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EPA

Wastewater Technology Fact Sheet
Package Plants

DESCRIPTION

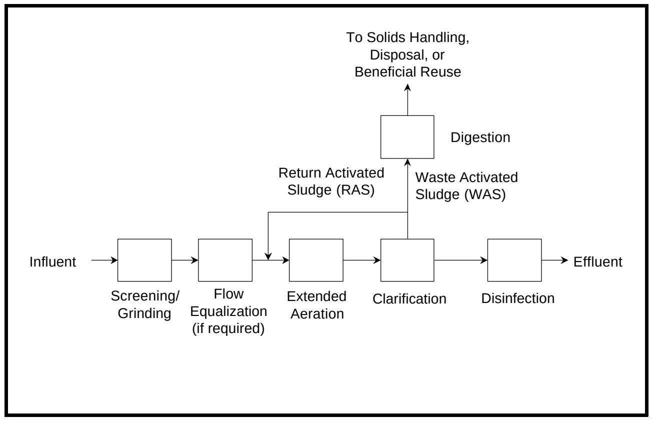
Package plants are pre-manufactured treatment facilities used to treat wastewater in small communities or on individual properties. According to manufacturers, package plants can be designed to treat flows as low as 0.002 MGD or as high as 0.5 MGD, although they more commonly treat flows between 0.01 and 0.25 MGD (Metcalf and Eddy, 1991).

The most common types of package plants are extended aeration plants, sequencing batch reactors, oxidation ditches, contact stabilization plants, rotating biological contactors, and physical/chemical processes (Metcalf and Eddy, 1991). This fact sheet focuses on the first three, all of which are biological aeration processes.

Extended aeration plants

The extended aeration process is one modification of the activated sludge process which provides biological treatment for the removal of biodegradable organic wastes under aerobic conditions. Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process. Mixing must be provided by aeration or mechanical means to maintain the microbial organisms in contact with the dissolved organics. In addition, the pH must be controlled to optimize the biological process and essential nutrients must be present to facilitate biological growth and the continuation of biological degradation.

As depicted in Figure 1, wastewater enters the treatment system and is typically screened immediately to remove large suspended, settleable, or floating solids that could interfere with or damage equipment downstream in the process. Wastewater may then pass through a grinder to reduce large particles that are not captured in the screening process. If the plant requires the flow to be regulated, the effluent will then flow into equalization basins which regulate peak wastewater flow rates. Wastewater then enters the aeration chamber, where it is mixed and oxygen is provided to the microorganisms. The mixed liquor then flows to a clarifier or settling chamber where most microorganisms settle to the bottom of the clarifier and a portion are pumped back to the incoming wastewater at the beginning of the plant. This returned material is the return activated sludge (RAS). The material that is not returned, the waste activated sludge (WAS), is removed for treatment and disposal. The clarified wastewater then flows over a weir and into a collection channel before being diverted to the disinfection system.



Source: Parsons Engineering Science, 2000.

FIGURE 1 PROCESS FLOW DIAGRAM FOR A TYPICAL EXTENDED AERATION PLANT

Extended aeration package plants consist of a steel tank that is compartmentalized into flow equalization, aeration, clarification, disinfection, and aerated sludge holding/digestion segments. Extended aeration systems are typically manufactured to treat wastewater flow rates between 0.002 to 0.1 MGD. Use of concrete tanks may be preferable for larger sizes (Sloan, 1999).

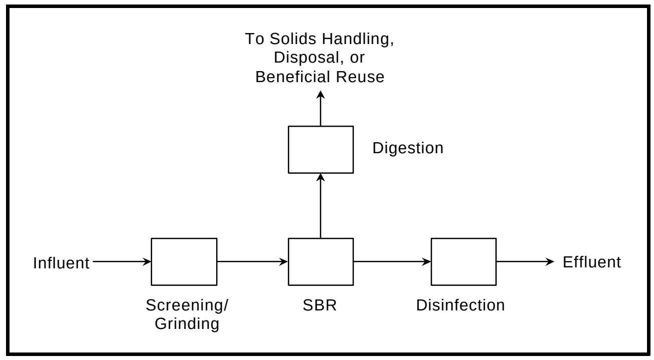
Extended aeration plants are usually started up using "seed sludge" from another sewage plant. It may take as many as two to four weeks from the time it is seeded for the plant to stabilize (Sloan, 1999).

Sequencing batch reactors

A sequencing batch reactor (SBR) is a variation of the activated sludge process. As a fill and draw or batch process, all biological treatment phases occur in a single tank. This differs from the conventional flow through activated sludge process in that SBRs do not require separate tanks for aeration and sedimentation (Kappe, 1999). SBR systems contain either two or more reactor tanks that are operated in parallel, or one equalization tank and one reactor tank. The type of tank used depends on the wastewater flow characteristics (e.g. high or low volume). While this setup allows the system to accommodate continuous influent flow, it does not provide for disinfection or holding for aerated sludge.

There are many types of SBR systems, including continuous influent/time based, non-continuous influent/time based, volume based, an intermittent cycle system (a SBR that utilizes jet aeration), and various other system modifications based on different manufacturer designs. The type of SBR system used depends on site and wastewater characteristics as well as the needs of the area or community installing the unit. Package SBRs are typically manufactured to treat wastewater flow rates between 0.01 and 0.2 MGD; although flow rates can vary based on the system and manufacturer.

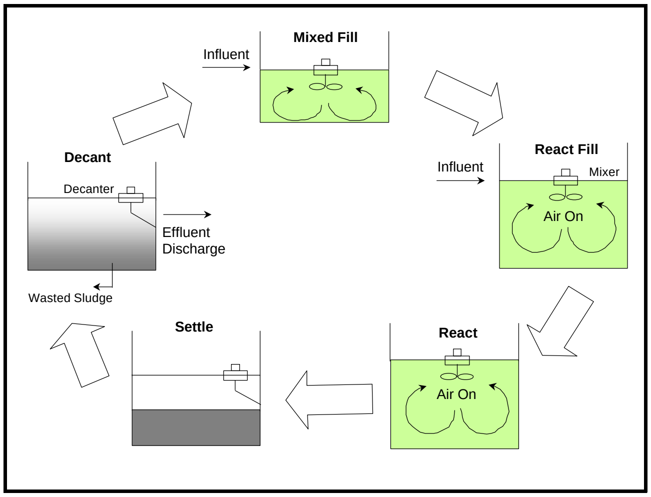
As seen in Figure 2, the influent flow first goes through a screening process before entering the SBR. The waste is then treated in a series of batch phases within the SBR to achieve the desired effluent concentration. The sludge that is wasted from the SBR moves on to digestion and eventually to solids handling, disposal, or beneficial reuse. The treated effluent then moves to disinfection. An equalization tank is typically needed before the disinfection unit in batch SBRs in order to store large volumes of water. If the flow is not equalized, a sizable filter may be necessary to accommodate the large flow of water entering the disinfection system. In addition, SBR systems typically have no primary or secondary clarifiers as settling takes place in the SBR.



Source: Parsons Engineering Science, 2000.

FIGURE 2 PROCESS FLOW DIAGRAM FOR A TYPICAL SBR

There are normally five phases in the SBR treatment cycle: fill, react, settle, decant, and idle. The length of time that each phase occurs is controlled by a programmable logic controller (PLC), which allows the system to be controlled from remote locations (Sloan, 1999). In the fill phase, raw wastewater enters the basin, where it is mixed with settled biomass from the previous cycle. Some aeration may occur during this phase. Then, in the react phase, the basin is aerated, allowing oxidation and nitrification to occur. During the settling phase, aeration and mixing are suspended and the solids are allowed to settle. The treated wastewater is then discharged from the basin in the decant phase. In the final phase, the basin is idle as it waits for the start of the next cycle. During this time, part of the solids are removed from the basin and disposed of as waste sludge (Kappe, 1999). Figure 3 shows this sequence of operation in an SBR.



Source: CASS Water Engineering, Inc., 2000.

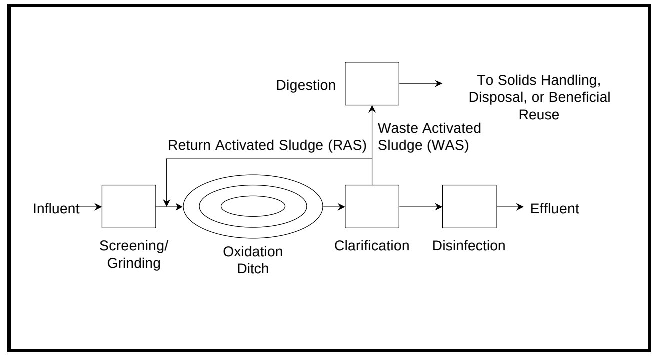
FIGURE 3 SBR SEQUENCE OF OPERATION

Sludge wasting is an important step in the SBR process and largely affects system performance. It is not considered a basic phase since the sludge is not wasted at a specific time period during the cycle. The quantity and rate of wasting is determined by performance requirements. An SBR system does not require an RAS system, as both aeration and settling occur in the same tank. This prevents any sludge from being lost during the react step and eliminates the need to return sludge from the clarifier to the aeration chamber (Metcalf and Eddy, 1991).

Oxidation ditches

An oxidation ditch, a modified form of the activated sludge process, is an aerated, long term, complete mix process. Many systems are designed to operate as extended aeration systems. Typical oxidation ditch treatment systems consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin. Horizontally or vertically mounted aerators provide aeration, circulation, and oxygen transfer in the ditch.

Package oxidation ditches are typically manufactured in sizes that treat wastewater flow rates between 0.01 and 0.5 MGD. As seen in Figure 4, raw wastewater is first screened before entering the oxidation ditch. Depending on the system size and manufacturer type, a grit chamber may be required. Once inside the ditch, the wastewater is aerated with mechanical surface or submersible aerators (depending on manufacturer design) that propel the mixed liquor around the channel at velocities high enough to prevent solids deposition. The aerator ensures that there is sufficient oxygen in the fluid for the microbes and adequate mixing to ensure constant contact between the organisms and the food supply (Lakeside, 1999).



Source: Parsons Engineering Science, 1999.

FIGURE 4 PROCESS FLOW DIAGRAM FOR A TYPICAL OXIDATION DITCH

Oxidation ditches tend to operate in an extended aeration mode consisting of long hydraulic and solids retention times which allow more organic matter to break down. Treated sewage moves to the settling tank or final clarifier, where the biosolids and water separate. Wastewater then moves to other treatment processes while sludge is removed. Part of it is returned to the ditch as RAS, while the rest is removed from the process as the waste activated sludge (WAS). WAS is wasted either continuously or daily and must be stabilized prior to disposal or beneficial reuse.

APPLICABILITY

In general, package treatment plants are applicable for areas with a limited number of people and small wastewater flows. They are most often used in remote locations such as trailer parks, highway rest areas, and rural areas.

Extended aeration plants

Extended aeration package plants are typically used in small municipalities, suburban subdivisions, apartment complexes, highway rest areas, trailer parks, small institutions, and other sites where flow rates are below 0.1 MGD. These systems are also useful for areas requiring nitrification.

Sequencing batch reactors

Package plant SBRs are suitable for areas with little land, stringent treatment requirements, and small wastewater flows. More specifically, SBRs are appropriate for RV parks or mobile homes, campgrounds, construction sites, rural schools, hotels, and other small applications. These systems are also useful for treating pharmaceutical, brewery, dairy, pulp and paper, and chemical wastes. While constant cycles with time-fixed process phases are sufficient in most cases, phases should be individually adapted and optimized for each plant. SBRs are also suited for sites that need minimal operator attendance and that have a wide range of inflow and/or organic loadings.

Industries with high BOD loadings, such as chemical or food processing plants, will find SBRs useful for treating wastewater. These systems are also suitable for facilities requiring nitrification, denitrification, and phosphorous removal. Most significantly, SBRs are applicable for areas where effluent requirements can change frequently and become stricter, as these systems have tremendous flexibility to change treatment options. However, part of the economic advantage of the SBR process is lost when advanced treatment processes must be added downstream since intermediate equalization is normally required.

Oxidation ditches

Oxidation ditches are suitable for facilities that require nutrient removal, have limitations due to the nature of the site, or want a biological system that saves energy with limited use of chemicals unless required for further treatment. Oxidation ditch technology can be used to treat any type of wastewater that is responsive to aerobic degradation. In addition, systems can be designed for denitrification and phosphorous removal.

Types of industries utilizing oxidation ditches include: food processing, meat and poultry packing, breweries, pharmaceutical, milk processing, petrochemical, and numerous other types. Oxidation ditches are particularly useful for schools, small industries, housing developments, and small communities. Ultimately, this technology is most applicable for places that have a large amount of land available.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of package plants are listed below.

Extended aeration plants

Advantages

- Plants are easy to operate, as many are manned for a maximum of two or three hours per day.
- Extended aeration processes are often better at handling organic loading and flow fluctuations, as there is a greater detention time for the nutrients to be assimilated by microbes.
- Systems are easy to install, as they are shipped in one or two pieces and then mounted on an onsite concrete pad, above or below grade.
- Systems are odor free, can be installed in most locations, have a relatively small footprint, and can be landscaped to match the surrounding area.
- Extended aeration systems have a relatively low sludge yield due to long sludge ages, can be designed to provide nitrification, and do not require a primary clarifier.

Disadvantages

- Extended aeration plants do not achieve denitrification or phosphorus removal without additional unit processes.
- Flexibility is limited to adapt to changing effluent requirements resulting from regulatory changes.
- A longer aeration period requires more energy.

- Systems require a larger amount of space and tankage than other "higher rate" processes, which have shorter aeration detention times.

Sequencing batch reactors

Advantages

- SBRs can consistently perform nitrification as well as denitrification and phosphorous removal.
- SBRs have large operational flexibility.
- The ability to control substrate tension within the system allows for optimization of treatment efficiency and control over nitrogen removal, filamentous organisms, and the overall stability of the process.
- Since all the unit processes are operated in a single tank, there is no need to optimize aeration and decanting to comply with power requirements and lower decant discharge rates.
- Sludge bulking is not a problem.
- Significant reductions in nitrate nitrogen can occur by incorporating an anoxic cycle in the system.
- SBRs have little operation and maintenance problems.
- Systems require less space than extended aeration plants of equal capacity.
- SBRs can be manned part time from remote locations, and operational changes can be made easily.
- The system allows for automatic and positive control of mixed liquor suspended solids (MLSS) concentration and solids retention time (SRT) through the use of sludge wasting.

Disadvantages

- It is hard to adjust the cycle times for small communities.
- Post equalization may be required where more treatment is needed.
- Sludge must be disposed frequently.
- Specific energy consumption is high.

Oxidation ditches

Advantages

- Systems are well-suited for treating typical domestic waste, have moderate energy requirements, and work effectively under most types of weather.
- Oxidation ditches provide an inexpensive wastewater treatment option with both low operation and maintenance costs and operational needs.
- Systems can be used with or without clarifiers, which affects flexibility and cost.
- Systems consistently provide high quality effluent in terms of TSS, BOD, and ammonia levels.
- Oxidation ditches have a relatively low sludge yield, require a moderate amount of operator skill, and are capable of handling shock and hydraulic loadings.

Disadvantages

- Oxidation ditches can be noisy due to mixer/aeration equipment, and tend to produce odors when not operated correctly.
- Biological treatment is unable to treat highly toxic waste streams.
- Systems have a relatively large footprint.
- Systems have less flexibility should regulations for effluent requirements change.

DESIGN CRITERIA

Table 1 lists typical design parameters for extended aeration plants, SBRS, and oxidation ditches.

TABLE 1 TYPICAL DESIGN PARAMETERS FOR PACKAGE PLANTS

	Extended Aeration	SBR	Oxidation Ditch
BOD_5 loading (F:M) (lb BOD_5/ lb MLVSS)	0.05 - 0.15	0.05 - 0.30	0.05 - 0 30
Oxygen Required Avg. at 20EC (lb/lb BOD_5 applied)	2 - 3	2 - 3	2 - 3
Oxygen Required Peak at 20EC (value x avg. flow)	1.5 - 2.0	1.25 - 2.0	1.5 - 2.0
MLSS (mg/L)	3000 -6000	1500 -5000	3000 -6000
Detention Time (hours)	18 - 36	16 - 36	18 - 36
Volumetric Loading (lb BOD_5/d/ 10^3 cu ft)	10 - 25	5 - 15	5 - 30

Source: Adapted from Metcalf and Eddy, 1991 and WEF, 1998.

Extended aeration plants

Package extended aeration plants are typically constructed from steel or concrete. If the system is small enough, the entire system will arrive as one unit that is ready to be installed. If the system is larger, the clarifier, aeration chamber, and chlorine tank are delivered as separate units, which are then assembled on-site (WEF, 1985).

Key internal components of extended aeration treatment plants consist of the following: transfer pumps to move wastewater between the equalization and aeration zones; a bar screen and/or grinder to decrease the size of large solids; an aeration system consisting of blowers and diffusers for the equalization, aeration, and sludge holding zones; an airlift pump for returning sludge; a skimmer and effluent weir for the clarifier; and UV, liquid hypochlorite, or tablet modules used in the disinfection zone. Blowers and the control panel containing switches, lights, and motor starters are typically attached to either the top or one side of the package plant (Sloan, 1999).

Biological organisms within the system need sufficient contact time with the organic material in order to produce effluent of an acceptable quality. Typical contact time for extended aeration package plants is approximately 18-24 hours. The contact time, daily flow rate, influent parameters, and effluent parameters determine the size of the aeration tank where air is used to mix wastewater and to supply oxygen to promote biological growth. A package extended aeration system is sized based on the average volume of wastewater produced within a twenty-four hour period. Although provisions are made for some peaking factor, a flow equalization system may be necessary to prevent overloading of the system from inconsistent flow rates in the morning and evening. Equalization allows the wastewater to be delivered to the treatment plant at more manageable flow rates (WEF, 1985).

Systems should be installed at sites where wastewater collection is possible by gravity flow. In addition, the site should be stable, well drained, and not prone to flooding. The facility should be installed at least 30 meters (100 feet) from all residential areas and be in accordance with all health department regulations or zoning restrictions (WEF, 1985).

In order to ensure ease of operation and maintenance, extended aeration systems should be installed so that the tank walls extend nearly 0.15 meters (6 inches) above ground. This will supply insulation in the winter, prevent surface runoff from infiltrating the system, and allow the system to be serviced readily. If a plant is installed below ground, it must have distinct diversion ditching or extension walls in order to prevent surface water infiltration into the plant. When the plant is installed completely above ground, it may be necessary to provide insulation for cold weather and walkways for easy maintenance (WEF, 1985).

Sequencing batch reactors

Important internal components include an aeration system, which typically consists of diffusers and a blower; a floating mixer; an effluent decanter; a pump for withdrawing sludge; and a sequence of liquid level floats. The PLC and the control panel are usually positioned within a nearby control building (Sloan, 1999).

When the wastewater flow rate at the site is less than 0.05 MGD, a single, prefabricated steel tank can be used. This tank is divided into one SBR basin, one aerobic sludge digester, and one influent pump well. Concrete tanks may also be used, but in North America are not as cost effective as steel for small systems. If the plant must be able to treat 0.1 to 1.5 MGD, multiple concrete SBR basins are commonly used (CASS, 1999).

The design of SBR systems can be based on carbonaceous BOD removal only or both carbonaceous and nitrogenous BOD removal. The system can be expanded to achieve optimum nitrification and carbonaceous removal by operating primarily in an oxic state with few anoxic periods such as during settle and decant.

Denitrification and biological phosphorous removal can be promoted by providing adequate anoxic periods after intense aerobic cycles. This allows DO to be dissipated and nitrate to be used by the consuming organism and released as elemental nitrogen. By introducing an anaerobic process after the anoxic process, bacteria conducive to excess phosphorous uptake will develop. Phosphorous will be released in the anaerobic phase, but additional phosphorous is incorporated into the cell mass during subsequent aerobic cycles. Since the excess phosphorous is incorporated in the cell mass, cell wastage must be practiced to achieve a net phosphorous removal. Anaerobic conditions should be avoided in treating the waste sludge since they may result in the release of the phosphorous.

A low food to microorganism (F:M) ratio SBR system designed for an average municipal flow pattern will usually have an operating cycle duration of four hours, or six cycles per day. For a two reactor system, there will be twelve cycles per day and for a four reactor system, twenty-four cycles per day. The distribution and number of cycles per day can be adjusted based on specific treatment requirements or to accommodate alternate inflow patterns.

Cycle sequences are time controlled with sufficient volume provided to handle design flow rates. If incoming flow is significantly less than the design flow, only a portion of the reactor capacity is utilized and aeration time periods can be reduced to save energy and prevent over aeration. If flow rates are greater than usual resulting from storm runoff, the control system detects the high rise in the reactor and modifies the cycle to integrate peak flow rates. This will shorten the aeration, settle, and decant sequences, minimize the anoxic sequence (if supplied), and provide more cycles per day. As a result, hydraulic surges are incorporated and the diluted wastewater is processed in less time. In order to make the above optimizations, the logic control must be provided by the PLC (Kappe, 1999).

Small SBRs can experience a variety of problems associated with operation, maintenance, and loadings. Therefore, more conservative design criteria are typically used due to the wide range of organic and hydraulic loads generated from small communities. This type of design utilizes a lower F:M ratio and longer hydraulic retention time (HRT) and SRT (CASS, 1999).

Oxidation ditches

Key components of a typical oxidation ditch include a screening device, an influent distributor (with some systems), a basin or channel, aeration devices (mechanical aerators, jet mixers, or diffusers, depending on the manufacturer), a settling tank or final clarifier (with some systems), and an RAS system (with some systems). Typically, the basin and the clarifier are individually sized to meet the specific requirements of each facility. These components are often built to share a common wall in order to reduce costs and save space (Lakeside, 1999).

Concrete tanks are typically used when installing package plant oxidation ditches. This results in lower maintenance costs as concrete tanks do not require periodic repainting or sand blasting. Fabricated steel or a combination of steel and concrete can also be used for construction, depending on site conditions (Lakeside, 1999).

The volume of the oxidation ditch is determined based on influent wastewater characteristics, effluent discharge requirements, HRT, SRT, temperature, mixed liquor suspended solids (MLSS), and pH. It may be necessary to include other site specific parameters to design the oxidation ditch as well.

Some oxidation ditches do not initially require clarifiers, but can later be upgraded and expanded by adding clarifiers, changing the type of process used, or adding additional ditches (Kruger, 1999).

PERFORMANCE

The performance of package plants in general can be affected by various operational and design issues (Metcalf and Eddy, 1991).

- Large and sudden temperature changes
- Removal efficiency of grease and scum from the primary clarifier (except with oxidation ditches that do not use primary clarifiers)
- Incredibly small flows that make designing self-cleansing conduits and channels difficult
- Fluctuations in flow, BOD_5 loading, and other influent parameters
- Hydraulic shock loads, or the large fluctuations in flow from small communities
- Sufficient control of the air supply rate

Extended aeration plants

Extended aeration plants typically perform extremely well and achieve effluent quality as seen in Table 2. If chemical precipitation is used, total phosphorous (TP) can be < 2 mg/L. In some cases, extended aeration systems result in effluent with < 15 mg/L BOD and < 10 mg/L TSS.

TABLE 2 EXTENDED AERATION PERFORMANCE

	Typical Effluent Quality	Aldie WWTP (monthly average)
BOD (mg/L)	< 30 or <10	5
TSS (mg/L)	< 30 or <10	17
TP (mg/L)	< 2*	**
NH_3-N (mg/L)	< 2	**

* May require chemicals to achieve.
** DEQ does not require monitoring of these parameters.

Source: Sloan, 1999 and Broderick, 1999.

Aldie Wastewater Treatment Plant

The Aldie Wastewater Treatment Plant, located in Aldie, Virginia, is an extended aeration facility which treats an average of 0.0031 MGD with a design flow of 0.015 MGD. This technology was chosen because it would allow the area to meet permit requirements while minimizing land use. The plant consists of an influent chamber which directs the flow to two parallel aeration basins, parallel clarifiers, and a UV disinfection system.

Sequencing batch reactors

The treatment performance of package plant SBRs is largely influenced by the plant operator. While the process requires little assistance, training programs are available to teach operators how to become skilled with small plant operations. SBRs perform well, often matching the removal efficiency of extended aeration processes. Systems can typically achieve the effluent limitations listed in Table 3.

In addition, SBR systems have demonstrated a greater removal efficiency of carbonaceous BOD than other systems due to optimization of microbial activity via anoxic stress and better utilization of applied oxygen in the cyclic system. The system can consistently provide carbonaceous BOD effluent levels of 10 mg/L.

TABLE 3 SBR PERFORMANCE

	Typical Effluent	Harrah WWTP	
		% Removal	Effluent
BOD (mg/L)	10	98	3
TSS (mg/L)	10	98	3
NH_3 (mg/L)	< 1	97	0.6

Source: Sloan, 1999 and Reynolds, 1999.

Harrah Wastewater Treatment Plant

The Harrah wastewater treatment plant in Oklahoma treats an average wastewater flow of 0.223 MGD. The SBR has achieved tertiary effluent quality without filtration from the time it was first installed. Pretreatment involves an aerated grit chamber and comminutor. Waste activated sludge is taken to a settling pond where the settled sludge is dredged annually. A nitrogen removal study performed for nine months confirmed that nitrification and denitrification occur consistently without special operator care.

Oxidation Ditches

Although the manufacturer's design may vary, most oxidation ditches typically achieve the effluent limitations listed in Table 4. With modifications, some oxidation ditches can achieve TN removal to # 5 mg/L and TP removal with biological means.

City of Ocoee Wastewater Treatment Plant

Currently, the wastewater treatment plant in Ocoee, Florida accepts an average flow of 1.1 to 1.2 MGD. The city chose to use an oxidation ditch because it was an easy technology for the plant staff to understand and implement. The facility is also designed for denitrification without the use of chemical additives. Nitrate levels consistently test at 0.8 to 1.0 mg/L with limits of 12 mg/L (Holland, 1999). Table 4 indicates how well the Ocoee oxidation ditch performs.

TABLE 4 OXIDATION DITCH PERFORMANCE

	Typical Effluent Quality		Ocoee WWTP	
	With 2° Clarifier	With Filter	% Removal	Effluent
CBOD (mg/L)	#10	5	> 97	4.8
TSS (mg/L)	#10	5	> 97	0.32
TP (mg/L)	2	1	NA	NA
$N\text{-}NO_3$ (mg/L)	NA	NA	> 95	0.25

Note: 2° = secondary. NA = not available.

Source: Kruger, 1999 and Holland, 1999.

OPERATION AND MAINTENANCE

Operation requirements will vary depending on state requirements for manning package treatment systems. Manning requirements for these systems may typically be less then eight hours a day. Each type of system has additional operational procedures that should be followed to keep the system running properly. Owners of these systems must be sure to follow all manufacturer’s recommendations for routine and preventative maintenance requirements. Each owner should check with the manufacturer to determine essential operation and maintenance (O&M) requirements.

Depending on state requirements, most systems must submit regular reports to local agencies. In addition, system operators must make safety a primary concern. Wastewater treatment manuals and federal and state regulations should be checked to ensure safe operation of these systems.

Extended aeration plants

Operational procedures for these systems consist of performing fecal coliform tests on the effluent to ensure adequate disinfection and making periodic inspections on dissolved oxygen levels (DO) and MLSS concentrations in the aeration compartment. Sludge-volume index (SVI) tests in the clarifier must also be performed to determine how well the sludge is settling. Other sampling and analyses will be required on the effluent in accordance with state regulations.

Typical maintenance steps for extended aeration systems include checking motors, gears, blowers, and pumps to ensure proper lubrication and operation. Routine inspection of equipment is also recommended to ensure proper operation. Check with the manufacturer for specific O&M requirements.

Sequencing batch reactors

To ensure proper functioning of the system, O&M must be provided for several pieces of equipment. Operational procedures include sampling and monitoring of DO, pH, and MLSS levels. Additional sampling and analyses on the effluent will be required based on state regulations.

Maintenance requirements include regular servicing of aeration blowers, which is usually performed when greasing is done, and monthly inspection of belts on the blowers to determine if they need to be adjusted or replaced. Submersible pumps require routine inspections and servicing as required by the manufacturer. The decanter will require monthly greasing. Additional O&M may be required depending on system requirements. Check with the manufacturer for specific maintenance requirements.

Oxidation ditches

Depending on the manufacturer's design, typical operational procedures for oxidation ditches include monitoring of DO, pH, MLSS, and various other types of sampling and analyses.

Maintenance steps include periodically inspecting the aerator, regularly greasing rotors, and following manufacturer recommendations for maintenance of the pumps. Operators should follow all manufacturer recommendations for operation and maintenance of the equipment.

COSTS

Costs are site specific and generally depend on flow rate, influent wastewater characteristics, effluent discharge requirements, additional required equipment, solids handling equipment, and other site specific conditions. Manufacturers should be contacted for specific cost information.

Extended aeration plants

As provided by Aeration Products, Inc., smaller extended aeration package plants designed to treat less than 0.02 MGD cost approximately $4 to $6 per gallon of water treated, based on capital costs. For larger plants, capital costs will be approximately between $2 to $2.50 per gallon of wastewater treated. Maintenance processes for these plants are labor-intensive and require semi-skilled personnel, and are usually completed through routine contract services. Maintenance cost averages $350 per year.

Table 5 provides the cost estimates for various extended aeration packages. These costs include the entire package plant, as well as a filtration unit.

TABLE 5 COST ESTIMATES FOR EXTENDED AERATION

Flow (MGD)	Estimated Budget Cost per Gallon ($)
0.015	9-11
0.04	7
1.0	1.3

Note: Larger flow rates are available from the manufacturer. Estimated cost per gallon was determined based on the mid-flow range.

Source: Parsons Engineering Science, 1999.

Sequencing batch reactors

The capital cost per capita for small SBR plants is greater than for large SBR plants. Approximate equipment costs disregarding concrete or steel tanks costs are provided in Table 6. Operation energy costs are likely to be higher for small SBR plants than for larger plants as a result of numerous loadings.

TABLE 6 COST ESTIMATES FOR SBRs

Flow (MGD)	Estimated Budget Cost per Gallon ($)
0.01	4-5
0.05	2
0.2	0.7
1.0	0.25

Note: Larger flow rates are available from the manufacturer. Estimated cost per gallon was determined based on the mid-flow range.

Source: CASS, 1999.

System costs will vary, depending on the specific job. Factors influencing cost include average and peak flow, tank type, type of aeration system used, effluent requirements, and site constraints. Operation and maintenance costs are site specific and may range from $800 to $2,000 dollars per million gallons treated. Labor and maintenance requirements may be reduced in SBRs because clarifiers and RAS pumps may not be necessary. On the other hand, maintenance requirements for the more sophisticated valves and switches associated with SBRs may be more costly than for other systems.

Oxidation ditches

Table 7 lists budget cost estimates for various sizes of oxidation ditches. Operation and maintenance costs for oxidation ditches are significantly lower than other secondary treatment processes. In comparison to other treatment technologies, energy requirements are low, operator attention is minimal, and chemical addition is not required.

TABLE 7 COST ESTIMATES FOR OXIDATION DITCHES

Flow Range (MGD)	Budget Price ($)	Estimated Budget Cost per Gallon ($)
0 - 0.03	80,000	5.33
0.03 - 0.06	91,000	2.02
0.06 - 1.1	97,500	0.17
1.1 - 1.7	106,000	0.08
1.7 - 2.5	114,700	0.05

Note: Larger flow rates are available from the manufacturer. Estimated cost per gallon was determined based on the mid-flow range.

Source: Lakeside, 1999.

REFERENCES

Other Related Fact Sheets

Sequencing Batch Reactors
EPA 932-F-99-073
September 1999

Oxidation Ditches
EPA 832-F-00-013
September 2000

Aerobic Treatment
EPA 832-F-00-031
September 2000

Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owmitnet/mtbfact.htm

1. Broderick, T., 1999. Aldie Wastewater Treatment Plant, Aldie, Virginia. Personal communication with Dacia Mosso, Parsons Engineering Science, Inc.

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ADDITIONAL INFORMATION

Extended aeration plants

Ted Jackson (O&M)
Tim Coughlin (General questions)
Manager Engineering Programs
Aldie WWTP
P.O. Box 4000
Leesburg, VA 20177

Mr. Mike Lynn
Onsite Solutions
P.O. Box 570
Nokesville, Virginia 20182

Sequencing batch reactors

Steve Giarrusso
Operator
213 Osborne Street
Minoa, NY 13116

Steven Urich
Facility Manager
Medley Pretreatment Facility
9431 Live Oak Place
Suite 309
Ft. Lauderdale, FL 33324

Oxidation ditches

Robert Holland
Utilities Superintendent
Ocoee Wastewater Treatment Plant
1800 A. D. Mims Road
Ocoee, FL 34761

Michael Eldredge
Chief Operator
Edgartown Wastewater Department
P.O. Box 1068
Edgartown, MA 02539

For more information contact:

Municipal Technology Branch
U.S. EPA
Mail Code 4204
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

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