

# ANTIDEGRADATION ALTERNATIVES FOR MUNICIPAL SEWAGE TREATMENT

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Prepared for:

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COLLABORATIVE

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### APPENDICES

Appendix A: Effluent Characteristics of Technology Alternatives for Municipal Sewage Treatment

Appendix B: Anti-Degradation Alternatives Matrix for Municipal Sewage Treatment

## 1.0 INTRODUCTION

While the technology of wastewater treatment has made advances in treatment methodology in many areas, antidegradation laws are requiring communities to re-examine sewage treatment systems to find alternative treatment methods that further reduce pollutant loadings to water bodies. The purpose of this study is to compile operational, cost, design, and performance parameters on treatment alternatives for conventional municipal sewage treatment in order to demonstrate the feasibility of advanced and innovative methods and to assist decision makers in meeting antidegradation requirements.

Applied Ecological Services, Inc. (AES) was retained by Prairie Rivers Network (PRN) on behalf of the Mississippi River Collaborative (MRC) to develop a report that examines both the economic and technical feasibility of state of the art treatment alternatives for new or expanding municipal sewage treatment facilities. The product is to be used to present operators with environmentally sound sewage treatment alternatives that are feasible and cost effective to implement. AES has teamed with Environmental Consulting & Technology, Inc. (ECT) and Natural Water Solutions, LLC (NWS) in the creation of this document.

The intended audience of this document is operators of systems that treat excess of 10,000 gallons per day (gpd), or 100 persons served. The alternatives provided herein are divided into those applicable to medium sized systems (10,000 gpd to 1 million gallons per day- mgd, or 100 to 10,000 persons served) and large sized systems (greater than 1 mgd, or 10,000 persons served). A discussion on small system alternatives has also been included. The treatment alternatives presented will examine removal technologies for TSS, BOD, ammonia, total nitrogen, nitrate, total phosphorus, and pathogens.

Flow figures used for this comparison are the traditional units of 100 gallon per capita (person) per day. Over the past 10 to 15 years municipalities and industries are improving their collection system maintenance and practicing more water efficient methods of use. Thus we are seeing flow numbers often in the neighborhood of 65 gallons per capita per day.

Included in this document are a report text, an antidegradation matrix for municipal sewage treatment, and a matrix listing effluent characteristics of treatment alternatives. The purpose of the antidegradation matrix is to provide brief criteria on treatment alternatives for medium to large systems. The effluent characteristics matrix is a listing of achievable water quality results for the treatment alternatives listed in the antidegradation matrix. The report text should be consulted for additional detail on each system as well as brief descriptions of small system alternatives and a list of references used in the preparation of this document.

### **Wastewater Treatment Overview**

As all operators know, the final decisions on plant expansions are made by elected officials and/or appointed boards, all of whom rarely understand the mechanisms that control treatment efficiencies. For that reason, this report includes the following synopsis of wastewater treatment.

The purpose of wastewater treatment is to remove the contaminants from wastewater with the objective that it is treated enough to be released back into the environment. The treatment is achieved through physical, chemical and biological processes that occur naturally. Wastewater treatment facilities aim to accelerate such processes. Treatment can occur on-site, near the location where the wastewater is generated, or it can be transported to a facility (municipal treatment facility) through a network of pipes. Collection and discharge of wastewater is typically regulated by standards established at the local, state or federal level.

Conventional wastewater treatment can involve preliminary, primary, secondary and tertiary treatment. Preliminary treatment is used to remove large objects such as rocks, sticks, and trash from the wastewater, normally through the

use of bar racks and screens. Another component to preliminary treatment involves the removal of grit, sand, stones, and small debris from the wastewater. In primary treatment, the wastewater is collected and held so that solids are allowed to settle and oils and greases are allowed to float. The remaining wastewater is then sent to secondary treatment where micro-organisms digest the biological matter within the wastewater. Typically, the settled solids from primary and secondary treatment are sent to an anaerobic digester as part of secondary treatment to reduce the quantity and stabilize the solids. Anaerobic digestion is a biologic process that occurs by microorganisms in the absence of oxygen. Anaerobic activity reduces the volume of organic solids and by-products are carbon dioxide gas and methane which can be captured and utilized. Any additional treatment in addition to primary and secondary is tertiary treatment.

### Disinfection of Effluent

The report and matrices focus on nutrient s (nitrogen and phosphorus constituents), ammonia, BOD, and TSS removal. It is important to note that wastewater treatment facilities often have bacterial discharge standards and disinfection of the effluent is required to reduce the number of microorganisms discharged to the receiving water (stream, groundwater, lakes, or oceans). Methods of effluent disinfection include chlorination (chlorine or sodium hypochlorite), ozonation, and ultraviolet light (UV). The effectiveness of disinfection depends on the quality of the effluent water (suspended, BOD, pH, etc.), which is determined by the level of treatment. Highly treated wastewater is more readily disinfected to meet the bacterial standards.

Chlorination has been the most common form of wastewater disinfection due to its low cost and long-term history of effectiveness. However, the use of chlorine by treatment plants is currently decreasing due to safety concerns: chlorine released to the atmosphere can be toxic to people; combination with organics can produce chloramines or other compounds that are carcinogenic; residual chlorine is toxic to aquatic species. A dechlorination step is needed to remove residual chlorine before discharge to the receiving water.

Ozone (O<sub>3</sub>) is generated by passing oxygen through a high voltage potential. Ozone is very unstable, reactive, and oxidizes most organic material it comes in contact with, including many pathogenic microorganisms, BOD, and TSS. Ozone produces few disinfection by-products compared to chlorine but it also has safety concerns. It is highly poisonous if released accidentally, and as an oxidizer there is an explosive hazard when released. The high cost of the ozone generation equipment and the requirements for special operators are further limitations on its use.

In the last twenty years UV disinfection has become more common given concerns about the impacts of chlorine in chlorinating residual organics in the wastewater or chlorinating organics in the receiving water. UV is safer than either ozone or chlorine for the wastewater treatment operators and the public.

## 2.0 MEDIUM AND LARGE SYSTEM TREATMENT ALTERNATIVES > 10,000 GPD

The alternatives presented within this section are applicable to systems greater than 10,000 gpd.

The alternatives presented are separated into the following categories:

- Non-Discharging Alternatives- systems other than those considered surface water discharging by US EPA.
- Enhanced Treatment of conventional technology through modification of the treatment system to increase removal of effluent constituents
- Advanced Innovative Treatment Technologies- used to extend the treatment of conventional secondary treatment systems
- Conventional Alternatives- systems that are widely accepted and used.
- Seasonal Discharging Alternatives- surface water discharging during certain seasons.

System Size

- Small
- Medium
- Large

Pollutants Addressed

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input checked="" type="checkbox"/> TN      |

**Description**

Dedicated Land Application or Seasonal Application Systems typically utilize one of three application techniques: Drip Irrigation, Spray Irrigation and Overland Flow. Spray irrigation with center pivot equipment is the more commonly used technique. The land application itself provides a tertiary method of treatment and is used in conjunction with primary and secondary treatment. Dedicated application systems are used in warm areas where the soil is not frozen in the winter. A dedicated system in a warm area is usable year around. Seasonal systems are more common in the Midwest and North where the soil freezes in the winter. A seasonal system is used during spring to fall and effluent generated during winter months is typically stored in a holding lagoon for application after winter.

During Spray and Drip Irrigation the wastewater is distributed evenly on a vegetated plot of land where it is treated. During an Overland Flow application, the wastewater is distributed along the top contour of a gently sloping site. The water flows down the slope and is treated by the plants and infiltrates into the soil as it flows past. Generally the irrigation systems are designed to have no discharge from the land application. Application fields will have a collection point where runoff from an application field can be checked and released if the quality is acceptable. The performance of dedicated land application treatment is difficult to generalize as it is dependent on the type of vegetation and soil characteristics of the area where the water is being applied. Costs of these systems are dependent upon the capital needed to purchase the irrigation equipment, the amount of land required for application (a Seasonal system may require a constructed lagoon to hold the effluent over winter), the degree of pre-treatment to settle and remove solids prior to application, and the possible need for pathogen treatment prior to land application.

**Typical Applications**

Deep, well-drained and permeable soils are best suited for reclaimed water irrigation. Soils with good tilth in the surface layer facilitate the infiltration and percolation of water and prevent surface runoff. Good permeability in the subsoil layers fosters biological activity in the root zone that maximizes nutrient and water utilization by the growing plants. Adequate depths to bedrock and the seasonally high water table are required (> 4 feet).

**Critical Design Parameters**

- Hydraulic and nutrient loading of the site
- Pre-treatment
- Land Area and topography

**Effluent Characteristics**

The effluent characteristic will be a function of the pretreatment method and effectiveness, the type of vegetation and soil characteristics of the area of application. Generally, land application can provide good removal of BOD, TSS and Phosphorus. During the growing season, Ammonia can be removed as well.

**Cost Considerations**

- *Capital*- The capital cost of a Land Application System may require larger land areas, though land need not be purchased in all cases. Pre-treatment is often required prior to application and this could require additional plant facilities.
- *O&M*- Operation and Maintenance costs will include the costs for manual labor required for inspection and maintenance, power for operation, and materials used for the pre-treatment and irrigation system.

**Benefits**

- Because reclaimed water is being used to irrigate, there are potable water savings.
- Can provide source of irrigation water for off-site users.
- Nutrients are being recycled to plants.
- Potential water source to use for ground water recharge.
- Non-discharge can preserve in-stream water quality.

**Limitations**

- Large area of land may be required, but can land apply a portion of effluent reducing requisite land mass.
- Requires pre-treatment
- Requires buffer to control human contact

**Related Technologies**

- Reclaimed water reuse

System Size

- Small
- Medium
- Large

Pollutants Addressed

- |  |  |   |
|--|--|---|
| <input type="checkbox"/> Ammonia           | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO | <input checked="" type="checkbox"/> Phosphorus | <input type="checkbox"/> TN                 |

**Description**

Rapid infiltration Basins (RIBs) consist of a shallow vegetative basin overlying highly permeable soils. Treated wastewater enters the basin and continues treatment (polishing) as if flows through the soils. In some instances the wastewater can be collected by an under drain system for additional treatment. RIBs are typically used in medium size systems; however the key is suitable soil conditions. RIBs can provide quality reclaimed water groundwater recharge; however, seasonal storage is often required. In colder climates, there is a lower rate of treatment during the winter and, therefore, the water must be detained for longer periods to compensate. Additionally, the wastewater entering a RIB must be pre-treated, so pre-treatment costs must be considered.

**Typical Applications**

RIBS require highly permeable soils with no underlying constraints that could result in ground water contamination.

**Critical Design Parameters**

- Soil characteristics of underlying soils
- Hydraulic loading rate
- Lack of groundwater close to the infiltration basin
- No bedrock or highly fractured (Karst limestone) rock close to bottom of the infiltration basin

**Effluent Characteristics<sup>15</sup>**

Most Rapid Infiltration Basins discharge directly to the groundwater and do not have a discharge to surface water. Some RIB treatment facilities capture seepage from the applied water in under drains. The effluent quality from the under drain is represented by the following characteristics:

BOD: < 5mg/L ( 95% reduction)

TSS 1 mg/L

Nitrate: < 5 mg/L (40%-90% reduction)

P: < 1 mg/L (90 - 99% reduction)

**Cost Considerations**

- *Capital*- The underlying soil characteristic can affect the cost. The permeability of the soil will govern the size of the basin(s), and therefore the cost.
- *O&M*- The RIB will require periodic roto-tilling and vegetation removal.

**Benefits**

- Groundwater Recharge and reuse.
- Wildlife habitat in the basin vegetation.
- Can be integrated into trail and park developments for interesting diversity of plantings and wildlife.

**Limitations**



- Land area needed and no traffic is allowed in or around the RIB.

**Related Technologies**

- Groundwater Injection (not often practiced). With higher levels of treatment we will see this more and more in use and corresponding changes in regulations to allow.

System Size

- Small
- Medium
- Large

Pollutants Addressed

- Ammonia
- TSS
- Nitrate
- BOD/DO
- Phosphorus
- TN

**Description**

Traditional activated sludge plants do not address Ammonia, and can be modified to do so. This is achieved by extending the aeration provided and the detention time or by increasing the amount of biomass within the facility. Examples of modified activated sludge plants include:

- Integrated Fixed Film in Activated Sludge Systems (IFAS) - In the IFAS, additional surface area within the facility is provided by adding media in the aeration chambers to increase the surface available for microbial growth.
- Membrane Bioreactor (MBR) - Combines activated sludge treatment with a membrane liquid-solid separation process. The membrane acts as a micro-filter or ultra-filtration layer and the biomass growing on the membrane actively removes solids thereby lessening or eliminating the need for final clarification.

**Typical Applications**

Use to enhance removal of nitrogen, TSS, BOD, and phosphorus over conventional activated sludge plants using small footprint chambers containing the media or the membrane. Their removal efficiency produces high quality effluent which could be valuable for water reuse systems.

**Critical Design Parameters**

- Biomass effective area available on the media or membrane.
- Aeration delivery system design.
- Influent characteristics.

**Effluent Characteristics**

Ammonia: <2 mg/L  
 BOD: 10-30 mg/L  
 TSS: 10-30 mg/L  
 TN: little reduction  
 Nitrate: little reduction  
 P: 2.5 – 6 mg/L (15-20% reduction)

**Cost Considerations**

- *Capital*- The systems require additional mechanical controls .
- *O&M*- Cost of energy to operate the aeration system

**Benefits**

- Increase in solids retention time (SRT) with enhanced nitrification.
- More stable microbial populations which are less effected by hydraulic or organic shock loads than conventional activated sludge systems.
- Reduction in sludge production versus conventional activated sludge systems.

**Limitations**

- Membranes can be affected by grease or grit.
- High peak flow rates can cause problems. Work best with consistent flow rates.
- Fouling.

**Related Technologies**

- Conventional Activated Sludge.
- Oxidation ditches
- Sequencing Batch Reactors

System Size

- Small
- Medium
- Large

Pollutants Addressed

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input checked="" type="checkbox"/> TN      |

**Description**

The purpose of the Modified Ludzack-Ettinger (MLE) process is to remove nitrogen from wastewater. The MLE process consists of two zones, an anoxic zone and an aerobic zone. The wastewater enters the system and is mixed with return sludge (settled) recycling from the clarifier and the aeration tank effluent liquor. Both of these streams are high in nitrate (NO<sub>3</sub>). The microorganisms from the return sludge use the nitrogen from the aeration tank effluent liquor, consume ("eat") carbon in the influent wastewater, and convert the nitrate to nitrogen gas in the anoxic reaction (no dissolved oxygen).

**Typical Applications**

The MLE process may be used with any other activated sludge treatment system. It is commonly used upstream of an oxidation ditch.

**Critical Design Parameters**

- Recycle ratio for control over nitrogen removal
- Type of pre-treatment
- Adequate influent carbon (soluble food value)
- Effluent requirements

**Effluent Characteristics**

Ammonia: 0-2 mg/L  
 BOD: 10-20 mg/L  
 TSS: 10-20 mg/L  
 TN: 5-8 mg/L  
 Nitrate: 3-6 mg/L  
 P: 2-6 mg/L (15- 35% reduction)

**Cost Considerations**

- *Capital* - Because of the small footprint, the cost of land is not an issue. The capital cost associated with the MLE include all of the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and a control panel as well as the tanks, earthwork, and installation.
- *O&M* – Additional energy is required for aeration and a slight increase in operator monitoring time for proper system control.

**Benefits**

- Offers control over the amount of total nitrogen removed based on the recycling ratio.

**Limitations**

- Temperature dependent.
- Uncontrolled filamentous growth of biomass can occur
- Recycle volume monitoring to assure good reduction

**Related Technologies**

The Bardenpho process is the MLE process with two additional zones. The third zone is an anoxic zone. In the fourth zone, re-aeration helps remove nitrogen gas and increases the DO of the wastewater. The Bardenpho process can decrease the nitrogen concentrations to 3 to 5 mg/L (Nutrient Control Design Manual: State of Technology Review Report, EPA, 2009).

System Size

- Small  
 Medium  
 Large

Pollutants Addressed

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input checked="" type="checkbox"/> TN      |

**Description**

The Bardenpho process is the MLE process with two additional zones. The third zone is an anoxic zone and aeration occurs in the fourth zone to remove nitrogen gas and increase the DO of the wastewater.

**Typical Applications****Critical Design Parameters**

- Recycle ratio for control over nitrogen removal
- Type of pre-treatment
- Adequate influent carbon (soluble food value)
- Effluent requirements

**Effluent Characteristics**

The Bardenpho process can decrease the total nitrogen concentrations to 3 to 6 mg/L (Nutrient Control Design Manual: State of Technology Review Report, EPA, 2009).

Ammonia: 0-1 mg/L

BOD: 10-20 mg/L

TSS: 10-20 mg/L

TN: 3-6 mg/L

Nitrate: 1-7 mg/L

P: 2-6 (15-35% reduction)

**Cost Considerations**

- *Capital-* . The capital cost associated with Bardenpho includes large tanks with earthwork, and installation along with all the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and control panel.
- *O&M-* Additional energy aeration and more operator time needed to monitor the system to maintain the proper recirculation ratios. Possible methanol additions to optimize biologic activity.

**Benefits**

- Offers control over the amount of total nitrogen removed based on the recycling ratio.

**Limitations**

- Can be carbon limiting for biologic growth. Addition of methanol can overcome this issue.

**Related Technologies**

- Modified Ludzack Ettinger (MLE)
- Oxygen ditch with nitrogen removal.

System Size

- Small  
 Medium  
 Large

Pollutants Addressed

- Ammonia       TSS               Nitrate  
 BOD/DO       Phosphorus       TN

**Description**

An oxidation ditch consists of a long channel equipped with aeration within which wastewater is continuously circulated. The oxidation ditch can be designed to include nitrogen removal. This can be done through the addition of the Modified Ludzack-Ettinger process to the system, or modifications to the ditch to encourage nutrient removal between the anoxic and aerobic zones within the ditch. Pre-treated wastewater entering the ditch is aerated and mixed with return sludge from a secondary clarifier. The wastewater is circulated through the ditch and passes through multiple aeration zones. These zones result in a high DO just downstream of the aerators (where nitrification can occur) and a low DO just upstream of the operators (allowing for denitrification). The wastewater is then sent to a separate clarifier.

**Typical Applications**

The MLE process may be used with any other wastewater treatment system. Because it requires a large amount of land, oxidation ditches are applicable for small rural communities.

**Critical Design Parameters**

- Retention time
- BOD loading

**Effluent Characteristics**

When an oxidation ditch is designed for nitrogen removal, effluent concentrations can be less than 1 mg/L. (EPA Wastewater Technology Fact Sheet Oxidation Ditches, 2000).

Ammonia: 0-1 mg/L

BOD: 10-20 mg/L

TSS: 10-20 mg/L

TN: 3-6 mg/L

Nitrate: 2- 5 mg/L

P: 2-6 mg/L (15 – 35% reduction)

**Cost Considerations**

- *Capital*- The land required for an oxidation ditch can be significant and can contribute significantly to the cost.
- *O&M*- Oxidation ditches can provide lower operation and maintenance costs in relation to other secondary treatment systems.

**Benefits**

- Easy to maintain and operate
- Produces less sludge than other systems
- Can be operated efficiently

**Limitations**

- Requires a large area
- TSS concentrations can be high compared to other systems
- Takes about one to two years to optimize, after which the system is quite reliable.

**Related Technologies**

- Modified Ludzack Ettinger (MLE)
- Bardenpho Process.



System Size

- Small
- Medium
- Large

Pollutants Addressed

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input checked="" type="checkbox"/> TN      |

**Description**

The Intermittent Cycle Extended Aeration System offered by Sanitaire is a modified version of the sequencing batch reactor (SBR). In this system the wastewater flows into the reactor continuously, and thus the need for additional reactors or methods for flow receipt is eliminated. This is achieved within a single reactor containing two zones. The first zone allows the inflow to be aerated and mixed allowing the biological reactions to occur. The flow enters the second zone where settling occurs. After settlement the clear water is discharged and sludge is collected for additional treatment.

**Typical Applications**

Because of their small footprint, the ICEAS is used when space is limited.

**Critical Design Parameters**

- Influent characteristics
- Effluent requirements
- Number of basins
- Number of cycles
- Aeration equipment

**Effluent Characteristics**

SBRs can achieve good removal rates for BOD, TSS, Nitrogen and Phosphorus:

Ammonia: 0.5-5 mg/L

BOD: <10mg/L

TSS: <10mg/L

TN: 3-5 mg/L

Nitrate: 3-6 mg/L

P: 0.3-2 mg/L

(EPA Wastewater Technology Fact Sheet Sequencing Batch Reactors, 1999)

**Cost Considerations**

- *Capital-* Because of the small footprint, the cost of land is not an issue. The capital cost associated with the SBRs include all the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and control panel as well as the tanks, earthwork, installation. Furthermore, additional treatment may be required as part of the system.
- *O&M-* Because the primary and secondary clarifiers are included within the SBR, the cost associated with those is eliminated.
- *Modifications to progress from TSS/BOD removal to nitrogen and/or phosphorus removal are easily made with the addition of mixer(s), and programming changes.*

**Benefits**

- Less area required
- Easily modified for nutrient removal if required in the future
- Greater operator control allow for increased flexibility in treating variable wastewater influents
- Primary and secondary clarification within one reactor is possible (reducing cost and space)

**Limitations**

- Potential for sludge disposal during decant phase

**Related Technologies**

- Modified Ludzack Ettinger (MLE)
- Bardenpho Process.
- Oxygen ditch with nitrogen removal.

System Size

- Small  
 Medium  
 Large

Pollutants Addressed

- Ammonia       TSS       Nitrate  
 BOD/DO       Phosphorus       TN

**Description**

The A<sup>2</sup>/O is a modification to the sequencing batch reactor (SBR) that utilizes anaerobic/anoxic/aerobic biologic treatment zones to enhance removal of nitrogen and phosphorus in SBR plant. In this system the wastewater flows through a series of reactors where the oxidation state is controlled continuously to encourage microbial growth specific to its condition. This promotes uptake of additional phosphorus from the effluent in each stage which results in higher removal of Phosphorus. The nitrogen is subject to stages of nitrification followed by denitrification with additional nitrogen removed by the diverse microbial mass produced by the system. Often a carbon source such as methanol is required to maximize denitrification by the A<sup>2</sup>/O process. Internal recycle within the system to promote removal can be used. Nitrogen removal to less than 3 mg/l is achievable with careful operation and methanol addition.

**Typical Applications**

The A<sup>2</sup>/O process requires limited space and less energy than other SBR systems. It also is capable of giving good removal of nitrogen and phosphorus (best with additional filtration and metal salt precipitation).

**Critical Design Parameters**

- Influent characteristics
- Effluent requirements
- Number of basins
- Number of cycles
- Possible addition of a carbon source (methanol) for the anaerobic stage

**Effluent Characteristics**

SBRs with A<sup>2</sup>/O processes can achieve good removal rates for BOD, TSS, Nitrogen and Phosphorus:

Ammonia: 0-1 mg/L

BOD: 10-20 mg/L

TSS: 10-20mg/L

TN: 6-8 mg/L

Nitrate: 1-7 mg/L

P: 1-2 mg/L (lower concentrations achievable with metal salt addition)

(EPA Wastewater Technology Fact Sheet Sequencing Batch Reactors, 1999)

**Cost Considerations**

- *Capital-* Because of the small footprint, the cost of land is not an issue. The capital cost associated with the SBRs include all the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and control panel as well as the tanks, earthwork, installation. Furthermore, additional treatment may be required as part of the system.
- *O&M-* Because the primary and secondary clarifiers are included within the SBR, the cost associated with such clarifiers is eliminated.
- *Modifications to progress from TSS/BOD removal to nitrogen and/or phosphorus removal are easily made with the addition of mixer(s) and programming changes.*

**Benefits**

- Less area required.
- Easily modified for nutrient removal
- Operator control
- Primary and secondary clarification within one reactor is possible (reducing cost and space)

**Limitations**

- Potential for sludge disposal during decant phase

**Related Technologies**

- Modified Ludzack Ettinger (MLE)
- Bardenpho Process.
- Oxygen ditch with nitrogen removal
- Sanitaire's ICEAS Process

System Size

- Small
- Medium
- Large

Pollutants Addressed

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input checked="" type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input checked="" type="checkbox"/> TN      |

**Description**

Advanced nutrient removal beyond that achieved by the various sequencing batch reactor (SBR) processes. Post filtration of effluent after metal salt addition can significantly reduce the phosphorus effluent levels for an SBR advanced innovative system. Post denitrification of effluent (after complete nitrification has been established) can significantly reduce the nitrogen effluent levels for an SBR advanced innovative system. Several variations on processes utilizing post metal salt addition/filtration and post denitrification have been developed and used throughout the world on new plants or added to conventional treatment plants for increased nitrogen and phosphorus removal from wastewater. Both processes also lower the BOD and TSS in the effluent.

**Typical Applications**

Added to existing plants to meet more stringent discharge limits for nutrients.

**Critical Design Parameters**

- Influent characteristics
- Effluent requirements

**Effluent Characteristics**

Nutrient removal technologies can achieve excellent removal rates for Nitrogen and Phosphorus and the following concentrations are achievable:

Post Filtration with Metal Salt

Ammonia: Little Effect  
 BOD: 2-5 mg/L  
 TSS: 2-5 mg/L  
 TN: Little Effect  
 Nitrate: Little Effect  
 P: 0.03-1 mg/L

Post Denitrification Filter

Ammonia: 0-1 mg/L  
 BOD: 10 mg/L  
 TSS: 10 mg/L  
 TN: 3-5 mg/L  
 Nitrate: 1-2 mg/L  
 P: Little Effect

**Cost Considerations**

- *Capital*- The capital costs associated with the nutrient removal technology include all the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and control panel as well as the tanks, earthwork, installation.
- *O&M*- increased operator monitoring and active management required.

**Benefits**

- High removal of nutrients.

**Limitations**

- Additional basin and filtration areas required for most systems.

**Related Technologies**

- Modified Ludzack Ettinger (MLE)
- Bardenpho Process.
- Oxygen ditch with nitrogen removal.
- Sanitaire's ICEAS Process (SBR)
- A<sup>2</sup>O Process

System Size

- Small
- Medium
- Large

Pollutants Addressed

- |   |  |                                  |
|---|--|----------------------------------|
| <input checked="" type="checkbox"/> Ammonia | <input checked="" type="checkbox"/> TSS        | <input type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO  | <input checked="" type="checkbox"/> Phosphorus | <input type="checkbox"/> TN      |

**Description**

The activated sludge process is a secondary treatment process within which a mixture of wastewater and sludge solids is aerated. The wastewater and sludge mixture (mixed liquor) is first aerated in an aeration tank. From there the wastewater enters a secondary clarifier where the solids settle. The organisms, using the oxygen, reduce the organic content of the sewage. There are many configurations for an activated sludge system. For the purposes of this comparison we are talking about the use of conventional complete mix activated sludge process with diffused aeration into the wastewater or use of efficient mechanical aerators. Hydraulic retention times (HRT) of 8 to 12 hours are compared. Examples of other activated sludge process systems are: step feed aeration, pure oxygen, extended aeration, oxidation ditch, or contact stabilization.

**Typical Applications**

Commonly used as secondary treatment at many existing facilities

**Critical Design Parameters**

- Amount of oxygen supplied to the system
- Hydraulic retention time (size)
- Degree of preliminary and/or primary treatment
- Amount and duration of wet weather flow

**Effluent Characteristics**

Ammonia: little reduction  
 BOD: 10-50 mg/L  
 TSS: 15-60 mg/L  
 TN: little reduction  
 Nitrate: little reduction  
 P: 2.5-6 mg/L (15-20% reduction)

**Cost Considerations**

- *Capital*- Require tanks with mechanical aeration equipment
- *O&M*- Cost of energy to operate the aeration system

**Benefits**

- Active oxygen addition is used so units are smaller than other systems since surface area for oxygen diffusion into the wastewater is not required.

**Limitations**

- Requires energy to operate the aeration system, which can increase operation costs

**Related Technologies**

- Oxidation ditches
- Sequencing Batch Reactors

System Size

- Small
- Medium
- Large

Pollutants Addressed

- Ammonia
- TSS
- Nitrate
- BOD/DO
- Phosphorus
- TN

**Description**

A Sequencing Batch Reactor (SBR) is simply a single tank operated in a cyclic manner first as an aeration chamber, then as a mixing tank without aeration (anoxic) and then as a clarifier. Pre-treated (primary settled )wastewater fills the reactor, where it is aerated and mixed which increases the oxygen within the wastewater, allowing the aerobic bacterial population to grow which increases the consumption of wastes. In addition to consuming typical constituents (BOD/TSS), the process can be operated to reduce nutrients in the effluent. During the aeration process, the nitrogen from ammonia is converted into nitrate and a portion of the phosphorus is consumed by and becomes part of the bacterial cell wall and contents. When the biological reactions are complete, the aeration is turned off and a mixer is turned on, allowing the aerobic bacteria to continue to multiply until the dissolved oxygen is depleted. At this point, the anaerobic bacteria flourish, extracting the oxygen molecule from the nitrate (NO<sub>3</sub>) thereby converting the nitrogen into nitrogen gas. After this step, mixing is stopped, air is turned on for a short time, and then turned off again and the sludge formed by the bacteria is allowed to settle to the bottom of the tank. . Portions of the sludge are then removed for dewatering and/or disposal. And, separately, the treated supernatant (clear water) is removed for discharge.

**Typical Applications**

Because of a small footprint, the SBR is used where land is not available.

**Critical Design Parameters**

- Influent characteristics
- Effluent requirements
- Number of basins
- Number of cycles
- Aeration equipment

**Effluent Characteristics**

SBRs can achieve good removal rates for BOD, TSS, Nitrogen and Phosphorus:

Ammonia: 5-8 mg/L

BOD: 10mg/L

TSS: 10mg/L

TN: Little reduction

Nitrate: little reduction

P: 1-2 mg/L

(EPA Wastewater Technology Fact Sheet Sequencing Batch Reactors, 1999)

**Cost Considerations**

- *Capital-* Because of the small footprint, the cost of land is not an issue. The capital cost associated with the SBRs include all the equipment required such as blowers, diffusers, valves, mixers, pumps, decanters and control panel as well as the tanks, earthwork, installation.
- *O&M-* Because the primary and secondary clarifiers are included within the SBR, the cost associated with these is eliminated. Additionally, controls can be efficient and allow for consistent operation.



**Benefits**

- Less area required
- Easily modified for nutrient removal if required in the future
- Greater operator control allows for increased flexibility in treating variable wastewater influents
- Primary and secondary clarification within one reactor is possible (reducing cost and space)
- Short term wet weather can be handled nicely with SBRs. Programming allows for “storm” modes of operation whereby aeration is shortened and decant (discharge) is increased for the higher flows

**Limitations**

- Potential for sludge disposal during decant phase
- Prolonged wet weather will require equalization tanks.

**Related Technologies**

- Activated sludge plants
  - Conventional
  - Extended air plants.

System Size

- Small  
 Medium  
 Large

Pollutants Addressed

- Ammonia     TSS     Nitrate  
 BOD/DO     Phosphorus     TN

**Description**

An oxidation ditch consists of a long channel equipped with aeration within which wastewater is continuously circulated. Pre-treated wastewater entering the ditch is aerated and mixed with return sludge from a secondary clarifier. The wastewater is circulated through the ditch and passes through multiple aeration zones. These zones result in a high DO just downstream of the aerators and a low DO just upstream of the operators. The wastewater is then sent to a separate clarifier.

**Typical Applications**

Because it requires a large amount of land, oxidation ditches are applicable for small rural communities.

**Critical Design Parameters**

- Retention time
- BOD loading

**Effluent Characteristics**

Ammonia: 5-8 mg/L

BOD: 10-30 mg/L

TSS: 10-30 mg/L

TN: little reduction

Nitrate: little reduction

P: 2.5-6 mg/L (15% to 20% reduction)

**Cost Considerations**

- *Capital*- The land required for an oxidation ditch can be significant and can contribute significantly to the cost.
- *O&M*- Oxidation ditches can provide lower operation and maintenance costs in relation to other secondary treatment systems.

**Benefits**

- Easy to maintain and operate
- Produces less sludge than other systems
- Can be operated efficiently

**Limitations**

- Requires a large area
- TSS concentrations can be high compared to other systems

**Related Technologies**

- Activated sludge plants
  - Conventional
  - Extended air plants.

## CHEMICAL SETTLING WITH METAL SALTS (CHEMICAL PHOSPHATE REMOVAL) CONVENTIONAL

### System Size

- Small
- Medium
- Large

### Pollutants Addressed

- |  |  |                                  |
|--|--|----------------------------------|
| <input type="checkbox"/> Ammonia           | <input checked="" type="checkbox"/> TSS        | <input type="checkbox"/> Nitrate |
| <input checked="" type="checkbox"/> BOD/DO | <input checked="" type="checkbox"/> Phosphorus | <input type="checkbox"/> TN      |

### **Description**

Chemical settling with metal salts is used to remove phosphate from wastewater. The method is also called chemical phosphate removal. Chemical phosphate removal is achieved by treating the wastewater with a chemical that promotes phosphate precipitation. The precipitated compounds are then disposed of as sludge. The chemicals used are one of the following metals: Calcium, Iron, and Aluminum. These are most commonly used as salts in the following forms: alum, sodium aluminate, ferric chloride, ferric sulfate, ferrous sulfate and ferrous chloride.

### **Typical Applications**

Chemical phosphate removal can be used in conjunction with many other wastewater treatment systems. For example it can be used within the Modified Ludzack Ettinger process, or within any conventional biological system. In some instances it precedes or follows other systems as a stand-alone process.

### **Critical Design Parameters**

- Treatment with which chemical phosphate removal is being used

### **Effluent Characteristics**

Ammonia: little reduction

BOD: 15 mg/L

TSS: 15 mg/L

TN: little reduction

Nitrate: little reduction

P: 0.5-1.0 mg/L (<0.3 with Bio P followed by chemical phosphate removal by effluent filter)

### **Cost Considerations**

- *Capital*- The cost of this method is dependent on the type and amount of the chemical, and its availability.
- *O&M*- Increases the solids volume in the secondary clarifier and metal salts in the solids may cause upset of the biologic activity if introduced into anaerobic digesters.

### **Benefits**

- Well established technology
- Some of the chemicals can be inexpensive, resulting in an effective economical treatment
- Can be low maintenance

### **Limitations**

- It can be difficult to obtain low required phosphorus concentrations with chemical treatment alone.
- Chemicals used in the treatment do not fully react and are wasted and disposed of as sludge.
- Depending on chemicals being used, operator safety may be a concern
- Some chemicals and their application point in the process can significantly increase the amount of sludge.
- UV disinfection can be interfered with when excessive iron is used.
- Performance is effected by pH

### **Related Technologies**

Chemical precipitation for the removal of metals, in-organics, suspended solids, fats, oils, and greases

System Size

- Small  
 Medium  
 Large

Pollutants Addressed

- Ammonia     TSS     Nitrate  
 BOD/DO     Phosphorus     TN

**Description**

Lagoons are ponds used as a conventional method to treat municipal waste through the use of aquatic vegetation and microorganisms. They can be non-aerated (facultative), aerated, or anaerobic.

Facultative lagoons are approximately 4 to 8 foot deep earthen lagoons used to treat raw, screened or primary treated wastewater. In many cases the system consists of multiple lagoon cells. Dissolved oxygen, present at the water surface from the atmosphere and algal respiration, supports aerobic organisms, while sludge at the bottom of the lagoon supports the anaerobic organisms. Commonly, these types of lagoons are discharged seasonally.

Aerated lagoons are mechanically aerated to maintain minimum oxygen content. Similar to facultative lagoons, many aerated lagoon systems consist of multiple lagoon cells. Aerated lagoons can be up to 20 feet in depth and, therefore, require less land area than facultative lagoons.

Anaerobic lagoons are deeper than 8 feet with less surface area to limit oxygen transfer and create conditions for anaerobic activity. A combination with aerobic and anaerobic lagoons could be used to promote nitrogen removal by nitrification then denitrification with soluble phosphorus removal occurring by microbial growth.

**Typical Applications**

Lagoons can be an inexpensive system for a small community and in rural areas where land cost is not an issue.

**Critical Design Parameters**Facultative

- Liner may be required based on soil conditions
- Number of cells to maximize system effectiveness
- Detention time based on climate
- Usually shallow, thus more land area needed

Aerated

- Liner may be required based on soil conditions
- Number of cells to maximize system effectiveness
- Detention time based on aeration intensity
- Settling basin for TSS removal

Anaerobic

- Usually combined with an aerobic lagoon in series to provide additional nitrogen removal
- Liner may be required based on soil conditions
- Detention time based on climate
- Usually deeper, thus less land area needed

**Effluent Characteristics**Facultative Lagoon

Ammonia: 2.4-10 mg/L

BOD: 30 mg/L

TSS: 150 mg/L

TN: Little Effect  
Nitrate: Little Effect  
P: 1.5-3.5 mg/L

#### Aerated and Mixed Lagoon

Ammonia: more effective than facultative  
BOD: 15 mg/L  
TSS: 20-60 mg/L  
TN: Little Effect  
Nitrate: Little Effect  
P: Less effective than facultative

Facultative is moderately effective at Ammonia removal, but it is difficult to predict. Removal rates are based on the temperature, pH and detention time of the system. This is not consistent during colder seasons. Aerated lagoons must be designed appropriately to provide enough dissolved oxygen for nitrification.

Facultative lagoons are far less effective in TSS removal and can exceed 150 mg/L based on algal concentrations. TSS in aeration lagoons ranges from 20 to 60 mg/L and can depend on the design of the settling basin.

In facultative lagoons, the photosynthesis occurring with the algae causes fluctuation in oxygen and pH levels throughout a 24 hour period. Precipitation of phosphorus can occur seasonally, as well as re-release from the benthos (settled microorganisms and decomposing vegetation) seasonally.

#### **Cost Considerations**

- *Capital-* Costs can vary for facultative and aeration lagoons as it depends on land required, earthwork, and inlet and outlet structures. For aeration lagoons, the cost of aeration equipment must be considered. Based on soil conditions, the material and installation cost for a liner must be considered. Anaerobic lagoons have a small surface area to minimize oxygen diffusion but a greater depth to maintain anaerobic conditions. Typically excavation for anaerobic lagoons is still less than facultative and aerated lagoons.
- *O&M-* Most facultative and anaerobic lagoons rely on gravity flow and, therefore, operation and maintenance is minimum. The system must be inspected and sludge must be cleaned out (dredged) periodically. Aeration lagoons have cost associated with the power, operation and maintenance of the aeration equipment. Anaerobic lagoons will have higher cleanout costs for solids removal, when needed, due to their greater depth.

#### **Benefits**

##### Facultative

- Easy operation

##### Aerated

- Can discharge throughout the winter in colder climates

#### **Limitations**

##### Facultative

- Poor TSS and ammonia removal.
- Land area requirement.
  - Area required determined by organic loading rate and hydraulic detention time (HDT)
  - Typical min. recommendation – 4' deep (max), 40 lb/BOD/ac/d loading rate, 30 day HDT
- Objectionable odors can result.
- Seasonal discharge in colder climates
- Sludge requires periodic removal
- Mosquitoes can be a problem
- Burrowing animals may be a problem with dikes

- Long detention times, especially in northern climates

#### Aerated

- Land area requirement less than facultative due to active aeration.
  - Area required determined by organic loading rate and hydraulic detention time (HDT)
  - Typical min. recommendation – 4' deep (max), 40 lb/BOD/ac/d loading rate, 19 day HDT
- Sludge requires periodic removal
- Mosquitoes can be a problem
- Borrowing animals may be a problem with dikes
- Requires energy input

#### Anaerobic

- Land area requirement lowest for all lagoons.
  - Area required determined by organic loading rate and hydraulic detention time (HDT)
  - Typical min. recommendation – 8' deep (max), 175-2000 lb/BOD/ac/d loading rate, 20 day HDT
- Objectionable odors can result.
- Mosquitoes can be a problem
- Burrowing animals may be a problem with dikes
- Long detention times, especially in northern climates

#### **Related Technologies**

- Activated sludge system
- Constructed Wetland biosystems using subsurface (anaerobic) flow and surface (aerobic) flow units in series.

As explained above, this document focuses on systems greater than 10,000 gpd; however, a discussion regarding smaller systems is warranted. The effluent quality of large scale wastewater treatment facilities has improved dramatically over the past decades. The same cannot be said for many of the smaller scale facilities, which includes treatment on individual parcels. Because the population continues to develop beyond the urban core, these sources are a growing portion of the pollutant load in our waterways. One specific challenge is reducing the effluent discharge volumes in areas that cannot accept the flow (notable wetlands, impermeable clay soil, and areas with high water tables.) Equally important is nutrient control from these smaller facilities. The following is a discussion of treatment alternatives for such systems:

### **2.1 Conventional Septic Systems**

A conventional septic system for a small facility consists of a septic tank and a septic field. Wastewater enters the first chamber of the septic tank where solids settle and oils and grease float. Often the remaining liquid then flows into a second chamber where additional settling occurs. The water flows into the septic field that consists of a trench filled with sand or gravel within which perforated pipe is placed. Conventional systems are typically only used for single family residences. The governing factor in the performance of a trench system is the size and material of the trenches and the underlying soils. Fewer of these systems are being used because of the limited suitability of soils and the tendency not to be sustainable in the long term. Often replacement sites are necessary in zoning codes.

### **2.2 Mound System**

A mound system is an alternative to explore when sites have soil conditions with slow permeability and/or the water table is high and a conventional septic system would not allow for proper treatment of the wastewater and is typically only used for single family residences. A mound system consists of a conventional septic tank, a dosing chamber from which the wastewater is pumped and distributed to the mound. The mound itself is made up of sands and aggregates and a pipe network for wastewater distribution, all covered with a layer of soil and vegetated. It provides secondary treatment and also provides dispersal of the treated water to soil horizon for further polishing and treatment. The governing factor in the performance of a mound system is the size and material of the mound and the underlying soils. The cost of the system is more than a conventional system because of the cost for the dosing chamber and the mound.

### **2.3 Dedicated Land Application**

Dedicated Land Application or Surface Application Systems typically result in three techniques: Drip Irrigation, Spray Irrigation and Overland Flow. The land application itself provides a tertiary method of treatment and is used in conjunction with primary and secondary treatment. During Spray and Drip Irrigation the wastewater is distributed evenly on a vegetated plot of land where it is treated. During an Overland Flow, application of the wastewater is distributed along the top contour of a gently sloping site. The water flows down the slope and is treated by the plants and infiltrates into the soil as it flows past. Generally the irrigation systems are designed to have no discharge from the land application. Application fields will have a collection point where runoff from an application field can be checked and released if the quality is acceptable. The performance of dedicated land application treatment is difficult to generalize as it is dependent on the type of vegetation and soil characteristics of the area where the water is being applied. Costs of these systems are generally high due to the amount of land required, the degree of pre-treatment needed to settle and remove solids prior to application, and the possible need for pathogen treatment prior to land application. All three types of irrigation can be used in small systems. Additional detail for the use of dedicated land application for medium and large systems is included in subsequent sections of this report.

## **2.4 Unlined Wetland System**

An unlined wetland system for wastewater treatment maintains a subsurface flow within a pervious media that supports wetland vegetation, or surface flow through and across soil with wetland vegetation. The flow through nature of the system provides the physical, chemical and biochemical reactions to treat the wastewater. An unlined system provides distribution as well, depending on the characteristics of the underlying soils. These systems can be used for systems up to 60,000 gpd (EPA Wastewater Technology Fact Sheet. Wetlands: Subsurface Flow, 2000). The wetland systems are efficient in removing BOD and TSS. They can be efficient in removing nitrogen and phosphorus based on detention time. Unlined wetland systems can be economical to construct and operate in relation to their mechanical counterparts. Cost of land, however, must be considered.

## **2.5 Evapotranspiration**

Evapotranspiration (ET) is the process of uptake of water within the soil by evaporation and plant transpiration. For wastewater treatment, evapotranspiration is used to dispose of treated wastewater. In most ET systems, the wastewater is transported from the treatment facility through distribution pipes to an area planted with water tolerant plants. The system is normally lined, or consists of impermeable soils. ET systems are applicable for arid climates and are often expensive due to their large size and special material requirements.

## **2.6 Water Recycling or Re-Use**

Wastewater can be divided into two categories: black water or grey water. Black water is wastewater from toilets, while grey water is wastewater coming from all other plumbing fixtures. If separated from black water, grey water can be treated by filtration prior to reuse to flush toilets or used with minimal treatment for irrigation purposes. This technique can be used for single family residences and small managed communities. Grey water re-use is applied frequently in some foreign countries. Technology providers are currently beginning to tap into the United States market with particular interest in areas where water is costly and/or scarce. Re-use can be applied in small systems as well as large. There are some large systems that are unique in their use of large quantities of water that does not need to be of drinking quality. Examples can include paper mills or irrigation (i.e. golf courses).

## **2.7 Subsurface Flow Wetland with Re-Circulating Sand Filter with Recycle**

A re-circulating sand filter (RSF) can be used in conjunction with a subsurface flow wetland to provide tertiary treatment. After solids are removed, typically through a septic tank, and then treated in the subsurface flow wetland, the wastewater is distributed over the top of an open sand filter where the water percolates through the sand filter and is collected by under-drains. A portion is dispersed, while the rest is returned back to the wetland. The RSF provides treatment (aerobic) via the microorganisms within the sand filter, reduces BOD and TSS, while converting ammonia to nitrate. A system such as this can be used for small communities up to 20,000 gpd. Working together, the wetland and sand filter provide for efficient removal of BOD, TSS, and Nitrogen and can provide very good effluent quality. Subsurface flow wetlands with re-circulating sand filter with recycle can be economical to construct and maintain. Cost considerations include cost of land and sand filter media cost.

## **2.8 Enhanced Aerobic Treatment Unit (ATU)**

An Aerobic Treatment Unit (ATU) is similar to a traditional septic system, but uses an aerobic treatment process. The system consists of an aeration compartment where oxygen is mixed with the wastewater with an air blower or compressor. With the presence of oxygen, the aerobic bacteria break down some of the solids within the wastewater. An ATU is used in conjunction with pre-treatment by screening, grit removal, and primary settling operations and once treated by the ATU the wastewater is sent for dispersal. ATUs are typically used for single family residences or small communities up to 20,000 gpd. An ATU is efficient in reducing BOD, TSS and Ammonia and can be retrofitted with controls that aid in the reduction of Total Nitrogen. These systems increase the capital costs and tend to have higher ongoing O&M costs.

## **2.9 Subsurface Flow Wetland with ATU with Recycle**

A subsurface flow wetland with ATU with recycle will be of similar configuration to the subsurface flow wetland with re-circulating sand filter with recycle. Both the subsurface flow wetland and ATU are described above. This system



is applicable to a similar size community, provides similar effluent characteristics and similar costs as the subsurface flow wetland with re-circulating sand filter with recycle.

### **2.10 Re-Circulating Sand Filter with Anaerobic Up Flow or Peat Filter**

After being pre-treated the wastewater is distributed over the top of an open sand filter (aerobic component) where the water percolates through the sand filter and is collected by under-drains where a portion of it is dispersed to an up flow or peat filter, while the rest is sent back to the top of the sand filter. The sand filter traps suspended solids which reduces BOD and the organic nitrogen and ammonium is converted to nitrates. The up flow filter or peat filters (anaerobic component) offer additional nitrogen removal by denitrification. A system such as this can be used for small communities up to 20,000 gpd

### **2.11 Chemical Settling with Metal Salts**

Chemical settling with metal salts is used to remove phosphate from wastewater. The method is also called chemical phosphate removal. Chemical phosphate removal is achieved by treating the wastewater with a chemical that promotes phosphate precipitation. The precipitated compounds are then disposed of as sludge. The chemicals used are one of three of the following metals: Calcium, Iron, and Aluminum. These are most commonly used as salts in the following forms: alum, sodium aluminate, ferric chloride, ferric sulfate, ferrous sulfate and ferrous chloride. The cost of this method is dependent on the type and amount of the chemical, and its availability.

### **2.12 Soil Horizon Dispersal**

Soil horizon dispersal is often combined with or “following” a mound system or a trench system in that it provides secondary treatment and dispersal. In Soil Horizon Dispersal the wastewater is usually pretreated to secondary or higher standards, and then dispersed to the soil promoting its flow horizontally through the soil horizon for “polishing” treatment. It, unlike the mound system, can be used for small communities, up to 20,000 gpd. The governing factor in the performance of soil horizon dispersal is the degree of pretreatment and characteristic of the underlying soils. The cost is dependent on the soil conditions and the degree of pretreatment.

## 4.0 CONCLUSIONS

Antidegradation requirements and impending numeric nutrient criteria are helping drive advances in wastewater treatment for the removal of ammonia, BOD, TSS and nutrients, and will continue to do so as more states implement their antidegradation rules and adopt water quality standards for nitrogen and phosphorus.

Operator experience and published literature indicate that existing innovative treatment technology can produce wastewater that meets nutrient removal goals. Concentration levels of 1.0 mg/L monthly average for phosphorus and total nitrogen of 6-8 mg/L annual average are readily achievable at most locations with the treatment technology available. Several POTW's in the nation and around the world have achieved effluent limits of nitrogen of less than 3 mg/L and phosphorus levels near or less than 0.1 mg/L. Each site and its wastewater are unique and require flexibility for operators and the owners (public or private) to choose the best technology for their situation. As nutrient removal requirements become more stringent, the cost of the advanced innovative technologies will decrease and newer variations to the processes currently used will undoubtedly evolve to enhance nutrient removal.

As affected communities plan upgrades or new treatment plants, both operators and regulators need performance and operational data to determine how to incorporate enhanced and innovative treatment technologies in order to prevent unnecessary degradation and to meet nutrient standards. Operators around the world have used these processes and variations thereto to enhance pollutant removal. The number of variations to the basic process is limited only by creative innovation applied by operators.

The attachments to this report compile the performance, operational, and cost data in matrices that can be used as guides in determining what each alternative (enhanced innovative and conventional) is capable of achieving in the removal of nutrients, BOD, ammonia, and TSS.

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## APPENDIX A:

### Effluent Characteristics of Technology Alternatives for Municipal Sewage Treatment

**APPENDIX B:**

**Anti-Degradation Alternatives Matrix for Municipal Sewage Treatment**