DEC 2 9 2017

Best Management Practices for Nutrient Reduction at the City of Forrest City WWTP

This document is developed based entirely on the EPA Draft Publication "Case Studies on implementing Low-Cost Modifications to Improve Nutrient Reduction at Wastewater Treatment Plants" (August 2015 – EPA-841-R-15-004). In the write-up we took the liberty to use excerpt from the publication verbatim since those excerpt are very appropriate.

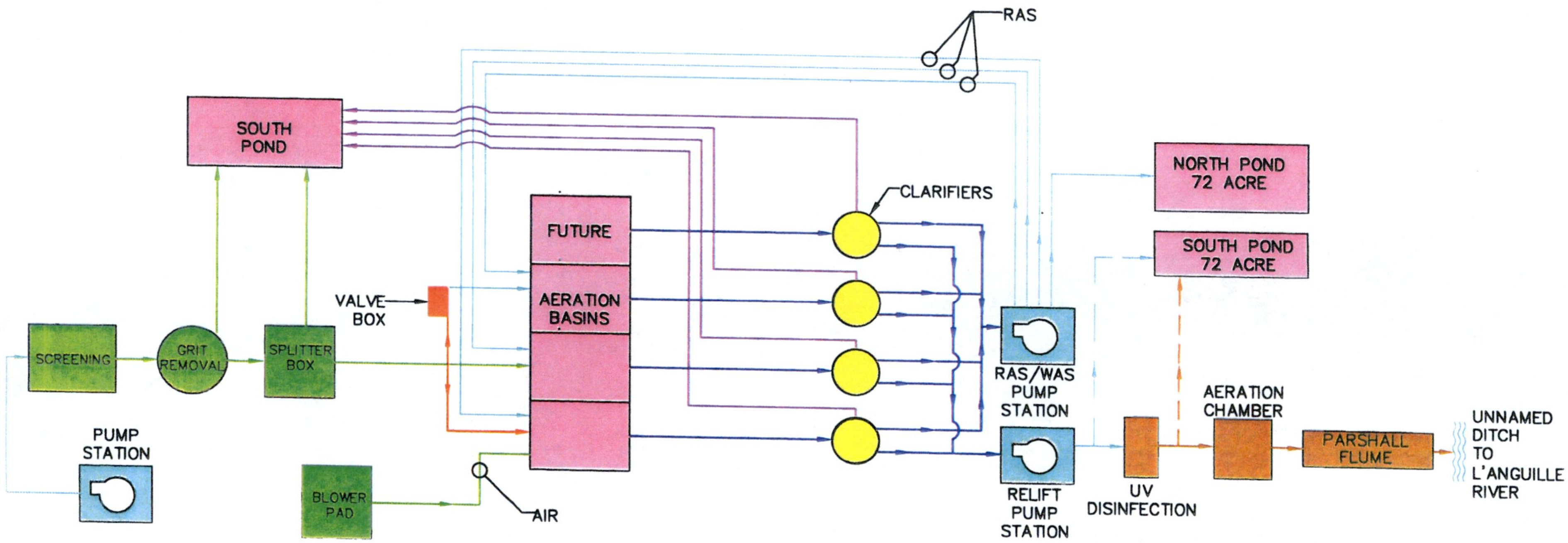
Forrest City Wastewater Treatment Plant (FCWWTP) is a conventional Activated Sludge treatment plant (See attached Flow Diagram and Treatment Process Component Description) without any specific design feature to provide nutrient removal. The referenced EPA publication outlines some potential low cost options that may be available to FCWWTP to further reduce nutrient (total Nitrogen and total Phosphate). The applicability of the suggested options must first be analyzed based on actual design criteria of the existing WWTP. A cost analysis will also be necessary in order to determine preferred options and anticipated nutrient reduction.

The referenced EPA publication concluded from studying 80 different WWTP that a number of modifications can be considered for improving nutrient removal at any existing conventional Activated Sludge (non-advanced) WWTPs including (but not limited to) one or more of the following. Many of the modifications described below are complimentary to one another. Therefore, such modification will most likely require control system additions or modifications.

Aeration modifications:
Implementing aeration changes such as cyclical aeration (primarily using existing tanks and mechanical equipment), often supplemented with basic in-line monitoring instrumentation and associated controls. Aeration modifications are typically used to optimize anoxic conditions that support denitrification for biological nitrogen removal. Creating anaerobic zones before aerated activated sludge treatment can also support enhanced biological phosphorus removal (EBPR). These are changes to physical aeration equipment, controls, operation, and function of equipment and aerated areas. They include installing energy efficient blowers, variable frequency drives (VFDs), diffusers with improved distribution and oxygen transfer efficiency (OTE), airflow meters, airflow control valves, and on/off cycling; and dissolved oxygen (DO), ammonia, or oxidation reduction potential (ORP) control.

Process modifications:
Treatment process performance improvement is the for process modification. These may include adjustments to process control characteristics, including solids retention time (SRT), mixed liquor suspended solids (MLSS), food-to-microorganism (F/M) ratio, and recycle/return rate. Physical process improvements might include adding VFDs and/or return activated sludge (RAS) pumps for internal recycling; adding online monitoring equipment for process control and optimization; or providing new screens or grit removal equipment at the headworks.

Configuration modifications:
Enhancing environments for denitrification (e.g., by returning nitrate rich mixed liquor back to an anoxic zone) is the aim for configuration modification. These are changes to, or the addition of, flow streams within the process or changes to the process configuration. They might include changes to channels; manipulating gates; or modifying or adding piping, such as adding internal recycle lines or step-feed provisions.



FLOW DIAGRAM
FORREST CITY
WASTEWATER TREATMENT PLANT

FORREST CITY WASTEWATER TREATMENT PLANT

TREATMENT PROCESS COMPONENTS

A. WASTEWATER ENTERS THE PLANT BY GRAVITY AND IS PUMPED TO THE HEADWORKS.

B. FLOW THEN PASSES THROUGH THE BAR SCREENS FOR REMOVAL OF TRASH AND LARGE OBJECTS.

C. FROM THE BARSCREEN THE FLOW GOES TO THE GRIT REMOVAL SYSTEM TO REMOVE SOLID PARTICLES SUCH AS SAND AND GRIT.

D. WASTE WATER THEN PASSES THROUGH THE V-NOTCH WEIR WHERE THE INFLUENT FLOWMETER MEASURES AND RECORDS THE FLOW ENTERING THE PLANT.

E. WASTE WATER THEN ENTERS THE AERATION BASINS TO BE AERATED AND MIXED.

F. FROM THE AERATION BASINS THE MIXED LIQUID TRAVELS TO THE CLARIFIERS, WHERE THE FLOW SLOWS DOWN AND SOLIDS SETTLES OUT TO BE REMOVED FROM THE FLOW.

G. CLEAN WATER PASSES OVER THE CLARIFIER WEIRS AND INTO THE WET WELL.

H. EFFLUENT WATER FROM THE WET WELL IS PUMPED BY THE RELIFT PUMPS INTO THE UV UNIT.

I. AT THE UV UNIT THE EFFLUENT WILL BE SANITIZED AND DISINFECTED IN ORDER TO REMOVE ALL PATHOGENS.

J. FROM THE UV UNIT THE EFFUNTS TRAVEL TO THE OXY CHARGER UNIT AND DOWN THE CASCADE STAIRS WHERE THE DISSOLVED OXYGEN LEVEN IN THE EFFLUENT IS RAISED TO THE ACCEPTED LEVEL.

K. FROM THE CASCADE EFFLUENT PASSES THROUGH THE PARSHALL FLUME WHERE THE EFFLUENT IS MEASURED AND RECORDED. EFFLUENT SAMPLES ARE ALSO TAKEN AT THIS POINT FOR TESTING AND MONITORING.

L. FROM THE PARSHALL FLUME WATER FLOWS TO THE OUTFALL DITCH.

Chemical modifications:
These are the addition of, or changes to supplemental alkalinity and organic carbon feed to support biological nitrogen removal.

Discharge modifications:
These are made at the end of the treatment system to further reduce nutrients prior to delivery to receiving surface waters. They generally use natural systems and might include soil-based treatment systems or wetland assimilation discharge.

FCWWTP Treatment Process

Forrest City WWTP employs Activated Sludge treatment process to treat its domestic wastewater. This process is a suspended growth biological treatment process in which a large mass of aerobic floc-forming microorganisms convert organic material and other constituents to gases or assimilate them into cell tissue. A portion of the solids is removed from the process or wasted in order to maintain an active, growing biomass population, and to remove solids-associated constituents (like phosphorus). FCWWTP was not designed to reduce nutrient load. Conventional Activated sludge treatment processes are typically designed and operated with a focus on BOD and TSS removal. Nitrogen and phosphorus removal in those processes predominantly occurs from the nutrients being assimilated into the cell biomass during microbial (net) growth. Approximately 1 mg of phosphorus removal and 5 mg of nitrogen removal can be expected per 100 mg of BOD reduced in the system, although the ratio can vary depending on system characteristics and other factors. In addition, solids handling and treatment processes, such as aerobic or anaerobic digestion, often release some of these nutrients back into the solution during the reduction of the biomass, which is then returned back to the treatment process via the solids-handling sidestreams. As a result, overall nutrient removal in conventional activated sludge treatment processes is typically relatively low. Average nitrogen removal is 37.5% (based on average influent TKN of 40) and Phosphorus removal is 20% (based on average influent TP of 7). To address this limitation if nutrient removal is required, FCWWTP conventional processes will have to be modified and new processes incorporated for targeted biological removal of nitrogen and phosphorus from wastewater.

NITROGEN REMOVAL

Urine and food waste are the primary source of Nitrogen in FCWWTP. Urea and organic nitrogen in wastewater influents are typically quickly converted to ammonia under anaerobic conditions within sewer collection systems via a process called "ammonification". Removal of nitrogen during wastewater treatment is typically the result of natural biological processes including uptake, biological nitrification and denitrification (generically termed "biological nitrogen removal" - BNR), and anaerobic ammonia oxidation.

"Denitrification", the biochemical reduction of oxidized nitrogen—nitrate—to dinitrogen gas, is much less sensitive to temperature, although it is still affected, and requires a relatively short anoxic SRT. Denitrification is performed by heterotrophic bacteria and requires an organic carbon source. Available carbon sources already present in wastewater or provided within the treatment process include COD. Supplemental sources of carbon can also be added to the system if carbon is lacking or to achieve higher levels of denitrification.

Biological Nitrogen Removal

"Biological nitrogen removal" (BNR) is the general term used to describe the 2-step nitrification-denitrification process, which is the primary approach used to deliberately remove nitrogen during municipal wastewater treatment. Nitrification is the biological oxidation of ammonia to nitrate. Influent ammonia is first oxidized to nitrite (NO_2) by ammonia-oxidizing bacteria (AOB), then nitrite is oxidized further to nitrate (NO_3) by nitrite-oxidizing bacteria (NOB). Nitrification requires both oxygen and alkalinity to buffer against a pH drop that can inhibit nitrifying bacteria. A portion of this lost alkalinity is recovered in the subsequent denitrification process. Figure 1 schematic diagram is representative of the FCWWTP treatment process. Primary settling takes place in the screening and grit chamber. To convert this facility to reduce nutrient level by denitrification, three options are available. They are as follows:

Option 1 - Pre-anoxic denitrification (Figure 2): – this will require creation of a dedicated unaerated or anoxic reactor ahead of the activated sludge reactor for denitrification. Pre-anoxic denitrification typically relies on the carbon in the influent or primary clarifier effluent to feed the denitrifying organisms that reduce nitrate, which is produced in the downstream aerobic zone. It must, therefore, be returned to the pre-anoxic zone in the return activated sludge (RAS) and/or internal recycle streams.

Option 2 – Post-anoxic denitrification (Figure 3): - this will require creation of a dedicated unaerated or anoxic reactor following the activated sludge reactor for denitrification. The post-anoxic zone follows the aerobic zone and the carbon from endogenous decay is used for denitrification, which results in a much lower nitrate/nitrite reduction rate than in the pre-anoxic zone. Carbon from external sources can also be added to this zone to increase the denitrification rate.

Option 3 - Single-reactor nitrification/denitrification (Figure 4) – this process uses single-reactor nitrification and denitrification. Nitrification and denitrification is processed in the same activated sludge reactor space. This includes simultaneous nitrification/denitrification, which is promoted under low dissolved oxygen (DO) conditions; cyclic processes where aeration is switched on and off and others. Simultaneous and/or cyclic nitrification/denitrification are commonly used in systems with long SRTs (20 days or more) and hydraulic retention times (HRT), such as oxidation ditches and lagoons. Nitrification and denitrification rates are relatively slow, which is why longer SRTs are required to achieve complete nitrification.

Figure 1: FCWWTP Treatment Process Schematic Diagram

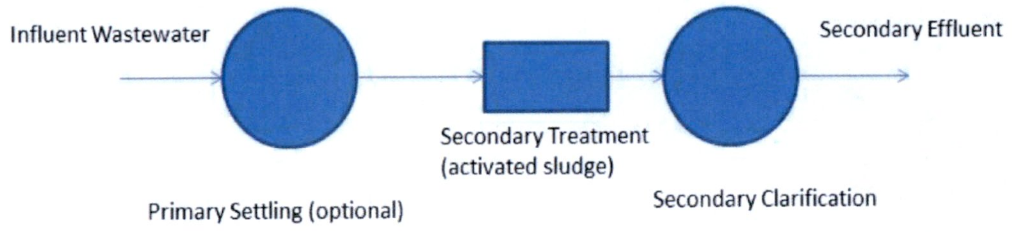


Figure 2: Pre-Anoxic Zone Nitrification/Denitrification Process Schematic Diagram

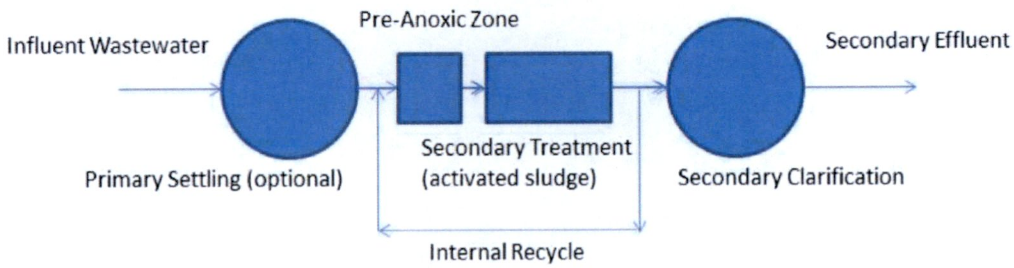


Figure 3:Post-Anoxic Zone Nitrification/Denitrification Process Schematic Diagram

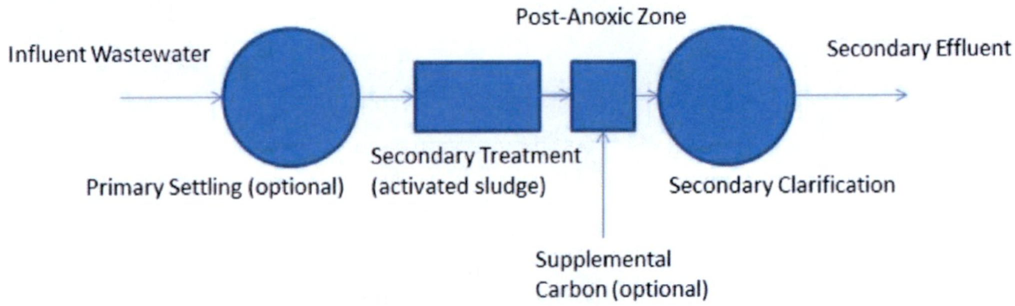
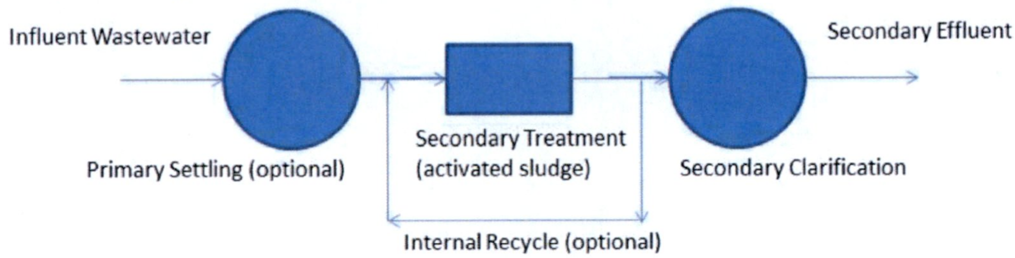


Figure 4:Single Reactor Nitrification/Denitrification Process Schematic Diagram



The FCWWTP is equipped with three activated sludge reactors where influent wastewater is introduced by splitting the flow equally. There is also adequate space for adding one additional reactor. Therefore based on very preliminary assessment, FCWWTP can be modified to adopt Option 1 or Option 3 Nitrification/Denitrification process.

Nitrogen Removal Optimization Opportunities at FCWWTP

There are a variety of physical and operational modifications that can be made to the Forrest City wastewater treatment system to improve nitrogen removal. This document mainly focuses on operational modifications and physical modifications that are relatively minor infrastructure modifications, like adding a new reactor. Optimization activities have been grouped into the following main categories:

Aeration Modification:

The oxidation-reduction (or redox) state of the treatment environment is a major controlling factor for nitrogen removal processes with aerobic (or oxic) conditions required for nitrification, and anoxic conditions required for denitrification. Like most treatment plants the FCWWTP aeration systems may have not been optimized and as such overaerate. Historically, WWTPs were not designed with energy efficiency as a top priority; therefore, oversizing of aeration systems has generally been standard practice. Likewise, aeration controls might not have been prioritized either in capital programs or in ongoing performance evaluation.

Improving the control of aeration is often the easiest and lowest cost operational change that yield highest towards improving nitrogen reduction. Reducing overall aeration has the added bonus of reducing energy costs. Generally, aeration equipment typically has the single largest energy demand of internal plant processes. The EPA study has shown many wastewater utilities significantly improved nitrogen removal as a by-product of energy-efficiency efforts.

Nitrification is a prerequisite for biological nutrient removal. Nitrification requires a sufficient solids retention time (SRT) (which translates into a sufficient reactor volume) and sufficient aeration capacity to convert ammonia to nitrate. Most small treatment plants that use activated sludge processes generally have relatively long solids retention time and hydraulic retention time (HRT) long enough to affect nitrification. The anoxic conditions required for denitrification can be created in several different ways in an activated sludge system, provided that the system has some excess treatment capacity (even a small amount). These include on/off cycling or throttling of aeration (for enhancing simultaneous or phased denitrification within a single reactor), or the creation of dedicated anoxic and aerobic zones by turning off the air to a portion of the aerated volume—typically at the front end of the basin (to create a dedicated anoxic zone). Frequently, mixers are added to keep solids in suspension or provide mixing in dedicated anoxic zones, or when air is turned down or cycled off. Other modifications that improve the ability to modulate aeration include adjusting the pitch angle of centrifugal blower blades and the use of synchronous blower motors.

FCWWTP activated sludge reactors and the aeration system will be evaluated to determine its current capacity and effectiveness. The evaluation will also include analysis of the piping system, valving system and electrical system to develop a concept for necessary modification. Some type of improved aeration control is the most common nitrogen removal optimization technique at existing WWTPs, although it can often be supplemented with process, piping, and/or chemical activities for enhanced effectiveness.

Aeration modifications may include the following:

1. Changes to physical aeration equipment, controls, operation, and function of equipment.
2. Changes to aerated areas.
3. Installation of energy-efficient blowers.
4. Variable frequency drives (VFDs) to provide adjustable control to air blowers or surface aerators.
5. Diffusers with improved distribution and oxygen transfer efficiency (OTE), airflow meters, airflow control valves, on/off cycling.
6. Installation of DO, and ammonia or oxidation-reduction potential (ORP) control.

Process Modification

Process modifications at the FCWWTP include adjustments to process control characteristics.

As previously indicated, SRT is a particularly important process parameter for nitrification. Mixed liquor suspended solids (MLSS) and food-to-microorganism (F/M) ratio are related parameters. Internal recycle and RAS return rate can be particularly important for denitrification. Physical process improvements can include the addition of VFDs and/or RAS pumps for improved control of internal recycling; the addition of online monitoring equipment for process control and optimization.

Other process modifications that will be evaluated may include flow equalization improvements, optimizing internal mixed liquor recycle rates, modifying plant recycle flow patterns, controlling sidestream flows, and adding the capability to ferment primary sludge.

As previously discussed, denitrification is often limited because of a lack of proper conditions (i.e., nitrate, organic carbon, anoxia). Providing anoxic conditions is largely a function of aeration control. Although a WWTP might be nitrifying, it is critical to get the nitrate into the anoxic environment, along with organic carbon, for denitrification. For this reason, establishing anoxic conditions at the influent end of the process, where influent organic carbon should be readily available, is generally preferred. With anoxic conditions and organic carbon, treatment effectiveness depends largely on exposing nitrified mixed liquor to these conditions, typically by internally recycling mixed liquor to the denitrification reactor. Adding or improving the control of internal mixed liquor recycle systems is, therefore, an important process control parameter for nitrogen removal. Likewise, it is important to minimize aeration occurring within other unit processes and structures (e.g., influent and return channels) that may increase DO carry-over into existing or new anoxic zones.

For systems that recycle mixed liquor for denitrification, the recycle rate can be optimized by monitoring the nitrite and/or nitrate leaving the primary anoxic zones either by manually sampling or using online monitoring to set the internal recycle (IR) rate. Only the amount of NO_x that can be denitrified needs to be returned to the primary anoxic zones. This can be an automated process involving a feedback loop or use a manually set rate. The IR pumps will need to be equipped with VFDs or multiple small pumps will need to be used to effectively control the IR rate.

Configuration Modification

Configuration modifications are changes to, or the addition of, flowstreams within the process or changes to the process configuration. They might include changes to channels, manipulation of gates or baffles, or modifying or adding piping, such as adding internal recycle lines or step-feed provisions. Configuration modifications are distinguished from process modifications in that they will require some (although usually minimal) new infrastructure. Process modifications use existing infrastructure but might require new monitoring or control equipment. Since FCWWTP lacks an anaerobic reactor for denitrification along with necessary circulation and recycling pump and piping system, some modification to the configuration will be necessary. Such proposed modifications can only be decided after proper evaluation of the existing plant.

Chemical Modification

Chemical modifications include the addition of alkalinity and supplemental carbon to improve nitrification and denitrification, respectively. If low alkalinity is limiting nitrification, then alkalinity can be added to the process (e.g., using lime) to improve nitrification. Performance can also be improved by using inline monitoring and controls to maintain an optimum feed rate.

Supplemental carbon can be added, usually to a post-anoxic zone, to improve or speed up denitrification. Nitrogen removal optimization using chemical addition is supplemental to other aeration, process, and/or piping modifications and as such is not anticipated in the FCWWTP.

Discharge Modification

Discharge modifications are made at the end of the treatment system to further reduce nutrients prior to delivery to receiving surface waters. They generally use natural systems and might include land application or wetland assimilation discharge. This category of nitrogen removal enhancement is typically independent of the other four approaches.

Modifying a WWTP discharge can be an effective way to reduce nitrogen delivery to surface waters, however it might not be practical or affordable in the FCWWTP.

PHOSPHORUS REMOVAL

Phosphorus in municipal wastewater can come from multiple sources. Urine contains over 90 percent of the phosphorus excreted by humans. Food wastes and some industrial processes can also contribute significant amounts of phosphorus to municipal wastewater influents. Soluble phosphorus in wastewater is typically in the form of orthophosphate (PO_{4-3}).

Removal of phosphorus during wastewater treatment is typically the result of natural biological processes, including uptake and enhanced biological phosphorus removal (EPBR), although many WWTPs will use metal salts to precipitate phosphorus to the solids (sludge) fraction. In either case (biological or chemical treatment), phosphorus is removed by converting it to a solid, so it partitions to the sludge.

Biological Uptake

Wastewater treatment systems not specifically engineered for phosphorus reduction, a certain amount is removed (usually about 2 mg/l). These reductions are generally modest, however, and rarely sufficient to meet water quality objectives or effluent permit limits.

Enhanced Biological Phosphorus Removal

Specialized bacteria in activated sludge mixed liquors called "polyphosphate accumulating organisms" (PAOs) can be used to biologically remove phosphorus from wastewater to levels that might meet water quality objectives. PAOs require two stages for phosphorus removal. The first stage is anaerobic, in which PAOs uptake volatile fatty acids (VFAs) from the organic carbon in the influent (or added as a sidestream flow) and store it as polyhydroxy-alkanoate (PHA) for later oxidation in an aerobic zone. During this process, the PAOs also release phosphorus in the form of orthophosphate under anaerobic conditions, which provides the energy required for the uptake and storage of the VFAs. This first anaerobic stage is sometimes called an "anaerobic selector" because it preferentially selects for the proliferation of PAOs.

The second stage takes place under aerobic (or oxic) conditions. In the aerobic stage, the stored PHA is metabolized, providing energy for cell growth and the luxury uptake of soluble orthophosphate, which is stored as polyphosphates. The PAOs uptake and store more phosphorus under aerobic conditions than is released under anaerobic conditions, providing a net uptake and storage of phosphorus. This also provides the PAOs with a competitive advantage over other organisms, allowing them to thrive under these conditions. The stored phosphorus is then removed from the system with the waste sludge. If secondary clarifiers are allowed to become anaerobic or the waste activated sludge (WAS) is treated in an anaerobic digester, the PAOs can release stored phosphorus back into the process stream. Up to four times as much phosphorus can be removed biologically using EBPR than conventional activated sludge treatment.

Chemical Precipitation

Phosphorus can also be removed using chemical precipitation. The most common chemicals used for the precipitation of phosphate are aluminum sulfate, ferric chloride, and ferrous chloride. The precipitated phosphates must be removed by sedimentation and/or filtration. Note that the use of metal salts for the precipitation of phosphorus will add to the sludge production of the plant (EBPR generally does not increase sludge production appreciably). If the secondary clarifiers are used for the removal of precipitants, inert solids will also be added to the activated sludge process, decreasing the capacity for volatile solids or active biomass.

Phosphorus Removal Optimization Opportunities

EBPR can be added to an activated sludge treatment system by creating an anaerobic selector zone at the front of the secondary treatment process. The anaerobic selector must be upstream of the internal (nitrified) recycle if used in conjunction with a nitrification/denitrification process. Soluble VFAs can be provided for EBPR through primary sludge fermentation. Primary sludge can be fermented to produce volatile fatty acids (VFAs) or available soluble carbon for use in biological nutrient removal. Primary sludge fermentation can be accomplished in the primary clarifier sludge blanket by modifying the primary sludge wasting rate to provide a deeper blanket and longer residence time to allow fermentation, adding available soluble BOD to the secondary treatment process influent. However, since the FCWWTP does not have a primary clarifier a separate reactor will have to be build. These are typically a gravity thickener used as a fermenter. Fermenting in a separate reactor will involve a higher capital cost, but will also provide more carbon to the process and more flexibility over where the carbon-rich stream is returned.

Supplemental carbon can also be added to provide the VFAs needed for EBPR. Unlike BNR, EBPR generally requires a dedicated anaerobic reactor, so some type of partitioning and strict anaerobic conditions are required, which makes low-cost upgrades less feasible for plants not originally designed with EBPR in mind.

For activated sludge and most other types of WWTPs, metal salts can be added to chemically precipitate orthophosphate, which can then be removed with solids, during primary or secondary clarification and/or tertiary filtration. Metal salts can be added upstream of the primary and/or secondary clarifiers as well as at other points within the treatment system. Chemical precipitation, however, can limit EBPR. To optimize EBPR, chemical precipitation of phosphorus should be used as part of a tertiary treatment process. Chemical precipitation is the most common technique to achieve higher levels of phosphorus removal in plants not designed for EBPR. However, this technique is well-established and fully documented and described in various references, so it is not a focus of this document.

Optimization opportunities at the FCWWTP plant for Phosphorus removal is limited.

Considerable modification may be necessary to implement EBPR. However, chemical addition at the tertiary treatment level will be explored to determine its applicability and cost.

Modified Discharge

As with nitrogen removal, modifying a WWTP discharge through land application or wetland assimilation can be an especially effective way to reduce phosphorus delivery to surface waters, although it may not be widely practical. Phosphorus removal in "natural" systems is typically the result of physiochemical immobilization reactions either in the soil matrix or in, solution in free surface wetlands (e.g., precipitation).

Decision Consideration for Enhancing Nitrogen Removal at Existing FCWWTP

WWTP type	Key questions to ask	Optimization efforts to consider
Activated Sludge	Is there excess plant capacity? - Is peak daily flow < 75% design capacity? - Are additional tanks/reactors available? - Is flow equalization provided?	- Is it feasible to create anoxic zone(s) - On/off cycling for nitrification/denitrification in single reactor - Feed influent and internal recycle to dedicated tank - Denitrify in flow equalization with internal recycle
	Is there excess aeration capacity? - Can aeration be throttled? - Does aeration system have automatic control? - Can contents be mixed without aerating?	Facilitate anoxic environments - Maintain lower DO setpoint or dedicated anoxic zone - Install DO and/or ORP meters for auto control - Consider adding mixers
	Are process parameters sufficient? - Can nitrified liquor be returned to low DO zone? - Is alkalinity sufficient for full nitrification? - Is carbon available to drive denitrification?	Modify process parameters as warranted - Internal recycle to introduce nitrified liquor to anoxic - Add alkalinity - Consider step-feed, pre-fermentation additives

Opportunities for Phosphorus Optimization (are limited)

1. For activated sludge, are reactors/tanks available or can the existing process be segmented to provide an anaerobic selector reactor with an HRT of at least 30 minutes?
2. Is it feasible to discharge either seasonally or year-round for land application or to wetland assimilation?

Steps to screen, evaluate, and implement nutrient reduction improvements.

1. Look at WWTP influent nutrient sources and concentrations. Can any nutrients be controlled at their source?

2. Evaluate whether nutrients are being loaded to the WWTP through internal recycle lines (particularly if the WWTP uses anaerobic digestion) and consider managing these loads through sidestream control or treatment.

3. Identify existing unit processes, design parameters, and actual operating conditions. For biological processes in particular, determine whether excess reactor or aeration capacity exists. Note that plants with highly variable flows (e.g., I&I) or loading may have excess capacity at most, but not all, times.

4. Compile TN and TP performance data and analyze process variables and other important characteristics (e.g., time of year/temperature) to determine whether trends are discernible.

5. Consider using quick field tests to analyze various nutrient species throughout the biological treatment process at different times and under different conditions.

6. Use this document to determine potential broad areas where performance can be optimized.

7. Change only one variable at a time, allow to reach steady-state, and document performance implications.

In many cases, optimizing nitrogen reduction at non-advanced WWTPs focuses on maximizing simultaneous nitrification and denitrification, rather than creating new, dedicated anoxic zones, which may be infeasible and/or cost-prohibitive. Keys to effective simultaneous nitrification/denitrification include (Daigger and Littleton, 2014):

- An aerobic SRT that exceeds that needed for nitrification (considering the highest expected loads and lowest expected temperature)

- Promoting on-uniform hydraulic flow patterns with the aeration and/or mixing systems

- Having the ability to effectively manage oxygen input

Selection of Optimization Activities

Aeration

- _Aeration cycling – includes on/off cycling of aeration, including the creation of dedicated anoxic and oxic zones, and associated controls.
- _Adjustable control aeration – use of variable frequency drives to control aerator output and/or use of on-line monitoring tools to inform aerator operational mode.
- _Mixer addition – addition of mixers to facilitate on/off cycling or maintain suspension of solids when aerators are turned down.
- _Equipment retrofit – replacement with energy efficient aeration equipment.

Process

- _Flow equalization improvement – improving the influent flow to biological treatment process to improve performance consistency.
- _Recycle rate control – modifying internal mixed-liquor recycle rate to optimize denitrification in primary anoxic zones.
- _Sidestream control – modifying nutrient-rich internal plant return flows, such as sludge dewatering returns.
- _Pre-digestion of primary sludge – modifying primary sludge wasting rate to facilitate biochemical oxygen demand (BOD) solubilization from settled sludge into secondary process influent.
- _Batch program modifications - changes to SBR program settings.

Configuration

- _Plug flow/series operation – conversion of complete mix reactor to plug flow to facilitate oxic/anoxic zonation.
- _Anoxic zone bleed – introduction of influent wastewater or return activated sludge (RAS) into anoxic reactors to provide carbon for denitrification.
- _Anaerobic zone VFA addition – introduction of RAS into anaerobic selector to provide carbon for enhanced biological phosphorus removal (EBPR).

Chemical

- _Alkalinity feed improvements – modifications to alkalinity control systems to facilitate effective nitrification.
- _Carbon product addition – addition of soluble BOD products to enhance denitrification or EBPR.

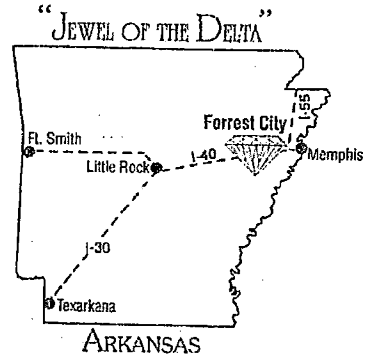
Discharge

- _Soil dispersal – conversion of a surface discharging system into a soil discharging system.
- _Wetland discharge – discharge into wetlands for further attenuation of nutrients prior to receiving water delivery.

City of Forrest City

The Hub of Commerce & Industry for Eastern Arkansas

Larry Bryant, Mayor



December 28, 2017

Mr. Layne Pemberton
Enforcement Analyst
ADEQ Office of Water Quality
Enforcement Branch
5301 Northshore Drive
North Little Rock. AR 72118

Re: Permit #AR0020087
Compliance Plan

Dear Mr. Pemberton,

Attached please find a document titled "Best Management Practices for Nutrient Reduction at the City of Forrest City WWTP" submitted in fulfilment to the compliance plan requirement of the Forrest City negotiated CAO.

It is our intent to develop a more specific action plan based on the suggested BMPs for reduction of nutrients. However, in order to develop a specific action plan extensive sampling data will be needed, unit processes will have to be analyzed, cost implications of all modifications and their alternatives fully developed and plant modification priorities established. This will require considerable financial and physical resources on the part of the City and will also require adequate time .

Please feel free to contact me if you have any questions.

Sincerely,
City of Forrest City

Larry S. Bryant
Mayor

Attachment:
Report titled "Best Management Practices for Nutrient Reduction at the City of Forrest City WWTP"

P.O. Box 1074 Forrest City, Arkansas 72336-1074 Phone (870) 633-1315 Fax (870) 261-1424