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Region 10
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Idaho
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Washington
Office of Water and Watersheds

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EPA

Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus

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Abstract

In this report, EPA Region 10 presents observations of advanced wastewater treatment installed at 23 municipalities in the United States. These facilities employ chemical addition and a range of filtration technologies which have proven to be very effective at producing an effluent containing low levels of phosphorus.

Observations from this evaluation include:

- Chemical addition to wastewater with aluminum- or iron-based coagulants followed by tertiary filtration can reduce total phosphorus concentrations in the final effluent to very low levels. The total phosphorus concentrations achieved by some of these WWTPs are consistently near or below 0.01 mg/l.

- The cost of applying tertiary treatment for phosphorus removal is affordable, when measured by the monthly residential sewer fees charged by the municipalities that operate these exemplary facilities. The monthly residential sewer rates charged to maintain and operate the entire treatment facility ranged from as low as $18 to the highest fee of $46.

- There appeared to be no technical or economic reason that precludes other dischargers from using any of the tertiary treatment technologies that are employed at these WWTPs. Any of these technologies may be scaled as necessary to fulfill treatment capacity needs after consideration of site specific conditions.

- Other pollutants that commonly affect water quality such as biochemical oxygen demand, total suspended solids, and fecal coliform bacteria are also significantly reduced through these advanced treatment processes.

- WWTPs which utilize enhanced biological nutrient removal (EBNR) in the secondary treatment process can often reduce total phosphorus concentrations to 0.3 mg/l or less prior to tertiary filtration. While employing EBNR is not essential to achieving high phosphorus removal rates, EBNR enhances the performance and reduces operating costs (especially chemical use) of the subsequent tertiary filtration process. Recently published studies report that the longer solids retention times used in BNR processes also removes a significant amount of other pollutants contained in municipal wastewater, including toxics, pharmaceuticals, and personal care products.

- The low effluent turbidity produced by tertiary filtration allows for efficient disinfection of final effluent without chlorination through the use of ultraviolet treatment.

- The treatment processes and quality of the final effluent produced by tertiary filtration for phosphorus removal typically meet state criteria for wastewater reclamation. Reuse of this high quality effluent can be an attractive alternative to direct discharge into surface waters in situations where restrictive NPDES permit limitations apply.

Table of Contents

Nutrients and Water Quality Problems

Phosphorus and nitrogen are nutrients that are essential for aquatic plant and algae growth. Most waters naturally contain enough of these nutrients to support native aquatic life. However, an over-abundance of these nutrients can over-stimulate plant and algae growth such that they create water quality problems. Over 1,000 waterbodies in Idaho, Oregon and Washington are identified as being impaired due to excessive nutrient loading and are included on state Clean Water Act 2004 §303(d) lists for water quality problems. The problems caused by nutrient enrichment of lakes, stream, and rivers are not unique to the Northwest states as many other waterbodies across the United States have also been identified as impaired by nutrients. Nutrient impairments affect the survival of many aquatic species such as salmon; affect the safety of drinking water supplies; affect the aesthetics of recreational areas, and the ability to navigate through rivers and lakes.

In freshwater systems, phosphorus is typically the nutrient that is in short supply relative to biological needs, which means that the productivity of aquatic plans and algae can be controlled by limiting the amount of phosphorus entering the water. Many streams and lakes in the Northwest are documented to have very little capacity to assimilate phosphorus loading during the "critical" warm and dry summer period without significant water quality degradation. Large diurnal swings in pH and dissolved oxygen may occur as excessive amounts of nutrients are metabolized by aquatic plants and algae. The range of these swings is often measured to exceed the state water quality criteria established to protect fish and other aquatic organisms in their various life stages. Therefore, the amount of phosphorus currently entering these waters exceeds the seasonal loading capacity and must be reduced if these water quality problems are to be resolved.

The sources of phosphorus loading vary depending on the human activities and conditions in a specific watershed. In the Northwest, phosphorus loading into streams and lakes from nonpoint sources (e.g. agriculture, pet waste) is often minimal during the summer months because there is typically very little rainfall runoff to flush pollutants into receiving waters. The discharges of treated wastewater can be the most significant source of phosphorus loading during these critical summer months. To address these water quality problems, state environmental agencies and the Environmental Protection Agency (EPA) are requiring dischargers to reduce the amount of phosphorus in their effluent.

Achieving very low phosphorus levels in treated wastewater will require the installation of additional treatment. A number of water quality studies in Northwest states have determined waste load allocations which will require dischargers to achieve total phosphorus effluent concentrations that range from as low as 0.009 to 0.05 mg/l. Even as WWTP operators in the Northwest consider installing additional treatments to address water quality problem, they are also planning to upgrade capacity of their plants to accommodate rapid population growth. With many other interests competing for limited public and private resources, resolving water quality problems is often contentious and slow. Implementation of water quality improvement plans (called Total Maximum Daily Loads (TMDLs)) have been significantly delayed by arguments about the availability and cost of treatment technologies capable of achieving very low phosphorus targets.

In response to these discussions, EPA – Region 10 initiated a project to evaluate municipal wastewater treatment plants which have demonstrated exemplary phosphorus removal through their treatment processes. The primary goal of this project was to obtain and share information about the technology, performance and costs of applying advanced wastewater treatment for phosphorus removal.

Evaluation Considerations

The WWTPs included in this project were selected because monitoring results have demonstrated their treatment to be very effective at removing phosphorus. The reported performance at each of these facilities has been well documented by monitoring conducted over periods of several years. EPA attempted to include a variety of treatment technologies and facilities of different sizes in this evaluation. However, not all facilities that achieve exemplary phosphorus removal nor all filtration technologies could be presented in this report. A number of the WWTPs that are currently achieving good phosphorus removal are planning treatment upgrades that will allow them to also meet a total nitrogen limitation of 3 mg/l. Some information about treatment to remove nitrogen is presented in the description of the LOTT, Budd Inlet WWTP.

Treatment performance is characterized by discharge monitoring information required by the National Pollutant Discharge Elimination System (NPDES) permits which authorize these facilities to discharge treated wastewater. Monitoring of the final effluent per NPDES permit requirements is conducted and reported in accordance with EPA approved analytical methods and quality control procedures. This monitoring information provides the best readily available information with which to characterize WWTP performance. EPA presents the average and range of reported monthly average phosphorus concentrations to indicate long term treatment performance. These monthly average values may not be representative of daily fluctuations in effluent quality experience by these WWTPs. Effluent concentrations are sometimes reported as zero or less-than values on discharge monitoring reports when the monitored concentrations are well below permit limitations or laboratory reporting limits for phosphorus. The actual effluent phosphorus concentration in the final effluent of these facilities may be significantly better than characterized in discharge monitoring reports.

Although each of the WWTPs are very well maintained and operated, very few are being pressed by stringent NPDES limitations to optimize treatment to achieve the best phosphorus removal possible. The table under Summary of Observations lists the applicable NPDES permit phosphorus limitations for each of the facilities evaluated. The lowest phosphorus limitation established for any of these WWTPs was a monthly average limitation of 0.05 mg/l. Operators at many of these WWTPs conveyed that if necessary, even better phosphorus removal performance could be achieved through operational changes to the existing treatment system. This is a consideration that should not be overlooked by dischargers, consultants and regulators as they consider treatment options.

Summary of Observations

Information about treatment technology, performance and residential sewer treatment fees for each of the 23 WWTPs evaluated is summarized in the following table.

Facility Name and Location	NPDES Permit Number	Capacity	Advanced Phosphorus Treatment Technology	NPDES Permit Limitation for Phosphorus	*Average Effluent Phosphorus Concentration	Range of Monthly Average Phosphorus Concentrations	Monthly Residential Sewer Rate
Sand Creek WWRP Aurora, CO	CO0026611	5 mgd	BNR,filtration	None	0.1 to 0.2 mg/l	N/A	$2.38 + $4.50 / 1,000 gal used
Breckenridge S.D., Iowa Hill WWRP, CO	CO0045420	1.5 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 225 lbs/year	0.055 mg/l	0.017 to 0.13 mg/l	$19
Breckenridge S.D., Farmers Korner WWTP, CO	CO0021539	3 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 225 lbs/year	0.007 mg/l	0.002 to 0.036 mg/l	$19
Summit County Snake River WWTP, CO	CO0029955	2.6 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 340 lbs/year	0.015 mg/l	<0.01 to 0.04 mg/l	$36
Pinery WWRF Parker, CO	CO0041092	2 mgd	BNR, chemical addition, two-stage filtration	0.05 mg/l & 304 lbs/year	0.029 mg/l	0.021 to 0.074 mg/l	$18
Clean Water Services, Rock Creek WWTP, OR	OR0029777	39 mgd	Chemical addition, filtration	0.1 mg/l (monthly median limitation)	0.07 mg/l	0.04 to 0.09 mg/l	$16.07 + $1.11/ccf
Clean Water Services, Durham WWTP, OR	OR0028118	24 mgd	BNR, chemical addition, filtration	0.11 mg/l (monthly median limitation)	0.07 mg/l	0.05 to 0.1 mg/l	$16.07 + $1.11/ccf
Stamford WWTP Stamford, NY	NY0021555	0.5 mgd	Chemical addition, two-stage filtration	0.2 mg/l	<0.011 mg/l	<0.005 to < 0.06 mg/l	$10**
Walton WWTP Walton, NY	NY0027154	1.55 mgd	Chemical addition, two-stage filtration	0.2 mg/l	<0.01 mg/l	<0.005 to <0.06 mg/l	$10**
Milford WWTP Milford, MA	MA0100579	4.8 mgd	Multi-point chemical addition, filtration	0.2 mg/l	0.07 mg/l	0.04 to 0.16 mg/l	$27.50
Alexandria Sanitation Authority AWWTP, Alexandria, VA	VA0025160	54 mgd	BNR, Multi-point chemical addition, tertiary settling and filtration	0.18 mg/l	0.065 mg/l	0.04 to 0.1 mg/l	$4.17 + $4.49 / 1,000 gal used
Upper Occoquan Sewerage Authority WWTP, VA	VA0024988	42 mgd	Chemical (high lime) and tertiary filtration	0.10 mg/l	<0.088 mg/l	0.023 to <0.282 mg/l	$3.03 to $4.09/1,000 g
Fairfax County, Noman Cole WWTP, VA	VA0025364	67 mgd	BNR, chemical addition, tertiary clarification and filtration	0.18 mg/l	<0.061 mg/l	<0.02 to <0.13 mg/l	$3.28/1,000 g

Facility Name and Location	NPDES Permit Number	Capacity	Advanced Phosphorus Treatment Technology	NPDES Permit Limitation for Phosphorus	*Average Effluent Phosphorus Concentration	Range of Monthly Average Phosphorus Concentrations	Monthly Residential Sewer Rate
BluePro Treatment Pilot results at Hayden WWTP, ID	N/A	N/A	Iron coated sand in two-stage Centra-Flo Filters.	N/A	0.013 mg/l	N/A	N/A
CoMag Treatment Pilot results at Concord WWTP, MA	N/A	N/A	Chemical addition, ballast sedimentation, magnetic polishing	N/A	0.04 mg/l	N/A	N/A
WWTPs not visited for this evaluation :							
Delhi, NY	NY0020265	0.82 mgd	Activated sludge, chemical addition, filtration	0.11 mg/l	0.04 mg/l	<0.02 to 0.085 mg/l	$10 **
Pine Hill WWTP, NY	NY0026557	0.5 mgd	RBC, sand filters, chemical addition, microfiltration	0.2 mg/l	0.06 mg/l	0 to 0.12 mg/l	$10 **
NYC DEP-Grand Gorge STP, NY	NY0026565	0.5 mgd	RBC, sand filters, chemical addition, microfiltration	0.2 mg/l	< 0.04 mg/l	0 to 0.05 mg/l	$10 **
Hobart – V PCF, NY	NY0029254	0.18 mgd	Activated sludge, sand filters, chemical addition, microfiltration	0.5 mg/l	< 0.05 mg/l	0.026 to 0.07 mg/l	$10 **
Snyderville Basin Water Reclaimation District, UT	UT0020001	4 mgd	BNR, chemical addition, filtration	0.1 mg/l	0.04 mg/l	0.03 to 0.06 mg/l	$30
Ashland WWTP Ashland, OR	OR0026255	2.3 mgd ADWF	Oxidation Ditch, chemical addition, membrane filtration	1.6 lb/day (= 0.083 mg/l)	0.07 mg/l	0.05 to 0.12 mg/l	$11.55 + $1.73 per 100 cf used
McMinneville WWTP McMinneville, OR	OR0034002	5.6 mgd ADWF	Oxidation Ditch (BNR), Chemical addition, multi-media traveling bed filtration	0.07 mg/l	0.058 mg/l	0.036 to 0.092 mg/l	$46.15 (average based on 700 cf used)
Facility Name and Location	**NPDES Permit Number**	**Capacity**	**Advanced Nitrogen Treatment Technology**	**NPDES Permit Limitation for Total Inorganic Nitrogen (TIN)**	***Average Effluent TIN Concentration**	**Range of Monthly Average TIN Concentrations**	**Monthly Residential Sewer Rate**
LOTT WWTP Olympia, WA	WA0037061	28 mgd	Biological Nutrient Removal	3 mg/l	2.2 mg/l	1.23 to 2.81 mg/l	$25.50

* This is the average of monthly average measurements achieved as reported by the facility on NPDES discharge monitoring reports. The period for which these averages were determined is identified in the discussion about each facility. Many facilities have seasonal water quality-based limitations for phosphorus.
** The costs of construction, operation and maintenance of WWTPs discharging into the Delaware River watershed are partially subsidized by the City of New York.

Summary of Observations (continued)

- Tertiary filtration aided by chemical addition can reduce total phosphorus concentrations in the final effluent to very low levels. This treatment is employed at all but one of the WWTPs included in this evaluation. To achieve very low phosphorus concentrations, chemicals must be added to wastewater to associate phosphorus with solids that can then be successfully removed through filtration. Aluminum- or iron-based coagulants and polymer are the chemicals most commonly used for this purpose.

- Traveling sand bed filters, mixed- media gravity filters, Dynasand filters and variations of these filtration technologies are used by all of the WWTPs evaluated. Filtration has been employed for many years to treat drinking water and more recently applied to treat wastewater. Filtration technologies for treating wastewater are rapidly evolving as water quality agencies and dischargers strive to protect sensitive receiving waters from potential impacts of pollutants in the treated effluent. With proper design, there are no apparent reasons why any of these filtration technologies may not be installed in either small or large scale applications. Selection of a filtration technology includes the usual considerations such as: desired effluent quality; reliability of treatment equipment; capital, operating and maintenance costs; equipment footprint, and future expandability.

- Application of two-stage filtration processes produced the lowest phosphorus levels observed in this evaluation. Two-stage treatment may be achieved through use of a first and second stage filter or by providing tertiary clarification prior to filtration. The Walton and Stamford WWTPs achieved the lowest measured phosphorus concentration in their effluent (about 0.01 mg/l or less) by utilizing two-stage Dynasand filters from Parkson Corporation. Excellent treatment results were also obtained by Breckenridge WWTPs, the Snake River WWTP and the Alexandria AWWTP using a two-stage treatment process consisting of chemical addition with tertiary settling in advance of their sand bed filters. Modular two-stage filters from US Filter Corporation installed at the Pinery WWTP employs a synthetic media in the first stage and sand media in the second stage. The Fairfax County, Noman Cole WWTP utilizes large tertiary clarifiers followed by filtration through sand beds.

- Table 1 identifies which of the WWTPs include in this evaluation have also incorporated *enhanced biological nutrient removal* (EBNR) into their secondary treatment processes to remove phosphorus. An EBNR treatment system promotes the production of phosphorus accumulating organisms which utilize more phosphorus in their metabolic processes than a conventional secondary biological treatment process. The average total phosphorus concentrations in raw domestic wastewater is usually between 6 to 8 mg/l and the total phosphorus concentration in municipal wastewater after conventional secondary treatment is routinely reduced to 3 or 4 mg/l. Whereas, EBNR incorporated into the secondary treatment system can often reduce total phosphorus concentrations to 0.3 mg/l and less. Facilities using EBNR significantly reduced the amount of phosphorus to be removed through the subsequent chemical addition and tertiary filtration process. This improves the efficiency of the tertiary process and can significantly reduce the costs of chemicals used to remove phosphorus. Staff at the Fairfax County WWTPs reported that their chemical dosing was cut in half after EBNR was installed to remove phosphorus.

- The treatment provided by these WWTP also removes other pollutants which commonly affect water quality to very low levels. Biochemical oxygen demand (BOD) and total suspended solids are routinely less than 2 mg/l and fecal coliform bacteria less than 10 fcu/100 ml. Turbidity of the final effluent is very low which allows for effective disinfection using ultraviolet light, rather than chlorination. Recent studies report finding that WWTPs using EBNR also significantly reduce the amount of pharmaceuticals and health care products from municipal wastewater, as compared to the removal accomplished by conventional secondary treatment.

- Only four of the WWTPs included in this evaluation utilize anaerobic digesters to stabilize removed solids. Facilities which utilize anaerobic digesters need to consider the potential that a significant phosphorus load might be released from the removed solids and thereafter returned to the wastewater being treated. The Clean Water Services WWTPs manages the phosphorus loading associated with the use of anaerobic digesters by equalizing the flow of these return streams (supernatant and centrate) over time. Other studies indicate that phosphorus removed with alum does not resolubilize in anaerobic digesters, whereas phosphorus removed with iron salts may solubilize in the absence of adequate iron. Operators have identified the amount of alum or iron necessary to control resolubilization of phosphorus in anaerobic digesters to be a cost consideration.

- Applying advanced water treatment to remove phosphorus is affordable for most municipalities as demonstrated by the monthly residential sewer fees charged by the WWTPs included in this evaluation. These fees are listed in the Summary of Observations Table and are typically less than $30. EPA intended to identify in more detail the costs incurred by these WWTPs to install and operate tertiary treatment for phosphorus removal. However, it was soon determined that separating the costs of the tertiary treatment from overall facility operating costs was beyond the resources and time available to complete this project. EPA instead presents the monthly residential sewer fees charged by each of these WWTPs as an indicator of the costs to construct, maintain and operate these facilities, including the tertiary treatment for phosphorus removal.

City of Aurora - Sand Creek Wastewater Reuse Plant

Contact Information:
Mailing address:
18301 EAST QUINCY AVENUE
Aurora, Colorado 80010
303-326-8807

NPDES permit No. CO0026611, expiration date December 31, 2002

Receiving water: Sand Creek or reclaimed for irrigation use

Sand Creek WWRP Treatment:

Raw Wastewater → Primary Clarification → Biological Nutrient Removal → Secondary Clarification → Effluent Filtration (Parkson Dynasand Filters) → UV Disinfection

Treatment capacity: 5 mgd average daily flow

Aurora WWRP Performance Information:

Parameter	Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
TSS	30/45 mg/l	1.0 mg/l	0.5 to 1.84 (6/04)	7.0 mg/l	4/01 to 5/06
N-NH3	None	*<0.14 mg/l	*<0.1 to <0.33 mg/l	1.7 mg/l	8/03 to 5/06
BOD	30/45 mg/l	* <2.3 mg/l	<2.2 to <4.0 mg/l	6.1 mg/l (6/05)	4/01 to 5/06
Phosphorus	none		**0.1 to 0.2 mg/l		4/01 to 5/06

* Most of these measurements were reported as less than (<) values

Monthly Sewage Service Charge: $2.16 plus a usage fee of $1.99 per 1,000 Gallons water used.

Facility description:

The City of Aurora is east of the City of Denver in Colorado. This facility began operation in 2001 and either discharges treated effluent to Sand Creek or the wastewater is reused for irrigation on public lands, such as parks and golf courses. Some of the irrigation sites are as far as 17 miles away from the WWTP. Although this is a long distance to pump water, the high demand for the water in this arid area causes the value of reclaimed wastewater to be nearly the price of potable water!

Treatment at this WWTP involves screening and grinding; primary clarification; biological nutrient removal (BNR) in the contact basins; secondary clarification; filtration through single pass Dynasand filters (four cells with 4 filters per each cell); UV disinfection. Solids removed during the course of treatment are routed back into the sewer main where they are ultimately treated at the Denver, Metro WWTP. BNR is accomplished by exposing wastewater through sequential anoxic, anaerobic and aerobic zones maintained in the contact basins.

Direct discharge from this WWTP is into the Cherry Creek watershed. The Cherry Creek watershed includes a reservoir that is currently impaired due to excessive loading of nutrients. The Aurora WWTP currently does not have any effluent limitation for phosphorus. At the time of this visit, the NPDES permit for this facility was expired and WWTP operators expected that phosphorus limitations might be included in the proposed permit reissuance. Monitoring for total phosphorus is conducted weekly and analyses achieve an analytic reporting level of 0.05 mg/l.

No chemicals are currently used at the plant to enhance phosphorus removal. Nevertheless, the final effluent typically contains between only 0.1 to 0.2 mg/l total phosphorus. Influent BOD and ammonia nitrogen were reported to be approximately 200 to 300 mg/l and 30 mg/l, respectively. Effluent BOD concentrations average about 2.2 mg/l and ammonia nitrogen is less than 0.1 mg/l.

Operational considerations:

- The single pass Dynasand filters used as tertiary treatment at the Aurora WWTP include four cells, each with four continuous backwashing upflow sand media filters. The surface area of each filter measures seven by seven feet and the filters are 16 feet deep.
- Plant operators state they had encountered no serious maintenance or operational problems with the DynaSand filters. WWTP operators also responded that they were unaware of any reason why application of these filters could not be “scaled-up” to accommodate a much larger treatment capacity than the 5 mgd currently being treated through the Aurora facility. Additional filters will likely be added in the future to accommodate increasing treatment capacity needs in the service area.

Breckenridge Sanitation District - Iowa Hill Wastewater Reclamation Plant

Contact Information:
District Office:
1605 Airport Road
Breckenridge, CO 80424

Phone: 970-453-2723
Fax: 970-453-2013

Mailing Address:
PO Box 1216
Breckenridge, CO 80424

NPDES Permit No. CO0045420, expiration date 31 December 2004

Receiving water: Blue River (tributary to Dillon Reservoir)

Iowa Hill WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement (date)	Reporting period
BOD	30 mg/l	1.55 mg/l	0.64 to 3.02 mg/l	12.6 mg/l (4/00)	4/00 to 12/02
TSS	30 mg/l	2.07 mg/l	0.49 to 6.2 mg/l	18.1 mg/l (4/00)	4/00 to 12/02
N-NH3	10 mg/l	0.41 mg/l	0.16 to 1.8 mg/l	8.2 mg/l (4/00)	4/00 to 12/02
Phosphorus	0.5 mg/l daily max & 225 lb/year	0.55 mg/l	0.017 to 0.13 mg/l	0.13 mg/l (6/00)	5/00 to 12/02

Iowa Hill WWTP Process:

Influent (Scalping Plant) → Screening & Grit Removal → Activated Sludge Biological Treatment → Biological Aerated Filter (IDI "BioFor") → Chemical Addition (Alum) → Mixing & Settling (Densadeg) → Filtration (Parkson DynaSand Filter) → Disinfection

Design Treatment Capacity: 1.5 MGD average dry weather flow

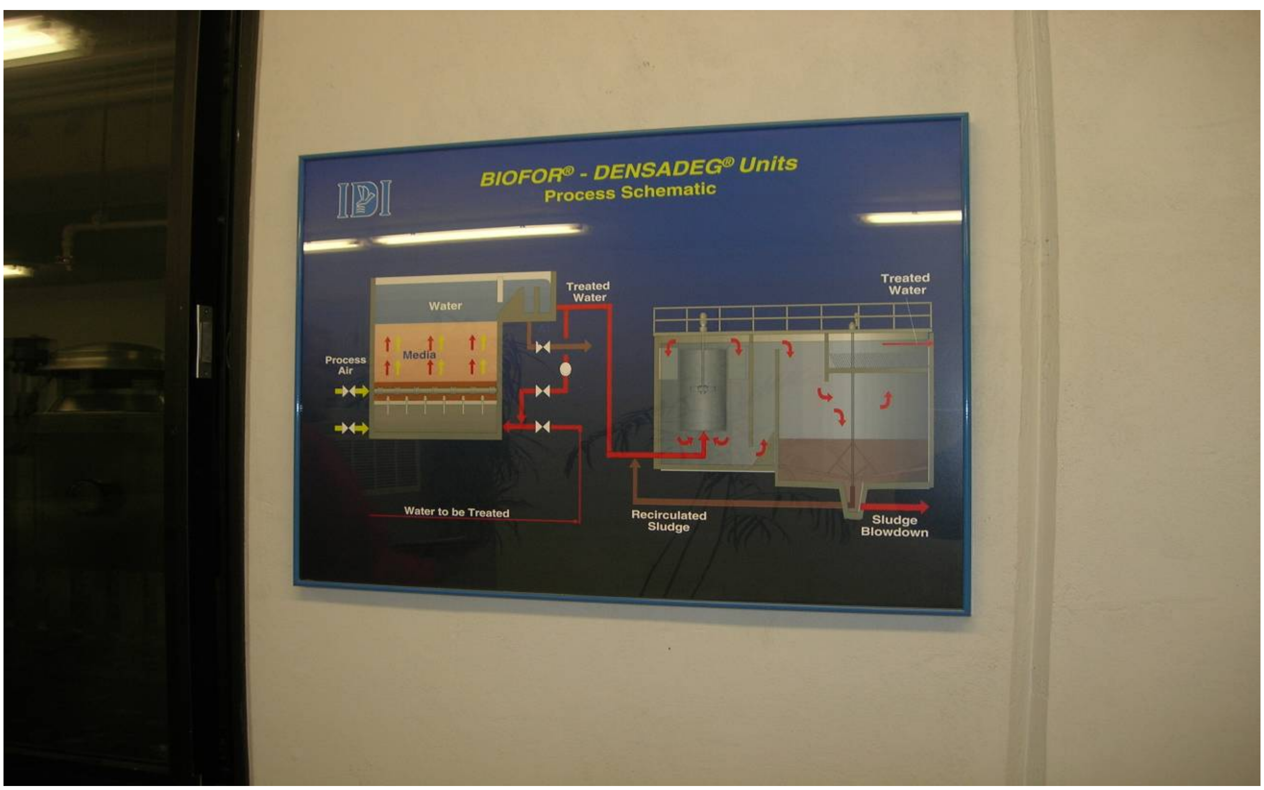
Monthly household sewer use fee: $19/month

Facility description:

The Breckenridge Sanitation District collects wastewater from the town of Breckenridge and the surrounding area. The District operates three (3) wastewater treatment facilities including the Iowa Hill WWTP and the Farmers Korner WWTP which were visited as part of this evaluation. A small package plant is also operated by the district. The Iowa Hill WWTP was newly constructed in 1999 and has since been widely cited for its quality of effluent, especially its low effluent total phosphorus. Influent flow to the plant is “scalped” from the main District interceptor in the Blue River Valley. Solids removed during treatment at the Iowa Hill WWTTP are routed back into the interceptor for treatment at the Farmers Korner WWTP.

Discharge from both of these facilities enters Dillon reservoir which is used to supply drinking water to the Metropolitan Denver area. To prevent eutrophication of Dillon reservoir, an annual maximum mass loading limitation of 225 pounds per year and daily maximum concentration of 0.5 mg/l for total phosphorus were established. Facility operators target achieving an effluent concentration of 0.01 to 0.02 mg/l total phosphorus to meet the annual loading limitation.

Treatment at this WWTP is accomplished by screening and grit removal in the headworks; activated sludge biological treatment; biological aerated filter (IDI “BioFor” for nitrification); chemical coagulation using alum; flocculation and clarification using tube settler (IDI “Densadeg”); filtration (single stage Parkson “Dynasand” filters); disinfection and dechlorination. The Dynasand filter reject rate is reported to be about 15 to 20%. The Dynasand filters are configured in four, two-cell units for a total of 8 filters beds which are each 8 feet deep.



Influent concentrations of total phosphorus were measured to be about 6 mg/l during the time of this visit (winter) which is very a typical value for untreated domestic wastewater. The aeration basins are operated with an anoxic zone to provide for biological removal of phosphorus. About sixty percent of the influent phosphorus was reported to be removed through the biological treatment process.

Sodium sulfate is added to maintain alkalinity through the treatment process for phosphorus removal. Approximately 100 to 120 mg/l sodium sulfate is applied to the wastewater just upstream of where alum is added. Alum is used to precipitate phosphorus. The alum dose at the time of this visit was approximately 135 mg/l and is used with 0.5 to 1.0 mg/l cationic polymer.

Operational considerations:

- The District representative indicated that construction to double the current 1.5 mgd treatment capacity at this plant is being considered to accommodate growth in the service area.
- It was reported that the airlift tube in the Parkson (Dynasand) filters had to be replaced because of wear caused by sand abrasion.
- Backwashing of the BioFor unit and improved hydraulic controls in the Densadeg unit presented some operational difficulties.

- Fecal coliform levels in the final effluent are so low (0 to 10 colonies/100 ml) that they typically meet permit limitations without disinfection. Accordingly, the use of chlorine and sodium bisulfite (for dechlorination) are minimal.
- Facility operators prefer the more conventional flocculation-clarification units with tube settlers and bed filters that are installed at the Breckenridge Sanitation District, Farmers Korner WWTP. The Farmers Corner WWTP effluent quality is reported to be as good as that produced by the Iowa Hill WWTP with less operational attention.

Breckenridge Sanitation District - Farmers Korner Wastewater Treatment Plant

Contact Information:
District Office:
1605 Airport Road
Breckenridge, CO 80424

Phone: 970-453-2723
Fax: 970-453-2013

Mailing Address:
PO Box 1216
Breckenridge, CO 80424

NPDES permit No. CO0021539 expiration date 31 July 2008

Receiving water: Blue River (tributary to Dillon Reservoir)

Design Treatment Capacity: 3.0 MGD average dry weather flow

Farmers Korner Treatment Processes:

Influent → Screening & Grit Removal → Activated Sludge (with BNR) → Secondary Clarification → Chemical Addition → Tertiary Clarification (tube settlers) → Filtration → Disinfection

Residential sewer use fee: $19/month

Farmers Korner WWTP Performance Information:

Parameter	**NPDES Limitation**	**Avg of monthly averages**	**Range of monthly averages**	**Maximum individual measurement**	**Reporting period**
BOD5	30 mg/l	1.0 mg/l	0.57 to 2.40 mg/l	5.78 (Dec 03)	Aug 03 thru Apr 06
TSS	30 mg/l	1.07 mg/l	0.3 to 3.10 mg/l	5.2 (Dec 05)	Same
NH3-N	10 mg/l	3.36 mg/l	0.31 to 16.66 mg/l	21.88 (May 05)	Same
Total Phosphorus	225 lb/yr & 0.5 mg/l daily max	0.007 mg/l	0.002 to 0.036 mg/l	0.06 (Dec 05)	Same

Facility Description:

The Breckenridge Sanitation District collects wastewater from the town of Breckenridge, Colorado and the surrounding area. The District operates three wastewater treatment facilities including the Iowa Hill and Farmers Korner WWTPs which were visited as part of this evaluation. Facilities at the Farmers Korner WWTP were upgraded in 1999 to the present treatment configuration. Influent flow to this plant includes municipal wastewater from the service area and removed solids from the District's Iowa Hill WWTP.

Discharge from the Farmers Korner WWTP enters Dillon reservoir which is used to supply drinking water to the Metropolitan Denver area. To prevent eutrophication of Dillon reservoir, the NPDES permit established an annual maximum mass loading limitation of 225 pound/day and a daily maximum concentration of 0.5 mg/l for total phosphorus. Facility operators target achieving an effluent concentration of 0.01 to 0.02 mg/l total phosphorus to ensure meeting the annual loading limitation.

Treatment at Farmer Korner WWTP consists of screening and grit removal; biological nutrient removal; chemical coagulation and flocculation using polymer and alum; clarification via tube settlers; filtration though mixed media bed filters; disinfection with chlorine and dechlorination (using sodium bisulfite). Solids removed during treatment are routed to an aerated storage tank, dewatered by centrifuge; and the solids utilized at a mine reclamation site. Caustic soda is added to maintain alkalinity though the treatment process.

Operational Considerations:

- Ten operators are employed to run the three Breckenridge District wastewater treatment plants and also maintain 20 pump stations in the collection system.
- Fecal coliform levels in the final effluent are so low (0 to 10 colonies/100 ml) that they typically meet permit limitations without disinfection. Accordingly, the amount of chemicals used for disinfection are minimal.
- The alum dose applied at the time of this visit was approximately 135 mg/l and is used with 0.5 to 1.0 mg/l cationic polymer.

Snake River Wastewater Treatment Plant

Contact information:
Summit County Board of Commissioners
Snake River Wastewater Treatment Plant
4344 Swan Mountain Road
Dillon, Colorado 80435-8474
970-468-5794

Chuck Clause, Utility Director
Stoner Turner, Chief Operator

NPDES Permit No. CO0029955, expiration date JanAN-31-2008

Receiving water: Dillon Reservoir

Snake River WWTP Process:

Influent →Screening →Aeration Basins → Secondary Clarifiers → Chemical Coagulation → Flocculation →Clarification →

→Filtration→ Disinfection

Snake River WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement (date)	Reporting period
BOD	30/45 mg/l	0.7 mg/l	0.3 to 2 mg/l	3 mg/l (8/03)	2/03 to 5/06
TSS	30/45 mg/l	0.6 mg/l	0.2 to 2 mg/l	4 mg/l (8/04)	2/03 to 5/06
N-NH3	5.8 mg/l	0.25 mg/l	<0.01 to 1.82 mg/l	9.85 mg/l (7/04)	
Phosphorus	340 lb/year total & 0.5 mg/l daily max	0.015 mg/l	<0.01 to 0.04 mg/l	0.08 (2/84)	2/03 to 5/06

Design Treatment Capacity: 2.6 MGD

Residential sewer use fee: $36/month ($108 quarterly)

Facility Description:

The Snake River WWTP treats domestic wastewater collected from a service area that is south and east of the Dillon Reservoir. Treated effluent is discharged into Dillon Reservoir which is used as a drinking water supply for the Denver Metropolitan area. Water quality-based effluent limitations for phosphorus have been established in the NPDES permit issued to this WWTP and other dischargers into the reservoir to prevent eutrophication. Construction to upgrade treatment and capacity of the plant was completed in 2002.

Treatment at the Snake River WWTP includes screening and grit removal; aeration basins; secondary clarification; chemical coagulation and flocculation using with alum and polymer; tertiary clarification (rectangular conventional with inclined plate settlers); mixed media bed filters (5 feet deep); and disinfection (the filtration process removes enough fecal coliform so that conventional disinfection is not normally required). The average alum dose is 70 mg/l in the wastewater and is reported to vary from 50 to 180 mg/l. A greater dose of alum is applied during the winter period. The operator reported the polymer dose concentration to be about 0.1 mg/l. Removed solids are routed to an aerobic digester from which waste solids are dewatered by centrifuge and utilized for mine site reclamation.

Empty rectangular clarifier with inclined plate settlers at Snake River WWTP

Operational considerations:

- Air supplied to the aerobic digesters is turned off for 2 hours three times a day to raise the pH.
- Recycle streams that are routed to the headworks make up about 40 percent of the total plant flow, including grit screenings wash water, WAS thickener decant mixed-media filter backwash waste water, aerobic digester decant and centrate.
- Plant operators are very pleased with operation of the upgraded plant. Good phosphorus removal is achieved through the aeration basins without EBPR. Total phosphorus concentrations measured in the secondary effluent range from 0.5 to 3.0 mg/l. Facility operators speculated the variability of phosphorus in the secondary effluent is possibly because chemical sludge that is recycled to head of plant aids removal of phosphorus through the biological process and secondary clarification. Return streams include WAS thickener decant, aerobic digester decant and centrate.
- Essentially complete nitrification of wastewater is achieved in the aeration basins.
- The filtration process removes enough fecal coliform so that conventional disinfection is not normally required.

Pinery Wastewater Reclamation Facility

Contact Information:
Pinery Water and Wastewater District
6516 North State Highway 83
Parker, Colorado 80134

Mailing address:
P.O. Box 1660
Parker, Colorado 80134

Telephone: 303-841-2797

NPDES Permit No. CO0041092, expiration date Sept 30, 2010

Receiving water: Groundwater in Cherry Creek Reservoir subbasin

Design Treatment Capacity: 2.0 MGD

Treatment Processes:

Influent → Screening & Grit Removal → EBNR (BardenPho 5 stage) → Secondary Clarification → Chemical Addition → Filtration "Memcor" → UV Disinfection

Pinery WWTP Treatment Performance:

Parameter	NPDES Limitation (monthly average)	Average of monthly averages	Range of monthly averages	Maximum measurement (date)	Reporting period
BOD	30 mg/l	1.1 mg/l	0.36 to 5.2 mg/l	6.4 mg/l (8/05)	1/03 to 9/05
TSS	30 mg/l	2.2 mg/l	0.6 to 13.3 mg/l	33.3 mg/l (4/04)	1/03 to 9/05
Phosphorus	0.05 mg/l & 304 lbs/year	0.029 mg/l	0.021 to 0.074 mg/l	0.234 mg/l (11/05)	1/03 to 9/05

Monthly residential sewer use fee: $18 month ($36 bimonthly, plus additional fee for water usage over 6,000 gallons)

Facility Description:

The Pinery Wastewater Treatment Plant was originally constructed in 1990 and upgraded in 2005. The plant treats domestic wastewater from a service area located south of Parker

Colorado. Discharge from the treatment plant is directed into Cherry Creek. Water quality-based limitations for phosphorus and other pollutants have been established in the NPDES permit to protect the shallow Cherry Creek aquifer and the reservoir. The enhanced biological nutrient removal process utilized at the Pinery Plant is recognized as being very well operated and has been studied and cited numerous times as an example of exemplary application of this technology.

Treatment consists of screening and grit removal; BNR Activated Sludge (BardenPho 5 Stage [Anaerobic Basin, Anoxic Basin, Oxidation Ditch Aeration Basin, Anoxic Basin, Reaeration Basin]); Clarifiers [2 parallel rectangular]; Chemical addition using alum and polymer; Effluent Polishing and filtration [using 4 US Filter Memcor filter modules] ; and UV disinfection. The US Filter units utilize two-stage filtration in which the first stage is upflow through a plastic media with air scour. The second stage filtration is through a downflow, mixed media with backwash cleaning. The concentration of alum used for coagulation was reported to be 95 mg/l. Residuals solids removed during treatment are routed to aerobic digester tanks. These solids are dewatered on a belt filter press and dried/composted for land application.

Operational Considerations:

- The concentration of total phosphorus in the plant influent is high (8 to 10 mg/l) because phosphoric acid is used in the District's water supply for corrosion control.
- Ortho-P is monitored by on-line instrumentation (Hach series 5000 Low-Range) in the influent to the chemical treatment system and the final filter effluent. This equipment is capable of measuring phosphorus to concentrations as low as 0.01 mg/l.
- The Memcor filters used for effluent polishing are upflow through plastic media (adsorption) and downflow through an anthracite sand media filter. Backwash of the filter unit components is automatically initiated when a preset head loss is measured. The total flow of backwash water used to clean the filters is about 15%. Flushing and backwash water is equalized and introduced to the reaeration basin ahead of the secondary clarifiers.
- Sulfuric acid is used for pH control in the treatment process as optimum $AlPO_4$ precipitation occurs when the pH = 6.0.

Modular Memcor Filter (US Filter Company) at Pinery WWRP. Each of these modules has a treatment capacity of approximately 0.5 mgd.

Metering equipment used for chemical addition at Pinery WWRP

Memcor filter module at Pinery WWRP undergoing backwash

- The laboratory TP and Ortho-P procedures use a Hach DR4000 colorimeter with 1" cuvettes which can achieve total phosphorus detection levels to less than 0.01 mg/l.
- Chemical sludge does not settle well in the secondary clarifiers at the Pinery WWTP, so a portion goes over the weirs and is removed again in effluent filter system.
- Water conservation measures and the progressive water and sewer use fee are working in the District. The result is that water consumption is decreasing and the concentration of influent wastewater is increasing.
- Operators have found measuring the oxidation-reduction potential (ORP) of wastewater in the plant to be an effective parameter for managing the biological treatment system.

Clean Water Services, Rock Creek Advanced Wastewater Treatment Plant

Contact Information:
Clean Water Services
Rock Creek Advanced Wastewater Treatment Plant
3235 SW River Road
Hillsboro, OR 97123
503-648-8774

NPDES Permit No. OR0029777, expires 31-JAN-2009

Design capacity: 39 mgd dry weather treatment

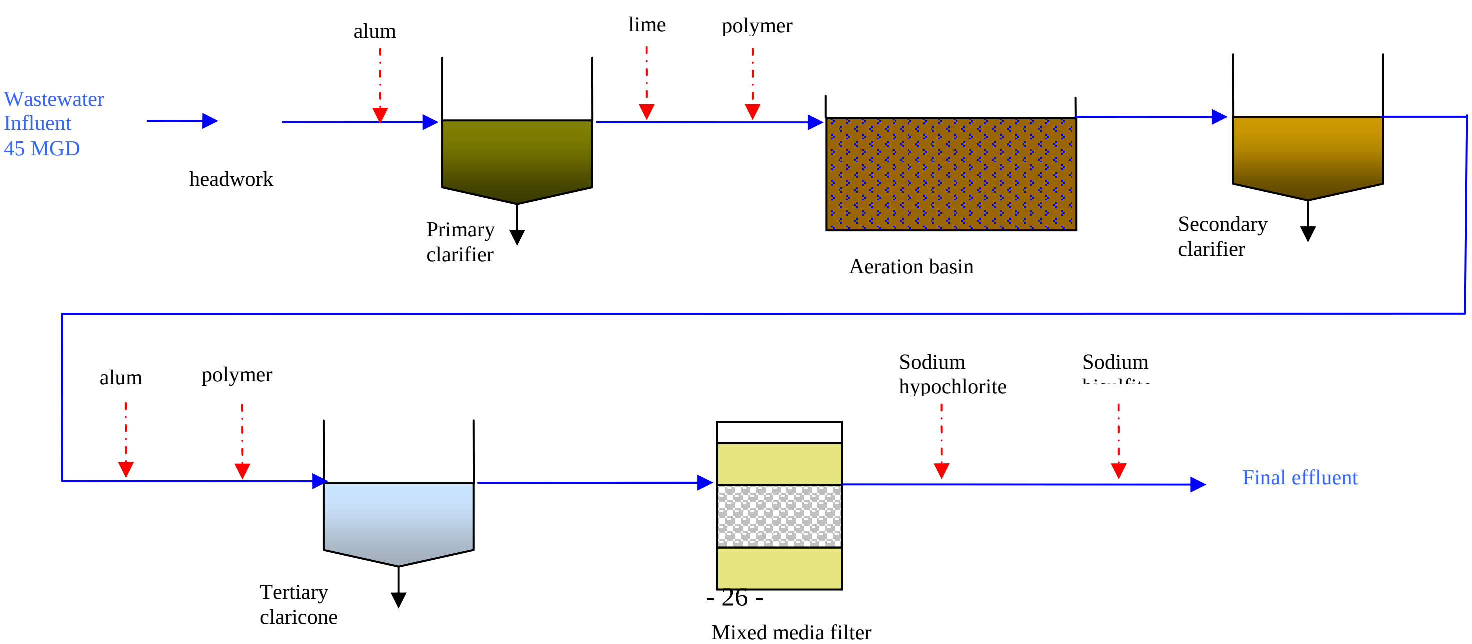
Receiving water: Tualatin River

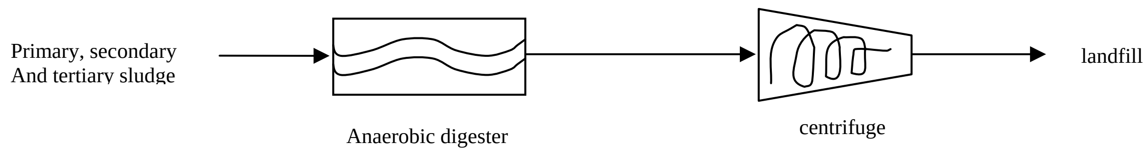
Clean Water Services, Rock Creek AWWTP Performance Information:

Parameter	NPDES Limitation (monthly avg)	[1]Avg of monthly averages	[1]Range of monthly averages	[1]Maximum individual measurement (date)	Reporting period
CBOD	8 mg/l (seasonal)	1.4 mg/l	1.3 to 1.5 mg/l	1.6 mg/l (5/05)	5/05 to 10/05
TSS	8 mg/l (seasonal)	1.2 mg/l	0.9 to 1.8 mg/l	1.8 mg/l (8/05)	5/05 to 10/05
Phosphorus	*0.10 mg/l	0.07 mg/l	0.04 to 0.09 mg/l	0.09 mg/l (9/05)	5/05 to 10/05

* Limitation established as a monthly median concentration
[1] Monitoring information from dry season when nutrient limitations apply (May through October

Rock Creek AWWTP Treatment Processes:





Monthly residential sewer use fee: $16.07 plus $1.11/ccf/month. The average monthly residential fee is $27.

Facility Description:

Clean Water Services Rock Creek AWWTP (from CWS informational publication)

Clean Water Services operates four wastewater treatment plants with a service area that includes over 800 miles of collection system piping in Washington County, Oregon. The largest of these WWTPs is the Rock Creek facility which discharges into the Tualatin River. These Clean Water Services plants are staffed by well trained operators with support from knowledgeable operations analysts. Numerous upgrades to treatment have been installed at the Rock Creek WWTP over time. The most recent upgrade to improve phosphorus removal was installed in 1993. The Tualatin River contains natural background levels of phosphorus that are significantly higher than observed in many other northwest watersheds. Because the water quality of the Tualatin River was impaired by excessive nutrient loading from various sources in the watershed, a TMDL was established which includes a wasteload allocation for phosphorus loading from the Rock Creek AWWTP. The wasteload allocation is equivalent to the natural background concentration of phosphorus in the River at the point of discharge. This wasteload allocation is expressed in the NPDES permit as a monthly median limitation of 0.1 mg/l which applies seasonally from May through October.

Wastewater flow is divided for treatment through the east and west side treatment trains. Treatment at the Rock Creek WWTP consists of screening and grit removal; alum addition; primary clarification; extended aeration; secondary clarification; flocculation using alum and polymer; tertiary clarification; filtration; disinfection (with chlorine) and dechlorination. Four 60 foot diameter ClariCone tertiary clarifiers are used on the east treatment train to provide contact time and settling after addition of polymer and alum. Filtration on the east train is accomplished with six monomedia anthracite gravity flow bed filters. The west treatment train uses conventional clarifiers for tertiary settling followed by filtration through four dual media gravity flow bed filters.

Phosphorus is removed in four locations within the Rock Creek treatment system: alum enhanced removal in the primary clarifiers; biological removal in the aeration basins; chemical flocculation and removal in the tertiary clarifiers; and removal through filtration. Treatment upgrades to install enhanced biological nutrient removal of phosphorus are being considered as a means for reducing the current cost of chemicals used for phosphorus removal. Clean Water Services maintains an informative website (http://www.cleanwaterservices.org/AboutUs/Wastewater/TreatmentProcess.aspx) which provides additional information about current treatment and planned upgrades of this facility.

Operational Considerations:

- The average concentration of total phosphorus in the raw plant influent is 6 mg/l.

- Lime is added to maintain pH and alkalinity through the treatment process. The cost of lime used for treatment is about $150,000 per year.

- System analysts have determined that the phosphorus limitation will usually be met if the total suspended solids concentration is 1.5 mg/l or less in the final effluent. A strong empirical relationship has also been observed that when the aluminum to total phosphorus ratio is 5:1 to 7:1 in the secondary effluent, that the total phosphorus concentration in the final effluent will be less than 0.1 mg/l.

- A ratio (not stoichametric) of about 50:1 dry alum to phosphorus is the target dose rate in the tertiary clarifiers. Alum use during May through October (when phosphorus limitations apply) costs about $250,000, based on acquiring alum at $172 per dry ton. This usage of alum equates to a cost of approximately $1,500 per day, or about $50 per mgd of wastewater treated.

- The formation of struvites (ammonium, magnesium, phosphorus crystals) has been an operational problem in some of the slow velocity piping, such as in the heat exchanger recirculation.

- Resolubization of phosphorus in return streams from anaerobic handling of removed solids represents about 20 percent of the phosphorus and ammonia-nitrogen loading to the plant. The loading from these return streams is managed by storage and flow equalization back into the treatment system.

- The secondary effluent that goes to tertiary treatment typically has the following characteristics: total phosphorus < 0.5 mg/l; orthophosphorus <0.1 mg/l; TSS < 10 mg/l; COD < 50 mg/l and N-NH3 <0.01 mg/l.

- Performance records kept by Clean Water Services staff document that the 50th percentile of monthly average total phosphorus concentrations achieved over the previous eight years is 0.071 mg/l. Concentration of total phosphorus in the final effluent have been reduced to as low as 0.032 mg/l. CWS systems analysts expect that better phosphorus removal could be achieved if more effective final filtration equipment were installed. They estimate that if a final effluent TSS concentration of 0.5 mg/l were achieved, the total phosphorus concentration would be about 0.03 mg/l.

Aeration basin at Clean Water Services, Durham AWWTP. The basins at the Rock Creek WWTP may be modified in the future to also provide enhanced biological phosphorus removal.

Clean Water Services, Durham Advanced Wastewater Treatment Plant

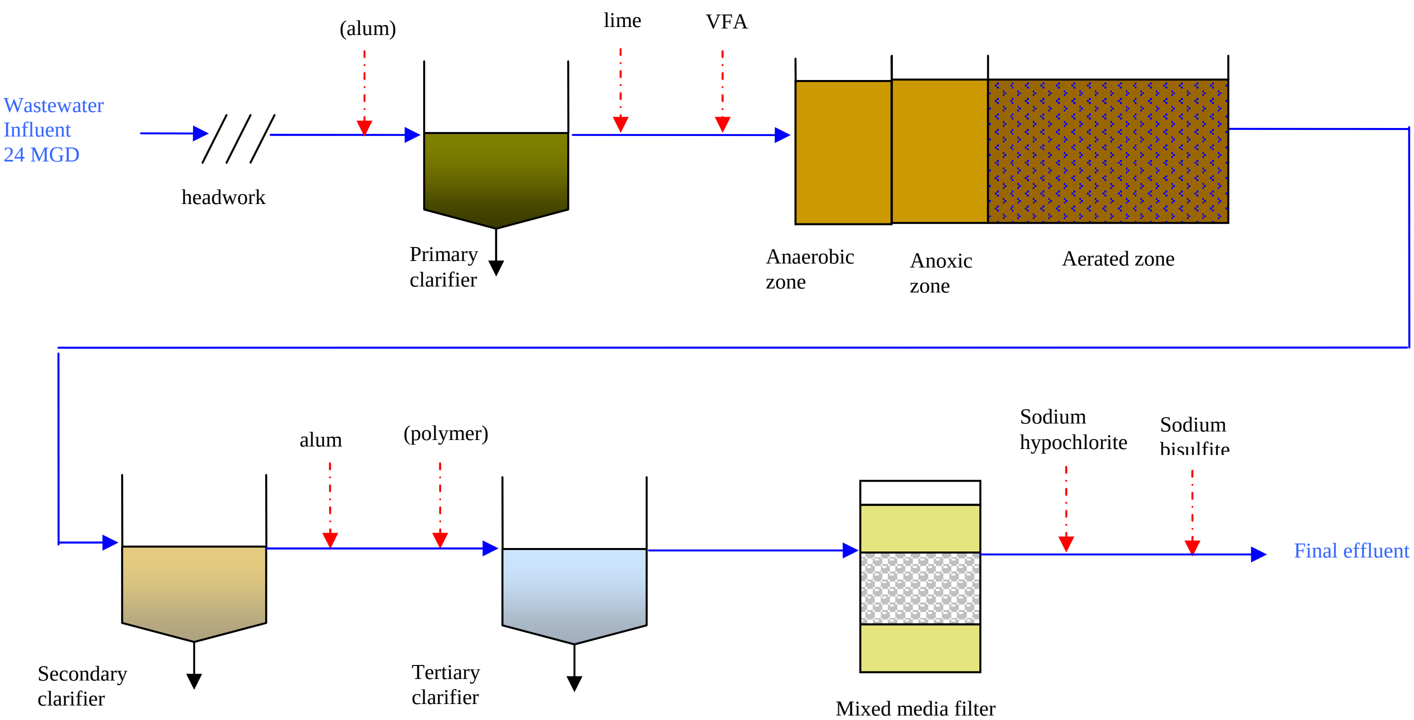
Contact Information:
Clean Water Services
Durham Advanced Wastewater Treatment Plant
16580 SW 85th Street
Tigard. OR 97224
Phone No. 503.831.3600

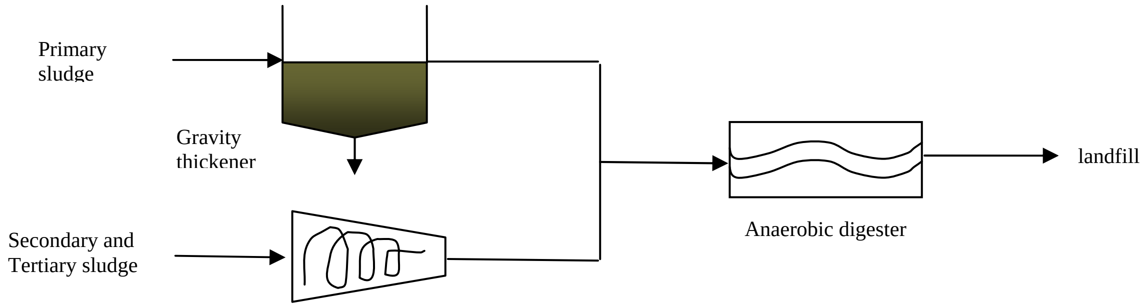
NPDES Permit No. OR0028118, expiration date JAN-31-2009

Design capacity: 24 mgd average dry weather treatment flow

Receiving water: Tualatin River

Durham AWWTP Treatment Process:





Clean Water Services, Durham AWWTP DMR information:

Parameter	NPDES Limitation (monthly avg)	[1]Avg of monthly averages	[1]Range of monthly averages	[1]Maximum individual measurement (date)	Reporting period
CBOD	8 mg/l (seasonal)	2.2 mg/l	1.7 to 2.6 mg/l	4.2 mg/l (6/05)	5/05 to 10/05
TSS	8 mg/l (seasonal)	1.8 mg/l	1.7 to 2.8 mg/l	2.8 mg/l (5/05)	5/05 to 10/05
Phosphorus	*0.11 mg/l	0.07 mg/l	0.05 to 0.1 mg/l	0.1 mg/l (9/05)	5/05 to 10/05

* Limitation establishes as a monthly median concentration
[1] Monitoring information from period when seasonal nutrient limitations apply (May through October)

Monthly sewer use fee: $16.07 plus $1.11/ccf/month. The average monthly residential fee is $27.

<u>Facility Description:</u>

Clean Water Services operates four wastewater treatment plants with a service area that includes over 800 miles of collection system piping in Washington County, Oregon. These Clean Water Services plants are staffed by well trained operators with support from knowledgeable operations analysts. The Durham Advanced Wastewater Treatment Plant is the second largest of the four WWTPs and discharges treated effluent into the Tualatin River. This plant was constructed in 1976 and upgraded to the existing treatment configuration in 1989. Maximum daily wet weather treatment capacity is about 80 mgd.

The Tualatin River reportedly contains natural background levels of phosphorus that are significantly higher than observed in many other northwest watersheds. Because the water quality of the Tualatin River was impaired by excessive nutrient loading from various sources in the watershed, a TMDL was established which includes a wasteload allocation for phosphorus loading from the Durham AWWTP. The wasteload allocation is equivalent to the estimated natural background concentration of phosphorus in the River. This wasteload allocation is expressed in the NPDES permit for this facility as a monthly median limitation of 0.11 mg/l which applies seasonally from May through October.

Treatment at the Durham AWWTP consists of screening and grit removal; primary clarification; biological treatment with enhanced biological nutrient removal; secondary clarification:

chemical addition of alum and polymer for phosphorus removal; tertiary clarification; filtration through dual media gravity bed filters and disinfection. Lime is added to the biological process to maintain pH and alkalinity. Removed solids are anaerobically digested, dewatered by centrifuge, and utilized as fertilizer. A two-stage fermenter is operated to produce volatile fatty acids which are added to the biological contact basins. The enhanced biological nutrient removal process at times reduces total phosphorus to levels that are less than the 0.11 mg/l permit limitation. However, this performance is not achieved during the entire period when the seasonal phosphorus limitations are in effect. The tertiary treatment with chemical addition and filtration provides assurance that the final effluent is of consistently good quality. Some of the treated effluent is reclaimed for irrigation.

Operational considerations:

- Nitrate-nitrogen may interfere with biological phosphorus removal if sufficient volatile fatty acids (VFAs) are not maintained. Therefore, creation of volatile fatty acids (VFAs) is necessary for the enhanced biological phosphorus removal process to work properly. Operators route solids from the primary clarifier to a two-stage fermenter system. The fermenter produces 500 mg/l VFAs when provided a two and one half day solids retention time. For good biological removal of phosphorus, the optimal relationship for VFAs to phosphorus in the contact basins is about 5:1.

- Operators have determined that orthophosphorus comprises about 75 to 80 percent of the total phosphorus. Automatic sampling equipment provides continuous, low level orthophosphorus information that can be used to adjust treatment as necessary. A target of 0.02 mg/l orthophosphorus was identified as representing optimal treatment performance by the current treatment configuration.

- Secondary effluent quality information is used to operate the biological phosphorus removal process. Operators target achieving a final effluent concentration of 0.07 mg/l by reducing total phosphorus in the secondary effluent to 0.50 mg/l or less.

- The amount of biosolids generated by biological phosphorus removal is somewhat more than would be produced by using only chemical treatment for phosphorus removal.

- Return streams from anaerobic handling of removed solids (supernatant from digesters and centrate from centrifuges) comprises about 20 percent of the total phosphorus loading to the plant. The loading from these return streams is managed by storage and equalizing its flow back into the treatment system.

Empty tertiary clarifier at Clean Water Services, Durham AWWTP

Empty gravity flow bed filter at Clean Water Services, Durham AWWTP

Stamford Wastewater Treatment Plant

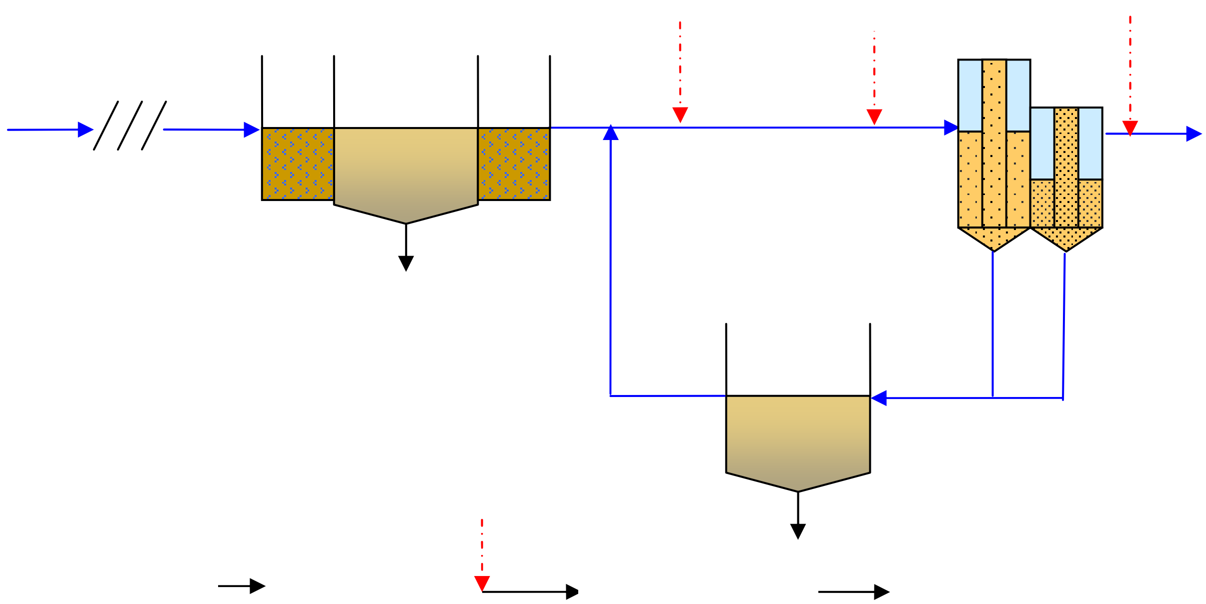
Contact Information:
Village of Stamford Wastewater Treatment Plant
Railroad Avenue
Stamford, New York 12167
Telephone: 607-652-3172

Operated by: Delaware Operations

NPDES Permit No. NY0021555, expiration date JUL-01-2009

Receiving water: West Branch Delaware River Watershed

Stamford WWTP Treatment Process:



Stamford WWTP Performance Information:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Phosphorus	0.2 mg/l	*<0.011 mg/l	<0.005 to < 0.06 mg/l	0.06 (11/05)	2/03 to 5/06
N-NH3	2.5 mg/l	*<0.98 mg/l	<0.03 to 0.63 mg/l	0.63 (7/05)	7/04 to 5/06
TSS	30 mg/l	*<3.3 mg/l	< 2 to 8 mg/l	8 (3/03)	2/03 to 5/06
CBOD	25 mg/l	*<4.5 mg/l	<3.5 to 8 mg/l	8.5 (8/04)	7/04 to 5/06

* Almost all measurements were reported as less than (<) values

Design Treatment Capacity: 0.5 MGD (requested certification for 0.7 mgd pending @ New York State Department of Environmental Conservation (NYSDEC)

Monthly household sewer use fee: $10 /month

Note about sewer fees: The costs of construction, operation and maintenance of any and all unit processes (which are in excess of New York State standards at this and other WWTPs discharging into the Delaware River watershed) are subsidized by the City of New York. The Stamford WWTP unit processes funded by the City of New York include the chemically-enhanced tertiary filtration, redundant disinfection, dechlorination systems, emergency stand-by power generation, telemetry and alarm systems, and sludge dewatering. The incremental O&M cost increase of these unit processes, as well as additional operations staffing and accounting personnel, are funded annually by the City of New York.

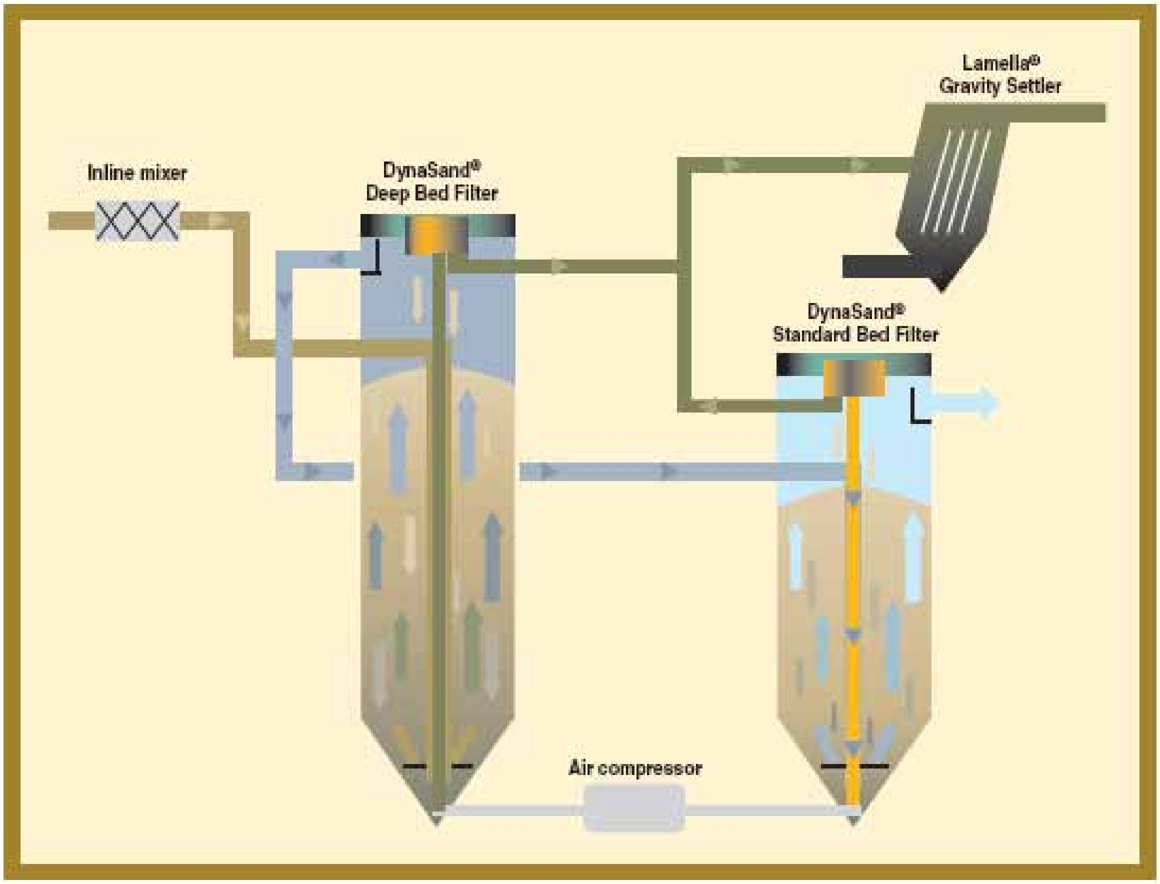
Facility Description:

The Village of Stamford wastewater treatment plant (Stamford) receives municipal wastewater from residences and a number of businesses in this community. Delaware Operations is contracted to operate this facility for Stamford. Discharge of treated effluent from Stamford is into the 2,000 square mile New York City Watershed, including the Delaware River watershed, which is a primary drinking water supply for the City of New York. To protect the quality of this receiving water, the City of New York provides funding for municipal dischargers in the watershed to construct and operate advanced wastewater treatment. In return for this financial assistance, these municipalities must maintain and operate their facilities to produce high quality effluent. Design criteria for tertiary treatment and NPDES permit limitations are established by the New York State Department of Environmental Conservation.

Wastewater treatment at the existing Stamford WWTP was upgraded and became fully operational in 2003. Treatment consists of grit removal and screening; extended aeration and secondary clarification (in combined aeration basin/clarifier); chemical addition for flocculation using PASS and filtration through two-stage Dynasand filters. Removed solids are routed to an aerobic digester. Waste solids are dewatered in a belt press and sent to a landfill. There are also large equalization basins available to which raw wastewater may be routed for storage during times of high influent flow.

Combined aeration basin and clarifier (in center of unit) at Stamford WWTP

The DynaSand filters installed at Stamford were obtained from the Parkson Corporation. Both the first stage and the second stage filters operate as continuous backwashing, upflow, sand media filters. There are nine sets of first and second stage filters, each with an approximate surface area of fifty square feet. The sand media in the two meter deep first stage filter has an average diameter of 1.3 millimeters. The second stage sand media is 0.9 millimeters. Secondary treated wastewater is pumped to a distribution header from which it flows by gravity through the first and then the second stage filters. Influent to the first stage filters is chlorinated to inhibit biological growth. Because PASS hydrolyzes so quickly, this flocculant is added to the influent of each first stage filter, rather than being mixed in the distribution header. The reject stream from the filters is routed to a small clarifier and the overflow is returned mixed with influent to the first stage filter. Solids removed in the reject clarifier are routed to a new aerobic digester, into which secondary solids are also mixed, and then dewatered in a newly installed 1.0 meter belt press.



Generic diagram of two stage DynaSand filtration system (courtesy of Parkson Corporation). Note: the Stamford WWTP uses a concrete clarifier in lieu of a lamella settler.

Operational Considerations:

- Analyses for phosphorus, BOD and TSS in the final effluent are conducted using EPA-approved testing methodologies by a NYS-certified laboratory. For data quality control purposes, samples of final effluent are routinely split and sent to a state certified contract laboratory which specializes in achieving extremely low reporting levels for phosphorus. Nevertheless, most of the sample results are reported as less than values (<) on the monthly discharge monitoring. These results routinely demonstrate the effluent as being significantly below permit limitations but do not necessarily accurately characterize the very low phosphorus concentrations in the effluent.
- A correlation between pathogens and turbidity in the effluent was established for municipal dischargers in the watershed. Continuous monitoring of turbidity is a closely watched NPDES permit requirement. Treatment plant operation is optimized to achieve very low effluent turbidity. The excellent removal of other pollutants such as phosphorus, is primarily a by-product of WWTP operation focused on maintaining low turbidity in the final effluent.
- The design hydraulic loading rate specified by New York City for the Parkson Dynasand filters is 3.36 gallon/square foot/minute (g/ft^2/min). Operators report the best performance has been achieved at Stamford with a filter loading rate of between 4.0 and

4.5 gpm/sq. ft. but stated that the filters continue to perform very well up to loading rates of over 5.0 gpm/sq.ft.

- The filters in use are routinely rotated based on the amount of time they have been in service. There are nine (9) filter trains at the Stamford WWTP; under typical operating conditions, only 2 filters are running.

- PASS is obtained from the Eaglebrook Company (phone number 450.652.0665) at an approximate cost of $4/gallon. Stamford operators say the addition of PASS is flow paced at a rate of about 30 gallons per one half mgd of wastewater treated. This equates to a cost of approximately $240/day/per mgd for flocculant.

- There is essentially no sand lost from the DynaSand filters during operation.

- The reject rate from the filters is designed and operated to be about 10 percent of the total flow. The percent reject decreases at higher loading rates.

- The overflow rate from each DynaSand filter can easily be adjusted by inserting different size plastic weirs.

Plastic weirs used for adjusting overflow rate from DynaSand Filters

- The turbidity of the effluent was 0.053 NTU at the time of EPA's site visit. Turbidity is closely monitored as it has been determined to be a good surrogate for measuring pathogens potentially present in the discharge. The NPDES permit limit for turbidity is 0.5 NTU.

Walton Wastewater Treatment Plant

Contact Information:
Walton Wastewater Treatment Plant
54 South Street
Walton, New York 13856
Phone Number (607) 865-6993

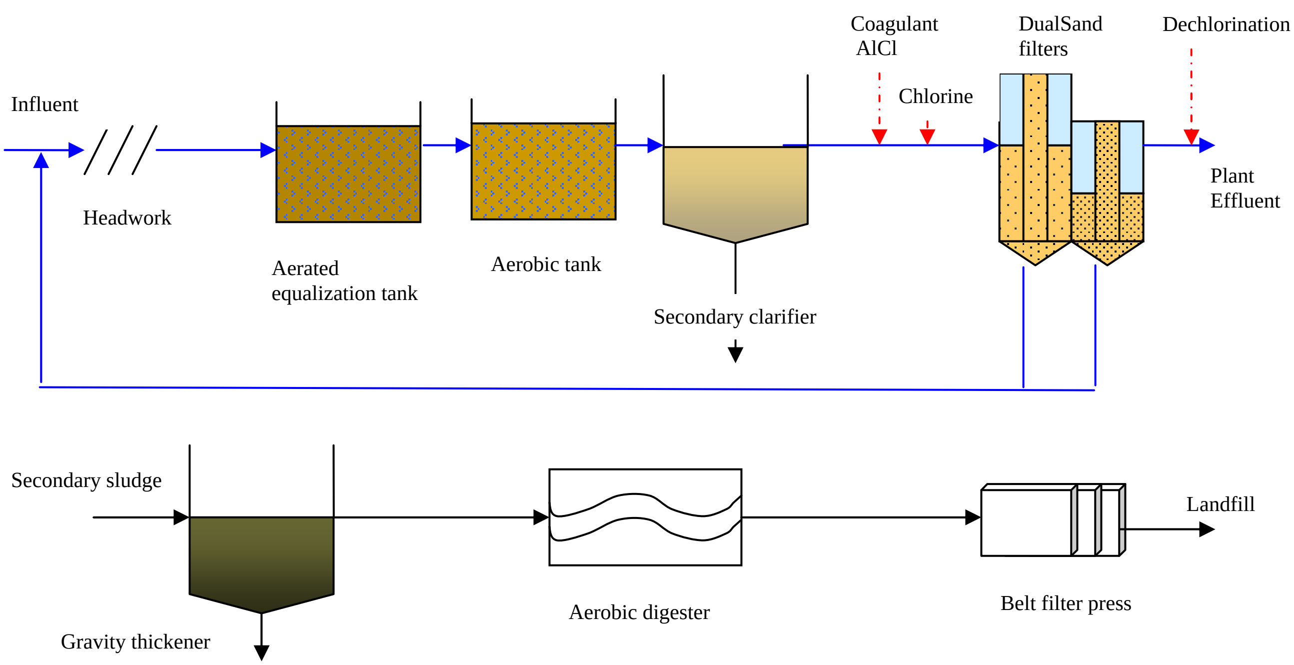
Operated by: Delaware Operations

NPDES Permit No. NY0027154, expiration date Feb 2008

Receiving water: Delaware River Watershed

Design Treatment Capacity: 1.55 mgd (average daily flow)

Treatment Process Diagram:



Walton WWTP Performance Information:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Total P [1]	0.2 mg/l	<0.01 mg/l	<0.005 to < 0.06 mg/l	<0.06 mg/l (3/06)	2/03 to 3/06
N-NH3 [2]	8.8 mg/l	0.24 mg/l	<0.05 to 1.4 mg/l	1.4 mg/l (6/05)	6/03 to 6/06
TSS	30 mg/l	<3.5 mg/l	<2.6 to <4.9 mg/l	<4.9 mg/l (12/05)	2/03 to 3/06
CBOD	25 mg/l	<3.7 mg/l	<2.5 to <4.5 mg/l	<21 mg/l (7/04)	2/3 to 3/06

[1] Almost all phosphorus measurements were reported as less than (<) a specified detection value. The reported detection value was used for summarizing performance, although the actual concentration is lower.
[2] There are seasonal limitations for ammonia nitrogen and performance is summarized for the period when this limitation applies.

Monthly household sewer use fee: $10 month plus charges based on water usage. (Note: the costs of construction, operation and maintenance of this and other WWTPs discharging into the Delaware River watershed are subsidized by the City of New York.)

Facility Description:

The Walton Wastewater Treatment Plant (WWTP) receives municipal wastewater from residence and a number of businesses in this community plus a significant amount of wastewater from a nearby dairy creamery. Wastewater from the creamery constitutes about 80 percent of the organic loading and 40 percent of the flow into the WWTP. The influent to the WWTP would be characterized as high strength with an average BOD concentration of 350 mg/l. Discharge of treated effluent from Walton is into the 2,000 square mile Delaware River watershed, which is a primary drinking water supply for the City of New York. To protect the quality of this receiving water, the City of New York provides funding for municipal dischargers in the watershed to construct and operate advanced wastewater treatment. In return for this financial assistance, these municipalities must maintain and operate their facilities to produce high quality effluent. Design criteria for tertiary treatment and NPDES permit limitations are established by the New York Department of Environmental Conservation.

Wastewater treatment at the existing Walton WWTP was upgraded and became fully operational in 2003. Treatment consists of grit removal and screening; extended aeration and secondary clarification; chemical addition for flocculation using aluminum chloride (added to the wastewater at both the secondary clarifiers and the distribution header for the DynaSand filters); and filtration through two-stage Dynasand filters; disinfection with chlorine and dechlorination with sulfur dioxide. Chlorine is added to the filter influent to control biological growth in the filters. Removed solids are routed to an aerobic digester. Waste solids are dewatered in a belt press and sent to a land fill.

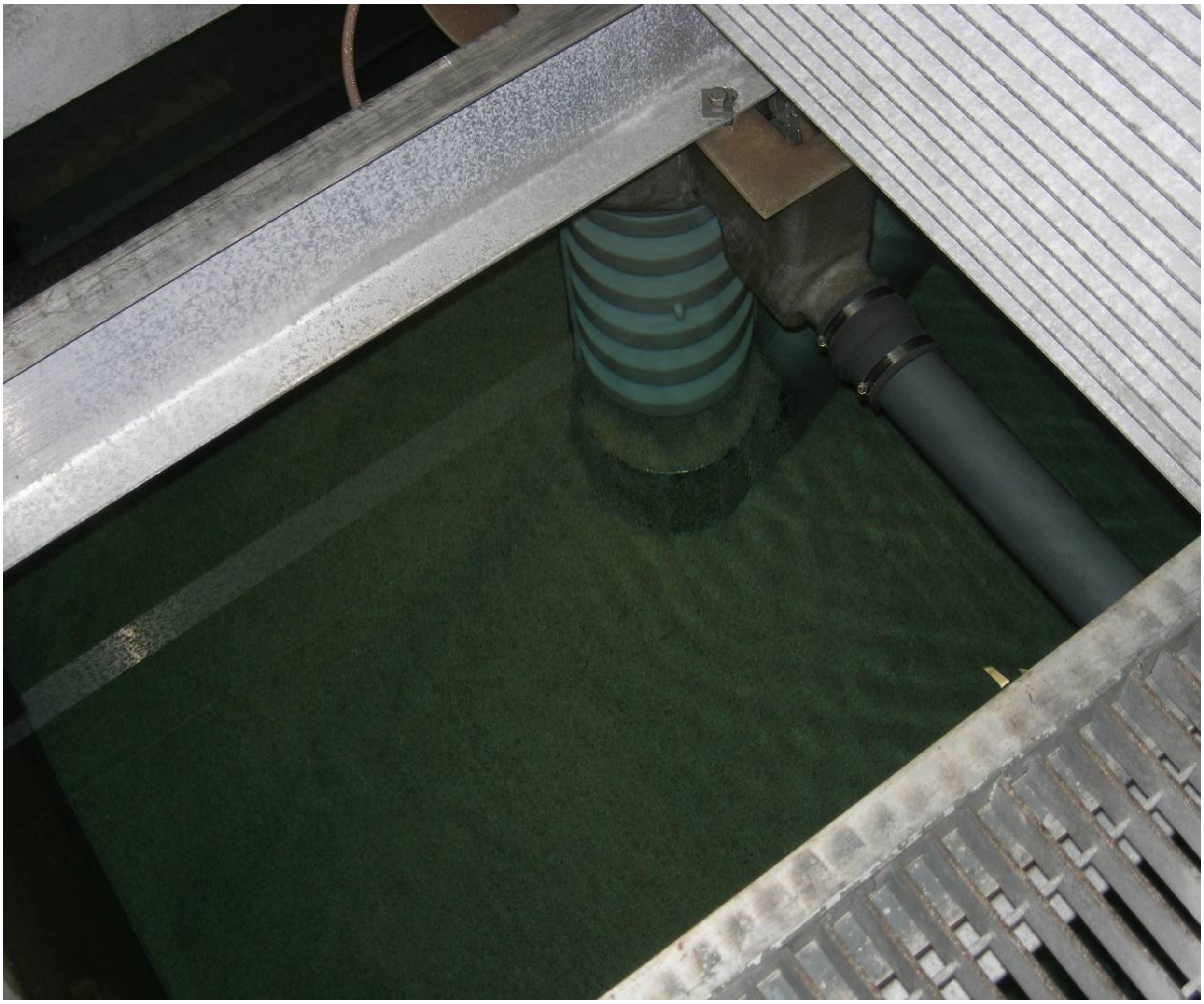
The DynaSand filters installed at the Walton WWTP were obtained from the Parkson Corporation. Both the first stage and the second stage filters operate as continuous backwashing, upflow, sand media filters. There are five sets of first stage and second stage filter modules.

Each module contains four DynaSand filters which have an approximate surface area of two hundred square feet (or eight hundred square feet per module). So, there is total of 40,000 square feet surface area of primary filters and the same amount of secondary filter surface area. The sand media in the two meter deep first stage filters has an average diameter of 1.3 millimeters. The second stage filters are one meter deep and contain sand media of 0.9 millimeter average diameter. The number of filters in use is adjusted as needed to accommodate flow through the plant. The filter modules in use are routinely rotated according to time in service.

Secondary treated wastewater is pumped to a distribution header where aluminum chloride and chlorine is added and from which it flows by gravity through the first and then the second stage filters. The reject stream from the filters is routed to the headworks of the plant.

DynaSand Filters at
Walton WWTP

The above picture shows a side view of the distribution header (far right), first stage and second stage DynaSand filters installed at the Walton WWTP. Flow through the filters is by gravity from the distribution header. The people shown in this picture are standing on grating above the second stage filters. This building houses twenty (2 meter deep) first stage and twenty (1 meter deep) second stage DynaSand filters which have a combined total surface area of about 80,000 square feet. The installation is configured to create five banks of filters which are rotated into use on a time basis. At the time of this visit, two of the five filter banks were being used to treat the entire wastewater flow at this plant.



View into top of DynaSand filter at Walton WWTP. This picture shows sand being returned from washer at top of lift tube in a second stage filter. These filters are designed to wash sand continuously (without any backwash cycle).

Operational Considerations:

- About 80 percent of the loading and 40 percent of the wastewater flow into the Walton WWTP comes from the Kraft Dairy operation.
- Analyses for phosphorus, BOD and TSS in the final effluent are conducted using EPA approved testing methodologies. For data quality control purposes, samples of final effluent are routinely split and sent to a state certified contract laboratory which specializes in achieving extremely low reporting levels for phosphorus. Nevertheless, most of the sample results are reported as less than values (<) on the monthly discharge monitoring. These results routinely demonstrate the effluent as being significantly below permit limitations but do not necessarily characterize the excellent quality of the effluent.

- The turbidity of the effluent was 0.062 NTU at the time of EPA's site visit. Turbidity is closely monitored as it has been determined to be a good surrogate pollutant for measuring the pathogens potentially present in the effluent. The NPDES permit limit for turbidity is 0.5 NTU.
- The maximum treatment capacity of the plant is 3 mgd. The DynaSand filters are not the limiting factor as this flow can be treated by using only 3 of the 5 filter modules.
- Total phosphorus concentrations in the secondary effluent typically range between 1 to 2 mg/l.
- The cost of aluminum chloride to the Walton WWTP was reported to be $4.64/gallon. A streaming current meter (which measures the negative charge of particles in the water) is used to control aluminum chloride dosing. Approximately 50 to 60 gallons of aluminum chloride are used each day which equates to a daily cost of about $250/day at this 1.5 mgd facility.
- The filter press is operated 3 times a week to dewater solids from the aerobic digester. Solids are sent to a landfill and removed liquid is returned to the plant headworks. Operators reported observing no changes in treatment plant performance caused by the solids handling return streams.
- The design hydraulic loading rate specified by New York City for the Parkson DynaSand filters is 3.36 gallon/square foot/minute ($g/ft^2/min$). Operators report they typically run filters at hydraulic loading rate of between 4.0 and 4.5 $g/ft^2/min$ but stated the filters would continue to perform very well up to loading rate of 5.0 $g/ft^2/min$.
- The filters in use are routinely rotated based on the amount of time they have been in service.
- There is essentially no sand lost from the DynaSand filters during operation.
- The reject rate from the filters is designed and operated to be about 10 percent of the total flow.
- The overflow rate from each DynaSand filter can easily be adjusted by inserting different size plastic weirs (pictured in Stamford WWTP description).

Milford Wastewater Treatment Plant

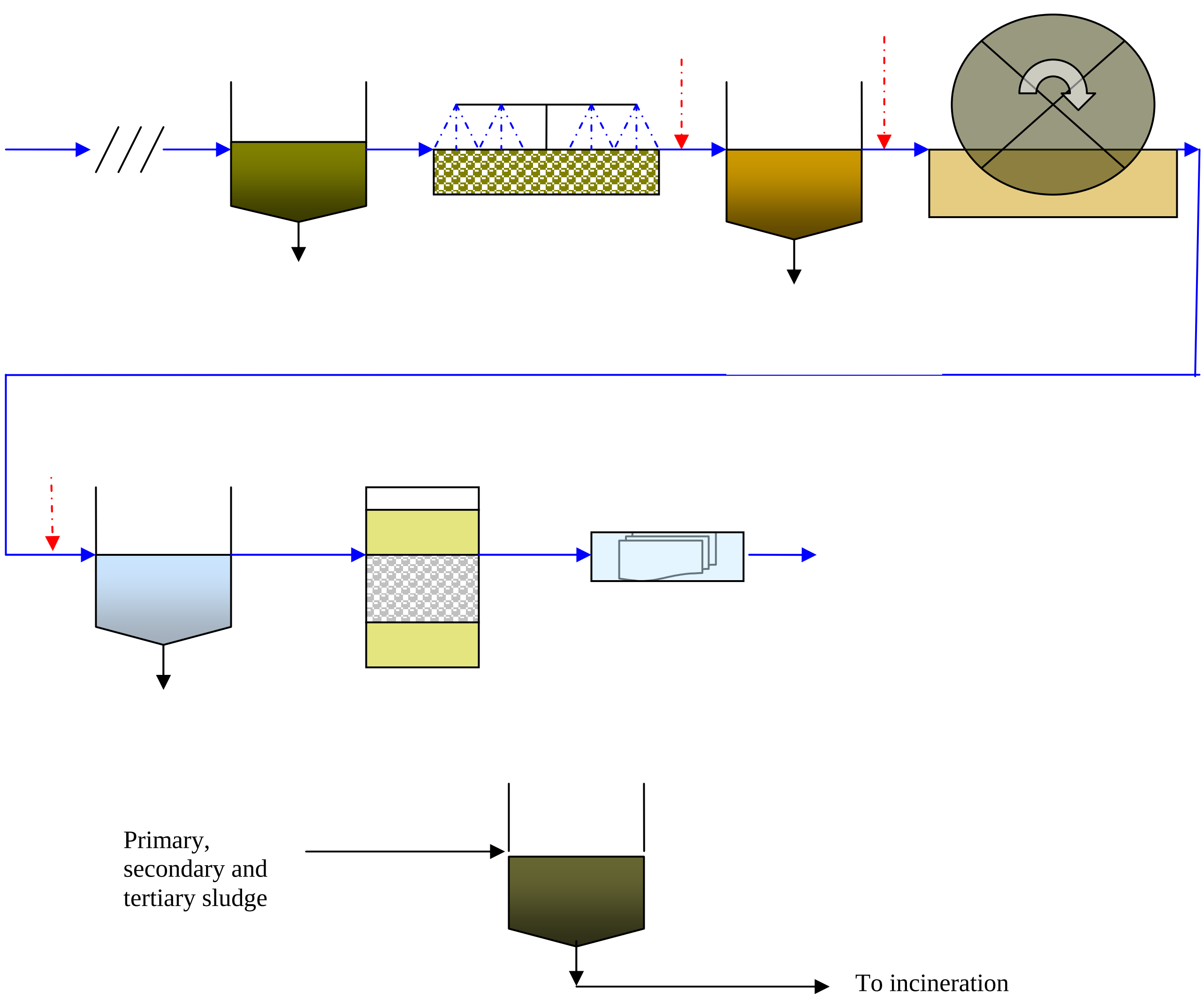
Contact information:
Mailing address:
Milford Wastewater Treatment Plant
P.O. Box 644
Milford, MA 01757
Phone Number: 508-478-0059

NPDES Permit No. MA0100579, expiration date 31-MAR-2010

Receiving water: Headwaters of Charles River

Permitted flow: 4.8 mgd (monthly average)

Milford WWTP Process Diagram:



Milford WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement(date)	Reporting period
BOD	30/45 mg/l	3.7 mg/l	1.3 to 7.4 mg/l	9.1 mg/l (4/05)	7/03 to 4/06
TSS	30/45 mg/l	1.7 mg/l	0.48 to 8.0 mg/l	13.6 (2/03)	1/03 to 4/06
N-NH3*	1.0 mg/l	0.26 mg/l	0.05 to 0.48 mg/l	0.19 mg/l (6/03)	6/03 to10/05
Phosphorus*	0.2 mg/l	0.07 mg/l	0.04 to 0.16 mg/l	0.16 mg/l (6/04)	6/03 to10/05

* NPDES limitations for phosphorus and ammonia are seasonal. The 0.2 limit for phosphorus applies April 1 - October 31. The ammonia limitation for the month of May is 5.0 mg/l only and is 1.0 mg/l for the period from June 1 - October 31. The performance information shown is for the periods of each year when these seasonal water quality-based limitations apply.

Monthly residential sewer use fees: $27.50 ($330/year)

Facility Description:

Wastewater treatment facilities were originally constructed to serve the local community in 1902. Remnants of that original facility and some of the subsequent treatment upgrades may still be observed. The current treatment facility was constructed in 1985 and treats domestic wastewater from the surrounding service area. Discharge is into the headwaters of the Charles River. During the dry period of the year, the discharged effluent constitutes the entire flow at this point of the river. The collection system suffers from inflow and infiltration problems which cause influent flow to the WWTP to be quite high in response to significant rain events. As a result, influent BOD concentrations are sometimes diluted to below 80 mg/l. Severe rainfall during the preceding week resulted in influent flows being greater than 8 mgd at the time of the site visit. Although the permit limitation for flow is 4.8 mgd, the plant has demonstrated the ability to treat these high flows and still produce an excellent quality effluent.

Treatment at the Milford WWTP consists of screening and grit removal; primary clarification; trickling filters; intermediate clarification (with polymer addition to aid settling); rotating biological contactors; secondary clarification; chemical addition using poly-aluminum chloride; filtration through mixed media traveling bed filters; ultraviolet disinfection. The final effluent is discharged down a cascading outfall to achieve reaeration prior to mixing in the receiving water. Approximately 1 mgd per day of the final effluent is utilized by the local power company for cooling water.

Operational considerations:

- A colorimetric method is used for analyzing total phosphorus. The reportable level achieved in the Milford laboratory using this testing methodology is typically about 0.02 mg/l total phosphorus.
- Approximately 17 to 20 gallons of polymer are added prior to the intermediate clarifiers.
- Approximately 300 to 400 gallons per day of PACl are used to flocculate phosphorus. Facility representatives stated the cost of PACl to be $1.50/gallon. So, the total daily cost of PACl ranges from about $450 to $600.
- Removed solids are routed to an aerobic thickener. The concentration of thickened solids coming out of the thickener is only about 3%. Having to haul so much water with these solids represents the largest single cost ($350,000/year) of operating this WWTP.
- The trickling filters and rotating biological contactors appear to be very resilient to increase flows caused by inflow and infiltration. However, the record setting rainfall during the winter months of 2006 had affected treatment removal of ammonia-nitrogen.

Trickling filters at Milford WWTP

Cascading discharge structure into Charles River at Milford WWTP

Alexandria Sanitation Authority (ASA) Advanced Wastewater Treatment Plant

Contact Information:
Alexandria Sanitation Authority
1500 Eisenhower Avenue
Alexandria, VA 22314 1987
Phone: 703-549-3381

Aerial View on ASA Advanced Wastewater Treatment Facility (from ASA staff)

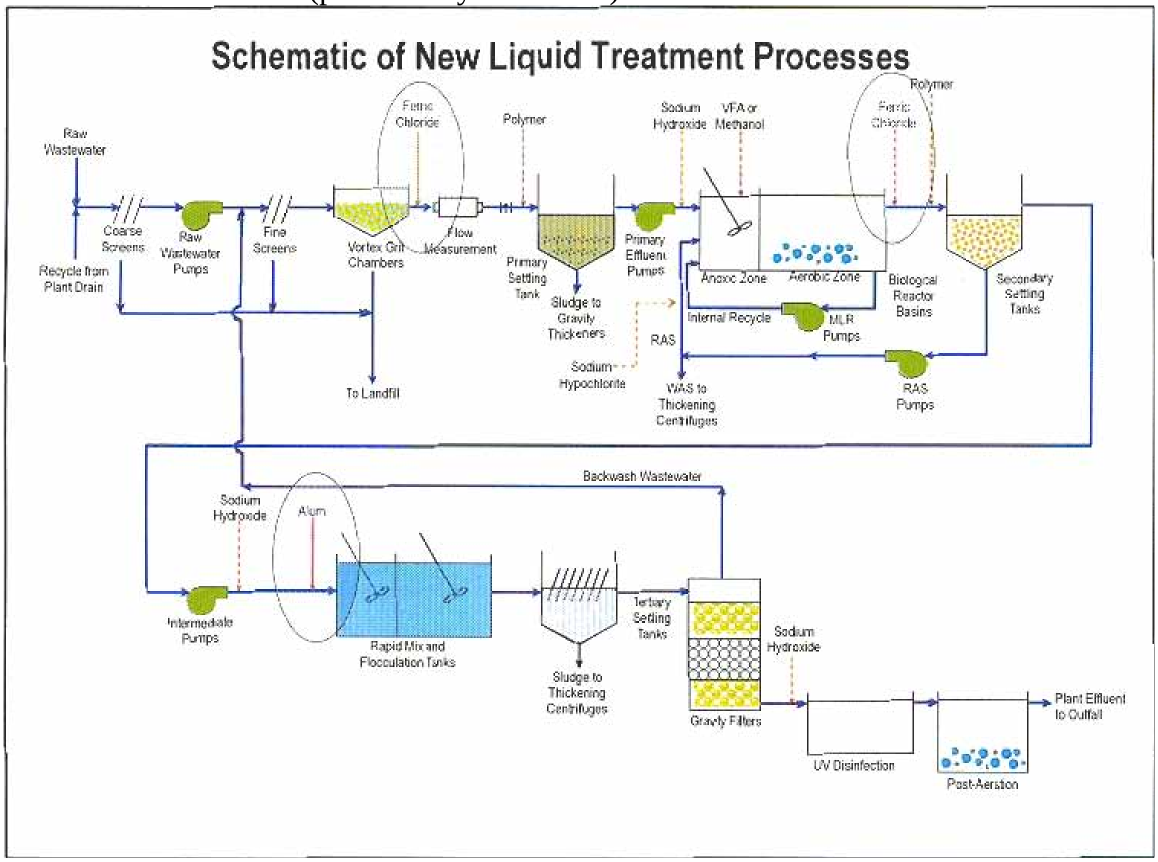
NPDES Permit: No. VA0025160 , expires 20-JAN-2009

Receiving water: Hunting Creek (a tributary to the Potomac River)

Design Treatment Capacity: 54 mgd (average dry weather)

Phosphorus treatment technology: Triple point chemical addition in which ferric chloride is added to primary and secondary settling tank influents and alum is added to the tertiary settling tank influent.

Alexandria AWWTP (provided by ASA staff)



Alexandria Advanced WWTP Performance Information:

Parameter	[1]NPDES Limitation (monthly avg)	Average of monthly averages	Range of monthly averages	Maximum individual measurement	[1]Reporting period
Phosphorus	0.18 mg/l	0.065 mg/l	0.04 to 0.1 mg/l	0.15 mg/l (4/05)	9/04 to 5/06
N-NH3	8.4 mg/l	*<0.1 mg/l	0 to 0.2 mg/l	0.6 mg/l (1/06)	9/04 to 5/06
TSS	6 mg/l	1.5 mg/l	<0.1 to 5.4 mg/l	9.2 mg/l (2/04)	9/04 to 5/06
CBOD	5 mg/l	*<0.1 mg/l	0 to 0.5 mg/l	1.0 mg/l (12/05)	9/04 to 5/06

* Monitoring results during this period were typically reported as zero or less than detection
[1] The summarized monitoring data is inclusive of all values submitted during the reporting period regardless of when seasonal water quality based effluent limitations apply

Monthly household sewer use fee: $4.17 plus $4.49 per 1,000 gallons water used

Facility Description:

The ASA Advanced WWTP treats wastewater with combined storm sewers from a service area of approximately 51 square miles including the City of Alexandria and portions of Fairfax County. The population served is approximately 400,000 people. ASA began construction to upgrade the 54 mgd design flow facilities in 1999 to meet the water quality requirements of the Potomac Embayment Standards and the Chesapeake Bay Agreement. Initial operation of the new Biological Nutrient Removal (BNR) system was achieved in December 2002.

Treatment consists of screening; grit removal; primary settling with possible addition of ferric chloride and polymer; methanol or volatile fatty acid added to biological reactor basins to aid BNR; ferric chloride and polymer addition prior to secondary settling; alum addition and mixing; tertiary clarification with inclined plate settlers; dual media gravity bed filtration; UV disinfection and post aeration. Removed solids are dewatered in centrifuges and the centrate is returned to the primary clarifiers. Then sludge is pre-pasteurized; anaerobically digested; centrifuged again and sent to land application as Class A biosolids. The moisture content of the biosolids after treatment is about 70 percent.

Operational Considerations:

- High influent flows during rain events often exceed 80 mgd. The plant has treated peak influent flows of 108 mgd during extreme storm events.

- The average influent concentration of total phosphorus was reported to be about 4.5 mg/l.

- Operators reported an observed trend of increasing influent concentrations while influent flow has remained steady. Speculation about the cause of these phenomena is that the ASA progressive sewer rates (which are based in part on water usage) have promoted water conservation.

- The facility is currently considering treatment upgrades necessary to achieve a required monthly average effluent target for total nitrogen of 3.0 mg/l.

- Multiple point chemical addition is utilized for phosphorus removal. Ferric chloride is added to primary and secondary settling tank effluents. Alum is mixed into the influent to the tertiary settling tanks. The alum contained in the return stream was reported to aid in phosphorus removal through the plant processes.

- Sodium hydroxide is added to the primary effluent, the secondary effluent and after the gravity filters to increase pH and maintain alkalinity.

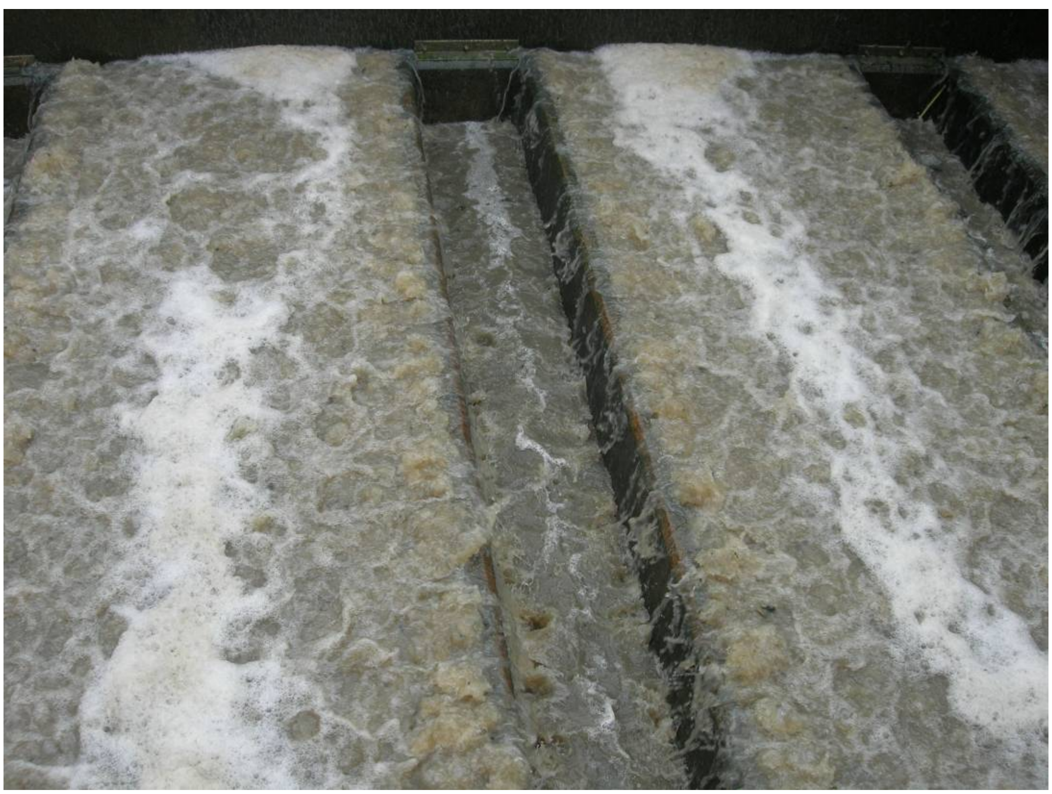
- The concentration of total phosphorus in the secondary effluent is typically about 0.4 to 0.5 mg/l. Facility representatives reported that the average concentration of phosphorus in the final effluent during 2005 was approximately 0.05 mg/l.

- The approximate annual cost for chemicals used in treatment is $2.4 million. This includes $1.4 million for sodium hydroxide, $300,000 each for alum and polymer, and $300,000 for ferric chloride and methanol.

- The plant is equipped with custom-made computerized controls (supervisory control data acquisition system) to enhance the efficiency of operation.

- Biological treatment at ASA includes methanol fed to sequential anoxic and aerobic zones in the secondary process. Primary wastewater is ‘step fed’ into the secondary basins. A portion of the wastewater from each aerobic zone is recycled back to the preceding anoxic zone.


Chemical mixing paddles in front portion of sedimentation tanks at Alexandria AWWTP


Bed filter undergoing backwash at Alexandria AWWTP

Upper Occoquan Sewage Authority (UOSA)

Millard H. Robbins Regional Wastewater Reclamation Facility

Contact information:
Upper Occoquan Sewage Authority
Millard H. Robbins Regional Water Reclamation Plant
14631 Compton Road
Centreville, VA 20121-2506
Phone No. 703-830-2200

NPDES Permit: No. VA0024988, expiration date FEB-19-2007

Treatment capacity: 42 mgd annual average flow, 128 mgd instantaneous peak flow

Receiving water: Unnamed Tributary of Bull Run Creek (Bull Run is a major tributary of the Occoquan Reservoir)

UOSA WRF Treatment Performance Information:

Parameter	NPDES Limitation	Average of monthly** averages	Range of monthly** averages	Maximum individual measurement	Reporting period
Total Phosphorus	0.10 mg/l	*<0.088 mg/l	0.023 to <0.282 mg/l	0.580 mg/l (2/03)	3/02 to 12/04
TSS	1 mg/l	*<0.549 mg/l	0 to 2 mg/l	NA	3/02 to 9/03 2/05 to 6/06

* estimated average because many measurements were reported as less than (<) values or below detection limit
** Weekly averages for Total Phosphorus

Monthly residential sewer use fees: (of the 4 four UOSA member jurisdictions):

- Fairfax County sewer rates: $3.03/1000 gallons (FY 2004)
- Prince William County sewer rates: $3.75/1000 gallons (FY 2003)
- City of Manassas sewer rates: $4.09/1000 gallons (FY 2004)
- City of Manassas Park sewer rates: $35.00 as monthly Water and Sewer Service Charge (FY 96 through FY 2004)

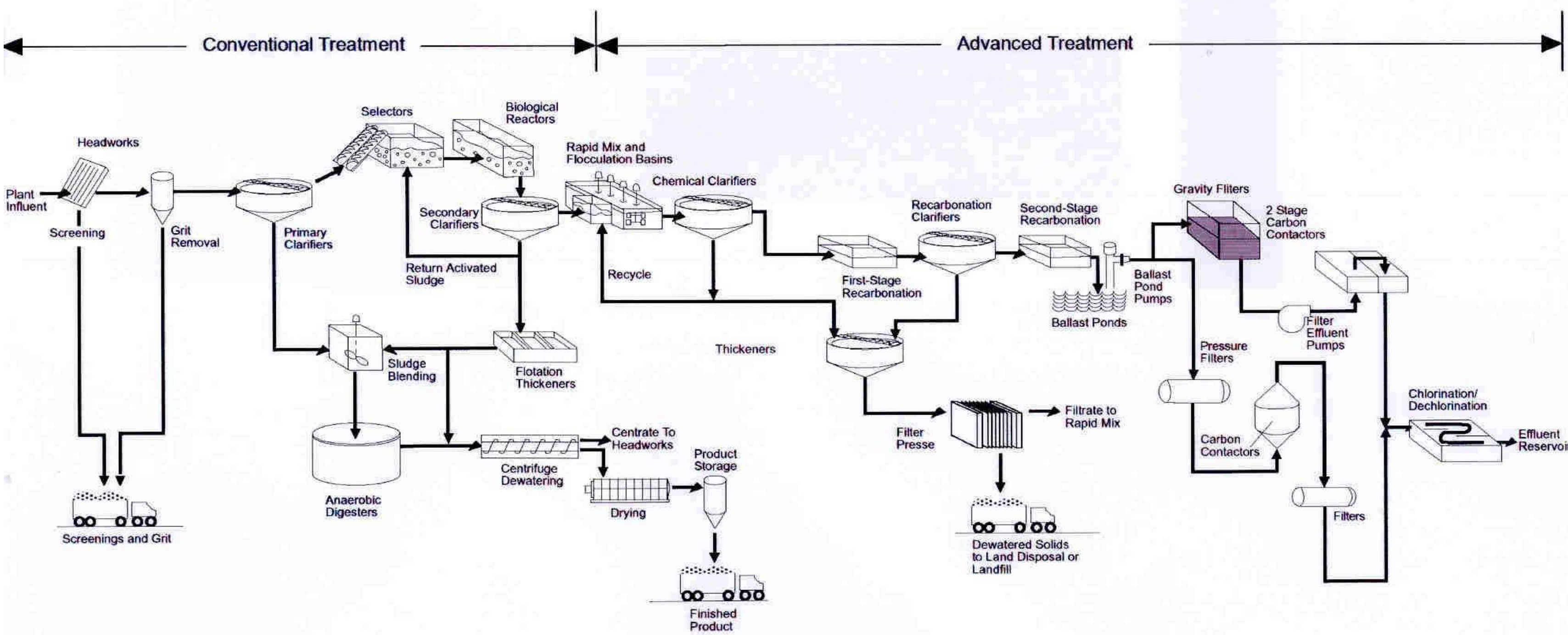
UOSA Treatment plant schematic (provided by UOSA)**:**

Millard H. Robbins Regional Water Reclamation Plant

Capacity
42 MGD Annual Average flow
54 MGD Peak Month (30-day rolling)
128.4 MGD Peak Instantaneous influent
90 Million gallons on-site emergency storage
7.5 MW emergency generator capacity

Key Permit Requirements

Chemical Oxygen Demand (COD)	< 10 mg/L
Total Phosphorus (TP)	<0.1 mg/l
Total Suspended Solids (TSS)	<1.0 mg/L
Total Kjeldall Nitrogen (TKN)	<1.0 mg/L
Turbidity	<0.5 NTU



Facility Description:

For nearly 30 years, the Upper Occoquan Sewage Authority (UOSA) has provided advanced wastewater treatment water reclamation for a service area in Virginia that includes portions of Fairfax County, Prince William County, and the cities of City of Manassas, and the City of Manassas Park. Nineteen miles downstream from the UOSA discharge is a drinking water withdrawal from the Occoquan Reservoir that serves approximately 1.3 million people. Around 1972 UOSA selected a biological, physical, chemical treatment process (high lime treatment system) that could reliably produce a high quality reclaimed wastewater that would both protect the quality and augment the amount of water in the reservoir.

The 10 mgd treatment capacity of the original plant has been upgraded in several stages to about 54 mgd since it began operation in 1978. Continuing rapid development and population growth in the service area is again prompting consideration of treatment plant expansion to accommodate the need for additional wastewater treatment capacity. In 1972, the high lime treatment process represented the best technology for consistently achieving the necessary high quality effluent. However, since that time other treatment technologies have evolved that also produce high quality effluent. The next plant expansion may include use of a technology other than high lime treatment.

UOSA maintains and operates this facility with well- qualified staff that routinely provides educational tours of their treatment facility. EPA greatly appreciates that UOSA allowed use of their educational materials for describing the treatment process in this report.

UOSA liquid treatment process is composed of:

- A conventional treatment that removes 90% of most incoming pollutants: screening; grit removal; primary clarification; aerobic biological selectors; activated sludge aeration basins with nitrification/denitrification processes; secondary clarification.

- A chemical advanced treatment – high-lime process – to reduce phosphorus to below 0.10 mg/l, to capture organics from secondary treatment, to precipitate heavy metals and to serve as a barrier to viruses : lime slurry added to rapid mix basins (to achieve pH of 11); anionic polymer added in flocculation basins; chemical clarification; first stage recarbonation to lower pH to 10; recarbonation clarifiers to collect precipitated calcium carbonate; second stage recarbonation to lower pH to 7; storage in ballast ponds.

- Physical advanced treatment to meet stringent limits for TSS (1 mg/l) and COD (10 mg/l) including alum and/or polymer addition; multimedia filters; activated carbon contactors.

- Disinfection by chlorination/dechlorination process.

UOSA Water Reclamation Facility (WRF) – in the forefront are fine bubble diffuse aeration basins constructed during the plant expansion to 27 mgd which are off-line in this picture.

Secondary Clarifiers with lime handling buildings in background at UOSA WRF

Removed solids processing at UOSA WRF:

- Primary sludge and waste activated sludge are screened, digested, blended, dewatered by centrifuge and ultimately dried to produce fertilizer pellets.
- Chemical and recarbonation sludge are concentrated by gravity thickeners, filter press and then transported to a UOSA owned captive landfill.

Lime slurry being mixed into wastewater at UOSA WRF

Operational Considerations:

- The UOSA WRF experiences significant increased influent flows as the result of inflow and infiltration into the collection system. Although the annual average design flow into the plant is approximately 42 mgd, peak hourly influent flows of 120 mgd have been experienced during extreme storm conditions.
- Handling and mixing (slaking) lime is “messy”. Scaling in the treatment system after lime addition also presents a maintenance problem.
- Operators believe the existing treatment system could achieve even lower levels of phosphorus in the final effluent with additional chemical addition.
- The 2006 operating budget was $21,227,800 to operate and maintain this facility. Over half of this cost is for UOSA staff wages. Electrical power and chemical costs are approximately $2,691,000 and $1,562,000, respectively.

Lime scaling on chemical clarifier weirs at the UOSA WRF

Fairfax County Wastewater Management, Noman M. Cole Jr. Pollution Control Plant

Contact Information:
Wastewater Treatment Division
Noman M. Cole Jr. Pollution Control Plant
9399 Richmond Highway
Lorton, VA 22079
Phone No. 703.550.9740

NPDES Permit: No. VA0025364, expiration date APR-13-2008

Design capacity: 67 mgd

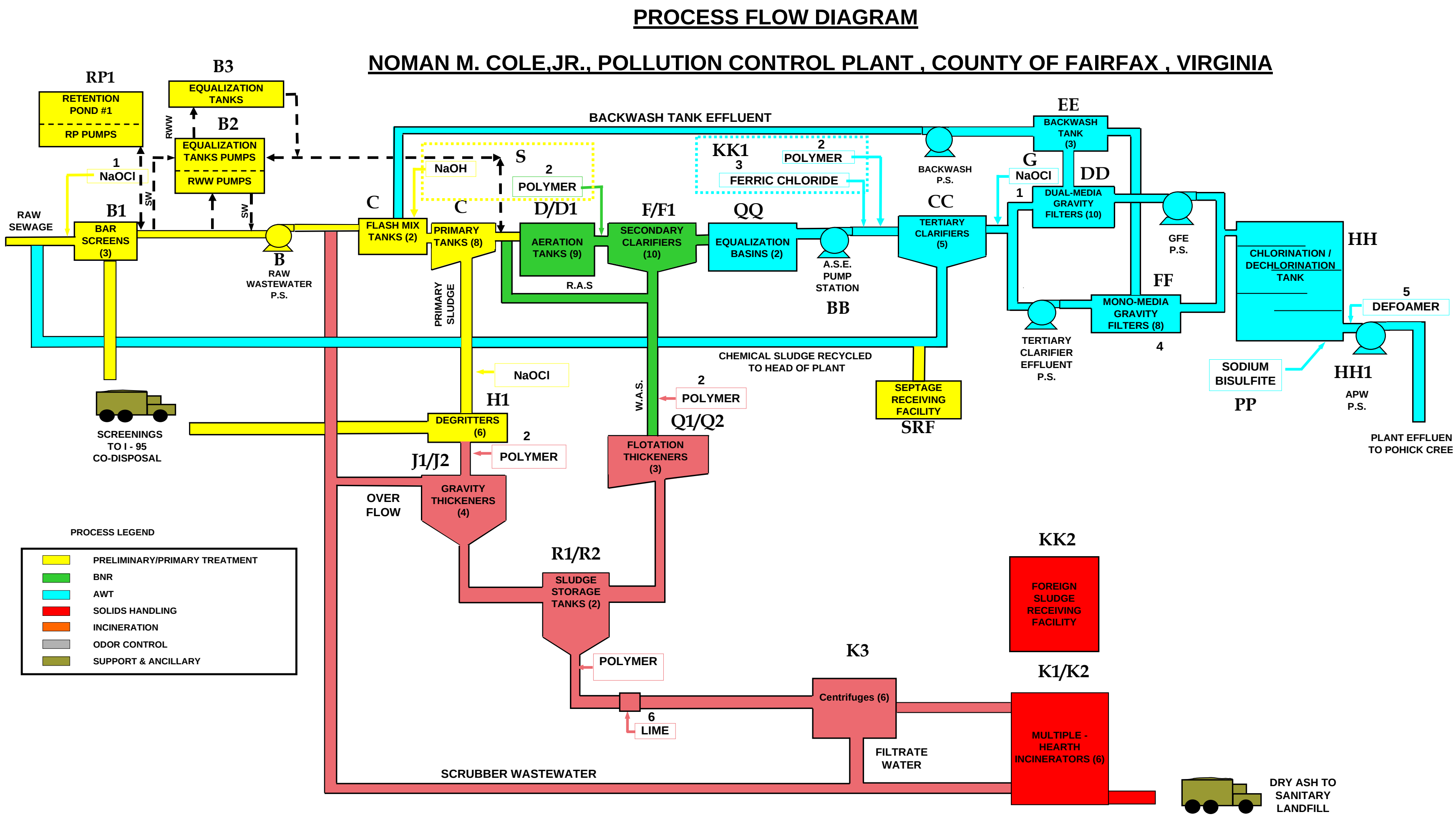
Receiving water: Pohick Creek, tributary of Potomac River and Chesapeake Bay

Noman Cole WWTP Performance Information:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Total Phosphorus	0.18 mg/l	*<0.061 mg/l	<0.02 to <0.13 mg/l	0.20 mg/l (10/05)	4/03 to 6/06
Ortho-phosphorus	none	*<0.057 mg/l	<0.05 to <0.11 mg/l	0.20 mg/l (10/05)	4/03 to 6/06
NH3 - N	**1 mg/l	*<0.040 mg/l	0 to 0.20 mg/l	0.64 mg/l (10/05)	4/03 to 6/06
BOD	5 mg/l	below detection limit	Non detectable to <2 mg/l	2 mg/l (4/03)	4/03 to 6/06
TSS	6 mg/l	*<1.21 mg/l	0 to 3.5 mg/l	4.1 mg/l (12/04)	4/03 to 6/06

* Many measurements were reported as less than (<) values or below detection limit
** Seasonal limitation : from April to October (2.2 mg/l from November to March)

Monthly sewer use fee: $ 3.28/1000 gallons used. The average monthly residential fee is $21.



(Diagram provided by Fairfax County WWTP staff)

Facility Description:

Fairfax County is one of 15 counties and cities in Virginia and Maryland that comprise the Washington D.C. Metropolitan Statistical Area. Fairfax County owns and operates the Noman M. Cole Jr. Pollution Control Plant. This facility receives mostly domestic wastewater from over 3,200 miles of sewer lines in the service area and currently treats an average influent flow of 45 mgd. This and other municipal dischargers to the Potomac River and Chesapeake Bay are required to achieve monthly and weekly average permit limitations for total phosphorus of 0.18 and 0.27 mg/l, respectively. A monthly average limitation of 3 mg/l for total nitrogen will become effective in the year 2010.

Treatment at the Noman Cole Plant consists of screening; primary clarification (covered for odor control); biological treatment with enhanced biological nutrient removal (BNR); polymer addition as needed; secondary clarification; equalization and storage in retention ponds; tertiary clarification with ferric chloride addition to remove phosphorus; disinfection with sodium hypochlorite; filtration through dual/mono media gravity bed filters. Tertiary sludge is routed to a gravity thickener to create volatile fatty acids (VFAs) which are added to aid the biological phosphorus removal process. Removed solids from the primary and secondary clarifiers are dewatered by lime addition, filter presses and centrifuge, and then incinerated in multiple hearth incinerators. The inert ash is hauled by truck to a landfill.

Baffles installed in wastewater contact basin (empty) to achieve anoxic and aerobic conditions for enhanced biological nutrient removal at Noman Cole PCP.

Wastewater contact basin in operation at Noman Cole PCP

Operational considerations:

- The combination of biological nutrient removal, chemical addition with tertiary clarification and filtration effectively reduces total phosphorus concentrations to well below the 0.18 mg/l permit limitation. Other pollutants such as BOD, TSS and fecal coliform are also reduced to very low levels through these treatment processes.

- The amount of ferric chloride added in the tertiary clarifier to remove phosphorus has been reduced since biological phosphorus removal was implemented. The ferric chloride dosage before installation of biological nutrient removal was 18 to 20 mg/l. The concentration used now is down to 9 to 10 mg/l.

- The treatment processes are continuously being evaluated and optimized by staff with the goal of consistently meeting permit limitations in the most cost effective manner.

- Treatment upgrades necessary to meet the new nitrogen limitation are currently being considered. It is likely that methanol addition and other changes to the biological treatment train will be made to enhance nitrogen removal from wastewater.

- Opportunities to reuse the high quality final effluent for irrigation or as cooling water are being considered.

- The Noman Cole annual operating budget is reported to be approximately $18 to $20 million.

- Ferric chloride costs in 2005 were about $180,000.

Empty tertiary clarifier at Noman Cole PCP

Blue Water Technologies, Inc– Full scale pilot facility installed at the Hayden Area Regional Wastewater Treatment Plant

Contact Information:
Hayden Area Regional Wastewater Treatment Plant
10108 North Atlas Road
Hayden, ID 83835

Blue Water Technologies, Inc:
10108 10450 North Atlas Airport Road
Hayden, ID 83835
Phone No 208-209-0391
Website: www.blueh2o.net

NPDES Permit: No. ID0026590, expiration date 02-NOV-2004

Design capacity of Hayden WWTP: 1.65 mgd

Receiving water: Spokane River

Monthly sewer use fee: Company representatives estimate that were the Blue PRO phosphorus removal system added to the existing Hayden WWTP as tertiary treatment, the residential sewer use fee would increase by only $1.20 / month to cover all costs of construction and operation. Company representatives estimate the capital cost for the Blue PRO phosphorus removal system as tertiary treatment is $178,000 for a 1-mgd treatment plant and $494,000 for a 3-mgd treatment plant.

Facility Description:

The Hayden WWTP is operated by the Hayden Area Regional Sewer Board, serving the greater Hayden, Idaho, area. The permitted plant flow is 1.65 mgd. All of the treated wastewater is utilized for silvacultural irrigation during the warm, dry summer period. During the other times of the year, WWTP effluent is discharged into the Spokane River. The quality of the Spokane River and Long Lake are documented as being impaired by excessive loading of nutrients during the summer period. An intensive water quality evaluation effort by the State of Washington determined that phosphorus loading from the point source dischargers must be significantly reduced to restore water quality. A TMDL is currently being developed by the state which will specify very low wasteload allocations for discharges into the river.

Treatment at the Hayden WWTP consists of screening and grit removal; oxidation ditches (2) with mechanical mixers; secondary clarification (3); and chlorine disinfection. Removed solids are aerobically stabilized and dewatered by a belt filter press. Although the Hayden WWTP is capable of providing treatment to nitrify ammonia, it is typically not operated in a nitrification mode during the summer months when the effluent is land applied.

Blue Pro filtration at the Hayden Wastewater Research Facility:

In 2004, Blue Water Technologies, Inc and the University of Idaho, in conjunction with the Hayden Area Regional Sewer Board constructed a full scale wastewater research facility to develop and test their treatment system. This installation is called the Hayden Wastewater Research Facility (HWRF). HWRF uses secondary effluent from the WWTP prior to chlorine addition and has the capacity to treat about one fourth of the total plant discharge.

Concentrations of phosphorus in the Hayden WWTP influent are typically about 7 to 9 mg/l. After secondary treatment the concentration of total phosphorus in the Hayden secondary effluent (without Blue PRO in operation) is typically about 4 mg/l. Since one purpose for testing this technology was to demonstrate how well it would perform as an add-on tertiary treatment to a secondary WWTP, the Hayden facility represented a good choice to test this technology.

Cutaway diagram of Centra-Flo filter at Blue PRO installation at Hayden HWRF

The Blue PRO technology combines co-precipitation and sorption to remove both particulate and soluble phosphorus. Through these processes, some phosphorus is precipitated and removed from water as it moves upward though the sand media. At the same time, some phosphorus is adsorbed onto the hydrous ferric oxide coated sand. This adsorption mechanism allows the process to achieve very low concentrations of phosphorus in the effluent. The phosphorus is then removed from the sand through abrasion and separated in the sand washer at the top of the filter. The treatment process installed at the HWRF is composed of:

- a pre-reactor where coagulant (ferric sulfate) is added and mixed with the secondary effluent;
- two continuous backwashing, upflow sand bed filters. The size of each filter is 14 feet deep, with a surface area of 50 square feet. The filters can be operated as single-pass or sequentially as a two-stage filtration system. The reject stream (around 7-8% of the flow to the filters) is recycled to the headworks of the Hayden WWTP.

A long-term, steady-state study was conducted from December 2005 through February 2006 using 0.25 mgd of the Hayden secondary effluent. Blue PRO was operated as a two-single-pass stage filtration system in December and as a two-stage filtration system in January and February during the study, although the second stage was not optimized until halfway through December. The reject stream (containing phosphorus and solids removed in the filters) returned to the WWTP headworks were observed to cause the phosphorus removal efficiency through the secondary process to improve significantly. This is likely the result of dosing the WWTP influent with the ferric compound used in the Blue PRO process. Concentrations of total phosphorus in the secondary effluent were observed to drop from 4 mg/l to about 1 mg/l during the steady state study. The monthly averages of total phosphorus in the Blue PRO effluent obtained during this steady-state study are:

- 0.036 mg/l in December (second stage filtration not optimized)
- 0.009 mg/l in January
- 0.016 mg/l in February
-

The average effluent TSS concentration using two-stage filtration during the study was about 1 mg/l. Considering all data from 2005 through 2007, the average phosphorus result was 0.014 mg/L TP, with a standard deviation of 0.006 mg/L. Based on the results of long term testing, Blue Water representatives state their phosphorus removal system can consistently achieve an effluent quality of less than 0.030 mg/l total phosphorus. This performance may vary when applied to the effluent of a different WWTP. Mobile pilot treatment facilities have been constructed and deployed to test the Blue PRO treatment process at other WWTPs. Results similar to those demonstrated at the HWRF have been achieved in these pilot studies.

A next-generation technology termed “Blue CAT” is currently in operation at HWRF. This patent-pending process adds an advanced oxidation component to the base Blue PRO process, achieving oxidation potentials up to 875 mV. In addition to improving phosphorus and solids removal over Blue PRO, this new technology adds disinfection to <2 cfu/100 mL and destructive removal of emerging micropollutants, such as endocrine disruptors, pharmaceuticals, and pathogens. The Blue PRO long-term, steady-state study report and other information about the Blue PRO phosphorus removal system are available from the Blue Water Technologies, Inc. website: www.blueh2o.net. Attributes claimed by this treatment system include:

- high efficiency, removing 99%+ of TP from municipal wastewater,
- low chemical dose, typically 6-10 mg/L Fe
- continuously flowing filtrate – no interruption for backwashing,
- low capital, operating, and maintenance costs (total for 1 MGD and 1 pass : less than $34.7300/lb of P removed),
- minimal sludge production, may improve sludge quality and reduce handling costs,
- works effectively without pH adjustment,
- highly tolerant of interfering water chemistry – wide usage
- significantly lowers turbidity and BOD (40% BOD removal and 80% TSS removal during the steady-state study),
- does not affect transmissivity for UV disinfection,
- mobile treatment units available,
- arsenic, selenium, and heavy metals such as zinc may also be removed.
- the Blue PRO tertiary treatment may also be adapted to denitrify through the filter(s).); installations achieve <3 mg/L total nitrogen.

CoMag™ Technology – Concord Wastewater Treatment Plant

Contact Information:
Concord Public Works Water/Sewer Division
135 Keyes Road
Concord, MA 01742

CoMag Process
Ray Pepin, Senior Engineer
Cambridge Water Technology (CWT)
Suite 100
41 Hutchins Drive
Portland, Maine 04102
207-774-2112 x3349

NPDES Permit: No. MA0100668, expiration date 28-FEB-2011

Design capacity: 1.2 MGD as average daily flow and 4.0 maximum daily flow

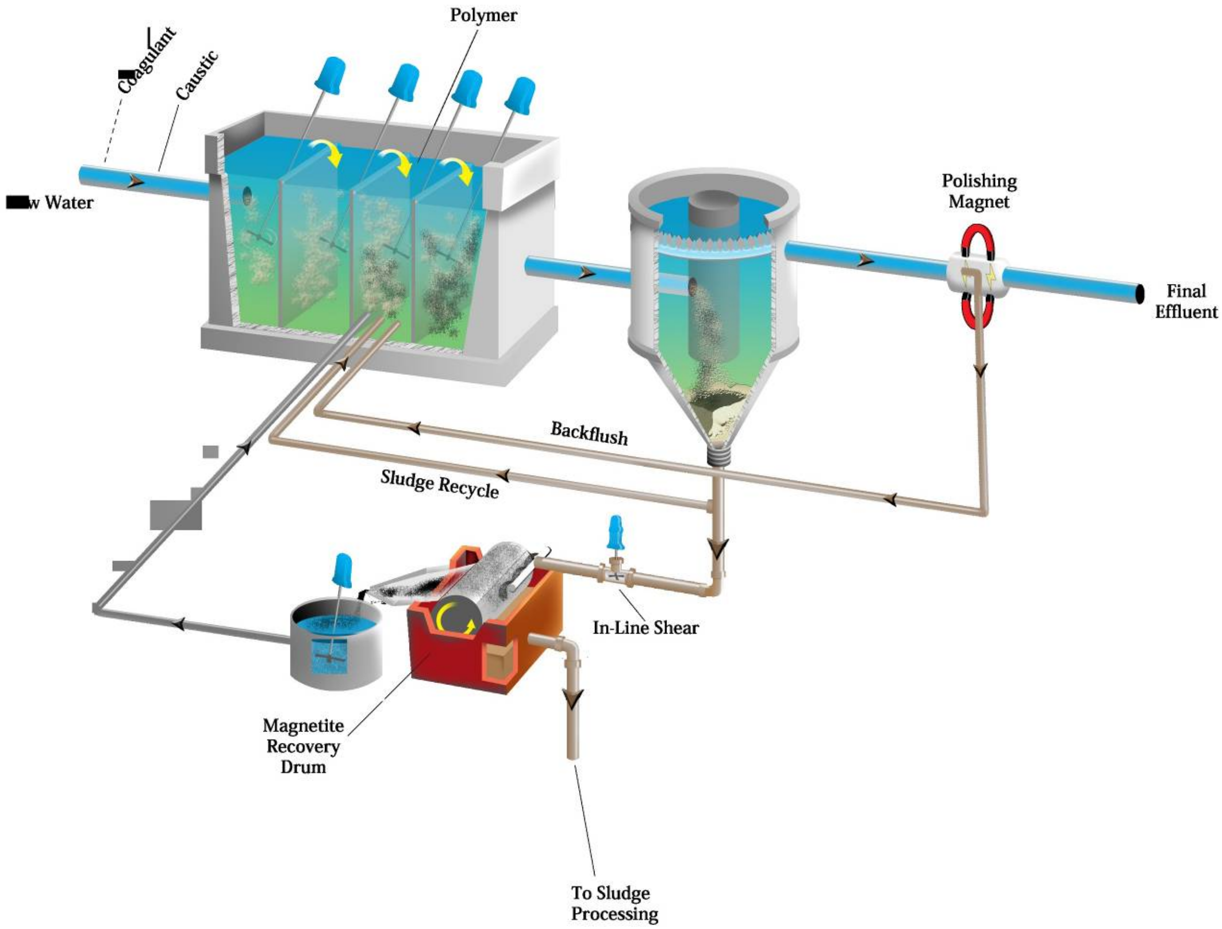
Receiving water: Concord River

Facility Description:

The existing Concord WWTP was built in 1986 and has a 1.2 mgd monthly average annual permitted discharge flow and discharges to the Concord River. Treatment through this WWTP currently consists of headworks, primary settling; trickling filters; secondary clarification; sand filters; and chlorine disinfection. Water quality of the Concord River is impaired, partially because of excessive amounts of nutrients entering the river. The seasonal total phosphorus effluent limitation which applies from April to October was lowered from 0.75 to 0.2 mg/l. The existing facility could only produce an effluent with a TP concentration of 0.6 to 0.7 mg/l by adding alum in advance of the secondary clarifiers. Therefore, a plant upgrade was needed to meet the proposed phosphorus limit and restore the quality of the receiving water.

The Concord WWTP is currently undergoing upgrade construction which, in addition to installing tertiary treatment for phosphorus removal (CoMag™), will improve the headworks, provide a new sludge dewatering process and switch from chlorine to UV disinfection. The tertiary process specification also required that the process be capable of meeting permit limits with one CoMag™ clarifier off line at maximum daily flow. The budget cost for the entire upgrade is $9.7 million, of which the CoMag™ process itself is less than 1/3 of the installed cost. The CoMag™ process supplier has certified that its treatment process will be capable of consistently achieving an effluent total phosphorus concentration of <0.05 mg/l.

CoMag™ Treatment Process:



CoMag is a "magneto-chemical" wastewater treatment process that incorporates the use of finely divided magnetic ballast to bind precipitated phosphorus and other fine particulates. The technology evolved from the minerals processing industry and all unit operations have been utilized for many years. Magnetite provides a "magnetic ballast seed" that when mixed with alum and polymer increases both flocculation and settling rates. These properties reduce the tank sizes necessary to remove the floc from wastewater. Since the floc particles are attracted to a magnet, High Gradient Magnetic Separation (HGMS) is used for final effluent "polishing filtration" rather than traditional sand filtration or membrane systems. The unit area flow rates that can be treated through the HGMS are claimed to be 50 times greater than those of traditional filters. The ballast seed is recovered from removed solids and from the effluent.

The CoMag™ process was selected for installation at the City of Concord because long-term pilot testing demonstrated its ability to achieve high phosphorus removal efficiencies at comparatively low costs. Other factors that prompted the Concord WWTP decision to install CoMag™ included:

- Reduced chemical doses are required to achieve low effluent total phosphorus concentrations, resulting in lower operational costs.
- CoMag™ utilizes simple clarifiers that are one-tenth the size of conventional clarifiers and does not require lamella style tubes which can plug or foul, thereby reducing capital costs and footprint requirements.
- The magnetic separator has a footprint 2 to 5 percent of the size required for conventional filtration processes.
- Ballasted sludge is very dense and cohesive, with little carry over of pin floc from the clarifier, even at high overflow rates, thereby allowing CoMag to handle wide variations in flows and loads.
- Ballasted sludge settleability is dependable and predictable.
- Ballast recycling and recovery is highly efficient and minimize ballast usage.
- The CoMag™ process has proven to be effective in removing TSS, metals, color, turbidity, pathogens and other pollutants.
- The process is simple and robust. All maintenance items are easily accessible and readily available. No specialized tools or training are required to operate or maintain the process.

* Information about CoMag™ was provided by company representatives at the Concord WWTP or extracted from the article "CoMag™ Process Achieves Low Effluent Total Phosphorus Levels While Reducing Footprint and Cost" by Steve Woodard.

LOTT Budd Inlet Wastewater Treatment Plant

Contact Information:
LOTT Budd Inlet Treatment Plant
500 Adams Street N.E.
Olympia Washington 98501-6911

NPDES Permit No. WA0037061, expiration date SEP-30-2010

Design capacity: 28 mgd

Receiving water: Budd Inlet (South Puget Sound)

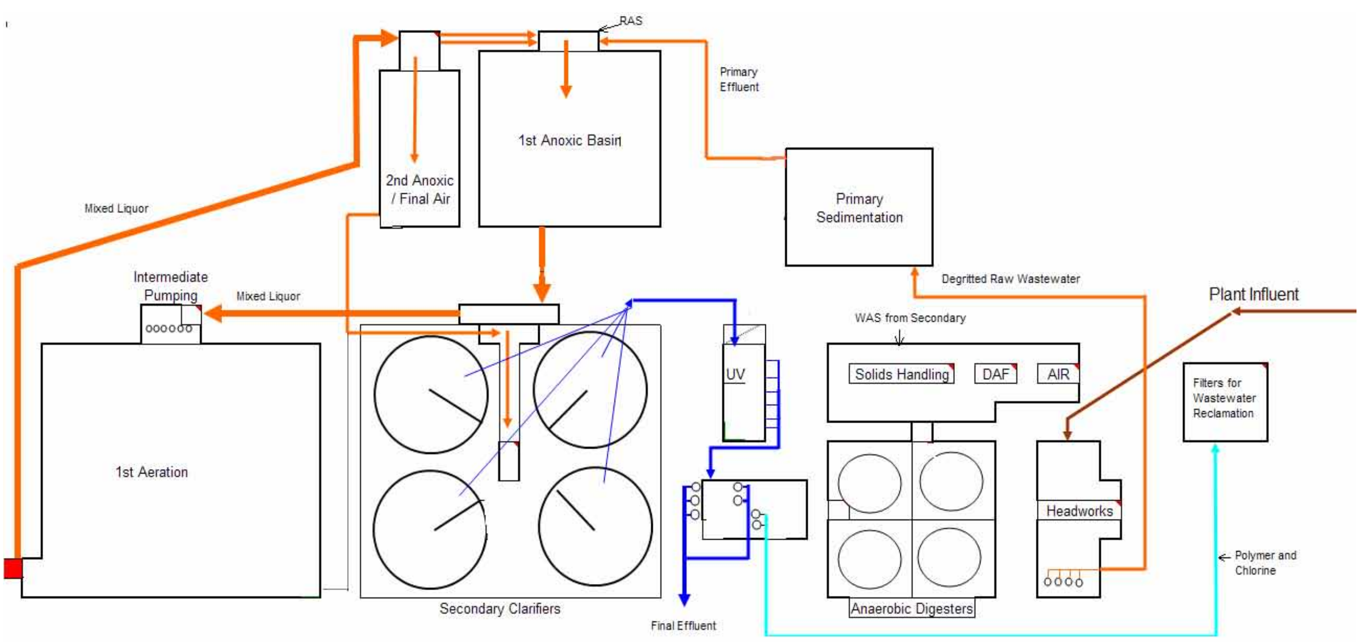
LOTT Budd Inlet Treatment Performance Summary:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages**	Maximum reported measurement (date)**	Reporting period
Total Inorganic Nitrogen	* 3 mg/l	2.2 mg/l	1.23 to 2.81 mg/l	2.81 mg/l (4/04)	4/03 to 9/06
BOD	* 9 mg/l	4.17 mg/l	2.14 to 8.66 mg/l	16.5 mg/l (5/06)	4/03 to 9/06
TSS	30 mg/l	7.15 mg/l	2.75 to 12.3 mg/l	21.3 mg/l (3/06)	1/03 to 9/06

* Seasonal limitation
** Data from period when seasonal limitations apply

Monthly residential sewer fee: $25.50

LOTT Budd Inlet WWTP Treatment Schematic:



Facility Description:

The LOTT Budd Inlet Treatment Plant provides advanced treatment of wastewater collected from a service area that includes the cities of Lacey, Olympia and Tumwater plus portions of Thurston County. These entities form the LOTT Alliance which operates the regional WWTP. Treated effluent is discharged into the marine waters of Budd Inlet which is located at the southern end of Puget Sound. This part of Puget Sound is poorly flushed and is very sensitive to nutrient loading, especially during the late spring through fall period. Excessive nutrient loading is blamed for low dissolved oxygen and excessive aquatic plant and algae growth in these waters. A TMDL is currently under development by Washington State for this water body which is expected to establish wasteload allocations (WLAs) for the Budd Inlet Treatment Plant as well as for other sources of nutrient loading. Although these WLAs have not yet been determined, it is a fact that Budd Inlet does not have any capacity for additional nutrient loading during the critical warm weather season.

The LOTT facility has undergone many changes since it was upgraded to provide secondary treatment in 1982. During this time most of the storm water collection systems have been separated from the sewage collection system, although a small portion in the downtown Olympia sewer is still a combined system. The original UNOX wastewater treatment basins were converted and additional tankage built to provide anoxic, aerobic; second anoxic and final aerobic wastewater contact areas necessary to accomplish enhanced biological nutrient removal (EBNR) of nitrogen. A high internal recycle rate of about 4:1 is maintained to provide adequate contact time for wastewater treatment through EBNR. This recycle rate means that for every 10 mgd of wastewater influent treated about 50 mgd is routed through the treatment system. The mixed liquor suspended solids concentration is maintained at about 1800 mg/l in the contact basins. This represents a solids retention time of about 20 days. Many other improvements to improve treatment efficiency at the LOTT plant are currently under construction or are being planned.

Secondary clarifiers undergoing upgrade construction at LOTT's Budd Inlet Treatment Plant (2006)

In addition to primarily domestic wastewater, LOTT received high strength wastewater from the Olympia brewery until that facility closed about three years ago. The resulting changes to the character of the influent wastewater required significant adjustment in operation of the WWTP. One associated change was that LOTT began adding methanol to provide food for the bacteria necessary to accomplish denitrification of the wastewater. Additional adjustments to wastewater recycling within the treatment system and to operation of the aeration basins have maintained excellent nitrogen removal efficiency. With the operation experience gained over time, these adjustments have significantly reduced the need to add methanol. At the time of the EPA visit to the LOTT WWTP, continuous monitors indicated that the total inorganic nitrogen level of the final effluent was less than 1 mg/l (0.1 mg/l NH3-N + 0.59 mg/l NO3-N + 0.1 mg/l NO2-N = 0.79 mg/l TIN).

Treatment at LOTT consists of: flow into an influent equalization basin (2.25 mgd); screening; grit removal; primary clarification; EBNR (methanol is added to the second anoxic basin); secondary clarification and ultraviolet disinfection. Removed solids are routed to dissolved air flotation thickeners, stabilized in anaerobic digesters, and dewatered by centrifuge before being disposed by land application. Centrate from the centrifuge is metered back into the primary effluent.

A portion of the LOTT effluent is reclaimed and utilized for irrigation of public lands. The final effluent destined for reuse is provided filtration through single-stage, continuous back-washing Parkson sand filters. These filters are each 14 feet deep and configured in three banks of two filters. Polyaluminum chloride (PACl) is added to aid filtration effectiveness. Additional disinfection is provided by chlorination.

Planning for the Future:

The rapid development and population growth in the South Puget Sound service area required the LOTT partners to carefully plan to meet future wastewater treatment needs. The marine waters of Budd Inlet are already impaired by excessive loading of nutrients and this situation precludes the option of simply increasing treatment capacity and discharge at the main plant. Although the existing LOTT plant already achieves about the best nitrogen removal that current biological treatment technology can accomplish, there is simply no assimilative capacity in South Puget Sound for additional nutrient loading during the critical period.

LOTT implemented numerous water conservation programs in the service area and began promoting use of reclaimed wastewater for irrigation and groundwater recharge. LOTT also decided to meet the need for additional wastewater treatment capacity by constructing ‘satellite’ facilities. These satellite wastewater treatment plants are located in areas needing sewer service where land is still available to accommodate reuse of the effluent. Advanced treatment is provided at the satellite WWTPs to meet state requirements for reclaimed wastewater such that it may be utilized for groundwater recharge and/or irrigation during the dry summer months. The first of the planned satellite treatment plants is a two mgd membrane bioreactor treatment plant that was placed in operation in 2006. The membranes are hollow fiber filaments produced by U.S. Filter Corporation. Treated effluent from this satellite WWTP is reclaimed and used for groundwater recharge. Solids removed during treatment at the satellite plant are returned to the sewer main for handling at the Budd Inlet WWTP. Land was recently purchased by LOTT for construction of a second satellite plant.

Operational Considerations:

- The five trains of aeration basins have excess capacity and only two of the five basins are typically needed to treat wastewater flows during normal dry weather. The aeration delivery system installed in these basins is somewhat limiting to operational control.
- Adjusting aeration (DO setpoints) has significantly reduced the need to add methanol as supplemental feed for bacteria necessary for nitrogen removal. Methanol is only fed during nighttime hours. Methanol currently costs about $1.60 per gallon (delivered to the plant).
- Nitrate concentration measured in the aeration basin effluent is used for process control for determining how much food additive (methanol) to use.
- Oxidation/reduction meters are installed and connect to the SCADA system to assist with operational control.
- A high internal recycle rate (4 gallons recycled: 1 gallon treated) is necessary to achieve the desired effluent quality. The electricity and maintenance costs associated with internal recycle pumping are quite expensive.

24 inch internal recycle piping at LOTT's Budd Inlet WWTP

- There have been some problems with filamentous bacteria (Microthrix parvicella). Operators are experimenting with polyaluminumchloride (PAX) to control this organism.
- Sludge collectors in the secondary clarifiers are being upgraded.
- An operational goal is to keep total inorganic nitrogen levels in the final effluent under 2 mg/l to insure that the 3 mg/l permit limitation is met consistently.