CHAPTER 7.
WASTEWATER TREATMENT ALTERNATIVES

This chapter summarizes wastewater treatment (including liquid process, disinfection, and solids handling), provides a technical evaluation of the alternative options, and presents a technical recommendation for preferred wastewater treatment, disinfection, and solids handling methods.

LIQUID PROCESS TREATMENT REQUIREMENTS

Discharge/Reuse Method Determines Treatment

The level of treatment is dependent upon the selected method of effluent disposal or reuse. The regulations dictate the requirements for treatment depending upon the end use of the final effluent. Table 7-1 summarizes the general level of treatment required depending upon the disposal or reuse option for the final effluent. The following sections describe the treatment requirements in greater detail.

Levels of Treatment

Water reuse systems must meet treatment standards, as defined by the Departments of Health and Ecology in the *Water Reclamation and Reuse Standards*. Reclaimed water standards vary depending on the type of end-use and the potential for human contact with the reclaimed water. The requirements vary from Class A (highest quality) to Class D (lowest quality). Reclaimed water of each quality level can be achieved through appropriate levels of secondary or advanced treatment and disinfection. Table 7-2 summarizes the treatment criteria for various reuse applications.

TABLE 7-1.
SUMMARY OF TREATMENT REQUIREMENTS FOR VARIOUS DISPOSAL/REUSE OPTIONS

Disposal/Reuse Option	Secondary Treatment	Advanced Treatment
Irrigation/Land Application	Certain Types of Fodder & Fiber Crops	Most Applications (food, public access)
Groundwater Recharge by Surface Percolation – Slow Rate Infiltration	No	Yes
Groundwater Recharge by Surface Percolation – Rapid Rate Infiltration	No	Yes
Marine Outfall	Unlikely	Likely
Constructed Wetlands	Possible	Likely
Groundwater Injection	No	Yes (with reverse osmosis)

TABLE 7-2.
WATER QUALITY REQUIREMENTS FOR REUSE PROJECTS

Parameter	Class A	Class B	Class C	Class D
BOD	30 mg/L	30 mg/L	30 mg/L	30 mg/L
TSS	30 mg/L	30 mg/L	30 mg/L	30 mg/L
Total Coliforms	2.2/100 ml (7 day); 23/100 ml at any time	2.2/100 ml (7 day); 23/100 ml at any time	23/100 ml (7 day); 240/100 ml at any time	240/100 ml (7 day)
Turbidity	2 NTU monthly; 5 NTU at any time	N/A	N/A	N/A
Dissolved Oxygen	>0 mg/L	>0 mg/L	>0 mg/L	>0 mg/L
Chlorine residual	0.5 mg/L in conveyance piping	0.5 mg/L in conveyance piping	0.5 mg/L in conveyance piping	0.5 mg/L in conveyance piping

NTU = nephelometric turbidity unit

Secondary Treatment

Secondary treatment typically involves a biological oxidation process which produces a biological "sludge" which can be separated from the liquid process. The liquid is then disinfected by one of a variety of methods prior to disposal or reuse. Wastewater treatment processes which achieve secondary levels of treatment include activated sludge, sequencing batch reactors (SBR), rotating biological contactors, trickling filters, lagoons and oxidation ditches. All are followed by secondary clarification. Wastewater treated to the secondary level *can* meet Class B, C, or D reclaimed water standards if specific design and operational standards are met. These standards and processes are discussed in further detail in subsequent sections of this chapter.

Advanced Wastewater Treatment

Some type of advanced wastewater treatment is needed to achieve Class A level final effluent. Advanced wastewater treatment processes include membrane bioreactors (MBR's), reverse osmosis or one of a variety or mechanical filtration systems following an appropriate secondary treatment process. Supplemental filtration is typically provided by media filters using sand and/or anthracite coal or cloth filters.

Advanced wastewater treatment can also provide ammonia removal (nitrification) and nitrate removal (denitrification) which are required for beneficial-reuse land-application in excess of agronomic uptake rates. For surface percolation facilities, nitrate levels must be reduced to 10 mg/L and nitrite levels reduced to 1 mg/L. These levels are based on the federal primary standards for drinking water.

Reliability and Redundancy Requirements

Washington State Department of Ecology's Criteria for Sewage Works Design stipulates reliability and redundancy requirements for the treatment system in Article 11 of the Water Reclamation and Reuse Standards. This article addresses the requirements for emergency storage and disposal of untreated or partially treated wastewater. A copy of this Article can be found in Appendix E.

WASTEWATER TREATMENT ALTERNATIVES

Alternatives Considered

Eight wastewater treatment processes were considered for evaluation. These alternatives are described below:

- Recirculating filters – This process uses a filtration media to treat the wastewater. Typically, a septic tank is provide upstream of the filter to remove settleable solids. Effluent from the septic tank is passed through a coarse media filter. A portion of the filter effluent is recirculated back through the filter combining with the incoming septic tank effluent. The remaining final effluent is discharged to disposal or reuse.
- Lagoons – Facultative lagoons, stabilization ponds and aerated lagoons use large, open, earthen lagoons to store wastewater, provide aeration, and settle solids.
- Constructed Treatment Wetlands – Constructed Treatment Wetlands are an artificial, man-made wetland into which wastewater is introduced. Resident plants, animals and microorganisms utilize any available nutrients and moisture for growth, metabolism and reproduction. These activities result in improved water quality, wildlife habitat (and associated public benefits), and water uptake through transpiration and evaporation.
- Fixed Film Processes – Fixed film or attached growth processes use an inert media as attachment sites for growth of microorganisms that convert organic material in wastewater into biological cell matter. Examples of fixed processes include trickling filters and rotating biological contactors.
- Oxidation Ditch – An oxidation ditch uses a long, continuous channel, typically oval or circular to provide an aerobic environment where oxidation of carbonaceous and nitrogenous wastes (BOD) occurs. This aerobic environment is typically created by low-speed surface aerators that also serve as mixers.
- Sequencing Batch Reactor (SBR) – SBR's are a variation of the activated sludge process that operate in a batch mode instead of a continuous-flow mode. Aeration and secondary clarification occur in the same tank. Two or more parallel basins are required so that influent flows can be treated continuously by this batch process. Control valves, mixers, aerators, and decanters cycle the wastewater flow through different operational modes within the tanks. Aeration can be in the form of diffused air or jet aeration. The sequential operating modes, which take place in the same basin, include filling, reacting, settling, decanting, and sludge wasting. If designed and operated properly, this type of system can remove nutrients such as nitrogen and phosphorus through proper programming of the batch process.
- Membrane Bioreactor (MBR) – The MBR process combines the extended aeration activated sludge process with a physical separation process using membranes immersed in the aeration basins. The membranes replace separate downstream clarifiers. By providing a positive barrier to virtually all particulate, colloidal and dissolved solids above the 0.1 micron range, the membranes produce an exceptional effluent quality, superior to that of extended aeration activated sludge followed by conventional filters. Chemical coagulation is likely not required for MBRs to meet Class A reclaimed water standards. Because the membranes provide a positive barrier to solids, the activated sludge system can operate at very high mixed-liquor suspended solids (MLSS) concentrations, significantly reducing the size of the aeration basin compared to typical extended aeration activated sludge plants.
- Reverse Osmosis (RO) – Reverse osmosis systems produce an ultra-high quality, purified Class A reclaimed water. RO systems are typically used to "polish" the effluent from an

advanced wastewater treatment system when direct discharge to ground water is employed as the preferred reuse option. Reverse Osmosis involves forcing the process water through a semi-permeable membrane at high pressure. Pollutant removal is achieved through diffusion and electrostatic charge exclusion as well as size exclusion, thereby providing significant virus, dissolved salt and metal ion removal.

Rejected Alternatives

Six alternatives were rejected early in the evaluation process. The rationale for their rejection is as follows:

Recirculating Filters + Filter

Recirculating filters can meet secondary effluent quality standards for biochemical oxygen demand (BOD) and total suspended solids (TSS). However, using this technology, it is difficult to producer an effluent which can be reliably filtered to meet advanced treatment requirements for Class A turbidity. Additionally, this process does not provide sufficient nitrogen removal without supplemental treatment. This process is generally not used for treatment plants over 0.5 mgd because it has high capital costs and requires a large area for the filters.

Lagoons + Filter

Lagoons were rejected because it is difficult to producer an effluent which can be reliably filtered to meet advanced treatment requirements for Class A TSS due to high levels of algae generated in the lagoon. Additionally, lagoons cannot provide consistent nitrogen removal, require significant land area, can be quite odorous and do not lend themselves to odor control.

Constructed Wetlands

Constructed wetlands require a large land area in order to meet anticipated regulatory standards. Past experience indicates wetlands can meet BOD, TSS, and nitrogen reduction requirements when operated at relatively low wastewater loading rates. However, constructed wetlands can provide polishing treatment after all standards have been met.

Fixed Film Processes + Filter

Fixed film processes can meet BOD and TSS requirements. However, using this technology, it is difficult to produce an effluent which can be reliably filtered to meet advanced treatment requirements for Class A turbidity. Additionally, fixed film processes are not able to meet nitrogen removal requirements without supplemental treatment. Finally, these processes are prone to high odor potential requiring expensive and complex odor control systems.

Reverse Osmosis

Reverse osmosis was rejected due to high capital and operating costs. The energy cost to provide high pressure feed water is prohibitive. Maintenance of the semi-permeable membranes is also expensive and time consuming. Since direct injection to the groundwater is not being considered, this alternative is not justifiable.

Oxidation Ditch + Filter

Oxidation ditch plus filtration was rejected due to the difficulty in implementing the system in phases adequate to provide redundancy and reliability. These systems are not modular and thus, result in oversizing of initial phases. This leads to higher initial costs and could prove to be difficult to operate at the subsequent low wastewater loading rates. Initial estimates suggest that the higher costs of phasing would not be sufficiently off-set by lower O&M costs.

ALTERNATIVES CONSIDERED FOR FURTHER EVALUATION

Sequencing Batch Reactor + Filter

Technology Description

SBRs are a variation of the activated sludge process that operate in a batch mode instead of a continuous-flow mode. Aeration and secondary clarification occur in the same tank. Two or more parallel basins are required so that influent flows can be treated continuously by this batch process.

Control valves, mixers, aerators, and decanters cycle the wastewater flow through different operational modes within the tanks. Aeration can be in the form of diffused air or jet aeration. The sequential operating modes, which take place in the same basin, include filling, reacting, settling, drawing or decanting, and idle mode when sludge is wasted from the wastewater treatment process to the solids handling processes. During the fill phase, the basin is filled with wastewater and aeration begins. Aeration continues through the react phase. The aerators are then turned off and the biomass is settled. During the draw phase, treated effluent is removed from the basin by a decanter. Finally, settled sludge is pumped from the basin for final treatment during the idle mode while the basin waits to receive the next batch of wastewater flow and repeat the cycle of phases. If designed and operated properly, this type of system can remove nutrients such as nitrogen and phosphorus through proper programming of the batch process. Figure 7-1 shows a simple process diagram and a photo of a typical SBR facility.

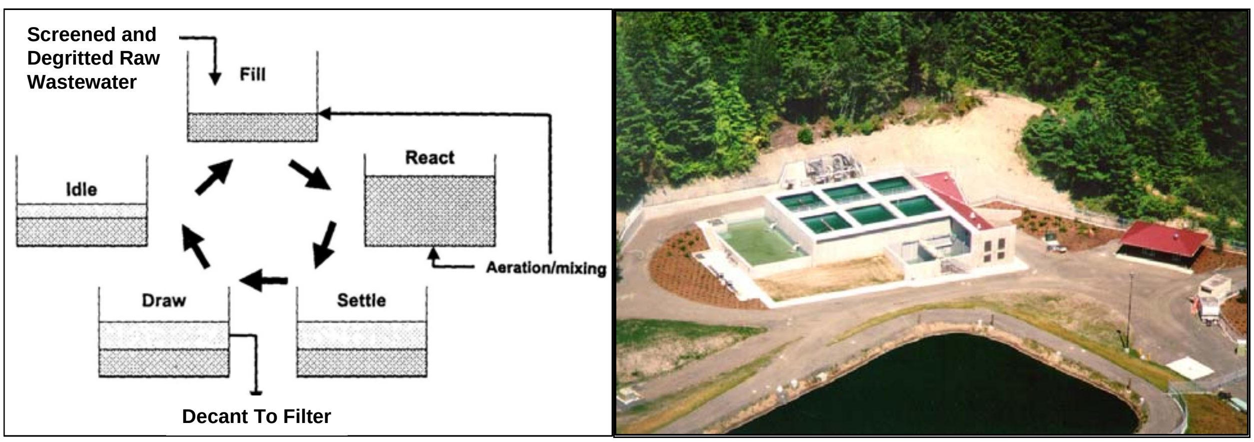

Figure 7-1. Sequencing Batch Reactor Process Schematic and Example Facility in Waldport, Oregon

Because mixed liquor is retained in the reactor during all cycles, separate secondary clarifiers are not required. However, batch treatment operation leads to peaking flows downstream, and these flows would have to be equalized to minimize the size of downstream facilities. Flow equalization would be sized to process decant flows. Tanks would not be allowed to fill and decant simultaneously at high flows.

The control system allows for control over a range of flows; a batch-proportional program is used for low-flow conditions and a flow-proportional program is used for average and peak-flow conditions. SBR systems are computer-controlled and tend to be more complex and mechanically intensive than other activated sludge treatment processes. Variation of the cycles and their timing results in greater operational flexibility to meet different effluent requirements. The reliance on automated equipment and computerized control demands a higher level of operational and maintenance sophistication than conventional activated sludge systems. Maintenance of these systems can be expensive and demanding.

Design Criteria: Sizing & Phasing

A sizing and phasing plan for an SBR with filter treatment system was developed for use in comparing alternatives. The system was sized and phased to meet population, flow, and loading estimates described in Chapter 4 – Population, Flow and Loads.

The system was planned in four distinct phases. These phases are described as follows:

- *Phase I: Two 0.125 mgd Reactors* **-** Construct two 0.125 mgd reactors with a third 0.125 mgd reactor for standby. The two 0.125 mgd reactors to be constructed as a single 0.25 mgd reactor cell which can be combined to function as one cell in the future. A filter building would be constructed and filter equipment needed for initial flows through Phase II installed.
- *Phase II: Two 0.25 mgd Reactors with Storage* – Expand the 0.125 mgd standby reactor cell to 0.25 mgd by constructing a 0.125 mgd expansion. Combine the two working cells from Phase I by demolishing the wall between them or opening a sluice gate between the two cells so they can operate as a single volume. This results in two working 0.25 mgd cells. Construct a 0.75 mgd storage basin for equalization and emergency storage. This emergency storage is in addition to the emergency storage provided at the disposal site. This would provide backup in conjunction with storage should one 0.25 mgd cell need to go offline.
- *Phase III: Three 0.25 mgd Reactors* – Construct a third 0.25 mgd reactor to accommodate increasing flows. The 0.75 mgd storage pond constructed in Phase II would still be used for equalization storage and to provide storage should one or more reactors need to go offline. Additional filter equipment would be installed to meet increased wastewater flow.
- *Phase IV: Four 0.25 mgd Reactors* – Construct a fourth 0.25 mgd reactor to accommodate increasing flows. The storage pond would still be used for flow equalization and backup should part of the system need to go offline. This would provide a firm treatment capacity of 1 mgd to meet the anticipated 2030 maximum monthly flow of 0.98 mgd.

Advantages and Drawbacks

Several advantages and drawbacks of sequencing batch reactors with filtration for processing wastewater were identified during the evaluation. Below is a summary of the advantages and drawbacks:

Advantages

- Provides good effluent quality – Can meet Class B, C, D reclaimed water standards.
- Can achieve Class A reclaimed water standards and nitrogen reduction with filtration.
- Proven technology – experience within Washington State.
- Modular – The system can be constructed in smaller phases to accommodate population growth.
- Operational Flexibility – Through variation of the cycles and their timing, greater operational flexibility can be achieved to meet different regulatory requirements.

Drawbacks

- Treats wastewater in batches making system timing and sequencing critical. This can present challenges when responding to significant variations from peak flow events. However, SBR's can address peaks by equalizing fill cycles. But equalizing fill cycles also can result in operational issues and problems with batch consistency.

- System requires more computer control and mechanical valving than other extended aeration treatment processes.
- Equipment maintenance – Prompt repairs are essential because SBR's usually have less redundancy than other activated sludge systems.

Membrane Bioreactor

Technology Description

The membrane bioreactor (MBR) process combines the extended aeration activated sludge process with a physical separation process using membranes immersed in the aeration basins. The membranes replace separate downstream clarifiers. By providing a positive barrier to virtually all particulate, colloidal and dissolved solids above the 0.1 micron range, the membranes produce an exceptional effluent quality, superior to that of extended aeration activated sludge followed by conventional filters. Chemical coagulation is likely not required for MBRs to meet Class A reclaimed water standards since sludge settleability is not a consideration. Figure 7-2 shows a membrane bioreactor system.

In addition to aeration air, coarse bubble diffused air is used to scour the membranes and prevent excessive fouling. Significant quantities of air are required for membrane scouring, usually equaling or exceeding the requirement for aeration air. This can result in significant operating costs, since aeration air production is often the most energy intensive component of wastewater treatment plant operation. Back-pulsing with chemical cleansing agents may be required to remove accumulated solids, depending on the type of membranes.

Because the membranes provide a positive barrier to solids, the activated sludge system can operate at very high mixed-liquor suspended solids (MLSS) concentrations, on the order of 10,000 to 15,000 mg/L. Typical extended aeration activated sludge plants operate at MLSS concentrations between 2,000 and 4,000 mg/L. The high MLSS concentrations mean that the plant can run at a low hydraulic retention time and a high solids retention time, significantly reducing the size of the aeration basin compared to typical extended aeration activated sludge plants.

Two types of membranes are available: hollow fiber units composed of a membrane wrapped around a reinforced hollow fiber tube; and flat membrane sheets on top of plastic panels for reinforcement. In either case, wastewater is filtered through the membrane, and filtered effluent passes through the membrane onto the next step of the treatment plant.

Settleability is not a consideration with this process due to the membranes' being a barrier to solids. This is a significant advantage over typical activated sludge plants, where the activated sludge biology must be monitored to encourage development of microorganisms that settle quickly in a clarifier basin.

A disadvantage of the MBR process is that the membranes are not well-suited to treating peak flows. Because membrane capacity must be designed for treating peak flows, much of the capacity will not be used until infrequent peak flows occur. In many cases, pre-MBR equalization basins are recommended to equalize peak flows to the MBRs. Alternatively, equalization can be achieved by providing additional freeboard in the membrane basins.

Another disadvantage is the requirement to replace membranes every five to ten years, depending on the manufacturer. The membranes make up a significant portion of the cost of the facilities, so frequent replacement can translate into high present worth costs.

Addition of an anoxic selector tank upstream of the aeration basins with internal recycle allows for nitrogen reduction.

Design Criteria: Sizing & Phasing

A significant advantage of the MBR process is its ability to be implemented in phases. It can be constructed in many small increments by adding basins and membrane cassettes as needed.

A sizing and phasing plan for an MBR system was developed for use in comparing alternatives. The system was sized and phased to meet population, flow, and loading estimates described in Chapter 4 – Population, Flow and Loads.

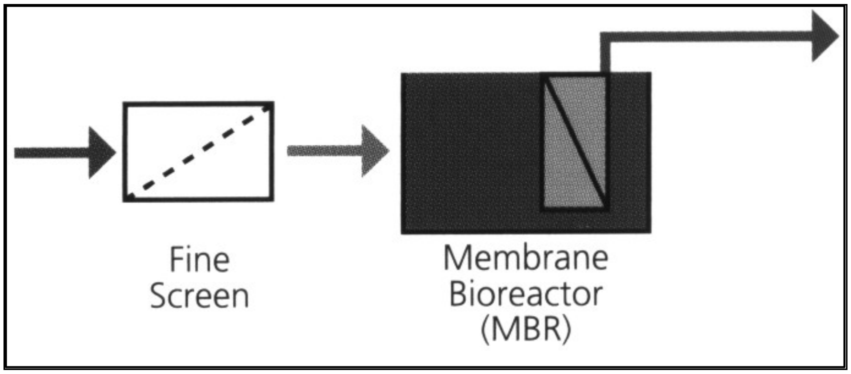

Figure 7-2: Membrane Bioreactor Process Schematic and Example Facility in Bandon Dunes, Oregon

The system was planned in four distinct phases. These phases are described as follows:

- *Phase I: Two 0.25 mgd MBR Treatment Trains* - Construct two 0.25 mgd reactors. One reactor will provide capacity for treatment of the initial flows, the other reactor will be standby to provide redundancy.
- *Phase II: Add Storage* – Once flows exceed 0.25 mgd, both reactor trains will be used for processing of wastewater. At this point, a storage basin sized for 3 days' of flow from a single treatment train will be added to provide emergency storage should one of the trains be taken

offline for maintenance or repair. Additionally, the storage can be utilized for flow equalization in the future when peak flows might temporarily exceed the capacity of the existing systems. This emergency storage is in addition to the storage provided at the disposal site.

- *Phase III: Add MBR Treatment Capacity* – Construct tankage for an additional 0.50 mgd of capacity. However, membranes will be installed in this phase for an additional 0.25 mgd of treatment capacity. This will result in a total treatment capacity of 0.75 mgd. The Phase II storage facility will still be used for equalization and for redundancy should any of the treatment process need to be taken offline.
- *Phase IV: Add Membranes for 1.0 mgd Total Capacity* – Install the remaining membranes in the Phase III tankage. This will provide 1.0 mgd total capacity and the storage will provide equalization and capacity should part of the treatment process need to be taken offline.

Advantages and Drawbacks

Several advantages and drawbacks of membrane bioreactors for processing wastewater were identified during the evaluation. Below is a summary of the advantages and drawbacks:

Advantages

- Continuous treatment of wastewater making controlling and monitoring the treatment process easier. This can result in more consistent and reliable effluent quality.
- Produces Class A reclaimed water without a separate filtration process.
- No separate secondary clarifiers or coagulation process required.
- State-of-the-art wastewater treatment process which is best suited to address future potential wastewater treatment requirements such as removal of pharmaceuticals and personal care products and endocrine disruptors (hormones) in wastewater.
- Modular and scalable process making expanding the treatment process easy throughout the development phases of the wastewater system.

Drawbacks

- Potentially higher cost – Membrane bioreactors have historically been a more cost intensive process due to the capital investment in the membranes and operations costs associated with additional aeration and pumping. However, these costs have been coming down significantly in recent years making MBR processes more competitive with other advanced waste treatment systems.
- Membrane Maintenance – The membranes must be maintained and kept clean so they do not foul. This increases the requirement for system air in order to “shake off” accumulated solids and keep the membranes clean.

EVALUATION OF WASTEWATER TREATMENT ALTERNATIVES

Evaluation Criteria

The following evaluation criteria were used when comparing the wastewater treatment alternatives:

Effluent Quality

Can the proposed process reliably and consistently provide effluent to an acceptable level of treatment? Are there any additional design provisions, operational considerations, and/or redundancies that need to be included in order to reliably and consistently perform?

Phasing

Does the technology lend itself to developing the treatment system in discreet phases? Are the components of the process modular and have some flexibility regarding size (i.e.) are they scalable?

Operational Characteristics

Are there any operational advantages or drawbacks associated with the proposed treatment technology?

Life Cycle Costs

What is the life cycle cost of the proposed method? These include costs for land purchase, equipment, design and installation, operation and maintenance, and equipment replacement costs. A lower life cycle cost is preferable.

LIFE CYCLE COST ESTIMATING

Cost Assumptions

Total present worth and annualized costs were estimated for a 20-year period assuming 2008 dollars. The 20-year period is consistent with an approach of designing mechanical equipment to its expected life. Structures, such as buildings, were sized based on anticipated 20-year needs. Replacement of buildings and structures were estimated based upon a 50-year life span. A detailed breakdown of the estimates is in Appendix C. Estimated costs were identified from the following sources:

- Land value per acre estimated from Jefferson County Assessor’s parcel database. A per acre estimate was calculated using representative parcels adjacent to the service area of $28,000/acre.
- Price quotes from local equipment suppliers.
- Unit prices for construction based on industry standards (Means 2008 Building Construction Cost Data).
- Bid tabulations from recent, similar projects.

Table 7-3 summarizes factors used when estimating quantities for the comparative life cycles costs.

TABLE 7-3.
CRITERIA USED FOR ESTIMATING TREATMENT PLANT COST QUANTITIES

Criteria	Value/Factor
Flow Condition	2030 Maximum Monthly Flow
Storage Ponds	8 feet deep
Land Area Contingency	Twice the land area needed for 2030 year facilities were estimated so the plant could be expanded in the future to buildout
Land Buffers	Added 25% of the total land area
Land Value	$28,000/acre

The capital cost represents the total project cost for implementation of each treatment alternative.

The life cycle costs include land cost, equipment costs, installation costs for piping, electrical, and controls, site work, mobilization/demobilization/bonding, contractor overhead and profit, escalation to mid-point of construction, planning-level contingency, engineering design and construction management, and Washington state sales tax. These amounts are reflected in the attached cost estimates.

Annual O&M costs for each wastewater alternative were estimated based on power requirements, chemicals, and labor (general operation, maintenance and cleaning). Additionally, replacement cost of equipment and structures are included in the comparative life cycle costs. Replacement costs represent a dollar amount required each year to be set aside in order to replace buildings, structures, and equipment. Replacement allowances of 2 percent for buildings and structures (replace every 50-years), and 4 percent for equipment (replace every 20 to 25 years) were included in the life cycle cost estimates. These amounts are reflected in the attached cost estimates.

Summary of Life Cycle Costs

Summaries of the 20-year life cycle costs for each of the wastewater treatment alternatives are located at the bottom of Table 7-4.

The life cycle costs do not include costs for associated effluent disposal/reuse. An evaluation of the costs for effluent disposal/reuse alternatives is presented in Chapter 6 – Effluent Discharge/Reuse Alternatives.

Summary of Wastewater Treatment Evaluation

The SBR and MBR treatment alternatives were evaluated against the above described criteria. Table 7-4 is a summary of the evaluation of the alternatives against the criteria.

RECOMMENDED WASTEWATER TREATMENT ALTERNATIVE

Stakeholder Workshop Process

The results of the alternative evaluation were presented to the Jefferson County Board of County Commissioners at a workshop on August 8, 2006. The workshop was open to the public and some key stakeholders in the community were invited to attend. A presentation was given outlining the alternative wastewater treatment options, their relative advantages and drawbacks, and their respective life cycle costs.

The design team presented its technical perspective on each of the alternatives and received feedback and questions from the Board of County Commissioners, County staff, the stakeholders/public attending the workshop. This feedback was considered in the technical recommendation.

RECOMMENDATION

Based upon the results of the alternative evaluation and feedback from the stakeholder workshop, a membrane bioreactor system (MBR) is recommended. This system is recommended primarily because of the reliable level of Class A effluent it can provide. Additionally, it is the most advance treatment technology available and is best suited to address existing and future regulatory requirements regarding treatment. The 20-year life cycle costs are slightly higher than anticipated for SBR. The additional cost does not outweigh the benefits provided through reliability and superior effluent quality offered by an MBR system.

TABLE 7-4.
SUMMARY OF WASTEWATER TREATMENT ALTERNATIVES EVALUATION

Evaluation Criteria	Alternative: Sequencing Batch (SBR) Reactor + Filter	Alternative: Membrane Bioreactor (MBR)
Effluent Quality	- Can provide Class A effluent with filtration. SBR without filtration can meet Class B, C, or D effluent quality standards. - Must monitor filters and system batches closely to ensure reliable Class A effluent quality.	- Provides Class A reclaimed water without a separate filtration process. - State-of-the-Art Wastewater treatment process which is best suited to address future potential wastewater treatment requirements such as pharmaceuticals and personal care products and endocrine disruptors (hormones) in wastewater.
Phasing	- The system is modular. Treatment cells can be added or enlarged to increase treatment capacity.	- The system is modular. Treatment capacity can be increased through addition of membranes and treatment cells.
Operational Characteristics	- Treats wastewater in batches making system timing and sequencing critical. - Requires more computer control and mechanical valving than other extended aeration treatment processes. - Operational Flexibility: Through variation of the cycles and their timing, greater operational flexibility can be achieved to meet different effluent requirements.	- Continuous Treatment of Wastewater making controlling and monitoring the treatment process easier. This can result in more consistent and reliable effluent quality. - Requires more computer control and mechanical valving than other extended aeration treatment processes. - No separate secondary clarifiers or coagulation process required. - Membrane maintenance: the membranes must be maintained and kept clean so they do not foul.
Comparative 20-year Life Cycle Costs		
Capital	$21,860,000	$26,242,000
O&M	$6,932,000	$9,005,000
Total 20-year Life Cycle Cost	**$28,792,000**	**$35,247,000**

DISINFECTION ALTERNATIVES

Effluent disinfection prevents the spread of waterborne diseases. The intent of the Class A reclaimed water standards are to produce reclaimed water that is essentially pathogen-free. This entire treatment process is geared towards this goal, with the disinfection step being the final means of achieving this goal.

Alternatives Considered

Four disinfection processes were considered for evaluation. These alternatives are described below:

- Liquid Sodium Hypochlorite – Disinfect the treatment plant effluent with 12.5 percent liquid sodium hypochlorite (bleach).
- Ultraviolet (UV) Disinfection – Disinfect the treatment plant effluent with ultraviolet light.
- Chlorine Gas – Disinfect the treatment plant effluent using chlorine gas.
- On-Site Generation of Sodium Hypochlorite – Disinfect the treatment plant effluent using <1.0 percent liquid sodium hypochlorite (bleach) generated on site using salt and hypochlorite generation equipment.

Rejected Alternatives

Two alternatives were rejected early in the evaluation process. The rational for their rejection is as follows:

Chlorine Gas

This alternative was rejected due to safety and transportation concerns. Chlorine gas is very toxic and a leak can cause harm or death. Due to the dangerous nature of chlorine gas, handling and transportation is a significant concern. Due to these concerns, chlorine gas is seldom considered in the design of small wastewater treatment facilities.

On-Site Generation of Sodium Hypochlorite

On-site generation of sodium hypochlorite uses complex, electrically powered mechanical equipment to generate low concentration (<1.0 percent) liquid sodium hypochlorite from salt water. The comparatively small amount of liquid sodium hypochlorite needed to disinfect the required effluent flows do not justify the costs for equipment, operation, maintenance and electricity when compared to purchasing liquid sodium hypochlorite from a bulk supplier.

ALTERNATIVES CONSIDERED FOR FURTHER EVALUATION

Liquid Sodium Hypochlorite

Technology Description

This alternative involves disinfecting the treatment plant effluent with liquid sodium hypochlorite (bleach). The chlorine in liquid sodium hypochlorite directly kills the microorganisms through its strong oxidizing power. Sodium hypochlorite (12-percent to 15-percent by weight) would be purchased and delivered by a vendor to the wastewater treatment plant site and stored within a chemical holding tank. Chemical metering pumps, control equipment, and associated piping would be used to inject the sodium hypochlorite into the chlorine contact tank (CCT) influent. The CCT is designed to provide gentle mixing and sufficient hydraulic residence time to kill pathogens to the required disinfection level prior to delivery of the reclaimed water to the point of reuse. Figure 7-3 shows typical equipment for disinfection using 12.5-percent sodium hypochlorite.

Figure 7-3. Sodium Hypochlorite Feed Pumps at Vashon Island, Washington (left) and Chlorine Contact Tank at Marysville, Washington

Design Criteria: Sizing and Phasing

The liquid sodium hypochlorite system would be designed for storage of at least 14 days of bleach at peak-month flows at a peak design dosage of approximately 2 mg/L (Department of Ecology criteria requires a minimum dose of 1 mg/L).

Building facilities will be designed to meet the anticipated 20-year maximum month flows. The storage area would initially house 3-55 gallon drums of liquid sodium hypochlorite to accommodate initial flows. The enclosed building is sized at 100 square feet to adequately house additional drums or a larger storage tank for bulk shipment of sodium hypochlorite to accommodate future flows.

Advantages and Drawbacks

Several advantages and drawbacks of using liquid sodium hypochlorite were identified during the evaluation process. Below is a summary of the identified advantages and drawbacks:

Advantages

- Low initial capital investment – The initial capital investment associated with this alternative is relatively low considering that no complicated mechanical equipment is required. The system involves chemical metering pumps, flow controls, piping, and chemical storage. Operation and maintenance costs involve purchase of liquid sodium hypochlorite, and operation and maintenance of the pumping equipment.
- Safety – This process is relatively safe. Liquid sodium hypochlorite is not as hazardous as chlorine gas, but provides excellent effluent disinfection.

Drawbacks

- Cost of Liquid Sodium Hypochlorite – Liquid sodium hypochlorite is relatively cheap to purchase. However, the relative advantages of this alternative could change in the future if the market price of liquid sodium hypochlorite should rise significantly.
- Chemical Storage – This alternative requires the handling and storage of a hazardous chemical (bleach) which will require worker safety training. Chemical containment around the storage tank area will be required in the event of a spill or a leak.

- Chemical Degradation – Liquid sodium hypochlorite tends to degrade over time due to temperature and exposure to sunlight. This decreases the effective concentration of chlorine and the ability of the chemical to oxidize microorganisms. This drawback can be easily mitigated with proper design and good operating practices.
- Corrosive Damage – Liquid sodium hypochlorite tends to be corrosive to piping and pumping systems. Although modern materials and equipment have mitigated many of these problems, some maintenance and replacement of piping, valves, and pump parts will be required.

UV Disinfection

Technology Description

This technology involves disinfecting the wastewater treatment plant effluent by exposing the wastewater to high levels of ultraviolet light. Ultraviolet light mutates microorganism DNA, preventing cell reproduction, which effectively kills the microorganism population since the organisms' life expectancies are short.

Ultraviolet disinfection systems use several types of technology: low-pressure open-channel systems, medium-pressure systems, and low-pressure, high-intensity systems.

One consideration of using UV disinfection in reuse applications is the requirement by Department of Ecology to have a chlorine residual at the point of use. This would require the use of chlorine after UV disinfection resulting in the need to provide chlorination equipment and facilities or equipment to provide contact time.

Design Criteria: Sizing & Phasing

The disinfection system was designed initially to handle 0.5 mgd of treated effluent and then doubled to handle 1.0 mgd for the 20-year maximum monthly flow. The UV and chlorine system sizing criteria for these flows were as follows:

UV System: 40 gpm/lamp, 200 watts/lamp, 24 hrs/day.

Chlorination System: 0.5 mg/L dose.

Advantages and Drawbacks

Several advantages and drawbacks of UV disinfection of treatment plant effluent were identified during the evaluation process. Below is a summary of the advantages and drawbacks:

Advantages

- UV disinfection systems are relatively safe and do not expose the operator to chemicals.
- Less contact time with UV light is required to achieve disinfection due to high germicidal efficiency.

Drawbacks

- Bulbs are prone to deposits and require routine wiping to prevent fouling.
- Bulbs loose their efficiency and require regular monitoring and replacement in order to ensure adequate disinfection.
- Supplemental chlorine-based disinfection would be required to provide chlorine residual in the distribution system in order to meet Class A effluent requirements. This requires a

chlorine system be installed and negates some of the benefits of not having to handle chemicals. This also will increase capital and O&M costs since two systems need to be constructed, operated, and maintained.

EVALUATION OF DISINFECTION ALTERNATIVES

Evaluation Criteria

The following criteria were used when comparing disinfection alternatives:

Effluent Quality

Does the system reliably provide the required level of disinfection?

Phasing

Does the proposed system lend itself to phasing? Can the system be designed to effectively accommodate increases in flow as the wastewater system develops?

Safety

What is the relative safety of the proposed system?

Life Cycle Costs

What are the comparative 20- year life cycle costs for the proposed system? These include costs for equipment, design and installation, operation and maintenance, and equipment replacement costs. A lower life cycle cost is preferable.

Summary of Disinfection Evaluation

Each of the alternatives was evaluated against the above criteria. Table 7-5 is a summary of the evaluation of the alternatives against the criteria.

TABLE 7-5.
SUMMARY OF DISINFECTION ALTERNATIVES EVALUATION

Evaluation Criteria	Alternative: Liquid Sodium Hypochlorite	Alternative: UV Disinfection
Effluent Quality	- Provides effective disinfection of microorganisms through oxidation with chlorine. - Well suited to provide the required chlorine residual of 0.50 mg/L for Class A reclaimed water.	- Provides effective disinfection of microorganisms through mutating microorganisms' DNA using UV radiation. - Supplemental chlorination required to provide residual of 0.50 mg/L for Class A reclaimed water.
Phasing	- The system is scalable. Additional storage capacity for liquid sodium hypochlorite can be installed. Chemical feed pumps and chemical feed piping can be enlarged or expanded to accommodate increased dosage requirements as effluent flow rates increase in the future.	- The system is scalable. Additional lamps and chambers can be installed to provide additional disinfection capacity as effluent flow rates increase in the future.
Safety	- System is safer than gaseous chlorine. However, stringent safety measures must be employed during chemical handling and equipment operation and maintenance.	- UV system does not involve the use of chemicals. However, since supplemental chlorination is required (sodium hypochlorite), stringent safety measures must be employed during chemical handling and equipment operation and maintenance.
Comparative 20-year Life Cycle Costs		
Capital	$512,000	$1,466,000
O&M	$179,000	$473,000
Total 20-Year Life Cycle Costs	**$691,000**	**$1,939,000**

RECOMMENDED DISINFECTION ALTERNATIVE

Stakeholder Workshop Process

The results of the alternative evaluation were presented to the Jefferson County Board of County Commissioners at a workshop on August 8, 2006. The workshop was open to the public and some key stakeholders in the community were invited to attend. A presentation was given outlining the alternative disinfection options, their relative advantages and drawbacks, and their respective life cycle costs.

The design team presented its technical perspective on each of the alternatives and received feedback and questions from the Board of County Commissioners, County staff, the stakeholders/public attending the workshop. This feedback was considered in the technical recommendation.

RECOMMENDATION

Liquid sodium hypochlorite is the recommended disinfection system. This system has a lower 20-year life cycle cost and provides acceptable and proven disinfection. It is suited to provide the required chlorine residual for Class A reuse and is easily scalable as the system grows. UV disinfection does not provide enough additional benefits and features to warrant the higher 20-year life cycle cost.

SOLIDS HANDLING/REUSE ALTERNATIVES

When evaluating alternatives for handling treatment plant solids, two distinct components were considered; solids handling and treatment/reuse. Solids handling involves removal of some of the water and storage at the treatment plant site prior to the treatment/reuse phase. Treatment/reuse involves treatment through digestion, composting, or chemical treatment and reuse through land application or land filling. Combinations of solids handling and treatment/reuse alternatives will be combined and evaluated.

Alternatives Considered

Three solids handling alternatives and five treatment and reuse alternatives were considered for evaluation. These alternatives are described below:

Solids Handling

The following processes were considered for solids handling prior to treatment/reuse:

- Decanting: Decanting involves allowing solids to settle by gravity either within a holding tank or within a treatment basin in the wastewater treatment plant. The clarified supernatant is then separated from the heavier subnatent.
- Thickening: Thickening involves some equipment dedicated to removing some water from the wastewater solids to about 4 percent solids. This is done in an effort to reduce transportation costs.
- Dewatering: Dewatering involves removing enough water from the wastewater solids to make it semi-solid (about 16 percent solids). This is done to further reduce transportation costs by reducing the amount of the water that needs to be hauled and or to concentrate the solids for use in composting or other reuse operations.

Solids Treatment and Reuse

The following processes were considered for treatment and reuse of treatment plant solids:

- Haul Locally to Port Townsend Composting: This involves hauling the treatment plant solids to a composting facility at the City of Port Townsend Solid Waste Facility for treatment and reuse.
- Haul Remote to Port Angeles WWTP: This involves hauling solids to another wastewater treatment plant which has facilities to digest and reuse solids.
- Contracted Haul & Reuse: A hired contractor would provide hauling, treatment and reuse of solids.
- On-Site Digestion: On-site digestion involves constructing facilities at the WWTP site to treat, and handle treatment plant solids. Treatment plant solids would be thickened and then sent to an aerobic digester where the solids would be stabilized aerobically (in the presence of oxygen). The resulting solids would be Class A or Class B depending upon the holding

temperature and solids retention time during the digestion process. Solids would then be hauled for reuse by a contract hauler.

- Forest Application: Forest application would involve sending thickened or dewatered solids to a forest application site. The solids would be aerobically digested to Class B standards. This alternative would require an agreement with a forest management company or the purchase of forest land for the application of solids.

Rejected Alternatives

Two alternatives were rejected early in the evaluation process. The rationale for their rejection is as follows:

On-Site Digestion

On-site digestion was rejected due to the extensive capital costs associated constructing, operating, and maintaining digesters and associated solids handling equipment. It is estimated that approximately 2,000 gallons per day of thickened 4 percent solids on average will be generated between 2010 and 2030. This would not justify the costs associated with constructing a digester system which could cost on the order of several million dollars.

Forest Application

Forest application was not considered for further evaluation due to the land costs associated with operating and maintaining a forest application site. Additionally, there are significant permitting and forest management practices which need to be implemented for this alternative which are dependent upon the treatment level (Class A or B) of the solids and the use of the land and crops. The associated costs and permitting requirements rendered this alternative unappealing compared to other alternatives being considered.

ALTERNATIVES CONSIDERED FOR FURTHER EVALUATION

Storage and Decanting

Technology Description

Solids are removed from the wastewater treatment system by removing a calculated volume of mixed liquor or waste activated sludge from the biological treatment process. This waste activated sludge is then stored on site in a storage tank or basin where the heavier solids are allowed to settle to the bottom. The heavier solids, or subnatant are then separated from the lighter supernatant by decanting.

Providing a decanting system is optional for an MBR process since the system operates at high mixed-liquor-suspended-solids concentrations. Solids can be pulled off the process and be at 1 – 1.5 percent solids without decanting. However, solids storage is essential during periods of inclement weather.

The decanting process requires only minimal equipment, labor and energy costs and can result in a remarkably improved subnatant with perhaps as high as a 50 percent volume reduction. The reduction in hauling and handling costs can be significant. Decanting and storage typically involves a holding tank for decanted solids, minor piping and pumps, and some provisions for odor control. Decanting and storage are accomplished in the same tank.

At a future date, the decanting process can be enhanced with polymer addition at minimal cost. Improved solids separation by use of polymer will essentially increase the emergency on-site solids storage capacity during periods of inclement weather when hauling and/or land application is curtailed.

Design Criteria

The following key design criteria were used when evaluating decanting:

- Decant to 1.2 percent solids by weight.
- No polymer or chemical addition initially.
- Provide 20,000 gallons of storage on site for decanted solids.
- Provide odor control for storage tank.

Advantages and Drawbacks

The following advantages and drawbacks were identified for decanting solids:

Advantages

- Low Capital Costs – This alternative does not involve expensive or complicated equipment for handling solids. No chemical addition is involved to flocculate solids.
- Operation and Maintenance – Since there is minimal equipment associated with this process, the system is easy and inexpensive to operate and maintain.

Drawbacks

- Solids Content – This system results in the lowest concentration of solids. The low solids content (high water content) will result in additional hauling and handling costs.

Thickening

Technology Description

Thickening involves some equipment dedicated to removing water from the wastewater solids. Enough water is removed to thicken the solids to about 4 percent. This results in reduced transportation costs. Several thickening processes were considered in this evaluation including gravity belt thickeners, dissolved air flotation thickeners, and rotary screen thickeners. Polymers can be added prior to the thickener to aid in the thickening process by coagulating and wetting the wastewater solids.

Ancillary equipment would include chemical storage systems, storage tanks, day tanks, mixers, metering pumps, piping, valving, safety equipment and odor control equipment.

Design Criteria

The following key design criteria were used when evaluating thickening:

- Thickening equipment assumed for this analysis is a rotary screen thickener.
- Polymer addition will be used to coagulate solids and aid in water removal.
- Provide 10,000 gallons of storage on site for thickened solids.
- Provide odor control scrubbers and blower equipment.

Advantages and Drawbacks

The following advantages and drawbacks were identified for thickening solids:

Advantages

- Solids Content – This system results in a higher solids content resulting in lower hauling costs than decanted solids.

Drawbacks

- Capital Costs – This system involves investment in equipment to thicken solids. Additional odor control is required since thickened solids have greater odor potential than decanted solids.
- Operation and Maintenance –This equipment will result in higher operation and maintenance costs. This will be in the form of labor, equipment maintenance, chemical costs, and power.

Dewatering

Technology Description

Dewatering involves removing enough water from the wastewater solids to make it a semi-solid. This is done to further reduce transportation costs by reducing the amount of the water that needs to be hauled. Dewatering is often accomplished employing the same equipment used for thickening sludge except the equipment is designed to remove more water from the solids. Typical equipment includes centrifuges, belt filter presses, and screw presses. Solids from activated sludge processes are typically dewatered to about 16 percent solids.

Ancillary equipment would include solids holding facilities, solids handling/conveyance systems, chemical storage systems, storage tanks, day tanks, mixers, metering pumps, piping, valving, safety equipment and HVAC systems, buildings, and odor control equipment

Design Criteria:

- Dewatering equipment assumed for this analysis is a belt filter press.
- Polymer addition will be used to coagulate solids and aid in water removal.
- Dewatered sludge to be conveyed to truck using belt conveyors.
- Provide odor control scrubbers and blower equipment.

Advantages and Drawbacks

The following advantages and drawbacks were identified for dewatering solids:

Advantages

- Solids Content – This system results in a higher solids content resulting in lower hauling costs than decanted or thickened solids.

Drawbacks

- Capital Costs – This system involves investment in more expensive equipment to remove additional water to achieve higher solids content. Belt conveyors will be needed to transport dewatered sludge to trucks so they can be hauled away for treatment and reuse. Additional odor control is required since thickened solids have greater odor potential than decanted solids.
- Operation and Maintenance –This equipment will result in higher operation and maintenance costs than for thickening. These higher costs will be in the form of labor, equipment maintenance, chemical costs, and power.

Haul Locally to Port Townsend

Technology Description

This alternative involves hauling the treatment plant solids to a composting facility at the City of Port Townsend Solid Waste Facility. The City operates a composting facility where it receives "clean green" yard waste, anarobically digested/dewatered class "B" biosolids from the Port Townsend WWTP and septage from septic tank pumping contractors. The septage is thickened using polymer and a gravity belt thickener and mixed with the shredded green material and biosolids prior to composting. Decant water from the thickening process is treated in a single sequencing batch reactor at the site. The treated effluent is then reused in a constructed wetland at the site.

Design Criteria:

- The distance to haul solids from the treatment plant to the composting facility is approximately 8 miles.
- The contractor would haul decanted sludge (unthickened) initially. Thickening equipment may be installed in the future to reduce the number of truck trips should it be economically feasible.
- Cost to treat unthickened sludge at the composting facility is estimated at $0.36/gallon (including haul costs).

Advantages and Drawbacks

The following advantages and drawbacks were identified when evaluating hauling solids to Port Townsend composting:

Advantages

- Short distance to haul. Reduced hauling expense.
- Beneficial reuse of solids.
- No need to install digesters at the treatment plant site which are a significant capital expense.

Drawbacks

- Costs for treatment are relatively high compared to other treatment providers.
- There is limited capacity at the composting facility to accept solids. The facility currently provides treatment services for local septic tank haulers and has spare solids handling capacity. However, the SBR treatment system at the compost facility is not designed, or permitted, to handle the anticipated liquid volume of unthickened sludge from the Port Hadlock system.

Haul Remote to Port Angeles WWTP

Technology Description

This alternative involves hauling solids to another wastewater treatment plant which has facilities to digest and transport the solids for reuse. The nearest facility identified which could receive solids was the City of Port Angeles WWTP.

Design Criteria:

- The distance to haul solids from the treatment plant to Port Angeles is approximately 43 miles.

- The contractor would haul decanted sludge (unthickened) initially. Thickening equipment may be installed in the future to reduce the number of truck trips should it be economically feasible.
- The cost to treat unthickened sludge at Port Angeles is estimated at $0.22/gallon.

Advantages and Drawbacks

The following advantages and drawbacks were identified when evaluating hauling solids to the Port Angeles WWTP:

Advantages

- No need to install digesters at the treatment plant site which are a significant capital expense.

Drawbacks

- Higher costs associated with hauling solids to Port Angeles. This method is dependent upon fuel costs and can change the economic viability of the alternative.
- Costs associated with treatment – This method is dependent upon treatment costs and can change the economic viability of the alternative.

Contracted Haul and Reuse

Technology Description

This alternative involves hiring a contractor to provide transportation, treatment and reuse of the wastewater solids. The contractor would load solids into a tanker truck and haul the material off site for treatment and reuse. Kitsap Bio-Recycle in Belfair Washington was identified as a contractor which could provide this service.

Design Criteria:

- The process for treatment and reuse is stabilization using lime, land application, and plowing under to reduce potential vectors and odors.
- The contractor would haul decanted sludge (unthickened) initially. Thickening equipment may be installed in the future to reduce the number of truck trips should it be economically feasible.
- Costs for haul and reuse of decanted solids to Kitsap Bio-Recycle is estimated at $0.12/gallon

Advantages and Drawbacks

The following advantages and drawbacks were identified when evaluating contracted haul and reuse:

Advantages

- Minimal capital costs – Facilities for storage and decanting and transferring solids to the contractor's truck are minimal compared to other alternatives. Costs for thickening equipment would be deferred until the future.
- If using decanted solids – No equipment for removing water or chemical treatment.
- Flexibility – This alternative involves the lowest initial capital cost and allows for flexibility to implement a different method of solids handling should the economics of hiring a contractor change in the future.

Drawbacks

- Costs associated with hauling, treatment, and reuse – This method is dependent upon contractor costs and can change the economic viability of the alternative.

EVALUATION OF SOLIDS HANDLING/TREATMENT/REUSE ALTERNATIVES

Evaluation Criteria

The following criteria were used when comparing the solids handling and treatment/reuse alternatives:

Phasing

Does the proposed combination of processes lend itself to phasing? Is there opportunity to change or alter the process in the future if the economics change?

Life Cycle Costs

What are the comparative 20-year life cycle costs for the proposed system? These include costs for equipment, design and installation, operation and maintenance, and equipment replacement costs. A lower life cycle cost is preferable.

Summary of Solids Handling/Treatment/Reuse Evaluation

Each of the solids handling and treatment/reuse alternatives were evaluated against the above described criteria. Table 7-6 is a summary of the evaluation.

TABLE 7-6.
SUMMARY OF SOLIDS HANDLING/TREATMENT/REUSE ALTERNATIVES EVALUATION

	Solids Handling Alternatives			Treatment/Reuse Alternatives		
Evaluation Criteria	Decanting	Thickening	Dewatering	Haul Locally to Pt. Townsend	Haul to Pt. Angeles WWTP	Contracted Haul & Reuse
Phasing	- Easy to phase. Minimal initial capital cost. Minor increases in holding tank as system develops	- System can be phased. However, additional capital investment will be required for thickening equipment and holding tanks..	- System can be phased. However, additional capital investment will be required for dewatering equipment, and conveying equipment	- Limited ability to expand. Existing system would be near or above capacity with projected solids at startup. - Desirability of alternative is sensitive to changes in per gallon cost to treat. Also dependent upon hauling costs.	- Ability to expand. Can send solids to one or more plants as system grows. - Desirability of alternative is sensitive to changes in per gallon cost to treat. Also dependent upon hauling costs.	- Ability to expand. Can send more solids to the contractor as the system grows. - Desirability of alternative is sensitive to changes in per gallon cost to haul and treat.
Comparative 20-year Life Cycle Costs						
Capital	$109,000	$1,388,000	$2,671,000	$148,000	$148,000	$148,000
NPV O&M	$4,418,000	$3,501,000	$2,012,000	$3,006,000	$1,837,000	$1,002,000
Total 20-Year Life Cycle Costs	**$4,527,000**	**$4,889,000**	**$4,683,000**	**$3,154,000**	**$1,985,000**	**$1,150,000**

RECOMMENDED SOLIDS HANDLING AND TREATMENT/REUSE SYSTEM

Based upon the results of the alternative evaluation, the Storage and Decanting alternative for Solids Handling is recommended and the Contract Haul/Reuse alternative for Treatment/Reuse is recommended. These recommendations are based upon the simplicity of the processes, the lowest initial capital cost, and the flexibility to switch to another system for handling and/or reuse in the future.

Each of the two recommendations has the lowest 20-year life cycle cost based upon today's available cost data. This is a "pay-as-you-go" system. If the economics of these options change in the future, the County will have very little capital investment in solids handling/reuse equipment and can comfortably explore other options.