpm/ft^2 to achieve the 80% treatment efficiency (when chemical addition is not used).

10.5.6 United Kingdom Water Industry Research (UKWIR) (1998)

The UKWIR developed a water treatment guidance manual that addresses recycling of spent filter backwash water (Logsdon, et al., 2000). The UKWIR recognized the risk posed by concentrated suspensions of *Cryptosporidium* oocysts in spent filter backwash. UKWIR developed the following guidelines to prevent passing oocysts into finished water:

- Backwash water should be settled to achieve a treatment objective of greater than 90% solids removal before recycling.

- Recycle flows should be at less than 10% of raw water flow and continuous rather than intermittent.

- Continuous monitoring of the recycle stream with on-line turbidimeters should be conducted.

- Jar tests should be conducted on plant influent containing both recycle streams and raw water to properly determine coagulant demand.

- Polymers should be considered if high floc shear or poor settling occurs.

- The recycle of liquids from dewatering processes should be minimized, particularly when quality is unsuitable for recycling.

10.6 EVALUATING TREATMENT

The evaluation of existing treatment processes used for recycle streams or evaluating the need for treatment is an important process. The following checklist can be used to conduct the evaluation:

- ✓ Compare finished water quality during periods of recycle to periods when recycling is not occurring. Contaminants of concern are *Cryptosporidium*, *Giardia*, DBPs, DBP precursors, TOC, iron, aluminum, and manganese. Other water quality parameters that could be examined are pH, turbidity, particle counts, and taste and odor. If contaminant concentrations increase during recycle events as compared to periods when recycling is not occurring, then treatment (or improvements to existing recycle stream treatment processes) may be warranted. Also, if treatment technique violations or MCL violations occur during recycle events, then treatment (or improvements to existing recycle stream treatment processes) should seriously be considered.

- ✓ Perform a similar process as previously described on individual treatment unit processes in the main treatment train for more information on how individual units are being impacted during recycle events.

- ✓ Examine flows and hydraulic loading rates during periods of recycle events. Make sure that hydraulic surge, plant capacity exceedance, and/or hydraulic loading rates of individual treatment units in excess of design rates are not occurring.

As a system considers treatment options for recycle streams, the following items should be considered:

- ✓ Estimate or measure the amount of residuals produced by the plant. Mass balance calculations can be used to determine residual stream loading rates. The liquid and solid residual stream quantities (peak and overall volume) should be obtained to properly size treatment units.

- ✓ Consider the benefits of adding equalization. Equalizing the recycle stream may allow a reduction in the required treatment unit loading rates.

- ✓ When designing any treatment process, allow for future modifications- flexibility is key.

The AWWA *Self-Assessment of Recycle Practices* provides additional information on how to evaluate existing recycle stream treatment facilities or the need for treatment (AWWA, 2002).

The case study (Bashaw, et al., 2000) presented in Chapter 9 (page 65) provides information on how treatment and equalization options for recycle streams can be evaluated. The following case study presents additional information on evaluating treatment.

Case Study (Nielson, et al., 1995)

The Cleveland Division of Water (CDW) is upgrading one of its four water treatment plants (Crown WTP) from 50 MGD to 125 MGD capacity. The upgrade will involve modifying existing conventional unit treatment processes (coagulation, flocculation, sedimentation and filtration) to high-rate processes. As part of the upgrades, the system evaluated recycle practices. Figure 10-1 contains a schematic of the existing system and residual streams. The Crown WTP handles residual streams as follows:

- Spent filter backwash is either equalized and recycled to the head of the plant or sent to the gravity thickeners for ultimate discharge to Lake Erie.
- Solids are thickened, dewatered, and the filter cake disposed in sanitary landfills. The pressate is sent to the sanitary sewer after pH adjustments. Thickener supernatant is discharged to Lake Erie.

In evaluating recycle practices, CDW developed a residual solids management plan. CDW considered the following to develop this plan:

- Existing data on both the quantity and quality of residual streams. An important part of this process was identifying additional data collection needs.
- Solids production throughout the treatment process. A mass balance was conducted to identify the point in the treatment train where solids were generated. The mass balance showed how residual solids were processed, and checking the results against existing data enabled the identification of erroneous data. Average quantity and average quality of residual streams in addition to maximum day, maximum week, and maximum monthly values were calculated.
- Cost and non-cost issues associated with each residual solids management alternative.
- The impacts on individual treatment processes or operational practice in the main treatment train during recycle events. For instance, the TOC concentrations in water leaving clarifiers and filters during recycle events was compared to periods of no recycling. In addition, DBP levels in the distribution system were monitored.
- Future needs and flexibility for future upgrades and expansions.

CDW selected the following options for residual solids management as part of the overall plant upgrade (see Figure 10-2):

- Filter-to-waste capabilities would be installed and filter-to-waste streams would be recycled directly to the head of the plant. This alternative was selected based on costs, the fact that the stream would be treated again by plant processes, and that the stream's quantity and quality would have little impact on operation of the expanded WTP.
- Spent filter backwash would be discharged to Lake Erie after being equalized and clarified. Spent filter backwash would not be recycled (and would not undergo chemical treatment). This alternative was selected to reduce solids loading on treatment units and eliminate water quality issues in the finished water (taste and odor, iron, manganese, TOC, DBP and DBP precursor concentrations, *Giardia,* and *Cryptosporidium*).

Figure 10-1. Crown Water Treatment Plant – Existing

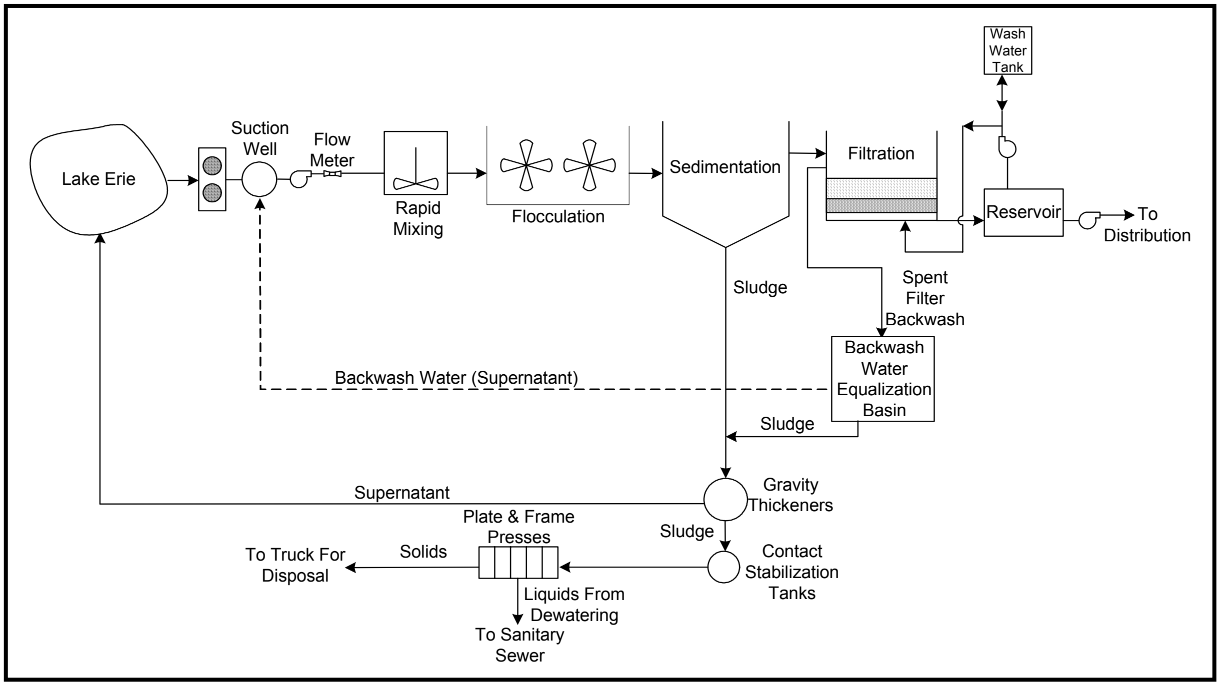
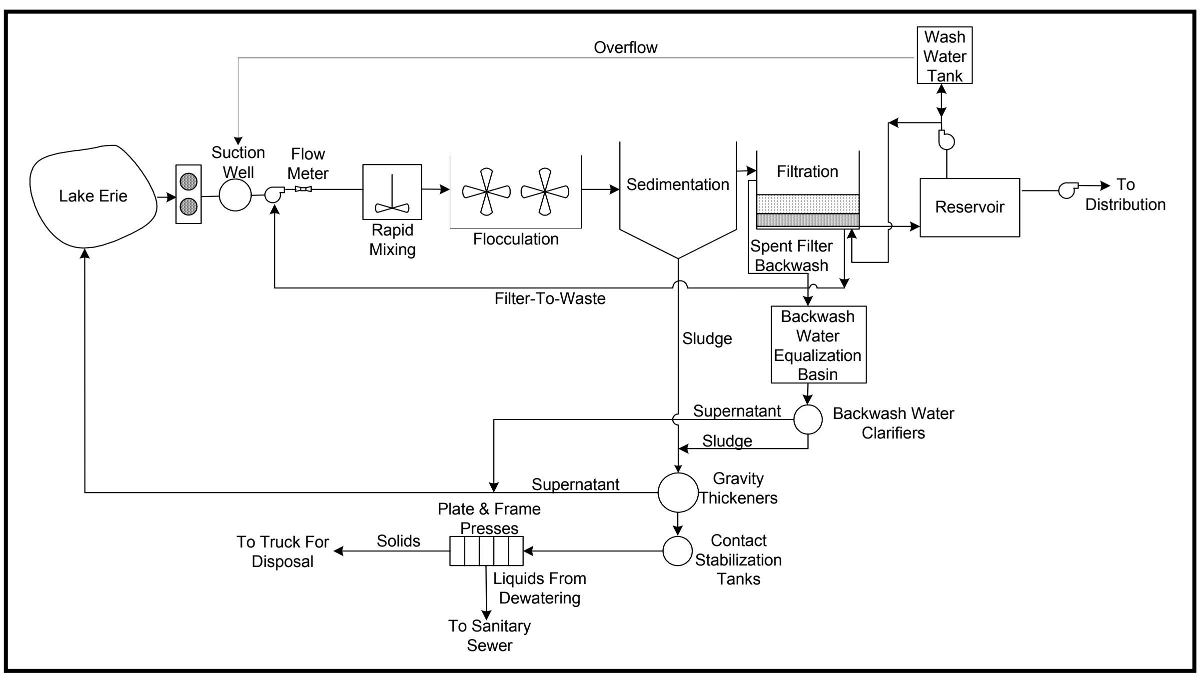


Figure 10-2. Crown Water Treatment Plant – Proposed



10.7 TREATMENT OPTIONS

Treatment options for recycle streams are similar to the treatment options used for raw water at a water treatment plant. Treatment can consist of solids removal and/or disinfection. There are several options for solids separation from spent filter backwash water and other recycle streams: sedimentation, granular-bed filtration, and membrane filtration. Disinfection can also be employed for treatment of recycle streams to provide inactivation of pathogens. This chapter presents general treatment capabilities, advantages, disadvantages, operational considerations, and case studies (where available) for each treatment type. Not all aspects of recycle stream treatment are discussed.

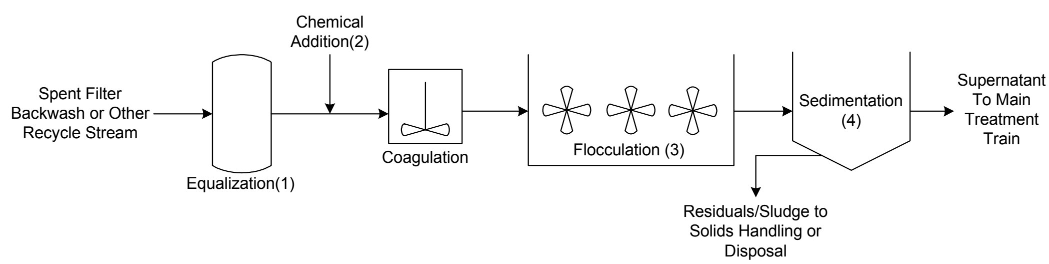
10.7.1 Sedimentation

<u>General</u>

Sedimentation is a process for removal of solids from liquids either by gravity or physical separation. The use of sedimentation on recycle streams has been shown to be effective in removing particles and pathogens. An example of a typical sedimentation process for recycle streams (in addition to the main treatment train) is shown in Figure 10-3.

Sedimentation can either be batch-flow or continuous-flow. Batch-flow sedimentation processes combine equalization and treatment in a single unit, and for this reason, are commonly used to treat recycle streams. Generally, batch flow systems consist of one or more basins sized to receive a large volume of flow, such as spent filter backwash water, in a short period of time.

Figure 10-3. General Sedimentation Process for Treatment of Recycle Streams (In Addition to the Main Treatment Train)



(1) Equalization is optional except for continuous-flow sedimentation.

(2) Chemical addition can consist of a coagulant or polymer. Chemical addition is optional but has been shown to improve treatment of the recycle stream.

(3) Flocculation is optional but may enhance treatment.

(4) Sedimentation unit can consist of a circular clarifier, a unit equipped with tube or plate settlers, or a solids contact clarifier.

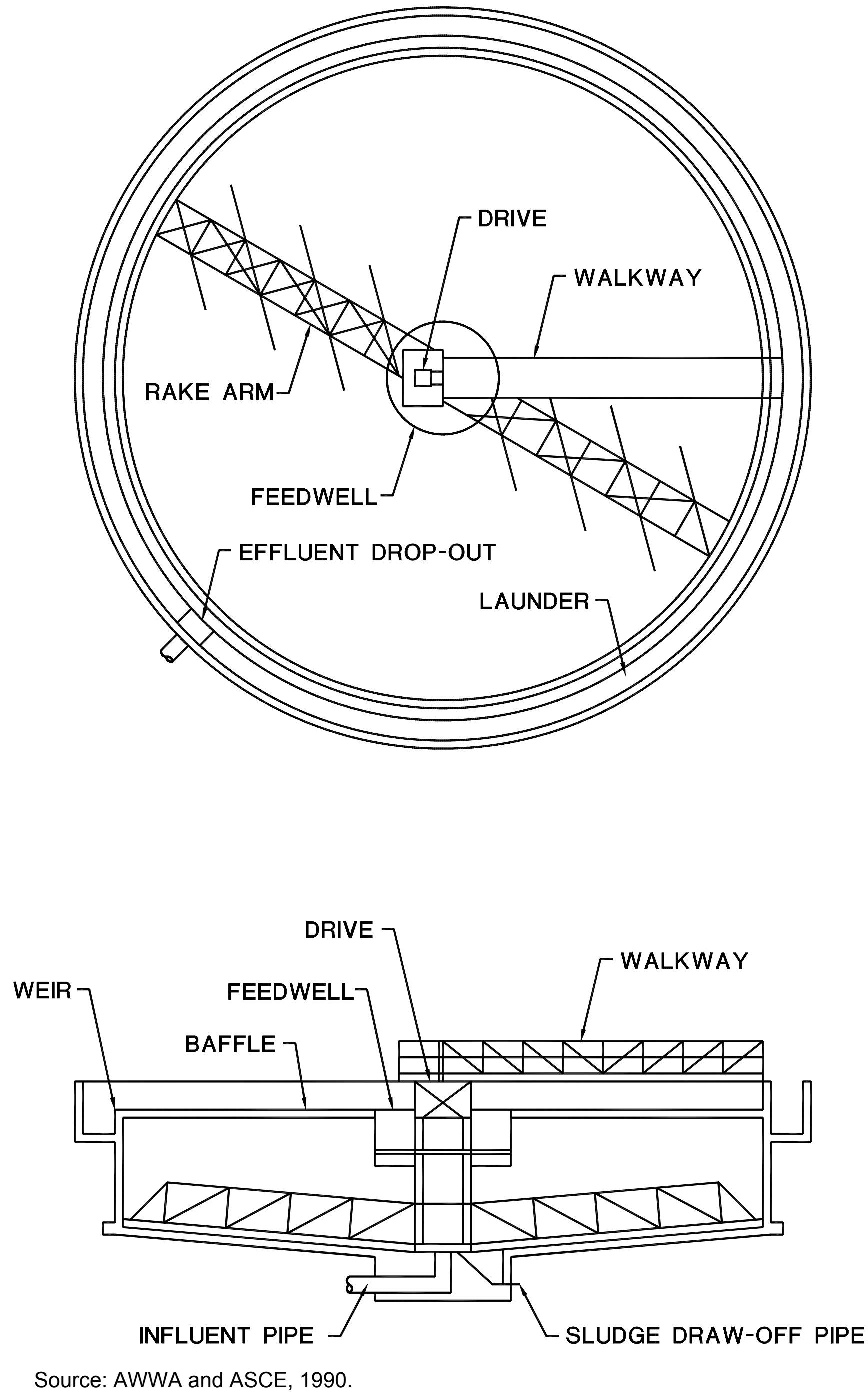
Continuous flow sedimentation basins (both circular and rectangular), similar to those used to treat the main process flow, may also be considered for recycle stream treatment. It is best to avoid operating continuous-flow systems intermittently. If generation of the recycle stream is too variable, then accommodation in the design for operational flexibility (e.g., variable flow rate from pumps) may be needed to maintain continuous flow.

A sedimentation basin typically consists of an inlet, an outlet for clarified water, and a solids collector and removal mechanism (see Figure 10-4). Clarified water may be removed by a floating decanter or from one or more fixed outlets above which all water is collected. The recycle stream can either be pumped or conveyed by gravity to the main treatment train. A pretreatment chemical may or may not be added to the flow before it enters the basin. The chemical mixing process could use a static in-line mixer or rapid-mix basin depending on the plant layout, hydraulic grade line, and capacity.

If recontamination of the recycle flow by the settled sludge is a concern, the system should employ a method to remove the solids frequently. This contamination could lead to objectionable taste, odors, and other undesirable qualities in finished water. Sludge removal should also be conducted at an appropriate frequency to avoid compromising the active storage and treatment capability in the sedimentation basin. Systems should use sedimentation basins with automatic sludge removal since manual cleaning has been shown to release significant amounts of manganese, iron, and TOC into the supernatant (Cornwell and Lee, 1993). For continuous-flow units, sludge removal should be automatic and continuous so as not to disrupt the continuous-flow process.

The remainder of this section provides information on three types of sedimentation processes: lagoons, chemical additions, and tube and plate settlers. Advantages and disadvantages of sedimentation are also provided and case studies of each type of sedimentation are included to further describe each.

Figure 10-4. Circular Radial-flow Clarifier



Source: AWWA and ASCE, 1990.

Lagoons

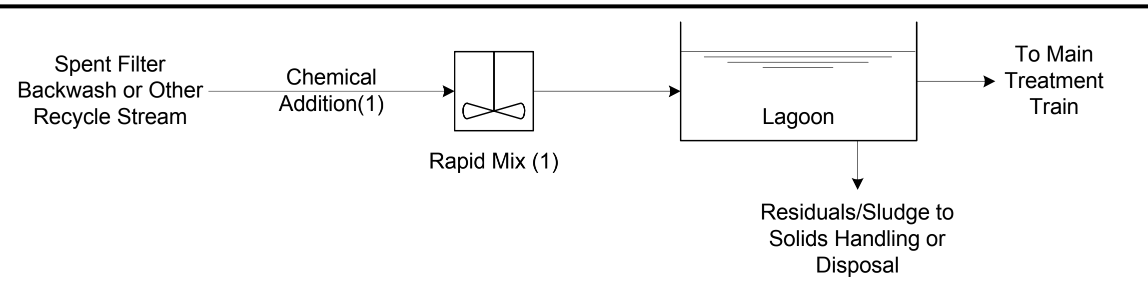
Where adequate land is available, lagooning may be an economical alternative for treating spent filter backwash water and other recycle streams. Lagoons are relatively simple earthen structures for sedimentation. They have an inlet for the recycle stream, an outlet for the settled water, access to remove the settled solids, and (typically) drain and overflow provisions. A generic schematic diagram for treating recycle streams in lagoons is presented in Figure 10-5.

Lagoons do not require a separate tank to equalize the incoming flow. However, the potential mixing effect created by a high rate of incoming flow does require special consideration. To minimize resuspension of settled solids by the influent, Kawamura (2000) recommends that the lagoon be sized to contain at least 10 backwashes. A series of three or more smaller lagoons, each holding three or four filter backwash volumes, may also be used.

All lagoons should be elongated in shape to maximize the distance between the inlet and outlet, and the inlet should be provided with an energy dissipator. The outlet should be designed to decant as well as drain the lagoon, and should act as an overflow facility. Depending on the design conditions, either a mixing device or a static in-line mixer that uses the turbulence of the influent flow may provide chemical mixing when chemical addition is used.

Additional considerations when using lagoons are the release of contaminants by the settled sludge, contamination by outside sources, or contamination to the local environment from the lagoon. Lagoons are often designed for infrequent sludge removal by equipment such as a front loader. If recontamination of the recycle flow from constituents of the stored sludge (e.g., manganese) is a concern, then the design should incorporate a method of frequent sludge removal. Also, contamination of the recycle flow by sources outside the lagoon, such as chemical delivery trucks, should be considered. The lagoon should be lined with an impervious liner to prevent contamination to the ground water. Another option is to install underdrains to collect leachate. Underdrains may be included in the lagoon design to collect and recycle the leachate, although quality of this water may be of concern. All of these considerations add costs to the installation of a lagoon.

Figure 10-5. Lagoon Process for Recycle Streams



(1) Chemical addition and rapid mix are optional but may enhance treatment of recycle stream.

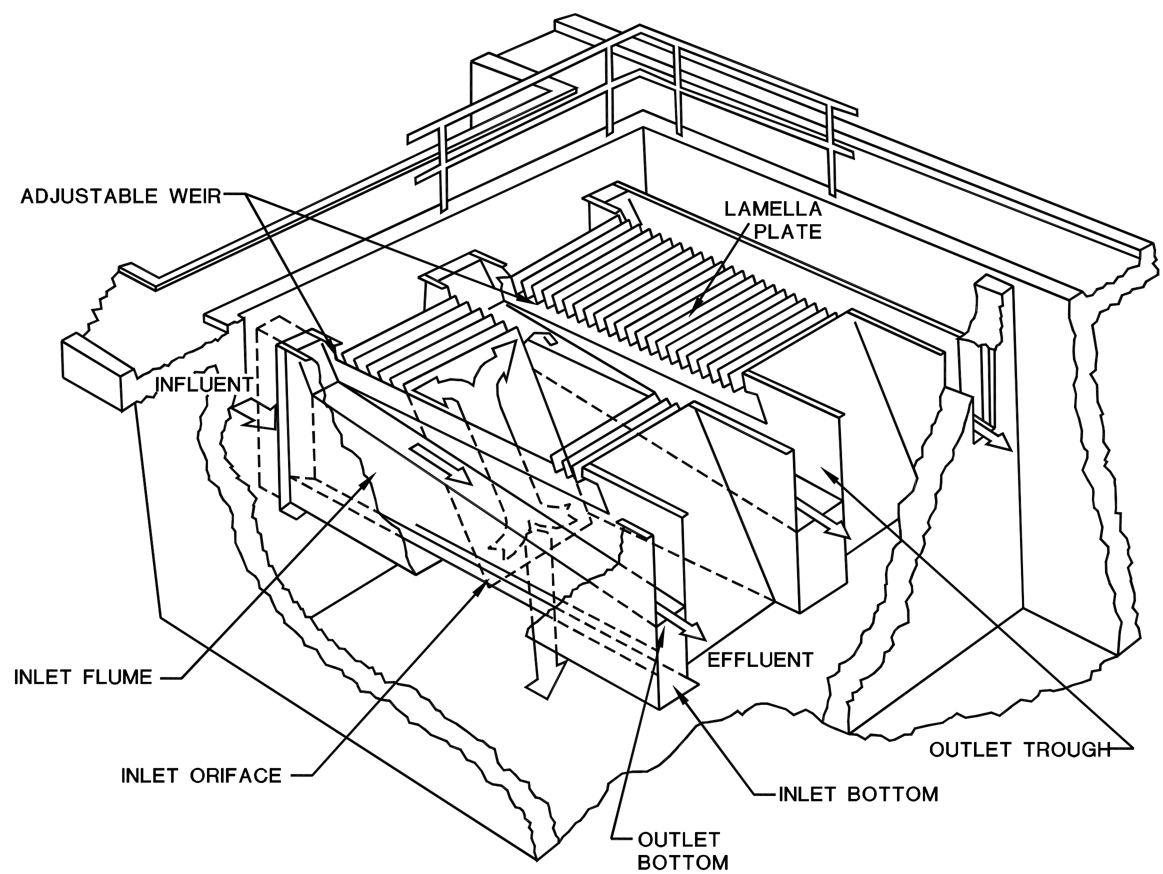
Chemical Addition

The sedimentation process can be enhanced by the addition of chemicals. The use of flocculation prior to sedimentation is recommended when the settling characteristics of the spent filter backwash water are less than desired unless conventional flocculation and sedimentation are implemented (Kawamura, 2000). A schematic diagram of this treatment train is shown in Figure 10-3. The optimal chemical type and dose should be determined based on jar tests and the particular application. The overflow rate should also be based on the desired amount of sedimentation. The case studies presented in this section demonstrate the benefits that can be realized with chemical addition.

Tube and Plate Settlers

Inclined tubes and plates can be used in sedimentation basins to allow greater loading rates than conventional sedimentation. Figure 10-6 shows a typical plate settler design. This technology relies on the theory of reduced-depth sedimentation: particles need only settle to the surface of the tube or plate for removal from the process flow. Generally a space of two inches is provided between tube walls or plates to maximize settling efficiency. The typical

Figure 10-6. Typical Plate Settler Design



Source: AWWA and ASCE, 1998.

angle of inclination is about 60 degrees, so that settled solids slide down to the bottom of the basin. The disadvantages of these processes are that the tubes and plates can become easily clogged in some applications, can serve as a surface for biological growth (often algae when uncovered), and can be difficult to clean. Uneven flow distribution at the inlet and inadequate spacing of the discharge flumes can create inefficiencies.

A generic process schematic diagram for tube and plate settling is shown in Figure 10-3. Flocculation may be beneficial for recycle streams, depending on the settling characteristics of the recycle stream. The type of chemical mixing used, if necessary, depends on factors such as the plant layout, hydraulic grade line, and design flow rate.

Tube and Plate Settler Case Study (Ashcroft, et al., 1997)

A full-scale plant was using both tube and plate settlers. The tube settlers were installed in an existing circular clarifier and the plate settlers were installed in a new circular basin. The spent filter backwash water was pumped to the clarifiers from an equalization basin. No separate flocculation facilities were provided.

Both clarifiers consistently achieved greater than 90% reductions in turbidity and 2- to 5-μm particles with the addition of 0.7 mg/L anionic polymer. Treated turbidities were in the range of 2.0-3.6 NTU. Loading rates of 0.20-0.38 gpm/ft^2 were tested with little variation in performance. These loading rates are very low when compared to the typical rates of 2-3 gpm/ft^2 used in treating main process flows.

TTHMs and TTHM formation potential were also measured in the untreated and treated backwash waters. TTHMs were about 40 μg/L in the untreated water, and were not significantly affected by treatment. Total TTHM formation potential, however, was reduced by 45% to 55%, to approximately 100 μg/L. Little difference between the performance of the tube and plate settlers was shown.

Plate Settler Case Study (Narasimhan, 1997)

Two full-scale WTPs in metropolitan Phoenix, AZ- the Verde and Mesa plants- have plate-settling facilities that include polymer feed, rapid mix, flocculation, and plate settlers to treat recycle streams. At the Verde plant, a combination of spent filter backwash water, centrate, and gravity thickener overflow is treated; the Mesa plant treats only spent-filter backwash water. Facilities at both plants are operated continuously for six to eight hours per day.

Results from the Verde plant showed consistent treated turbidities of less than 25 NTU with the addition of 0.4 mg/L polymer and loading rates of up to 0.39 gpm/ft^2 (0.95 m/h). At the Mesa plant, treated turbidities were consistently below 20 NTU at loading rates of up to 0.6 gpm/ft^2. Polymer addition did not have much impact on turbidity removal at Mesa. Turbidities of the influents to the recycle treatment facilities at both plants ranged from below 20 NTU to about 100 NTU.

Tube Settler Case Study (Cornwell, et al., 2001)

A full-scale study on a Central Utah Water Conservancy District direct filtration plant was conducted. The plant was equipped with a sidestream plant to treat spent filter backwash prior to recycle. The sidestream was equipped with rapid mix, flocculation, and sedimentation with tube settlers. The tube settler overflow rate range investigated in the plant was 0.19 to 0.37 gpm/ft^2 and treatment was compared with and without polymer. Average settled turbidities without and with polymer were 2.4 NTU and 1.2 NTU, respectively. The addition of 0.1 mg/L of the appropriate polymer resulted in 50% reduction in average settled turbidities. This study also demonstrated that the turbidity levels from the sedimentation basin increased steadily as the overflow rate was increased from 0.19 to 0.37 gpm/ft^2 when no polymer was added. In contrast, the turbidity levels from the sedimentation basin only increased marginally as overflow rates were increased when polymer was added.

Plate Settler Case Study (Hess, et al., 1993)

Plate settlers were used to treat spent filter backwash water from a direct filtration plant. The backwash solids were of low density, were highly organic, and had poor settling characteristics. The plate settlers were operated at a maximum of 0.25 gpm/ft^2 with polymer addition. The treated water averaged less than 1.5 NTU and was returned to the headworks, where the raw water is typically less than 1.0 NTU.

Advantages

When properly designed and operated, the sedimentation unit can remove significant amounts of turbidity and particles, including *Cryptosporidium* and *Giardia*. If overflow rates are low enough, additional contaminants, such as disinfection byproduct precursors, may also be removed.

Disadvantages

If not properly designed and operated, solids removal capabilities will be compromised. Adequate equalization and storage should be provided to avoid this situation. Sludge removal should be conducted frequently enough to avoid compromising the active storage and treatment capability of the sedimentation basin.

Sedimentation with Polymer Addition Case Study (Moss, 2000)

The Salt Lake City Public Utilities Department (SLCPUD) examined optimization of its recycle practices. SLCPUD recycles spent filter backwash at all three of its plants. The spent filter backwash passes through clarifiers prior to its return to the plant headworks. Turbidity levels in filtered water did not exhibit significant changes during recycle; however, increased particle counts in filtered water were very noticeable during recycle events. At one plant, particle counts in the filtered water (measured as particles greater than 2 µm) went from approximately 1,800 prior to recycle to greater than 8,000 during recycle. Recycle of spent filter backwash also resulted in an increase of *Cryptosporidium* and *Giardia* in plant influent as compared to raw water. SLCPUD examined a combination of treatment strategies to reduce the impacts of recycle on its plants. Optimization consisted of increasing settling time, polymer addition, adjusting rate of return at one of the plants, and adjusting coagulant dose at one of the plants in response to streaming current monitoring data. SLCPUD conducted jar testing to determine which polymer to feed to the spent filter backwash. A high charge anionic polymer was selected for two plants and a medium charge anionic polymer was selected for the other plant. The polymer dose at all plants was 0.1 mg/L. All plants exhibited a decrease in particle counts in filtered water due to optimization of recycle practices. Also, turbidity and TOC concentrations in the recycled spent filter backwash decreased as a result of optimization.

10.7.2 Microsand-Assisted Sedimentation

Microsand-assisted settling is not a new principle. The process has been used in the water treatment industry since the 1970's and has been identified by numerous names such as ballasted floc, ballasted sand, and Actiflo®. Microsand-assisted sedimentation relies on improved settling through the addition of microsand and a coagulant chemical to improve flocculation and clarification. The microsand is separated and recycled through the system numerous times. Figure 10-7 shows the typical process of microsand-assisted sedimentation. This process may have application in facilities that need clarification and do not have the space for conventional sedimentation or that need rapid startup clarification ability for variable source water qualities.

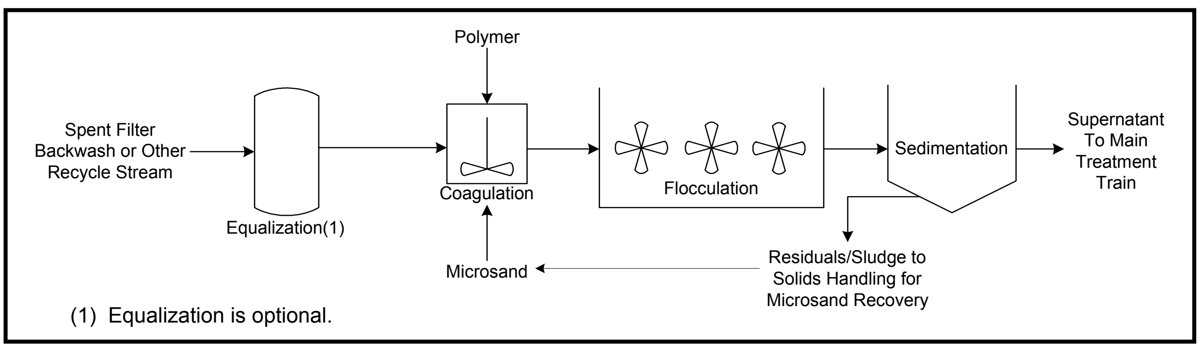
Advantages

According to Kawamura (2000) the advantages of this process are: requires a small footprint, has good performance, has a very quick process start up time, and may have reduced capital costs. As a result, systems may want to consider microsand-assissted sedimentation versus other sedimentation processes if space or money is limited.

Disadvantages

The disadvantages include heavy dependence on mechanical equipment and short processing time, dependence upon power, and may require higher dosage of coagulant.

Figure 10-7. Microsand-Assisted Sedimentation Process for Recycle Streams (In Addition to the Main Treatment Train)

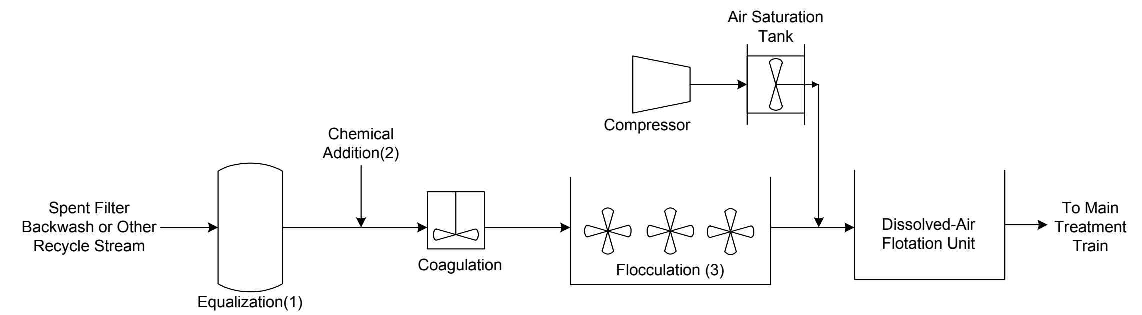


10.7.3 Dissolved-Air Flotation

Dissolved-air flotation (DAF) is most commonly used in two applications: potable water treatment as a clarification step prior to filtration, and wastewater treatment for sludge thickening. The DAF process is another form of solids separation and may be an appropriate technology for treating recycle streams.

In a typical water treatment system installation, DAF replaces sedimentation in a conventional treatment train. The upstream and downstream processes are similar; the raw water is coagulated and flocculated, and the DAF effluent is sent to the filters. A similar process train is likely to be used for treating recycle streams, as shown in Figure 10-8, where the treated stream is recycled to the head of the plant.

Figure 10-8. Dissolved-Air Flotation Process for Recycle Streams (In Addition to the Main Treatment Train)



(1) Equalization is optional but will allow reduction of dissolved-air flotation treatment unit size.

(2) Chemical addition is optional but has been shown to enhance treatment of the recycle stream.

(3) Flocculation is optional.

In the DAF process itself, a side-stream is saturated with air at high pressure and then injected into the flotation tank to mix with the incoming recycle stream. As the side-stream enters the flotation tank, the pressure drop releases the dissolved air. The air bubbles then rise, attaching to floc particles and creating a layer of sludge (also called float) at the surface of the tank. The float is removed either by a mechanical scraper or by flooding the tank over a weir. The clarified water is collected near the bottom of the tank.

DAF can be highly effective at removing low-density particles such as algae, protozoan cysts, coagulated natural organic material, and alum floc from low-turbidity, soft waters. In a bench-scale study on *Cryptosporidium* removal, DAF was shown to achieve at least 2-log removal of oocysts under most process conditions (Plummer, et al., 1995). In a pilot-scale study of DAF and lamella sedimentation, the average log removals by DAF for *Giardia* and *Cryptosporidium* were 2.4 and 2.1 respectively, compared to 1 to 1.2 and 0.91 to 1.1, respectively, for lamella sedimentation (Edzwald, et al., 2000). However, this study was conducted on a main treatment process rather than a recycle stream. These results were included in another study by Edzwald, et al., (2001). The same considerations for sludge removal, storage, and equalization apply to DAF, as discussed in Section 10.7.1.

Advantages

DAF has several advantages over sedimentation:

- *More compact:* DAF loading rates are high, so that much smaller tanks can be used than in sedimentation.

- *Shorter startup time:* The smaller tanks result in good effluent quality in less time.
- *Lower chemical dose:* In many cases DAF requires less coagulant than sedimentation.
- *Shorter flocculation time:* Flocculation times for DAF are normally one-half to one-fifth of those for sedimentation.
- *Thicker sludge:* The floated sludge from a DAF unit typically has a much higher solids concentration than does sludge from a sedimentation basin.

Disadvantages

The main disadvantage of DAF compared to sedimentation is that it requires more complex equipment, particularly the air saturation and recycle control equipment. A higher level of skill is needed to operate and maintain this equipment than is needed for equipment associated with sedimentation facilities.

As with sedimentation, the need for chemical pretreatment and flocculation prior to DAF treatment of the recycle stream is uncertain. DAF normally requires less coagulant and shorter flocculation times than does sedimentation, and particles in spent filter backwash water have already been coagulated and flocculated to some degree in the main treatment train. If DAF can provide adequate treatment without pretreatment, then DAF becomes a cost-effective option to treat recycle streams.

DAF Case Study (Cornwell, et al., 2001)

A bench-scale study was conducted using DAF with polymer addition to treat spent filter backwash. The pilot DAF plant could treat spent filter backwash at a rate between 36 and 54 gpm and had varying surface overflow rates and recycle ratio range capabilities. The spent filter backwash fed to the pilot plant had turbidity levels ranging from 30 to 300 NTU. The DAF was able to produce clarified effluent with turbidities of 1 to 2 NTU (99% or 2-log turbidity reduction) with 0.3 mg/L of polymer at surface overflow rates of 4 to 5 gpm/ft^2. A DAF recycle ratio of 10% was found to be adequate for effective treatment.

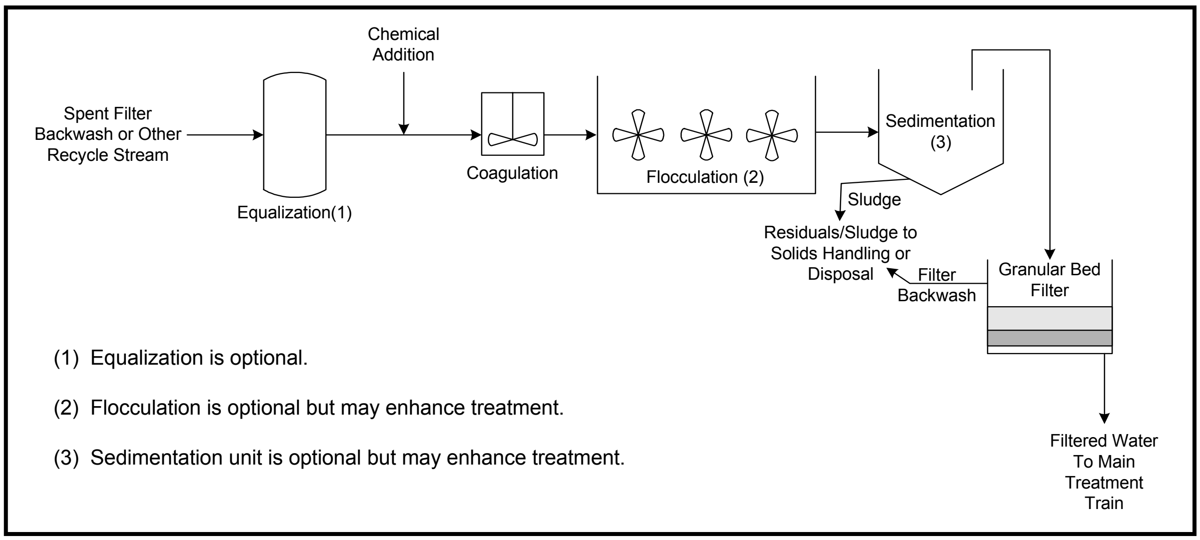
DAF Case Study (Lew and Patawaran 2000)

The Betasso Water Treatment Plant (Boulder, CO) selected DAF as the best treatment technology for spent filter backwash after assessing six alternative treatment types. The DAF process was able to achieve turbidity levels of 1 NTU on a consistent basis without extensive chemical manipulation. With consistent dosage of polymer, DAF was able to adsorb significant turbidity spikes and varying loading rates without compromising effluent water quality.

10.7.4 Granular Bed Filtration

Granular bed filtration may be an effective treatment method for spent filter backwash water and other recycle streams. Pretreatment by chemical addition with or without flocculation prior to the filter should be practiced. The high solids content of some backwash waters may result in unacceptable short filter runs, suggesting that clarification is needed prior to filtration, but higher-quality spent filter backwash waters may be quite amenable to filtration without sedimentation. A process schematic diagram for granular bed filtration, with pretreatment by chemical mixing, flocculation, and sedimentation, is shown in Figure 10-9. Pumping facilities may be required to convey the treated recycle stream depending on site-specific conditions.

Figure 10-9. Granular Bed Filtration Process for Recycle Streams (In Addition to the Main Treatment Train)



Advantages

The expected advantage of granular bed filtration over sedimentation and DAF is that it has a much higher rate of particle removal. Depending on water quality, pretreatment, filter media, and loading rates (among other factors), filtration of recycle streams may remove particles at or above the level achieved by the main treatment train.

Disadvantages

The disadvantages of filtration, compared to either sedimentation or DAF alone, are its high cost, process complexity, and greater volume of waste. Waste would be generated through the backwash of the recycle stream filter.

Granular Filtration Case Study (MacPhee, et al., 2000)

Several treatment scenarios were examined for spent filter backwash. The treatment scenarios consisted of sedimentation with polymer and DAF with polymer followed by granular media filtration. This treatment scenario provided 2.2 to 3.0 log reduction of turbidity and 2.4 to 4.4 particle log reduction of the spent filter backwash.

10.7.5 Membrane Filtration

A membrane treatment process, such as microfiltration (MF) or ultrafiltration (UF), is capable of very high levels of particle removal. MF has been used for a variety of industrial applications and, in recent years, has been used for particle removal in potable water treatment. Limited information is available on MF treatment of spent filter backwash water and other recycle streams, but research continues on this technology.

Microfilters provide an absolute barrier to particulates by straining them from the flow stream at the membrane surface. Nominal pore sizes for microfilters fall in the range of 0.05 to 5.0 µm. Microfilters with smaller pore sizes (≤0.2 µm) can remove virtually all bacteria and protozoa, including *Cryptosporidium* and *Giardia* (Jacangelo and Buckley, 1996). The removal of viruses is more highly dependent upon the specific virus, membrane, and water quality (Jacangelo and Buckley, 1996), though the removal of viruses may be less of a concern because of their high susceptibility to inactivation by most disinfectants.

Depending on the membrane and water quality, MF membranes can remove some natural organic matter (NOM), DBP, and TOC. The removal of NOM by MF membranes can also be improved by coagulation. NOM found in spent filter backwash water, having previously been coagulated to an extent, may be removed to a good degree by MF. Some membranes are susceptible to fouling by chemicals and chemical use should be carefully evaluated for each membrane type. A simple process schematic diagram for membrane filtration of recycle streams is shown in Figure 10-10. As noted above, microfiltration may require chemical pretreatment, depending on the recycle stream characteristics and treatment goals. Also, facilities for membrane cleaning would be required.

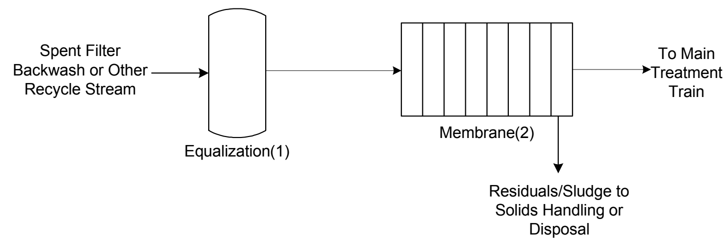
Advantages

One advantage of MF for recycle stream treatment is that it can normally treat wide variations in influent water quality with little or no adjustment to the process. Another advantage is that MF systems are compact and available as prefabricated, modular units that can easily be expanded. Also, hydraulic head is not typically “broken” in membrane systems, so a unit may be located at any elevation and require only one pumping facility.

Disadvantages

The primary disadvantage of a MF system, when compared to sedimentation or DAF, is the greater complexity of its equipment. Another disadvantage is that membranes are subject to fouling from bacteria, chlorine residual, coagulants, and polymers. The contaminants contained in the recycle stream may be substantial enough to foul the membranes. Therefore, extensive pilot testing should be conducted on the membrane for each type of recycle stream to evaluate potential fouling.

Figure 10-10. Membrane Treatment Process for Recycle Streams (In Addition to the Main Treatment Train)



(1) Equalization is recommended to provide some treatment (sedimentation) and reduce the size of membrane footprint.

(2) Depending on the type of membrane, pumps may be needed. Chemical pretreatment may be necessary to remove organics but chemicals may cause membrane fouling.

Microfiltration (MF) Case Study (Thompson, et al., 1995)

Thompson, et al. (1995) reported on pilot-scale testing of MF for recycle stream treatment. A membrane with a nominal pore size of 0.2 µm was used in all tests. In these tests, spent filter backwash water with turbidities around 500 NTU were reduced to less than 5 NTU. At another plant, MF was used to treat a combination of spent filter backwash water and clarifier sludge blowdown from a conventional treatment train. The recycle stream was spiked with *Giardia* cysts and *Cryptosporidium* oocysts before MF treatment. No cysts, oocysts, or coliforms were detected in the MF-treated water, and turbidities were consistently 0.1 NTU. High levels of particle removal were also shown using particle counters.

Ultrafiltration (UF) Case Study (Shealy, et al., 2000)

Several recycle water treatment alternatives were evaluated at the Orangeburg, SC plant. After narrowing the alternatives, the system chose to pilot test micro/ultrafiltration membrane treatment. The main objectives of the study were: contaminant removal and membrane flux rate, feasibility of full-scale application, and potential capital and operating costs. After months of research and evaluation, membrane treatment with immersed UF technology was selected for full- scale implementation. The conclusion was that, coupled with equalization basins, UF membranes produced excellent treated water quality. The permeate from the membrane unit is proposed to discharge to the head of the plant.

Microfiltration Case Study (Taylor, et al., 2000)

Bench-scale testing of MF to treat spent filter backwash water was conducted at the University of Central Florida. Backwash waters from nine water treatment plants across the United States were used in the testing. The treatment unit used in the study was an MF unit fitted with a single microfilter membrane (surface area of 1 m^2). One liter of filtrate water was collected approximately five minutes into filtration for chemical water quality analysis. True color, UV-254, total suspended solids (TSS), turbidity, and particle counts were the parameters measured. The changes in UV-254 and true color were not significant and therefore not considered a consequence of treatment. However, turbidity and TSS were significantly reduced by MF. Water turbidity was reduced from 31-168 NTU to 0.02-0.16 NTU. TSS was reduced from 66-206 mg/L to 1-3 mg/L (the limit of accurate TSS measurements).

A cost estimate for applying membrane filtration (MF and UF) to the treatment and recovery of spent filter backwash water was included in the study. Estimates for flows of 0.01, 0.1, 1.0, and 10.0 MGD were developed. The membrane system cost included feed water pumps, backwash and recycle pumps, air compressor, membrane modules and racks, piping and valves, instrumentation and controls, and the membrane cleaning system. The researchers found that unit capital and O & M costs decreased significantly by capacity and varied significantly by source. Unit capital costs varied from $10.35/gpd at 0.01 MGD to $0.38/gpd at 10 MGD. Unit O & M costs varied from $2.68/Kgal at 0.01 MGD to $0.16/Kgal at 10 MGD.

10.7.6 Disinfection

Disinfection can be a barrier to the recycling of pathogens from recycle streams. Results from the AWWA utility survey show that a small percentage of plants that do recycle practice disinfection of those streams (Pedersen and Calhoun, 1995). The most common disinfectant used by far was chlorine. The California Department of Health Services recommends that disinfection be considered for recycle streams (CDHS, 1995).

The main issues to be addressed when considering disinfection of recycle streams are:

- The level of inactivation to be provided for specific organisms;
- Whether disinfection is to be used alone or with a solids removal process; and,
- The potential impacts of recycle stream disinfection on finished water quality, particularly the formation of DBPs.

If disinfection is to be applied to recycle streams, the required level of disinfection and inactivation must be known in order to size the facility. No guidelines have yet been issued in regard to pathogen inactivation or removal from recycle streams. Under the current SWTR, IESWTR, and LT1ESWTR, the amount of disinfection provided to water supplies is determined by the inactivation and removal of *Giardia* and viruses. Credit is given for the removal of pathogens by properly operated treatment processes, such as filtration, and credit for inactivation is given based on the disinfectant concentration and contact time provided.

For the treatment of recycle streams, the removal and/or inactivation of *Cryptosporidium, Giardia,* and viruses is a concern. Disinfection options and inactivation levels are well known for *Giardia* and viruses. Ozone and UV both appear to provide inactivation of *Cryptosporidium*.

Disinfection Case Study (Cornwell, et al., 2001)

The oxidant demand of both potassium permanganate and chlorine dioxide was examined for spent filter backwash samples from five participating water utilities. Overall, the potassium permanganate demands were approximately 5.5 times higher for spent filter backwash with particles than in samples without particles. Potassium permanganate disinfection at 2,400 mg-min/L (CT value) with and without particles resulted in *Cryptosporidium* inactivations of 0.21 and 0.27-log, respectively. The presence of particles in spent filter backwash increased the chlorine dioxide demand by a factor of four when compared to samples without particles. Chlorine dioxide dosed at 115 mg-min/L (CT value) produced 2.7 and 2.1-log inactivation of *Cryptosporidium* for spent filter backwash with and without particles, respectively. Ultraviolet (UV) treatment was also examined for its effectiveness on *Cryptosporidium* in clarified spent filter backwash with turbidities between 10 and 14 NTU. UV doses as low as 3 milliJoules per square centimeter used in collimated beam experiments resulted in *Cryptosporidium* inactivations greater than 4 logs.

<u>**Advantages**</u>

Pathogens are contaminants of concern in recycle streams. Depending on the type and amount of disinfectant used, *Cryptosporidium*, *Giardia*, and/or viruses can be inactivated. More advantages may be realized through disinfection of recycle streams as more studies are conducted on this practice.

<u>**Disadvantages**</u>

Recycle stream disinfection should be examined for its potential effects on the main treatment train and finished water quality. Untreated recycle streams can have significant concentrations of TTHM precursors and TOC (Cornwell and Lee, 1993). If the recycle stream is treated with chlorine, then recycling may cause problems for the treatment plant in meeting DBP limits. The potential formation of DBPs through disinfection should be considered. Chapter 7 provides more information on DBP and DBP precursor levels in recycle streams.

10.8 COMPARISON OF TREATMENT OPTIONS

Seven different treatment scenarios for spent filter backwash at seven different treatment plants were examined (Cornwell, et al., 2001). Table 10-2 presents the turbidity and particle log reductions obtained from each treatment type. The results in Table 10-2 are based on both pilot-scale and full-scale plants. Sedimentation with polymer, DAF with polymer, granular media filtration with pretreatment, and membrane microfiltration appear to provide the best turbidity and particle reduction. Table 10-2 also presents relative costs of each treatment type. Membrane microfiltration was the most expensive treatment option based on this study. However, costs will vary from plant to plant depending on site-specific conditions, recycle stream characteristics, and desired level of treatment.

Table 10-2. Spent Filter Backwash Turbidity and Particle Log Reductions by Treatment Type

Treatment Process[1]	Turbidity Log Reduction	Particle Log Reduction	Relative Cost Ranking[2]
Sedimentation without polymer[3]	0.1 to 0.8	0.2 to 0.9	1
Dissolved Air Flotation (DAF) without polymer	0.7 to 1.4	0.8 to 1.7	-----
Sedimentation with polymer[3]	1.4 to 2.3	1.9 to 3.3	2
DAF with polymer	1.7 to 2.7	1.9 to 3.5	3
Coagulation/ Flocculation followed by Sedimentation[3]	0.5 to 1.7	0.4 to 2.1	------
Granular Media Filtration with pretreatment[4]	2.2 to 3.0	2.4 to 4.4	4
Membrane Microfiltration	2.6 to 3.9	1.6 to 3.5	5

[1]Treatment processes were conducted at seven different sites and consisted of both pilot-scale and full-scale studies.
[2]Relative costs are presented with 1 being the lowest-cost treatment process and 5 being the highest-cost treatment process. Costs were not available for DAF without polymer and coagulation/flocculation followed by sedimentation.
[3]Sedimentation consisted of either tube settlers or plate settlers.
[4]Pretreatment consisted of either sedimentation with polymer or DAF with polymer.

10.9 REFERENCES

Ashcroft, C.T., et al. 1997. Modifications to Existing Water Recovery Facilities for Enhanced Removal of *Giardia* and *Cryptosporidium.* Proceedings of Conference on Water Residuals and Biosolids Management: Approaching the Year 2000. WEF/AWWA.

AWWA. 1998. Spent Filter Backwash Water Survey. Denver, CO.

AWWA. 2002. Self Assessment of Recycle Practices. Denver, CO.

AWWA/ASCE. 1990. *Water Treatment Plant Design.* Second Edition. McGraw Hill. New York, NY.

AWWA/ASCE. 1998. *Water Treatment Plant Design.* Third Edition. McGraw Hill. New York, NY.

CDHS. 1995. California Safe Drinking Water Act, California Health and Safety Code, Articles 4 and 5.

Cornwell, D., M. MacPhee, N. McTigue, H. Arora, G. DiGiovanni, M. LeChevallier, and J. Taylor. 2001. Treatment Options for *Giardia, Cryptosporidium*, and Other Contaminants in Recycled Backwash Water. AWWARF. Denver, CO.

Cornwell, D., and R. Lee. 1993. Recycle Stream Effects on Water Treatment. AWWARF Report #90629. Denver, CO.

Edzwald, J.K., J.E. Tobiason, L.M. Parento, M.B. Kelley, G.S. Kaminski, H.J. Dunn, and P.B. Galant. 2000. *Giardia* and *Cryptosporidium* Removals by Clarification and Filtration Under Challenge Conditions. Journal AWWA 92(12):70-84.

Edzwald, J.K., J.E. Tobiason, M.B. Kelley, H.J. Dunn, P.B. Galant, and G.S. Kaminski. 2001. Impacts of Filter Backwash Recycle on Clarification and Filtration. AWWARF and AWWA. Denver, CO.

Hess, A., A. Affinito, H. Dunn, P Gaewski, and E. Norris. 1993. Relationship of WTP Residual Characteristics, Facility Design and Operational Practices on the Performance of Residual Treatment Facilities at a Direct Filtration Plant. Proceedings of the Joint Residuals Conference. AWWA/WEF. Phoenix, Arizona.

Jacangelo, J. G., and C. A. Buckley. 1996. Microfiltration. *Water Treatment Membrane Processes*, Ch. 11, AWWARF, Lyonnaise des Eaux, and Water Research Commission of South Africa. McGraw-Hill, Inc., New York, NY.

Kawamura, S. 2000. *Integrated Design and Operations of Water Treatment Facilities.* Second Edition. John Wiley & Sons, Inc., New York, NY.

Lew, J., and R. Patawaran. 2000. Pilot Identifies Best Backwash Pretreatment. AWWA. Opflow. Denver, CO.

Logsdon, G.S., A.F. Hess, M.J. Chipps, and A.J. Rachwal. 2000. Filter Backwash Water Processing Practices. Proceedings from the AWWA Annual Conference. Denver, CO.

MacPhee, M., et al. 2000. Critical Assessment of Alternatives for Treatment of Spent Filter Backwash Water. Proceedings AWWA Water Quality Technology Conference. Salt Lake City, UT.

Moss, Linda. 2000. Backwash Water Return Effects: Evaluation and Mitigation. Proceedings from the AWWA Water Quality Technology Conference. Salt Lake City, UT.

Narasimhan, R., et al. 1997. Design Criteria Evaluation for Washwater Treatment and Water Residuals Thickening Processes. Proceedings of Conference on Water Residuals and Biosolids Management: Approaching the Year 2000. WEF/AWWA.

Nielson, J.C., R. O. Schwarzwalder, and T. Wolfe. 1995. Evaluation of Waste Stream Recycling Alternatives. 1994 AWWA Annual Conference Proceedings. Denver, CO.

Pedersen, D. W., and B. Calhoun. 1995. Do You Recycle? Results of AWWA's Recycle Practices Survey. AWWA Annual Conference.

Plummer, Jeannie D., J. K. Edzwald, and M. B. Bailey. 1995. Removing *Cryptosporidium* by Dissolved-Air Flotation. Journal AWWA. (87)(9).

Shealy, C. E., F. L. Yandle, and H. G. Rutland. 2000. Membrane Treatment for Water Plant Residuals Handling and Water Reclamation. Proceedings from the AWWA Annual Conference. Denver, CO.

SPEHM. (Great Lakes- Upper Mississippi River Board of State Public Health and Environmental Managers). 1997. Recommended Standards for Water Works ("Ten State Standardss"). Health Education Services. Albany, NY.

Taylor, J., C.D. Norris, and L.A. Mufford. 2000. Recovery of Backwash Water by Size Exclusion Membrane Filtration. Proceedings from the AWWA Water Quality Technology Conference.

Thompson, M. A., J. C. Vickers, Dr. M. R. Wiesner, and Dr. J. L. Clancy. 1995. Membrane Filtration for Backwash Water Recycle. AWWA Annual Conference on Water Quality Proceedings, pp. 1051-1064.

U.S. EPA. February 2000. Cost and Technology Document for the Proposed Long-Term 1 Enhanced Surface Water Treatment Rule and Filter Backwash Recycling Rule. Office of Ground Water and Drinking Water.

United Kingdom Water Industry Research. 1998. *Guidance Manual Supporting the Water Treatment Recommendations from the Badenoch Group of Experts on Cryptosporidium.* First Edition. UK Water Industry Research Limited, London.