Chapter 7
Treatment Process Selection

7-1. Overview

It is very important that safe and effective disposal of human and domestic wastes be provided in recreational areas to ensure the preservation of the quality of surface water and groundwater. The selection of appropriate wastewater treatment facilities for recreational areas should be based on site visitation, design considerations, local resources, economics, health factors, aesthetics, safety, and access. A discussion of these parameters and how they affect the selection of the treatment process is presented in this chapter. Figure 7-1 presents the typical wastewater treatment and disposal alternatives available for treating waste produced at USACE recreational areas, and compares of the advantages/capabilities and disadvantages/limitations of these processes.

7-2. Site Visitation

For recreational facilities with less than 30,000 visits each year, the design engineer may consider selecting a wastewater collection system that does not involve water-carried waste. These would be single-unit installations such as comfort stations and facilities in remote areas. Generally, soil, climate, and availability of water and power will dictate the selection for this type of facility.

7-3. Local Resources

a. Resource-limited sites. Certain sites may be resource limited and may require specialized systems. For example, a comfort station having minimal quantities of water may require a plan using a combination of water for hand washing and a non-potable water source unit for urinals and water closets. Such a design would allow for the segregation of graywaters and blackwaters and possibly simplify the overall system design. Gray wastewater may, in some instances, be treated onsite by septic tanks and absorption fields. In other instances, it may be necessary to include additional facilities for pumping and trucking wastewater to a central facility for further processing.

b. Other sites. Other sites may not be resource limited and, when the annual visitation is small, may allow a total on-site treatment of wastewater through utilization of the appropriate processes.

7-4. Economic Considerations

Economic considerations must be site-specific and based upon alternatives available for a particular site.

a. Ranking of treatment alternatives. Computer-assisted techniques can be used to rank different wastewater treatment alternatives, each capable of meeting specified effluent criteria, on the basis of cost effectiveness. Two currently available computer programs which can aid the design engineer in the design and selection of recreational treatment facilities are described below. Both programs rank different alternatives based on overall cost estimates including capital costs and operation and maintenance (O&M) costs.

b. Capital costs. Capital costs are those associated with the purchase of land, equipment, plant construction, and other related facilities. The most accurate capital cost can be estimated by obtaining price

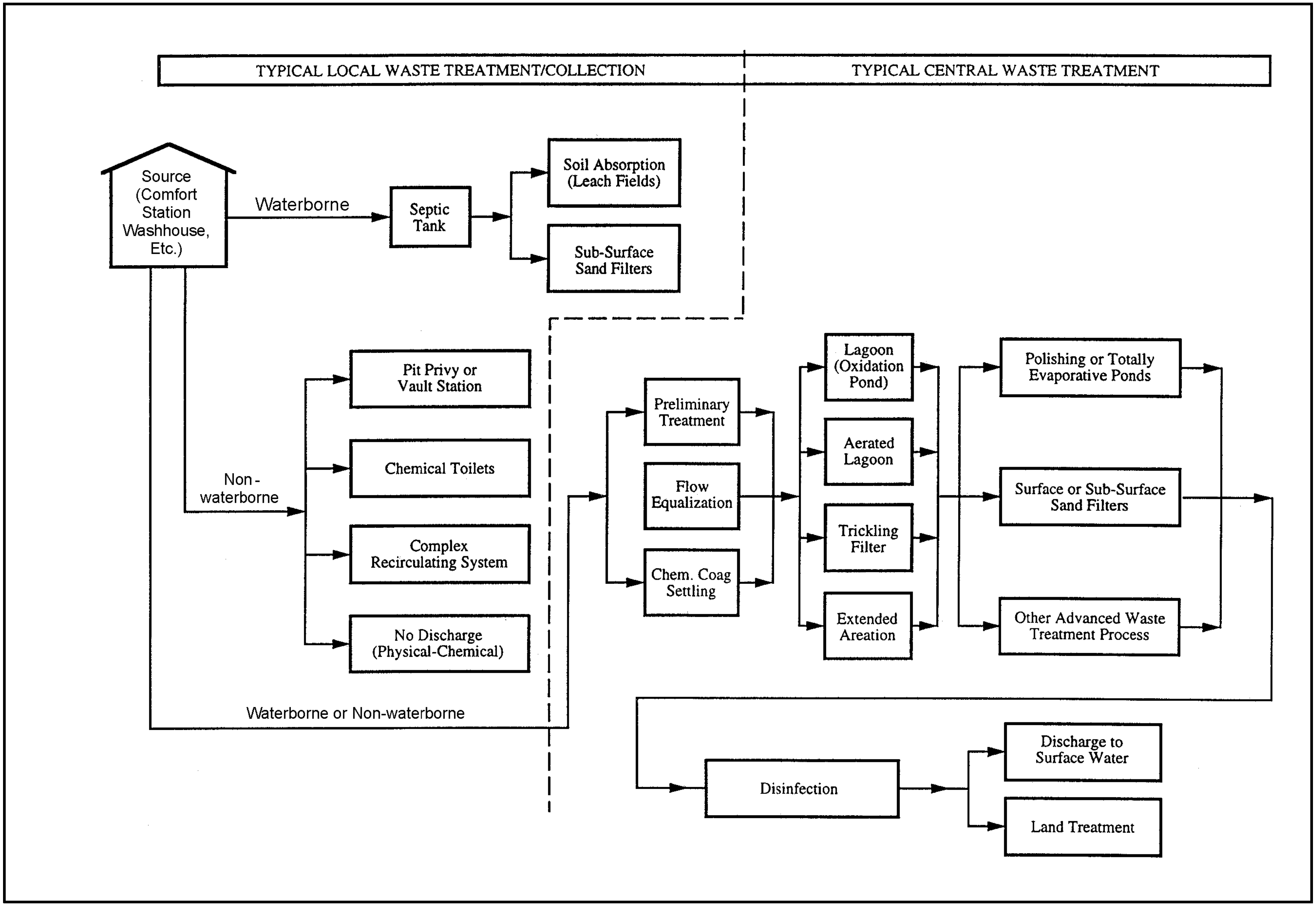

Figure 7-1. Typical wastewater treatment and disposal alternatives available for CE recreation areas

quotes from local equipment suppliers and contractors. If time and budgetary constraints prohibit the design engineer from obtaining actual quotes, the capital cost of any size treatment system may be estimated based on past costs. Because costs continually change, it is important that the capital costs of any treatment altenative are referenced to the same cost indices. The Environmental Protection Agency (EPA) periodically publishes wastewater treatment plant and sanitary sewer cost indices. One of the most commonly used cost indices is the Engineering News-Record Construction Cost (ENRCC) Index.

c. O&M costs. O&M costs are annual costs and for most treatment processes include the following categories: labor (supervision, report preparation, clerical, laboratory, yard, operation, and maintenance), power, chemicals, parts, supplies, and monitoring.

d. CAPDET. The Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems (CAPDET) was developed to provide accurate planning-level cost estimates. CAPDET has a component that specifically addresses small systems (flows less than or equal to 3 785 000 L/d (1,000,000 gal/d)), and includes programs to adjust unit labor, chemical, and other prices for current market conditions. It is strongly recommended that prior to using CAPDET, the design engineer becomes familiar with this program and, more importantly, with its limitations. The program is available from Hydromantis, Inc., 1685 Main St. West, Suite 302, Hamilton, Ontario, Canada L85 IG5 (Hydromantis 1992).

e. ECONPACK. PC-ECONPACK is a comprehensive economic analysis computer program that incorporates economic analysis calculations, documentation, and reporting capabilities. This program was developed to comply with the regulations governing proposed military construction projects within the Department of Defense. These regulations require that each construction request project estimate for facilities investments be accompanied by an economic analysis. ECONPAK performs standardized life-cycle cost calculations such as net present value, equivalent uniform annual cost, savings-to-investment ratio, and discounted payback period. More information on ECONPAK can be found in USACE 1986.

7-5. Health Considerations

a. General. As a general principle, waterside recreational treatment facilities should be located along a section of the receiving body of water having a low mosquito production potential. The normal summer water-level fluctuation zone should be identified and completely cleared of vegetation. Vegetation of a type and density favorable to mosquito production in flat, protected areas within the normal summer fluctuation zone should be periodically controlled by mechanical or chemical measures. Regulation of the water level in stabilization ponds and other man-made impoundments is an effective means of controlling aquatic weeds near dikes.

b. Mosquito control.

(1) In many U.S. locations, breeding of mosquitoes in natural and constructed wetland treatment systems may ultimately determine treatment system selection. Prevention of disease transmission and the suppression of mosquito-borne nuisance levels must become an objective of mosquito control techniques in any treatment environment. Often fish populations (particularly *Gambusia* spp.) are bred to control mosquitoes; however, fish cannot tolerate the anaerobic conditions when ponds stagnate or become organically overloaded. Thus, if plant growth conditions become dense, say in hyacinth systems, mosquitoes may develop and flourish. Also, some areas of such systems may be accessible to the multiplying mosquitoes but not to the fish.

(2) In addition to stocking ponds with fish, mosquito control strategies include:

- more effective pretreatment to reduce total organic loading on the aquatic system, thereby maintaining aerobic conditions.
- step-feed of influent waste stream with recycle.
- more frequent plant harvesting.
- water spraying in the evening hours.
- application of chemical control agents (larvicides).
- diffusion of oxygen with aeration equipment.
- biological control agents (e.g., BT/*israelensis*) (Metcalf & Eddy 1991).

(3) Provisions should be made for proper storage, collection, and disposal of garbage and refuse throughout all recreational areas in order to prevent and control flies. Care should be taken to ensure that screenings, etc., from wastewater treatment facilities are adequately protected from, and inaccessible to, flies.

7-6. Aesthetic Considerations

It is essential that wastewater treatment facilities not encroach upon the natural, scenic, aesthetic, scientific, or historical value of the recreational area. For maximum benefits to be derived from a recreational area, these facilities be designed using sound engineering principles and aesthetic judgment as well. The design engineer must ensure that recreational treatment facilities are located well away from the recreational area, and that land treatment systems and waste stabilization ponds are located downwind from the recreational treatment facilities. Odors can be controlled with masking agents or by using chemical additives (Ehlers 1965). When odors are associated with pumpage from septic tanks, it is best to pump and transfer wastes when the recreational area is closed or visitation is at a minimum. Preplanning conferences, open to all interested parties and agencies, should be held to assist planners in ensuring that the recreational wastewater treatment facility can serve the needs of the recreational area without impairing its future use.

7-7. Safety Considerations

The design engineer has the responsibility of incorporating as many safety features as possible into the plant design, the plant grounds, and all ancillary operations such as collection systems, lift stations, effluent structure, and standby generators. For specific safety requirements and their implementation, consult Occupational Safety and Health Administration (OSHA) standards and applicable Army regulations.

7-8. Access/Security Considerations

Roads providing direct access to a recreational wastewater treatment facility should be constructed in a manner that minimizes accidents, and should include all-weather surfaces for immediate access at any time and season. Access roads must be clearly marked with gates or appropriate signs to discourage their use by the public. The facility should be enclosed by a chain-link fence to prevent children and animals from wandering into the facility area, and in general to deny access to the facility by the public. “Off-Limits to the Public” signs should be posted on the gate and fence. A telephone number should prominently displayed on all gates for emergencies.

7-9. Comparison of Treatment Processes

This section presents an evaluation of the advantages/capabilities and disadvantages/limitations of small-scale wastewater treatment processes that are applicable to recreational areas. Table 7-1 presents the advantages/disadvantages of the conventional unit processes. See Chapter 5 for comparisons of natural systems and constructed wetlands. Table 7-2 lists operational characteristics of activated sludge processes currently available on the U.S. Army Engineer Waterways Experiment Station (WES) computing system.

Table 7-1
Evaluation of Conventional Wastewater Treatment Processes

Treatment Processes	Application	Advantages and Capabilities	Disadvantages and Limitations
a. Preliminary Treatment			
(1) Screening	Waste streams containing large solids (wood, rags, etc.)	Prevents pump and pipe clogging Reduces subsequent solids handling	Maintenance required to prevent screen plugging; ineffective for sticky solids
(2) Grit removal	Waste streams containing significant amounts of large, heavy, inorganic solids	Lowers maintenance costs and erosion Reduces solids loading to other treatment units	Solids to be disposed of are sometimes offensive
(3) Equalization	Waste streams with variability	Dampens waste Reduces chemical requirements Dampens peak flows, reduces treatment plant size Reduces corrosion and scaling	Needs large land areas Possible septicity, requiring mixing and/or aeration equipment
(4) Temperature adjustment	Waste streams with temperatures	Provides the proper conditions for biological treatment	High initial equipment costs
(5) Nutrient	Nutrient deficient wastes	Optimizes biological treatment	High initial equipment costs
b. Primary Treatment			
(1) Sedimentation	Waste streams in settleable suspended solids	Reduces inorganic and organic solids loadings to subsequent biological units By far the least expensive and most common method of solid-liquid separation Suitable for treatment of a wide variety of wastes Requires simplest equipment and operation Demonstrated reliability as a treatment process	Possible septicity and odors Adversely affected by variations in the nature of the waste Moderately large area requirement
c. Secondary Treatment			
(1) Trickling filter	Biologically treatable organic wastes	Moderate quality (80-85% BOD_5 removal) Moderate operating costs (lower than activated sludge and higher than oxidation pond) Withstands shock loads better than other biological systems	High capital costs Clogging of distributors or beds Snail, mosquito, and insect problems
(2) Activated sludge (aeration and secondary sedimentation)	Biologically treatable organic wastes	Flexible, can adapt to minor pH, organic, and temperature changes Small area required	High operating costs (skilled labor, electricity, etc.) Generates solids requiring sludge disposal

(Continued)

Table 7-1 (Concluded)

Treatment Processes	Application	Advantages and Capabilities	Disadvantages and Limitations
c. Secondary Treatment (continued)			
(2) Activated sludge (aeration and secondary sedimentation) (Cont.)		Degree of nitrification is controllable	Some process alternatives are sensitive to shock loads and metallic or other poisons
		Relatively minor odor problems	Requires continuous air supply
(3) Aerated lagoon	Biologically treatable organic wastes	Flexible, can adapt to minor pH, organic, and temperature waste changes	Dispersed solids in effluent
		Inexpensive construction	Affected by seasonal temperature variations
		Minimum attention	Operating problems (ice, solids settlement, etc.)
		Moderate effluent (50-75% BOD removal)	Moderate power costs
			Large area required
			No color reduction
(4) Oxidation Pond	Biologically treatable organic	Low construction cost	Large land area required
		Nonskilled operation	Algae in effluent
		Moderate treatment effectiveness (70-85% BOD_5 removal)	Possible septicity and odors
		Removes some nutrients from wastewater	Weed growth, mosquito, and insects problems
(5) Anaerobic contact	Waste streams with high BOD and/or high temperature	Methane recovery	Heat required
		Small area required	Effluent in reduced chemical form requires further treatment
		Volatile solids destruction	Requires skilled operation
(6) Spray irrigation	Biologically treatable organic wastes	Inexpensive initial cost	
		Minimum operator attention	

Table 7-2
Operational Characteristics of Activated Sludge Processes

Process Modification	Flow Model	Aeration System	BOD_5 Removal Efficiency	Application
Conventional	Plug-flow	Diffused-air, mechanical aerators	85-95%	Low-strength domestic wastes, susceptible to shock labels.
Complete-mix	Complete-mix	Diffused-air, mechanical aerators	85-95%	General application, resistant to shock loads, surface aerators.
Step-aeration	Plug-flow	Diffused-air	85-95%	General application to wide range of wastes.
Modified-aeration	Plug-flow	Diffused-air	60-75%	Intermediate degree of treatment where cell tissue in the effluent is not objectionable.
Contact-stabilization	Plug-flow	Diffused-air, mechanical aerators	80-90%	Expansion of existing systems, package plants, flexible.
Extended-aeration	Complete-mix	Diffused-air, mechanical aerators	75-85%	Small communities, package plants, flexible, surface aerators.
Kraus process	Plug-flow	Diffused-air	85-95%	Low-nitrogen, high-strength wastes.
High-rate aeration	Complete-mix	Mechanical aerators	75-90%	Use with turbine aerators to transfer oxygen and control floc size, general application.
Pure-oxygen systems	Complete-mix reactors in series	Mechanical aerators	85-95%	General application, use where limited volume is available, use near economical source of oxygen, turbine or surface aerators.