Wastewater Treatment Plants

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Module 1: Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary biological aeration processes used in package wastewater treatment plants.
- **Evaluate** the design capacities and typical flow ranges for pre-manufactured treatment facilities.
- **Identify** the core mechanical and biological components of extended aeration, SBR, and oxidation ditch systems.

Executive Summary: Package plants are modular, pre-manufactured treatment facilities designed for small communities or individual properties. They most commonly treat flows between **0.01 and 0.25 MGD**. The most prevalent configurations are biological aeration processes, specifically extended aeration, sequencing batch reactors (SBR), and oxidation ditches.

Design Fundamentals

Package plants are specialized treatment facilities used for decentralized wastewater management. While manufacturers can design units for flows as low as **0.002 MGD** or as high as **0.5 MGD**, the common application range is between **0.01 and 0.25 MGD**.

The industry recognizes several common configurations:

- **Extended Aeration Plants**
- **Sequencing Batch Reactors (SBR)**
- **Oxidation Ditches**
- **Contact Stabilization Plants**
- **Rotating Biological Contactors**
- **Physical/Chemical Processes**

This chapter focuses on the first three, all of which utilize **biological aeration processes**.

Extended Aeration Plants

The extended aeration process is a modification of the activated sludge process designed to remove biodegradable organic wastes under aerobic conditions.

- **Aeration:** Air is supplied by mechanical or diffused aeration to provide oxygen for the biological process.
- **Mixing:** Required to maintain microbial organisms in contact with dissolved organics.

- **Operational Requirements:** The pH must be controlled, and essential nutrients must be present to facilitate biological growth and degradation.

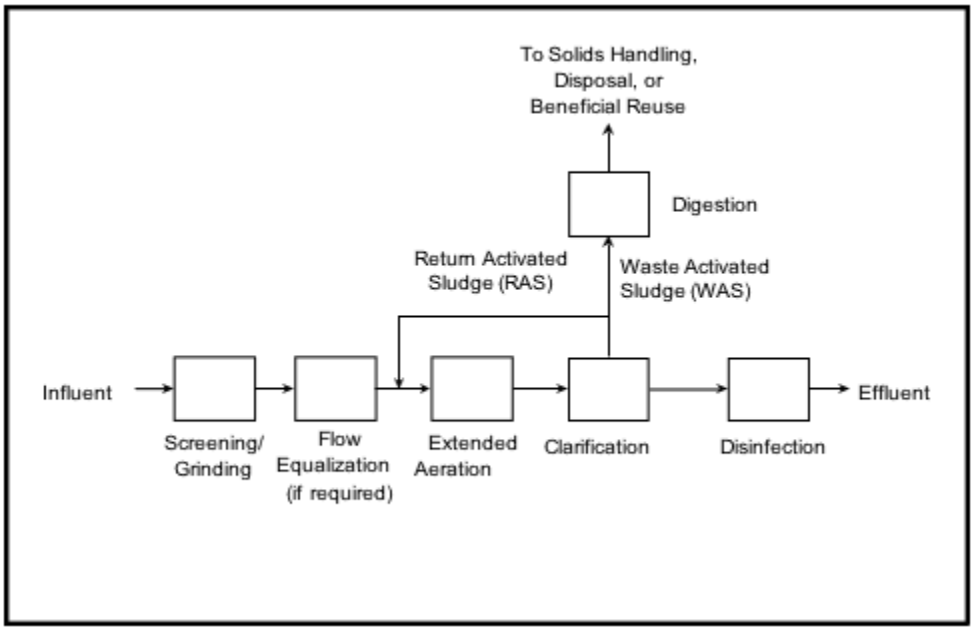

Figure 1: Process Flow Diagram for a Typical Extended Aeration Plant

Standard Process Sequence

1. **Screening:** Wastewater is typically screened to remove large suspended, settleable, or floating solids.
2. **Grinding:** Wastewater may pass through a grinder to reduce particles not captured in screening.
3. **Equalization:** If required, equalization basins regulate peak flow rates.
4. **Aeration Chamber:** Wastewater is mixed and oxygen is provided to microorganisms.
5. **Clarification:** Mixed liquor flows to a settling chamber where microorganisms settle.
6. **Sludge Management:** A portion of settled material is pumped back as **Return Activated Sludge (RAS)**. The remainder is removed as **Waste Activated Sludge (WAS)**.
7. **Effluent Discharge:** Clarified wastewater flows over a weir to the disinfection system.

💡 **Design Tip:** Extended aeration package plants typically consist of a steel tank compartmentalized into flow equalization, aeration, clarification, disinfection, and sludge digestion segments. Use of **concrete tanks** may be preferable for flow rates above **0.1 MGD**.

⚠️ **Safety Constraint:** Stabilization of a newly seeded plant using "seed sludge" from another facility can take **two to four weeks**.

Sequencing Batch Reactors (SBR)

An SBR is a variation of the activated sludge process where all biological treatment phases occur in a single tank. Unlike conventional systems, SBRs do not require separate tanks for aeration and sedimentation.

- **Tank Configuration:** Systems utilize two or more reactor tanks in parallel, or one equalization tank paired with one reactor tank.
- **Flow Ranges:** Package SBRs typically treat flow rates between **0.01 and 0.2 MGD**.

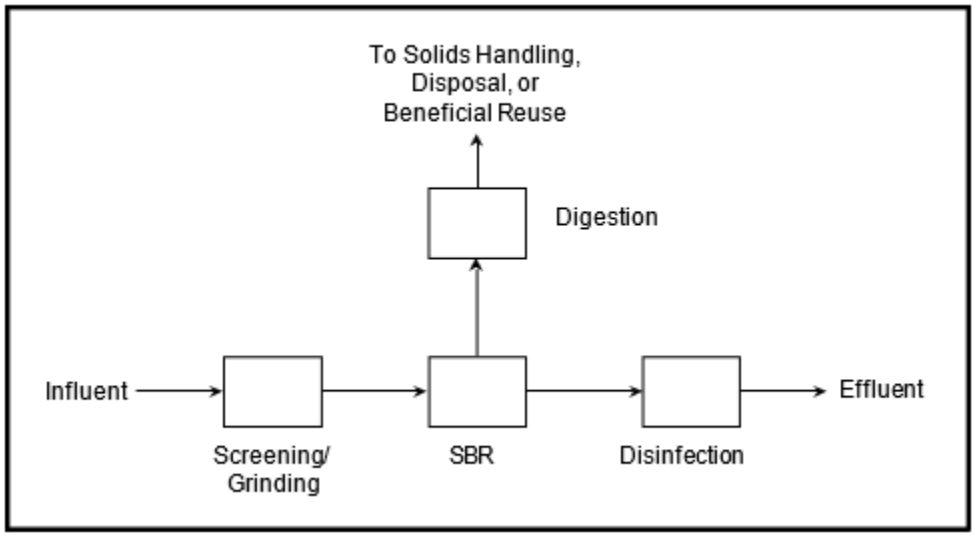

Figure 2: Process Flow Diagram for a Typical SBR

The Five Phases of SBR Operation

- **Fill:** Raw wastewater enters the basin and mixes with settled biomass from the previous cycle.
- **React:** The basin is aerated to allow for oxidation and nitrification.
- **Settle:** Aeration and mixing are suspended to allow solids to settle.
- **Decant:** Treated wastewater is discharged from the basin.
- **Idle:** The basin waits for the next cycle; excess solids are removed as waste sludge.

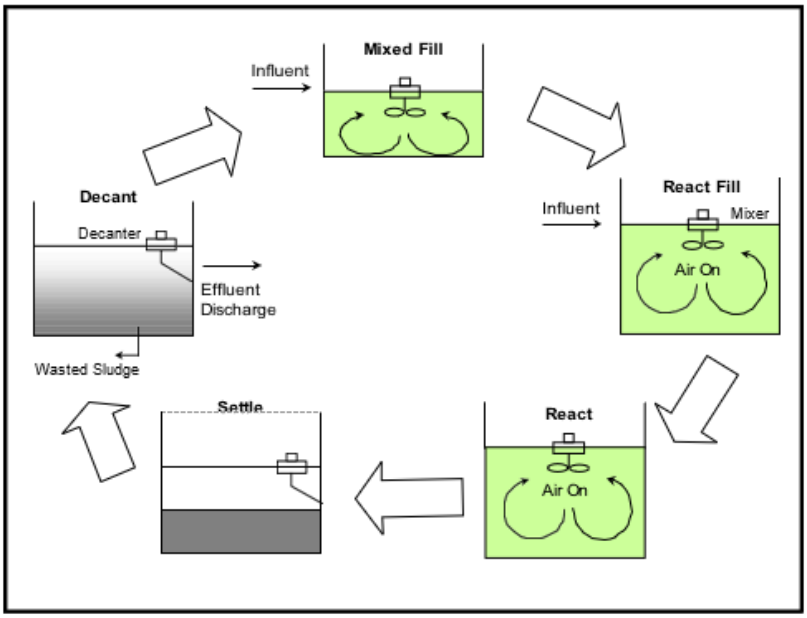

Figure 3: SBR Sequence of Operation

Calculation Note: The duration of each phase is controlled by a **Programmable Logic Controller (PLC)**, allowing for remote operation and adjustments based on organic or hydraulic loading.

Oxidation Ditches

An oxidation ditch is an aerated, long-term, complete-mix process. These systems utilize ring, oval, or horseshoe-shaped basins.

- **Aeration/Circulation:** Horizontally or vertically mounted aerators propel the mixed liquor at velocities high enough to prevent solids deposition.
- **Flow Range:** Package oxidation ditches typically treat flows between **0.01 and 0.5 MGD**.

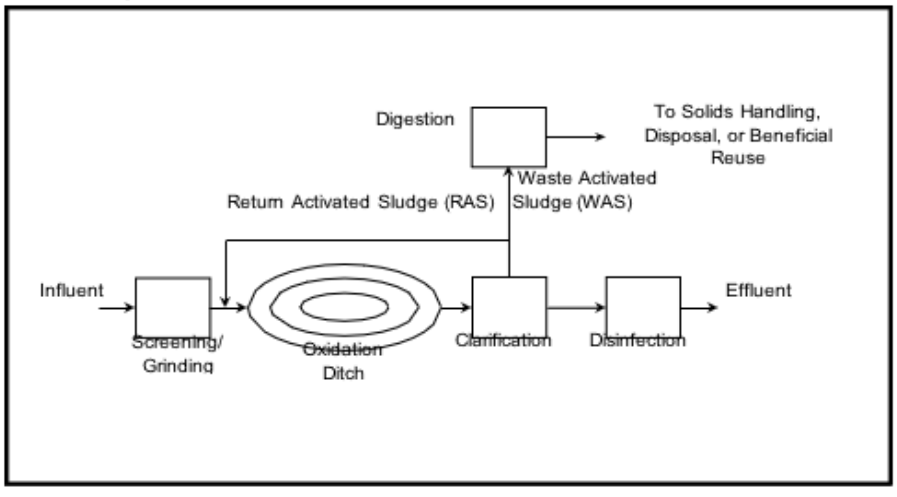

Figure 4: Process Flow Diagram.

Process Flow

1. Raw wastewater is screened and may pass through a grit chamber.
2. Once inside the ditch, oxygen is supplied to microbes and mixing is maintained.
3. Treated sewage moves to a final clarifier where water and biosolids separate.
4. Sludge is either returned as **RAS** or removed as **WAS**.

Applicability and Criteria

Package plants are applicable for remote locations like highway rest areas, trailer parks, and rural schools.

Table 1: Typical Design Parameters for Package Plants

Parameter	Extended Aeration	SBR	Oxidation Ditch
BOD5 loading (F:M) (lb BOD5/ lb MLVSS)	0.05 - 0.15	0.05 - 0.30	0.05 - 0.30
Oxygen Required (Avg) (at 20°C lb/lb BOD5 applied)	2 - 3	2 - 3	2 - 3
Oxygen Required (Peak) (value x avg. flow at 20°C)	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 BOD5/d/ 10^3 cu ft)	10 - 25 [17]	5 - 15	5 - 30

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

Performance Data

Table 2: Extended Aeration Performance

Parameter	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*	**
NH3-N (mg/L)	< 2	**

Notes:

- * May require chemicals to achieve.
- ** DEQ does not require monitoring of these parameters.
- **Source:** Sloan, 1999 and Broderick, 1999

Purchase this course to see the remainder of the technical materials.