Water Treatment – Phosphorous Removal

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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.

Evaluation Considerations

The WWTPs included in this course 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. Data presented 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.

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