flows are typically assumed to be 1.5 times and 2.0 times the monthly concentration, respectively. This results in a maximum weekly concentration of 23 mg/L and a maximum daily concentration of 30 mg/L.

In the wintertime, the maximum monthly effluent concentrations of BOD and SS are typically assumed to be 1.5 times those in the summer. The expected concentration during the maximum flow wintertime month is 23 mg/L. As with summertime flows, the weekly and daily maximum concentrations are expected to be 1.5 times and 2.0 times the monthly concentration, or 35 mg/L and 45 mg/L, respectively.

The expected effluent concentrations in the design year are summarized in the first column of values in Table 5-5 below.

Table 5-5. Expected Effluent Parameters From Upgraded Plant

Period	Concentration, mg/L	Flow, mgd	Mass load, ppd
Summer			
Monthly	15	2.3	288
Weekly	23	2.5	480
Daily	30	2.8	700
Winter			
Monthly	23	3.0	575
Weekly	35	3.4	990
Daily	45	4.0	1,500

EXPECTED MASS LOADING

The mass loading to the river is a function of the effluent pollutant concentrations and the concurrent flow rate. As discussed above, the allowable mass load is normally calculated based on maximum monthly, weekly, and daily flow rates on a 2-year return interval. These flow rates and the resulting mass discharges are summarized in Table 5-5.

EFFLUENT DILUTION

The amount of dilution affects the quantity of pollutants that can be assimilated by the river without degrading the water quality. A mixing zone study was recently completed to determine the level of dilution that could be expected for an assumed outfall configuration. The results of this study are summarized in more detail in Chapter 6. For a mixing zone encompassing a distance up to 210 feet from the outfall diffuser, the chronic toxicity dilution factor was determined to be 120:1. For a 21-foot ZID, the acute toxicity dilution factor was determined to be 30:1. The overall dilution in the estuary over a tidal cycle was estimated at a minimum of 930:1 during low streamflow periods.

EFFECT ON WATER QUALITY PARAMETERS

Oregon Administrative Rule 340-41-026 requires that before an increase in the allowable mass discharge can be granted, it must be shown that the increased discharge does not degrade the waters of the receiving stream. Specifically, the increased load may not cause water quality standards to be violated and must not impair any recognized beneficial uses. Because the Siuslaw is water quality limited with respect to temperature, the pollutant parameters associated with the increase must be unrelated to temperature. Each of these issues is addressed below.

Water Quality Standards

The basin standards for water quality parameters are summarized earlier in this chapter. An increased discharge must not cause any of these parameters to exceed the standards. The effect of the expected future discharge on each of these parameters is summarized below.

Dissolved Oxygen. The standard for DO in an estuary is 6.5 mg/L. Although DO data are lacking for the estuary, data upstream indicate that the ambient DO concentration is normally above 7.0 mg/L. Even if the plant effluent DO concentration were zero and BOD concentration were 20 mg/L, the DO depression at the edge of the mixing zone would be less than 0.1 mg/L.

Temperature. Temperature is the only parameter for which the river is water quality limited. Therefore, no measurable temperature increase in the river is acceptable. An increase of up to 0.25 degrees F is considered no measurable increase. For the temperature evaluation, an effluent temperature of 75 degrees F was assumed in the absence of temperature data at the Florence plant. This assumption is conservative. As an example, the maximum effluent temperature measured in the summer at the Bandon wastewater treatment plant is typically 68 degrees F. The ambient river temperature was assumed at 54 degrees F. This is the lowest mean observed at several sampling sites. Under these conditions, the temperature increase at the edge of the mixing zone would be 0.17 degrees F.

Turbidity. The maximum allowable increase in turbidity is 10 percent. Turbidity in the effluent is not a problem; it will probably be lower than the ambient turbidity in the river.

pH. The standard for pH 6.5 to 8.5. The plant effluent is expected to fall within this range. However, the current permit allows a range of 6 to 9. If the effluent pH were 9.0 and the ambient pH were at the 90th percentile level of 8.3, the resulting pH at the edge of the mixing zone would be 8.303, representing an insignificant increase.

Bacteria. For shellfish waters, the bacteria standard specifies a fecal coliform median of 14 cells per 100 mL, with no more than 10 percent of the samples at 43 cells per 100 mL. Assuming an effluent concentration of 200 cells per 100 mL, the increase at the edge of the mixing zone would be 1.7 cells per 100 mL. This increase is not significant.

Toxic Substances. The major toxic substances of concern are chlorine and ammonia. Chlorine will not be present in the effluent, as disinfection will be accomplished with ultraviolet light. Ammonia will be present, assuming that it is not nitrified in the aeration process. Determining ammonia toxicity is complex because it is dependent on pH, temperature, and salinity. However, reasonable ammonia permit limits can be set using the US EPA document, *Technical Support Document for Water Quality-based Toxics Control* (TSD, 1985). Using the dilution factors established above and conservative estimates for salinity, temperature, and pH, limits were calculated using a spreadsheet based on the TSD. These limits are 55 mg/L (as NH_3-N) for a daily maximum and 21 mg/L (as NH_3-N) for a monthly average. The effluent will be well under these limits. As discussed in Chapter 4, even the plant *influent* ammonia concentration should be below these levels.

Other toxic substances could also be present in wastewater effluent, depending on the characteristics of the incoming wastewater. A bioassay is generally recommended by DEQ to ascertain the toxicity of the effluent in helping to determine dilution requirements. A bioassay recently performed on treatment plant effluent indicated no acute or chronic toxicity. A summary of this study is included as Appendix E.

Beneficial Uses

The OAR states that the DEQ may rely on the presumption that if the water quality standards are met, then beneficial uses are protected. The beneficial uses in the Siuslaw include boating, fishing, and harvesting of clams and crabs. Maintaining the water quality standards will protect the beneficial uses.

DISCHARGE RECOMMENDATIONS

A mixing zone study has indicated that sufficient dilution can be achieved in the vicinity of the outfall to allow increased mass discharges without adversely affecting the water quality parameters. It is recommended that the mass limits summarized in Table 5-5 be incorporated into the revised discharge permit.

TREATMENT PLANT DESIGN CRITERIA

The design criteria that apply to sizing and selection of treatment units and equipment are presented below.

EQUIPMENT AND UNIT PROCESS RELIABILITY

The Florence wastewater treatment plant will fall into Reliability Class I or II as defined by the EPA, depending on the beneficial uses of the river in the area affected by the plant effluent. It is reported that some crab and fish are harvested in close proximity to the outfall, and that some clam beds are located within a few hundred feet. The most significant clam beds are reported to be more than a half a mile upstream. Because shellfish are harvested near the outfall, the plant may fall into Class I, depending on how the effluent plume is distributed in the river. Outfall modeling studies will be performed to determine distribution and dilution of the effluent plume. If the plant is not considered Class I, Class II requirements would apply. The requirements for the two reliability classes are summarized in Table 5-6.

Table 5-6. Treatment Plant Reliability Requirements

Component	Class I Requirements	Class II Requirements
Pumps	One backup pump. With one pump out of service, the remaining pumps can handle the peak flow.	Same as Class I.
Mechanically cleaned bar screen	One backup manually cleaned screen.	Same as Class I.
Primary sedimentation	With the largest unit out of service, the capacity of the remaining units to be at least 50 percent of the total design flow to the process.[a]	Same as Class I.
Secondary clarifiers	With the largest unit out of service, the capacity of the remaining units to be at least 75 percent of the total design flow to the process.[a]	With the largest unit out of service, the capacity of the remaining units to be at least 50 percent of the total design flow to the process.
Trickling filters	With the largest unit out of service, the capacity of the remaining units to be at least 75 percent of the total design flow to the process.[a]	With the largest unit out of service, the capacity of the remaining units to be at least 50 percent of the total design flow to the process.
Aeration basins	At least two equal-volume basins shall be provided.	Same as Class I.
Aeration equipment	With the largest unit out of service, the design oxygen transfer to be maintained.	Same as Class I.
Disinfection	With the largest basin out of service, the capacity of the remaining units to be at least 50 percent of the design flow to the process.[a]	Same as Class I.
Anaerobic digesters	At least two tanks to be provided.	Same as Class I.
Electric power[b]	A backup source required. Sufficient to operate all vital components during peak flow conditions, together with critical lighting and ventilation.	Similar to Class I, except secondary process components such as aeration need not be supported.

Notes: [a] For sedimentation, clarification, and disinfection, design flow is assumed to be peak wet weather flow (PWWF). For trickling filters, design flow is assumed to be peak month flow.

[b] Two separate, independent sources of power shall be provided whether Class I or II. Because only one substation feeds the vicinity of the treatment plant, an engine-generator set will be required.

As the table indicates, the requirements for the two classes differ only for trickling filters, secondary clarifiers, and backup power. Secondary clarifiers for a Class I plant would have a diameter about 20 percent greater than for a Class II plant.

PLANT FLEXIBILITY

Flexibility implies that portions of unit processes or entire unit processes can be bypassed with little effect on effluent quality. Operators should be able to take units out of service for maintenance without overloading the units remaining in service. Components should have provisions for isolating them from the flow stream for maintenance. The design should also account for the future addition of treatment units with minimum interference in plant operations.

SEISMIC CONDITIONS

Florence is located in Seismic Zone 3 as defined by the Uniform Building Code. All structures, piping, and equipment anchorage shall be designed to withstand the seismic forces as required by the code for Zone 3.

TSUNAMI PROTECTION

The Uniform Building Code specifies requirements for tsunami inundation zones. Restrictions are placed on critical facilities such as hospitals and emergency response facilities. The code specifies that "tanks and similar structures" may be constructed in a tsunami inundation zone. No other requirements are specified for such structures.

The treatment plant lies within the inundation zone as defined by the city planning department. The maximum wave, based on a 500-year recurrence interval, is estimated to rise to an elevation of about 16 feet above sea level in the vicinity of the plant. Grade at the existing plant ranges from about 10 to 12 feet in elevation. Design considerations include locating electrical equipment and the tops of tank walls several feet above the estimated maximum wave height.

SLUDGE MANAGEMENT

In order to apply sludge on land many requirements must be met to protect the health and safety of the public and to ensure that water bodies remain free of contamination. In general, higher quality biosolids (lower level of metals, pathogens, and vector attraction) have fewer restrictions in land application. These requirements are spelled out in the EPA Part 503 rule and in OAR Chapter 340, Division 50. The requirements and their impacts are summarized below.

PARAMETERS FOR CLASSIFYING SLUDGE

Classification of sludge is based on three independent parameters: metals concentration, presence of pathogens, and vector attraction level. The levels for the parameters are described below.

Metals Concentration

The *Ceiling Concentration Limits* are the maximum contaminant levels for all sludge applied to land. If these limits are exceeded for any one of ten metals, the sludge cannot be applied to land until tests show that the limits are no longer exceeded. High levels of metals indicate that industrial pretreatment may be necessary.

The *Pollutant Concentration Limits* are somewhat lower limits for metals concentration. Sludge with metals concentration within these limits can be land-applied without restrictions on metal accumulations in the soil. Tracking of metals is not required. Most domestic sewage sludges fall within these limits. For the metals that have been tested for Florence, the levels are within these limits.

Presence of Pathogens

The two categories for pathogen reduction are *Class A* and *Class B*. To meet Class A requirements, fecal coliform or *Salmonella* bacteria levels must meet specific density requirements at the time of use or disposal. Class A sludge contains minimal numbers of pathogens and is considered safe for public use. In addition to the bacteria requirement, the sludge must be treated by one of several alternatives. The alternatives include high temperature treatment, high pH treatment, or use of a Process to Further Reduce Pathogens (PFRP). PFRPs include composting, heat drying, irradiation, and pasteurization, among others.

To meet Class B requirements, the sludge must meet the requirements in one of two alternatives: testing for fecal coliform density at the time of use, and use of a Process to Significantly Reduce Pathogens (PSRP). Anaerobic digestion with a mean cell residence time of 15 days at 35 degrees C is considered a PSRP. The Florence digestion process currently meets this requirement. Class B sludge may contain significant numbers of pathogens, including coliform bacteria, salmonella, tapeworms, nematodes, cholera, amoebas, and virus. Consequently, restrictions apply to the use of Class B biosolids to prevent the transmission of disease.

Vector Attraction Levels

There are ten options to achieve vector attraction reduction. Anaerobic digestion, achieving a volatile solids reduction of 38 percent is an acceptable option. The Florence digestion process currently meets this requirement.

CATEGORIES OF SLUDGE

Sludge is classified into four categories, depending on the levels of metals and pathogens. The categories are described below. The terms used here for each category are not explicitly defined in the Part 503 rule, but are used in the EPA Guide to Part 503 Rule. The criteria for the categories and application restrictions are summarized in Table 5-7.

Table 5-7. Summary of Sludge Category Descriptions

Category	Meet Pollutant Concentration Limits	Pathogen Class	Site Restrictions[b]	Management Practices[c]	Track Metals
EQ	Yes	A	No	No	No
PC	Yes	B[a]	Yes	Yes	No
CPLR	No	B[a]	Yes	Yes	Yes
APLR	No	A	No	Label bags only	Yes

Notes: [a] Subcategories of PC and CPLR sludge exist for Class A sludge. Refer to Part 503 Rule for details.

[b] Site restrictions typically restrict harvesting for specified period after application, grazing after application, and public contact.

[c] Management practices address application on frozen, snow-covered, or flooded land, application near water bodies, and effect on threatened or endangered species.

Exceptional Quality (EQ)

Sludge in this category meets all the most stringent requirements: the Pollution Concentration Limit for metals, the Class A requirement for pathogens, and one of the vector attraction reduction requirements. This sludge can be applied to any land with very little restriction, similar to normal fertilizer.

Pollutant Concentration (PC)

This sludge meets the more stringent metals concentration limit (*Pollutant Concentration Limit*), but is not considered in Class A with respect to pathogens. Because PC sludge is categorized as Class B, land application is subject to site restrictions and management practices. The management practices take into account the life expectancy of the pathogens, which could be from 1 to 3 years, depending on the biosolids application procedure. Examples of the waiting periods required between application and contact or food harvesting are presented in Table 5-8. Because pathogens are present, this sludge cannot be bagged and given to the public. Digested sludge currently produced at the Florence plant would most likely be in this category.

Table 5-8. Examples of Management Practices for PC Biosolids

Description	Required waiting period
Food crops whose harvested parts touch soil	14 months
Food with harvested parts below ground where biosolids remain on surface at least 4 months	20 months
Food with harvested parts below ground with biosolids incorporated in less than 4 months	38 months
Animal grazing	30 days
Public access with high potential for exposure (for example, ballpark)	1 year

Cumulative Pollutant Loading Rate (CPLR)

This is the lowest quality sludge that can be applied to land. It does not meet the more stringent metals concentration limits but must meet the metals *Ceiling Concentration Limits*. It may meet either the Class A or B pathogen requirements. It must meet the vector attraction reduction requirements. Because of the higher metals concentrations, metals must be tracked during application, and the quantity of sludge applied to the land is limited by the accumulation of metals on the land. It is unlikely that digested sludge from Florence would fall in this category.

Annual Pollutant Loading Rate (APLR)

This sludge falls into Class A with respect to pathogens, but does not meet the more stringent metals concentration limits. Hence, the metals must be tracked and annual application is limited by the accumulation of metals on the land. It can be provided to the public in bags which are labeled to provide the application restriction information to the user.

IMPACTS OF SLUDGE APPLICATION RULES

Sludge from Florence will probably be classified as either EQ or PC because it will probably meet the more stringent metals concentration limits. The significant difference between these two categories is the pathogen requirement. To produce EQ sludge, an additional process, such as composting, would be required to meet the Class A pathogen requirement. The advantage of producing EQ sludge is that there are no site restrictions on its application. Because the city is currently limited in available site options, producing EQ sludge could be advantageous by providing more site options and disposal flexibility. If the city is unable to acquire additional sites within a reasonable distance of the plant, producing EQ sludge may prove cost effective.

OTHER REQUIREMENTS FOR SLUDGE MANAGEMENT

The OARs contain other requirements pertaining to land application of sludge. For most physical requirements of the sludge, the OARs reference the Part 503 Rule. However, the OARs impose certain regulatory, monitoring, and reporting requirements in addition to the requirements of Part 503.

A permit or license is required for any land application of sludge or preparation of sludge-derived products. To renew the permit, a sludge management plan must be submitted to the DEQ. The management plan must be kept current. Modifications require approval of the DEQ. The management plan must include a description of the treatment process, the quantities of sludge produced, a description of the sludge sampling and monitoring program and sludge analysis, and a description of application sites. The management plan also includes letters showing DEQ approval of all application sites.

EFFLUENT REUSE

Treatment requirements for reuse of WWTP effluent are detailed in OAR 340-55-015 and summarized in Table 5-9. Treating to Level II standards would be adequate for irrigating city-owned pasture land on which access is controlled. For essentially unrestricted irrigation of golf courses and city parks, treatment to Level IV standards is required. To comply with Level IV reclaimed water standards, the wastewater must receive biological treatment, coagulation, and filtration, and meet stringent turbidity and disinfection requirements. In contrast, Level II reclaimed water need only receive biological treatment and disinfection. Accordingly, the cost associated with producing Level IV reclaimed water are substantially higher than that for Level II treatment.

Table 5-9. Treatment and Monitoring Requirements for Use of Reclaimed Water

Category	Level I	Level II	Level III	Level IV
Biological treatment	X	X	X	X
Disinfection	N/R	X	X	X
Clarification	N/R	N/R	N/R	X
Coagulation	N/R	N/R	N/R	X
Filtration	N/R	N/R	N/R	X
Total coliform (organisms/100 mL):				
Two consecutive samples	N/L	240	N/L	N/L
7-Day median	N/L	23	2.2	2.2
Maximum	N/L	N/L	23	23
Sampling frequency	N/R	1 per week	3 per week	1 per day
Turbidity (NTU)				
24-Hour mean	N/L	N/L	N/L	2
5% of time during a 24-hour period	N/L	N/L	N/L	5
Sampling frequency	N/R	N/R	N/R	Hourly
Public access	Prevented (fences, gates, locks)	Controlled (signs, rural or nonpublic lands)	Controlled (signs, rural or nonpublic lands)	No direct public contact during irrigation cycle
Buffers for irrigation:	Surface: 10 ft. Spray: site specific	Surface: 10 ft. Spray: 70 ft.	10 ft.	None required

Note: N/L - no limit
N/R - not required

CHAPTER 6

DEVELOPMENT OF LIQUID STREAM TREATMENT ALTERNATIVES

In this chapter, liquid stream treatment alternatives for handling the future wastewater flows and loads are developed. The alternatives are developed from a wide range of processes considered initially, but screened out based on impracticality, inflexibility, or other flaws. Much of the screening is based on discussions with city staff and the Department of Environmental Quality (DEQ) during a brainstorming session held on March 12, 1997. The alternatives developed in this chapter are evaluated in Chapter 8, resulting in selection of preferred unit processes for the recommended plan. Alternatives for solids handling are developed in Chapter 7.

GENERAL ALTERNATIVES

Before any evaluation of system upgrade alternatives can be performed, it must be determined whether the existing plant should be upgraded or whether it is more beneficial to build a new plant elsewhere. The three general alternatives considered in this study are: No Action, New Plant at Alternate Location, and Expand Existing Plant. As discussed below, the recommendation of this study is to expand the existing plant.

NO ACTION

The city has entered into a Mutual Agreement and Order (MAO) with DEQ requiring that the city make improvements to the treatment plant. The MAO was established because the existing plant is overloaded to the point where frequent violations to the discharge permit occur. The city is subject to fines of $250 per day for each day of violation of the compliance schedule stipulated by the MAO. The MAO is described in more detail in Chapter 5. Choosing the No Action alternative is considered unacceptable because it represents an unacceptable level of risk to public health. This risk is the primary reason that DEQ is requiring the city to correct the problems through the MAO process.

NEW PLANT AT ALTERNATE LOCATION

Construction of a new plant at an alternate location has been discussed with city staff. Because most of the growth in the urban area is projected to take place northward, a more northerly location was considered. However, this alternative was screened out for several reasons. The current southern location is well suited to the topography in Florence. The land generally slopes gradually from north to south. A more northerly plant location would require pumping most of the city's wastewater from the south end of town back to the north. A new location would also require a new ocean outfall, construction of which would have significant environmental consequences. Furthermore, northward expansion of the city is limited by the presence of National Forest land to the north end of the study area.

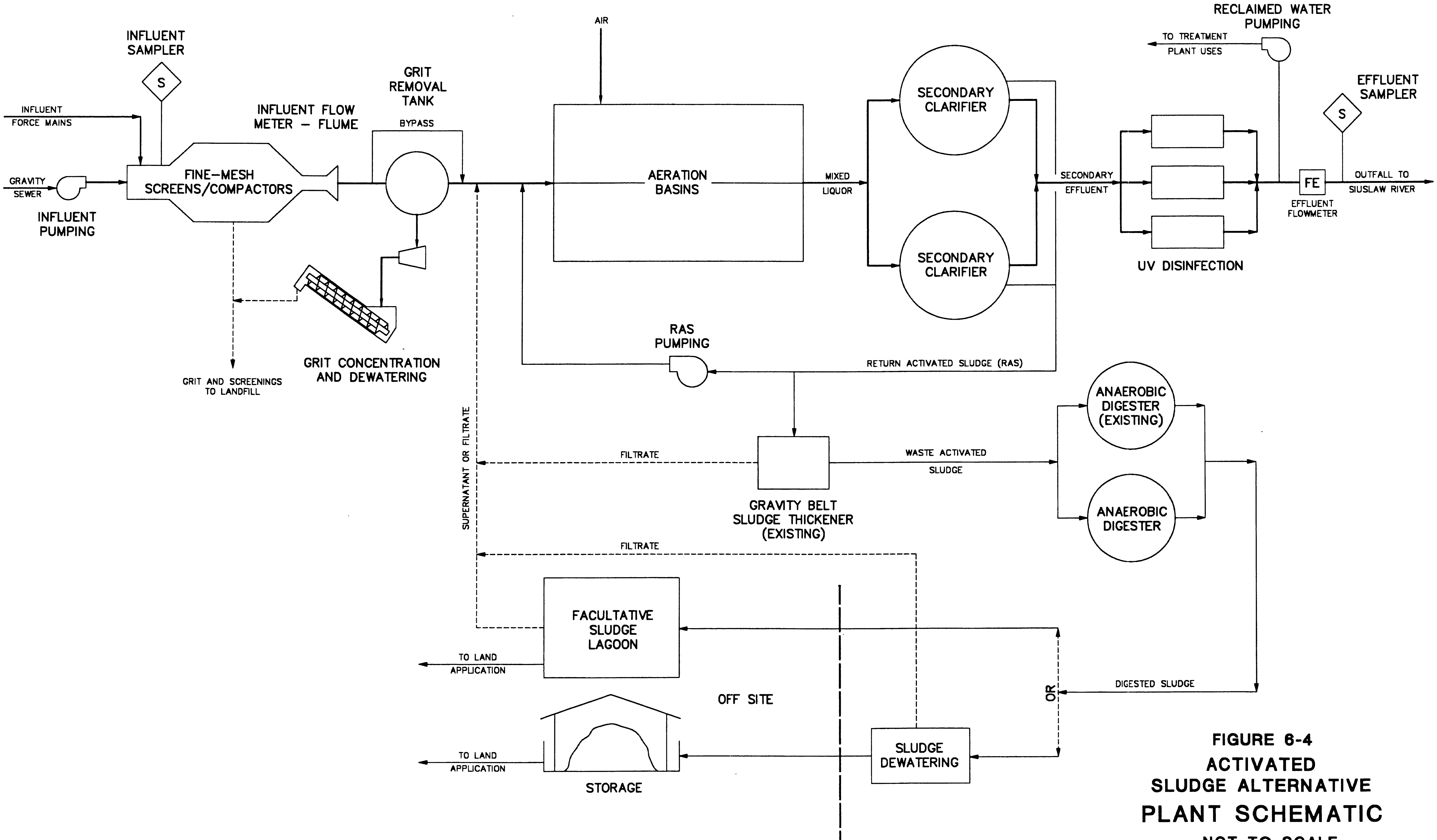

FIGURE 6-4
ACTIVATED SLUDGE ALTERNATIVE
PLANT SCHEMATIC
NOT TO SCALE

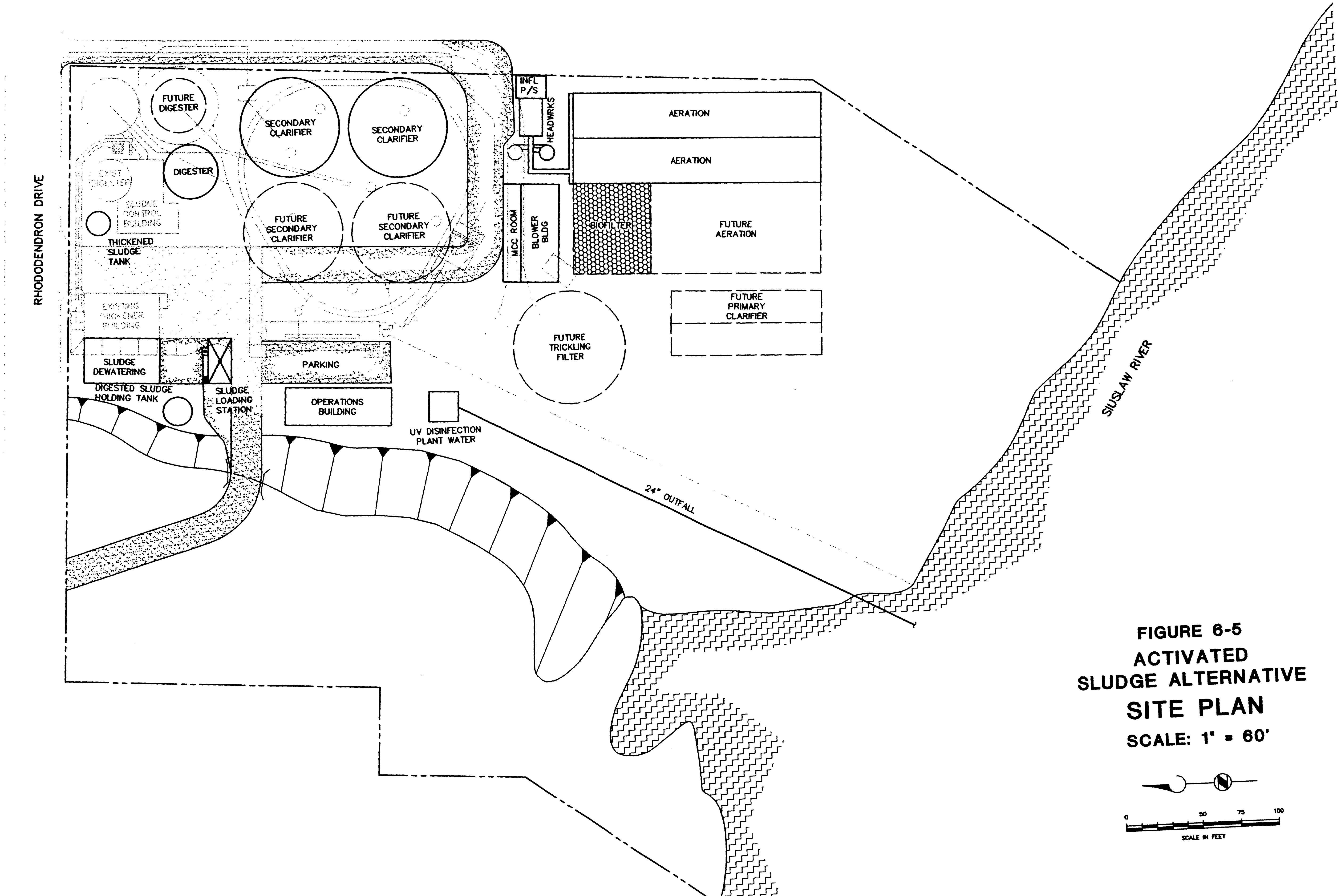

FIGURE 6-5
ACTIVATED SLUDGE ALTERNATIVE
SITE PLAN
SCALE: 1" = 60'

EXPAND EXISTING PLANT

The existing site is large enough to easily accommodate the unit processes required to handle the flows and loads projected through the study period. There is adequate space for future expansions that may be required at least 20 years beyond the study period. Expansion of the existing plant can be accomplished without interrupting the treatment process. Furthermore, savings can be realized by continuing to use some of the solids handling unit processes at the existing plant. Therefore, future flows and loads will be accommodated by expanding the existing plant.

UNIT PROCESS ALTERNATIVES

In this section alternatives are presented and evaluated for each unit process of the liquid stream. In this preliminary evaluation, the less desirable alternatives are eliminated while one or two alternatives for each unit process are retained for further evaluation.

INFLUENT PUMPING

Currently all wastewater is pumped to the plant from other points in the collection system. However, upgrades to the collection system will include a new interceptor that will carry some of the system flow by gravity to the treatment plant. Refer to Chapter 9 for details on upgrades to the collection system. An influent pump station will be required to lift this flow to the elevation of the headworks.

The influent pump station would utilize self-priming pumps similar to those used in the majority of the pump stations in the collection system. Three pumps would be provided, one of which would be a standby. The pumps would be operated by variable speed drives. The wet well would be self-cleaning by virtue of its narrow width and sloped bottom. The wastewater velocity in the narrow wet well exceeds scouring velocity each day, flushing out any solids that may have settled. The small size also prevents scum accumulation by minimizing the wastewater surface area. Minimizing the accumulation of scum and solids reduces odor potential and maintenance requirements.

HEADWORKS

The headworks would include screening and compaction equipment for removal of large solids. A grit removal system would be provided directly downstream of the screens. The headworks would also include flumes for controlling water surface elevation through the screens and measuring plant flow. The design data for the proposed headworks are included in the design data tables for the overall treatment alternatives. Refer to Tables 6-1 and 6-2 presented later in this chapter.

Screening and Compacting

Screening equipment generally falls into two categories: fine-mesh screens and bar screens. Fine mesh screens typically have a mesh of less than one-quarter inch, while bar screens normally have openings of at least one-half inch.

Fine-mesh screens. These remove relatively large amounts of material and allow very few discernible solids to pass through. Fine screening provides excellent protection of downstream process by removing essentially all rags, plastics, and other solids that could cause plugging problems downstream. The resulting sludge is nearly free of recognizable debris, making it more acceptable to end users. The removal of most solids at the headworks is of greater advantage in a plant without primary sedimentation because the lack of sedimentation allows these solids to enter downstream processes where they can cause more problems.

The primary disadvantage of these screens is that they remove large amounts of putrescible material. This can cause odor problems at the headworks and can be cause for rejection by landfill operators. These problems can be overcome by providing a screen that includes screenings washing equipment that removes most of the fecal matter. Another potential disadvantage is the tendency for fine screens to blind and for fibers and hairs to wrap around the individual wires in the screening element. This problem can be overcome by providing a screen that is cleaned with a mechanical rake or brush rather than only spray water. Another alternative is the use of perforated plate rather than parallel wires for a screening element.

Bar Screens. Conventional bar screens remove only larger debris and rags; small items and hairs pass through. The advantage is that the screenings are relatively free of fecal matter and are less voluminous. Less hauling is required and unwashed screenings can be more acceptable to landfills. However, without primary treatment, the debris that passes through the screen can cause problems downstream. Equipment subject to plugging includes pumps, grit separators, and ultraviolet disinfection units. The bar screen mechanism has a high profile, normally extending more than 15 feet above the top of the influent channel. This can be of concern where aesthetics are important. It also adds to the cost of containment and odor control.

Recommended Screening Installation. An in-channel fine-mesh screen with some form of positive mechanical cleaning is recommended for the headworks. The major consideration in this decision is the fact that primary treatment will not be provided. Fine screens also provide the flexibility to incorporate the trickling filter process in this phase or in the future without the addition of primary sedimentation.

To prevent the screen from blinding, a positive mechanical cleaning device will be included. This may consist of a rake device or brushes integral with the screenings auger, depending on which manufacturer is selected. The screening equipment will be pivot-mounted. This allows the unit to be lifted out of the channel easily for maintenance. Screenings washing equipment should also be included. The washing equipment would reduce the amount of organics in the screenings and return them to the process stream for appropriate treatment. Washed screenings would be more acceptable to landfill operators. Washing would also reduce the quantity of screenings, reducing hauling costs, and reducing the load on decreasing landfill space. Disposal of screenings will be increasingly difficult in the future. By washing and compacting to minimize the volume of screenings, the city will have taken all steps possible to minimize the screenings disposal problem.

For current cost comparison purposes, it is assumed that two screens will be installed in parallel channels with a combined total capacity equal to the peak wet weather flows (PWWF). A third channel will serve as an emergency overflow. The overflow channel will have a hand-cleaned bar rack. Other configurations, such as a single unit with PWWF capacity, will be evaluated during predesign.

A screenings compactor will also be included. The compactor dewaters screenings up to 40 percent solids. The compacted screenings are more readily accepted by landfills and cost less to haul. A bagging device should be considered. Bagged compacted screenings are easy to handle and generate less odor.

Odor control will be provided for the screenings area. The in-channel screen with an integral compactor is self contained, thereby reducing the amount of odor released. Total enclosure of the screening area is not required; only the screenings storage area need be covered.

Grit Removal

Two types of grit removal systems were considered for the Florence plant: a true vortex system similar to the existing (Eutek Teacup) and an induced vortex tank, which relies on gravitational force to settle grit. Because two of the existing four Teacup units perform well and could be reused, utilizing this system was considered. However, because the Teacups require several feet of pressure head to operate, the screening channel would need to be mounted several feet above the Teacups, or at least 10 feet above grade. This would require an imposing headworks structure which would be costly and aesthetically displeasing. Alternatively, if the screens were situated at grade, raw sewage pumping would be required between the screens and grit system.

An induced vortex grit removal tank requires no driving head and can be situated at the elevation required for the plant hydraulics. Because the induced vortex system has a lower grit removal efficiency at higher flows, the unit should be oversized to ensure efficient grit removal at peak flows. Alternatively, two tanks could be provided with the second unit in service only during peak flow periods. The grit tank would require a gallery below grade to house the grit pump and other ancillary equipment.

The grit slurry pumped from the bottom of the grit tank is further concentrated in a cyclone separator. The underflow from the separator is dewatered in a screw classifier. The dewatered grit falls into a collection box with the screenings. Odor control will be provided for the classifier.

Collection System Cleanings

The headworks could also include a station for receiving material removed from the collection system during cleaning operations. This material consists primarily of grit and grease, with occasional large objects such as rocks and other debris. A bar rack would remove rocks and debris. The material would then flow into the headworks for fine screening and grit removal. Grease would pass through the treatment process to the secondary clarifiers where it would be removed with the scum and pumped to the digester. The station would include a high pressure hose station and a hot water spray to aid in cleaning.

PRIMARY TREATMENT

Primary sedimentation basins generally remove about 70 percent of the incoming suspended solids and about 30 percent of the biochemical oxygen demand (BOD). The BOD removal reduces the load to the secondary process, resulting in smaller basins and a lower air requirement. The lower air requirement translates to less power consumption and annual cost savings. However, primary sedimentation represents an additional process at the plant with associated maintenance effort. The plant staff have noticed odor problems in the past when primary treatment was in use at the plant. Consequently, primary treatment will not be provided in this phase. Fine-mesh screens in the headworks provide a good removal of small solids that could cause problems in the absence of primary treatment. In developing site plan alternatives, space will be provided for the addition of primary sedimentation in a future expansion. Adding primary clarification in the future would allow the city to delay additional expansions to the secondary process.

SECONDARY TREATMENT

Secondary treatment is the heart of the wastewater treatment process. The design of the overall treatment plant is driven by the selection of the secondary treatment process. The biological treatment alternatives and secondary clarification are discussed below.

Biological Treatment

Three alternatives for biological treatment are discussed below: activated sludge, trickling filter/solids contact (TF/SC), and sequencing batch reactor (SBR). Detailed design data and preliminary layouts for the alternatives are presented in the summary section at the end of this chapter.

Activated Sludge. The conventional activated sludge process is the most common process used for secondary treatment of domestic wastewater. The existing system in Florence uses this process. Advantages include stability, a proven track record, simplicity of operation, flexibility, and operator familiarity with the process. The flexibility in the process applies to modes of operation and to alternatives for future expansion. Disadvantages include high energy consumption and operator attention required to change operating parameters or modes under changing flow and load conditions.

In this alternative, two new aeration basins would be provided with fine bubble diffuser aeration. The existing aeration basin would be eliminated, as it is too shallow for fine bubble aeration and could not be adapted to provide the desired modes of operation.

Modes of operation to be provided in this alternative include plug flow, step feed, contact stabilization, and anaerobic selector. Plug flow is the normal mode of operation in which raw sewage and return activated sludge (RAS) enter the head end of the basin and exit the downstream end. When flows are very high, the contact stabilization mode is used to prevent washout of solids. In this mode the first cell contains only RAS; raw sewage is fed to the basin further downstream. The high concentration of solids in the first cell enables the system to retain more solids despite high plant flows. Step feed is a combination of plug flow and contact stabilization. It is used during moderately high flows or as a transition between plug flow and contact stabilization. The anaerobic selector is an unaerated, mixed cell at the head end of the basin. The anaerobic selector is used during low flows in the summer to improve settling characteristics of the sludge.

As shown on Figure 6-5 in a later section of this chapter, the activated sludge process is flexible with respect to future expansion. When the system reaches capacity, it can be expanded by adding more basins incrementally. Alternatively, a trickling filter could be added, in which case, the aeration basins would serve as the solids contact portion of a TF/SC plant. This would provide substantial energy savings in the future. Another alternative would consist of adding primary sedimentation in the future, thereby increasing the effective secondary treatment capacity by about 30 percent. This alternative would provide capital and annual cost savings.

Trickling Filter/Solids Contact. In the TF/SC process, raw wastewater is pumped over the top of a trickling filter containing plastic media. The trickling filter effluent is collected at the bottom and flows into a small aeration basin. The aeration basin provides additional BOD removal and improves the settling characteristics of the sludge. In this alternative, a single trickling filter is provided with two parallel solids contact basins. The basins serve as backup aeration basins when the trickling filter is out of service.

The major advantages of the TF/SC process are its stability, ease of operation, and low energy consumption. Very little operator attention is required, regardless of changes in flow and load conditions. The trickling filter handles shock loads well, and washout of the process solids is difficult because much of the inventory is fixed to the media. The aeration requirements are about one-fourth that of the activated sludge process, resulting in energy savings. Another advantage is that the process produces sludge with better settling characteristics. Consequently, the secondary clarifiers can be smaller.

Disadvantages of the process include odor potential, lack of flexibility in unit process sizing, and growth of snails in the filter. Because raw wastewater is sprayed on the top of the filter odor can be released. The high and exposed location of the spray could result in the odor migrating off site. Because of the importance of odor control at this plant, a trickling filter should be covered and provided with odor control. At many trickling filter installations, large quantities of snails grow in the filter and eventually slough off, entering downstream processes. However, this problem can be addressed by including a snail removal section at the upstream end of the solids contact tank. This section acts as an aerated grit tank, settling the snails into a hopper. The snails are then pumped to the grit removal system.

Because the trickling filter must be sized for the maximum load in the design year, it would be oversized for most loads experienced during the early part of the design period. This could result in less effective treatment at times. One solution to this problem is to provide only part of the media initially, adding the rest in the future as the load dictates.

Sequencing Batch Reactor. The SBR is a modified activated sludge process that treats the wastewater in batches. It has a long sludge age similar to extended aeration. Advantages include the lack of secondary clarifiers and a lower operations staff requirement because of automation. SBRs are well suited to nutrient removal because they include adjustable aerobic and anoxic cycles.

Disadvantages include the lack of flexibility in future expansion, reliance on the automatic control system, difficulties with scum removal, difficulties in handling flows with high peaking factors, and poorer effluent quality characteristic of extended aeration.

Secondary Clarification

Two new secondary clarifiers would be provided in either the activated sludge or the TF/SC alternative. No secondary clarifiers are necessary in the SBR alternative. The clarifiers in the TF/SC alternative are slightly smaller than for activated sludge because they can handle a higher overflow rate due to the superior settling characteristics of TF/SC sludge. The clarifiers are sized to handle 75 percent of the PWWF with one unit out of service in accordance with Class I reliability requirements. The clarifiers would have flocculating centerwells to improve the settling characteristics of the sludge. The effluent launders would be mounted peripherally. Stamford baffles will be provided under the trough to deflect upward sidewall currents that would otherwise tend to carry solids over the weir. The advantage to peripheral launders is the ease of access for cleaning.

For the activated sludge alternative, return sludge pumping would be accomplished by two pumps dedicated to each clarifier. The pumps would draw from a sump attached to the side of each clarifier. Submersible pumps or self-priming pumps have typically been used for return sludge pumping. The final selection of pump type will be made during predesign. The pumps would be provided with variable speed drives. The operator would have the option of pacing the pumping rate to plant flow rate or selecting a pumping rate directly. The capacity with both pumps operating simultaneously would be about 150 percent of the average dry weather flow (ADWF) to the clarifier.

Sludge would be wasted through a branch pipeline of the return sludge piping. The existing thickener feed pump may continue to be used for this purpose pending an evaluation in the predesign phase.

DISINFECTION

The two means of disinfection considered were ultraviolet (UV) light and chlorination. Chlorination has been eliminated because of safety and effluent toxicity concerns. Chlorine storage requires containment and scrubbing in addition to other safety requirements. The safety concerns are greater because of the close proximity of several homes. Furthermore, the water quality and mixing zone evaluations have determined that the presence of chlorine in the effluent would cause toxicity. Consequently, dechlorination would also be required, increasing the cost and operator attention required.

Ultraviolet disinfection systems are available with two types of bulbs: low pressure and medium pressure. The medium pressure systems require about one-tenth as many bulbs as the low pressure systems, resulting in a much lower maintenance and space requirement. Both closed-vessel and open-channel systems are available with medium pressure bulbs. Recent evaluations and discussions with manufacturers indicate that for a plant this size, the closed-vessel system is more cost-effective. A closed-vessel medium pressure system is proposed for Florence, although the specific selection will be further evaluated during predesign. The system includes three parallel units with a combined capacity equal to the PWWF.

In sizing a UV system, it is necessary to know the transmittance of the effluent. A pilot test conducted by the city indicated a transmittance of nearly 70 percent. This is higher than is typically assumed for design and indicates that UV disinfection should be very effective for the Florence plant. An additional test should be conducted during the design process.

OUTFALL AND MIXING ZONE EVALUATION

A mixing zone and outfall evaluation was recently performed to determine the effect of plant effluent on the Siuslaw River water quality and to provide a basis for preliminary design of a new outfall. The results of the mixing zone evaluation provide the target treatment requirements that are used in developing the alternatives for liquid stream treatment. The detailed evaluation report is included as Appendix C.

Background

A more detailed evaluation of the water quality of the Siuslaw River is presented in Chapter 2. From that evaluation, it was determined that temperature is the only parameter for which the river is water quality limited. The dissolved oxygen (DO) concentration is also of concern because a few excursions of the water quality standards have been noted. Other parameters which are pertinent to the wastewater treatment plant evaluation include pH, bacteria, and toxic substances. The toxic substances of concern are ammonia and chlorine. A summary of these parameters is presented in Table 6-1.

Data for the estuarine portion of the river are scarce. Although tide information is available, the resulting velocity of the current in the river is mostly unknown. The best estimate of velocity is from local boaters. Local fishermen report that the maximum velocity of the current is about 4 knots.

Salinity data are also generally unavailable. However, the city recently gathered limited salinity and temperature data near the existing outfall location. These results are compiled in the evaluation in Appendix C.

Hydraulic Analysis

In order to perform the mixing zone analysis, an outfall location and diffuser configuration must be assumed. A configuration was chosen that could allow the plant to discharge the PWWF at high tide without effluent pumping while providing good dilution characteristics. The hydraulic analysis indicated a total head loss of 5.3 feet in the entire outfall and diffuser at PWWF.

Table 6-1. Summary of Pertinent Water Quality Parameters

Water quality parameter	Comments
Temperature	The Siuslaw River is listed as water quality limited for temperature during the summer. For marine and estuarine waters, no significant increase in temperature above natural background levels is allowed above 0.25 degrees F at the edge of the mixing zone.
Dissolved oxygen	DO concentration in estuaries must be maintained above 6.5 milligrams per liter (mg/L). DEQ may set more restrictive DO limits in the future if the Siuslaw River is listed as a water quality limited stream.
pH	pH for all fresh and estuarine waters must remain between 6.5 and 8.5.
Bacteria	Bacteria standards are relatively stringent because the wastewater treatment plant discharges into an estuary containing shellfish-growing areas. The median fecal coliform concentration cannot exceed 14 organisms per 100 mL. In addition, no more than 10 percent of the samples can have more than 43 organisms per 100 mL.
Toxic substances	Toxicity limits for chlorine in marine water are 0.0075 mg/L for chronic toxicity and 0.013 mg/L for acute toxicity. Ammonia toxicity is dependent on water temperature, pH, and salinity.

There were two goals in performing the dilution analysis. The first goal was to roughly characterize the amount of overall dilution of plant effluent within the estuary over a tidal cycle. The second goal was to determine the dilution occurring near the outfall on a shorter time scale. The shorter term localized dilution results are used to establish the mixing zone.

Overall Tidal Dilution. An estimation of the volume of water entering the estuary from stream flows and tidal ocean exchange can be used to determine if effluent accumulation in the estuary could be a problem. The amount of ocean water entering the estuary can be estimated from the tidal fluctuations and the extent to which saltwater reaches upstream. Recent salinity measurements taken by the city indicate that the saltwater reaches about 13,000 feet upstream of the treatment plant, or about 6.5 miles upstream of the mouth of the river. This is a conservative estimate of saltwater intrusion because the measurements were taken in wintertime during fairly high river flows. During the summer, saltwater would extend further upstream.

A search through the NOAA tide predictions for Florence yields a minimum tidal elevation change of 0.9 feet. Applying this elevation change over the lower 6.5 miles of the river, which has an average channel width of about 1,100 feet, results in a minimum tidal prism of about 38 million cubic feet. This prism represents an average flow rate of 1,700 cubic feet per second (cfs) occurring over a 6-hour tidal cycle. Jet-like discharge conditions through the jetty and consistent littoral currents disperse the river plume so it is not reintroduced with the next tidal cycle. Combining this tidal flow rate with the summertime river flow of 75 cfs provides dilution of the plant's ADWF to a ratio of about 930:1. With a dilution ratio this high, effluent accumulation in the estuary should not be a significant environmental problem.

Mixing Zone Dilution. An analysis of dilution in the vicinity of the outfall diffuser is used to develop the size of the mixing zone and of the zone of initial dilution (ZID). Chronic toxicity can be exceeded only within the mixing zone and acute toxicity can be exceeded only within the ZID. Computer simulations were used to estimate the dilution provided by an assumed outfall configuration. Acute dilution factors were estimated using the computerized model, PLUMES, while chronic dilution factors were estimated using the program, CORMIX2. PLUMES is more stable in the highly turbulent area near the diffuser whereas CORMIX2 is more suited to the chronic condition because it takes into account boundary effects such as stream bank reflections.

The dilution results predicted by the CORMIX2 simulation are plotted in Figure 6-1. For the evaluation of chronic toxicity, an ambient current velocity of 1 meter per second was assumed. This velocity represents the average of the two extremes of zero and 2 meters per second observed in the estuary. From Figure 6-1, a dilution factor of 120:1 corresponds to this velocity.

The dilution results predicted by the PLUMES simulation are plotted in Figure 6-2. For the evaluation of acute toxicity, an ambient current velocity of 0.1 meter per second was assumed. This velocity represents the 10^{th} percentile current velocity in the estuary. From Figure 6-2, a dilution factor of 30:1 corresponds to this velocity.

Applying the above levels of dilution to the expected amounts of pollutants in the effluent provides an estimate of the impact of the effluent on the water quality. The standards for water quality parameters and the effect of the effluent on these parameters are discussed in detail in Chapter 5. To summarize, the expected mass discharge in the design year 2020 will not cause any violations of the water quality standards based on the dilution described above.

Toxicity must be evaluated on both acute and chronic levels. The two parameters normally of concern are ammonia and chlorine. Chlorine will not be present in the effluent because disinfection will be accomplished using ultraviolet light. Ammonia toxicity is a complex calculation dependent on several parameters. Using conservative estimates of ambient salinity, temperature, pH, and background ammonia concentration, the potential permit limits for ammonia were calculated using a statistical approach documented in the Environmental Protection Agency *Technical Support Document for Water Quality-based Toxics Control.*

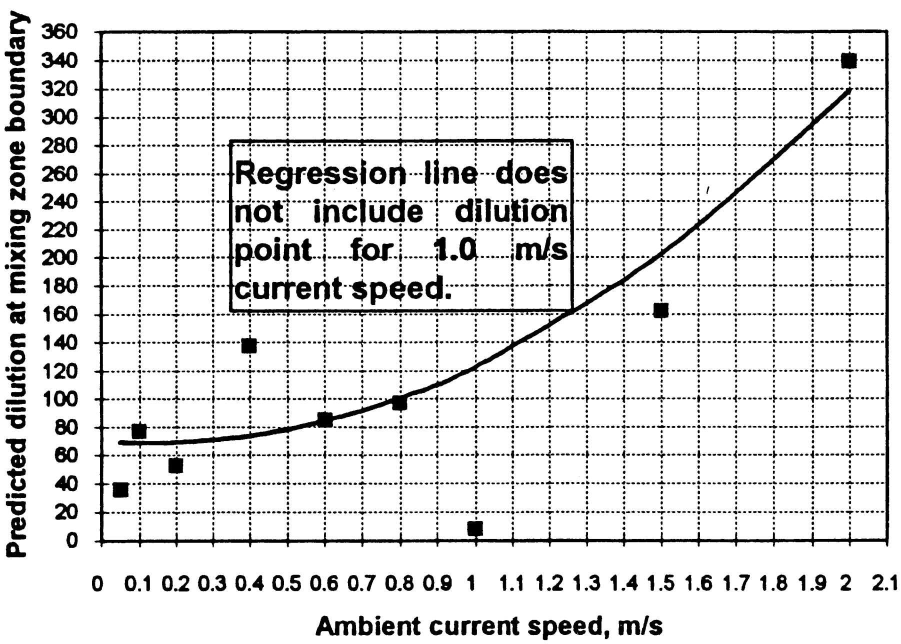

Figure 6-1. Chronic Dilution Predicted by CORMIX2 Model

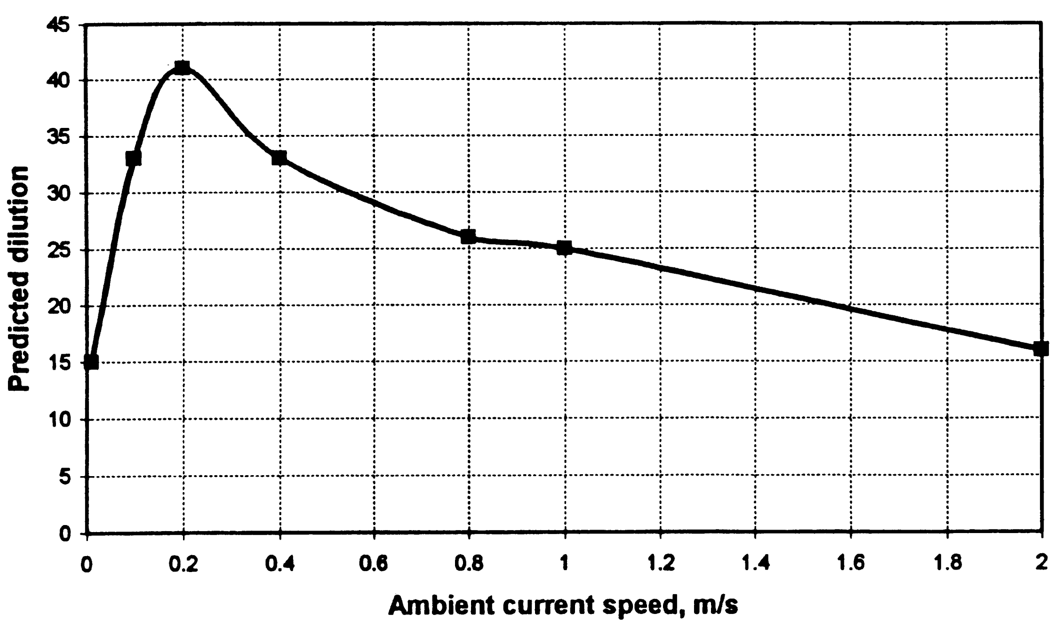

Figure 6-2. Acute Dilution Predicted by PLUMES Model

Based on this approach, the expected permit limits for ammonia would be 55 mg/L (as NH_3-N) for a daily maximum limit and about 21 mg/L for a monthly average limit. Refer to Attachment C in Appendix C for the detailed calculation.

Outfall Recommendations

Based on the mixing zone evaluation, DEQ should define the mixing zone to extend at least 210 feet both directions from the diffuser. The ZID should extend at least 21 feet upstream and downstream. More field data should be collected during the environmentally critical months of late summer. These data should include current velocity, salinity, temperature, pH, and background concentrations of DO and ammonia. The mixing zone study was based on conservative assumptions. Field data may show that less dilution is required, allowing construction of a smaller diffuser.

A new outfall would be required to carry the projected flows and to provide sufficient dilution to protect the water quality of the river. A profile of the proposed outfall and the river cross section is shown in Figure 6-3. Due to the inaccessibility of an outfall once constructed, the pipeline should be sized conservatively. The preliminary configuration consists of a 24-inch pipeline with a 200-foot diffuser extending nearly 700 feet from shore. The head loss through the 24-inch pipeline would be about 1.4 feet at the PWWF. The 24-inch pipeline would be adequate far beyond the design period. Even with a doubling of the design PWWF to 14 mgd, the head loss through the pipeline would be less than 6 feet. At the assumed population growth rate, flows this high would not be expected for more than 50 years.

The diffuser would be as close as possible to the dredged channel in the center of the river to utilize deeper water for better dilution. Submergence would be more than sufficient to prevent any interference with boating or other river activities. Precise location would be coordinated with the US Army Corps of Engineers to ensure that the diffuser would not interfere with future dredging operations. The diffuser would have 50 ports of 2-inch diameter. The head loss through the diffuser would be about 4 feet at the PWWF. The small ports would provide adequate velocity for good dilution at the design flows; however, the diffuser would require modification to handle flows much greater than the design PWWF.

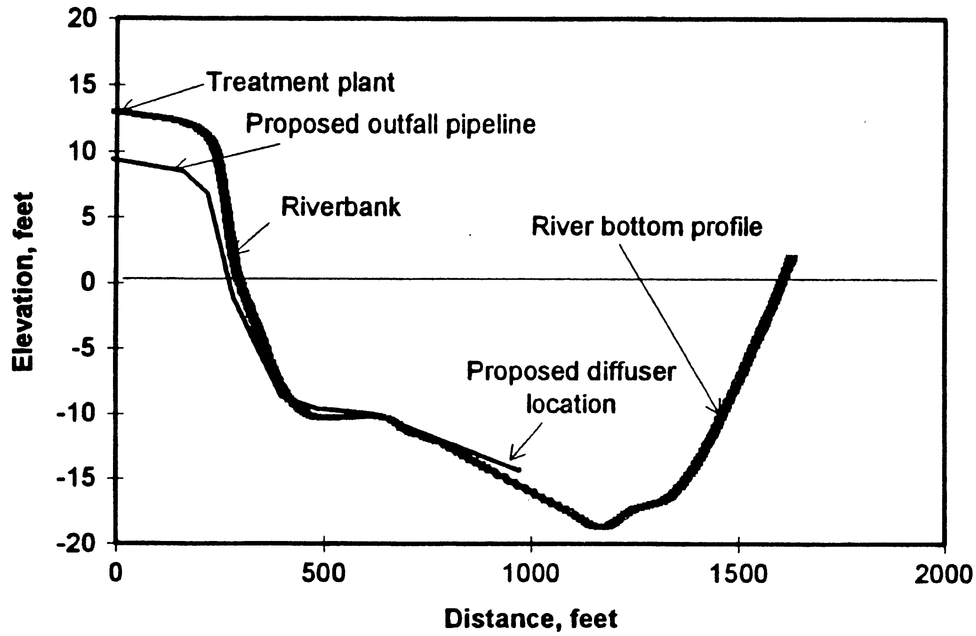

Figure 6-3. River Bottom and Proposed Outfall Profile

EFFLUENT REUSE

Effluent reuse is an option for treatment plants which are not allowed to discharge during the summer or whose mass discharge cannot be increased because of limitations in the receiving stream. The Siuslaw River water quality evaluation (refer to Chapter 5) has shown that the river is capable of assimilating an increased load. Because effluent reuse would require a much higher level of treatment, several miles of pipeline with effluent pumping facilities, and effluent storage, it is not a practical alternative to river discharge.

SEPTAGE RECEIVING

The existing plant does not receive or treat septage. Most of the septage haulers in the Florence area must either provide their own treatment or haul the septage at least 60 miles to Willamette Valley facilities. The treatment units described in this document have been sized without considering any septage load. The city has no obligation to accept septage; it is the city's choice whether to accept it, based on economic and political considerations.

If the city decides to accept septage, a septage receiving station would be included in the facilities. The receiving station would include coarse screening and grinding. The screened septage would probably be conveyed to the digester for treatment. Alternatively, it could be conveyed to the headworks. The digester would need to be larger to accommodate the additional load.

The septage receiving station and larger digester would add to the capital cost of the treatment plant improvements. Annual cost increases would be incurred in maintenance of the receiving station and in the additional sludge hauling and processing. However, septage treatment could possibly represent a source of revenue through fees for septage acceptance.

OPERATIONS BUILDING

As discussed in Chapter 3, the existing building is inadequate for storage, maintenance space, and laboratory space. A new building will be constructed housing the main control room, a laboratory, storage space, an office for the wastewater division supervisor, a meeting room, and locker and washroom facilities. The storage area will include a separate small room for flammable materials. The layout and relative area dedicated to each function will be developed during predesign. The area required is estimated to be roughly 1,800 square feet.

SUMMARY OF COMPLETE TREATMENT ALTERNATIVES

Three basic alternatives for wastewater treatment have been developed: activated sludge, SBR, and TF/SC. For the most part, the portions of the plant other than the secondary treatment process are similar for each alternative. In this section, schematics, site plans, and design data are presented for each complete alternative.

ACTIVATED SLUDGE ALTERNATIVE

This alternative would utilize the same treatment processes used currently at the existing plant. However, much more flexibility and redundancy would be built in.

Plant Schematic

A schematic diagram of the activated sludge alternative is presented in Figure 6-4. As the diagram shows, part of the influent flow is pumped to the plant through force mains and part of the flow enters the plant by gravity. All flow would be combined at the headworks.

The schematic shows that the major processes include parallel units. This provides redundancy, allowing the plant to continue to operate when one unit is out of service.

Site Plan

A proposed layout for the activated sludge alternative is shown on Figure 6-5. Details of the layout will be revised as the design process proceeds, but the general placement of the major unit processes is somewhat fixed. For example, the aeration basins must be constructed away from the existing facilities to allow the existing plant to remain in service during construction. Once the aeration basin and headworks are completed, the existing aeration basin can be shut down, allowing construction of new secondary clarifiers in the location of the old aeration basin. Once the clarifiers are complete, the existing clarifiers can be removed, allowing construction of a new digester.

Ample space is provided for sludge loading and removal of screenings and grit. The access is designed to eliminate the need for trucks to back in and turn around. The final design for traffic patterns is partially dependent on whether the city can obtain a permit to construct a driveway across the creek to the west of the plant.

Potential future expansions for the unit processes are shown in dashed lines on Figure 6-5. Several options are shown for expanding the secondary process. The process could be expanded directly by increasing the volume of aeration basin. Alternatively, primary sedimentation could be added thus reducing the load to the aeration basins. As another alternative, a trickling filter could be added with or without the addition of primary sedimentation. Regardless of which expansion option is selected, the layout can accommodate more than a doubling of the capacity provided in this phase.

Design Data

The design data for all of the unit processes in the activated sludge alternative are presented in Table 6-2. The values are those projected for the design year 2020. Although future units are shown on the site plan, design data beyond the design year are not included because it is unclear how much more the population could expand given geographical constraints in the urban growth area.

Table 6-2. Design Data For Activated Sludge Alternative

Item	Value
Plant flow	
ADWF, mgd	1.9
Peak month, mgd	3.6
Peak day, mgd	5.1
PWWF, mgd	6.9
Plant load	
BOD average, ppd	5,300
BOD max month, ppd	7,000
SS average, ppd	3,800
SS max month, ppd	4,800
Influent Pumps	
Type: Self-priming[a]	
Number	3
Capacity each, mgd[b]	1.5
Screen	
Type: Fine-mesh in-channel	
Number	2
Opening size, inches	0.25
Capacity each, mgd	5.3

Item	Value
Emergency bypass bar rack	
Number	1
Opening size, inches	1
Capacity, mgd	6.9
Grit Removal	
Grit chamber: Induced vortex	
Number	2
Diameter, ft	10
Capacity each, mgd	7.0
Grit pump: Recessed impeller	
Grit separation: Cyclone	
Grit dewatering: Auger	
Aeration	
Basins	
Number	2
Width, ft	30
Water depth, ft	15
Length, ft	165
Volume each, 1000 gallons	555
Operating modes available:	
Plug flow, step feed,	
contact stabilization	
Anaerobic selector	
Process performance[c]	
MLSS, mg/L	2,400
F/M, lb BOD/lb MLVSS/day	0.34
Sludge age, days	4.2
HRT, hours	7.3
Blowers	
Type: Multistage centrifugal[a]	
Number	4
Capacity each, scfm	2,000
Secondary clarifiers	
Type: Flocculator, peripheral weir	
Number	2
Diameter, ft	66
Sidewater depth, ft	17
SOR at peak day, gpd/sq ft	745
SOR at PWWF, gpd/sq ft	1,000
RAS pumping (per clarifier)	
Number of pumps	2

Item	Value
Capacity each, gpm	600
Disinfection	
Type: Closed vessel, medium pressure[a]	
Number of trains	3
Capacity each, mgd	2.3
Lamps per train	8
Outfall	
Length	700
Diameter, inches	24
Diffuser length, ft	200
Number of diffuser ports	50
Sludge thickener (existing)	
Type: Gravity belt	
Number	1
Belt width, m	1
Capacity, lb/hr	800
Thickened sludge tank	
Number	1
Diameter, ft	16
Volume, gallons	22,000
Height, ft	15
Anaerobic digesters	
Type: Mesophilic, fixed submerged cover	
Number	2
Diameter, ft (exist/new)	30/36
Sidewater depth, ft (exist/new)	14/24
Volume, cubic ft (exist/new)	12,070/28,400
SRT at peak month, days	28
Digested sludge holding tank	
Number	1
Diameter, ft	19
Height, ft	15
Volume, gallons	33,000
Sludge dewatering[d]	
Type: Belt or centrifuge[a]	

Item	Value
• Number	1
Capacity, lb/hr	1,900
Facultative sludge lagoon[d]	
Number	1
Area, acres	1.9
Depth, ft	12
Loading, lbVSS/1000 sq ft/day	20

Notes:
[a] Equipment type selection is preliminary for cost estimating purposes. Selection may change during predesign.
[b] Influent pump station receives flow from new interceptor only. All other flow is pumped to plant from collection system pump stations.
[c] At maximum month conditions.
[d] Either sludge dewatering or an FSL would be provided, not both. These solids handling options are preliminary selections subject to change during predesign.

TF/SC ALTERNATIVE

The trickling filter unit process would be new for the city. However, the solids contact portion operates on the same principles as an activated sludge plant. Overall operations would be similar to those for activated sludge, although simpler due to the stability of the trickling filter process.

Plant Schematic

A schematic diagram of the TF/SC alternative is presented in Figure 6-6. With the exception of the biological treatment, the schematic is similar to that of the activated sludge process shown in Figure 6-4. In this alternative, the plant flow is pumped over a trickling filter. Under most conditions, a single trickling filter pump would operate at constant speed. As plant flow varies, the amount of flow recycled over the trickling filter would vary accordingly. During high flow periods two pumps would operate.

Although only one trickling filter would be provided, redundancy is incorporated because the process can be operated as an activated sludge system with the solids contact tanks serving as aeration basins if the trickling filter is shut down. The other processes include parallel units for redundancy.

Site Plan

A proposed layout for the TF/SC alternative is shown on Figure 6-7. As with the activated sludge alternative, the general placement of the major unit processes is constrained by the site configuration and placement of existing process units. For example, the trickling filter and solids contact tanks must be constructed away from the existing facilities to allow the existing plant to remain in service during construction. Once the solids contact tank is completed, the existing

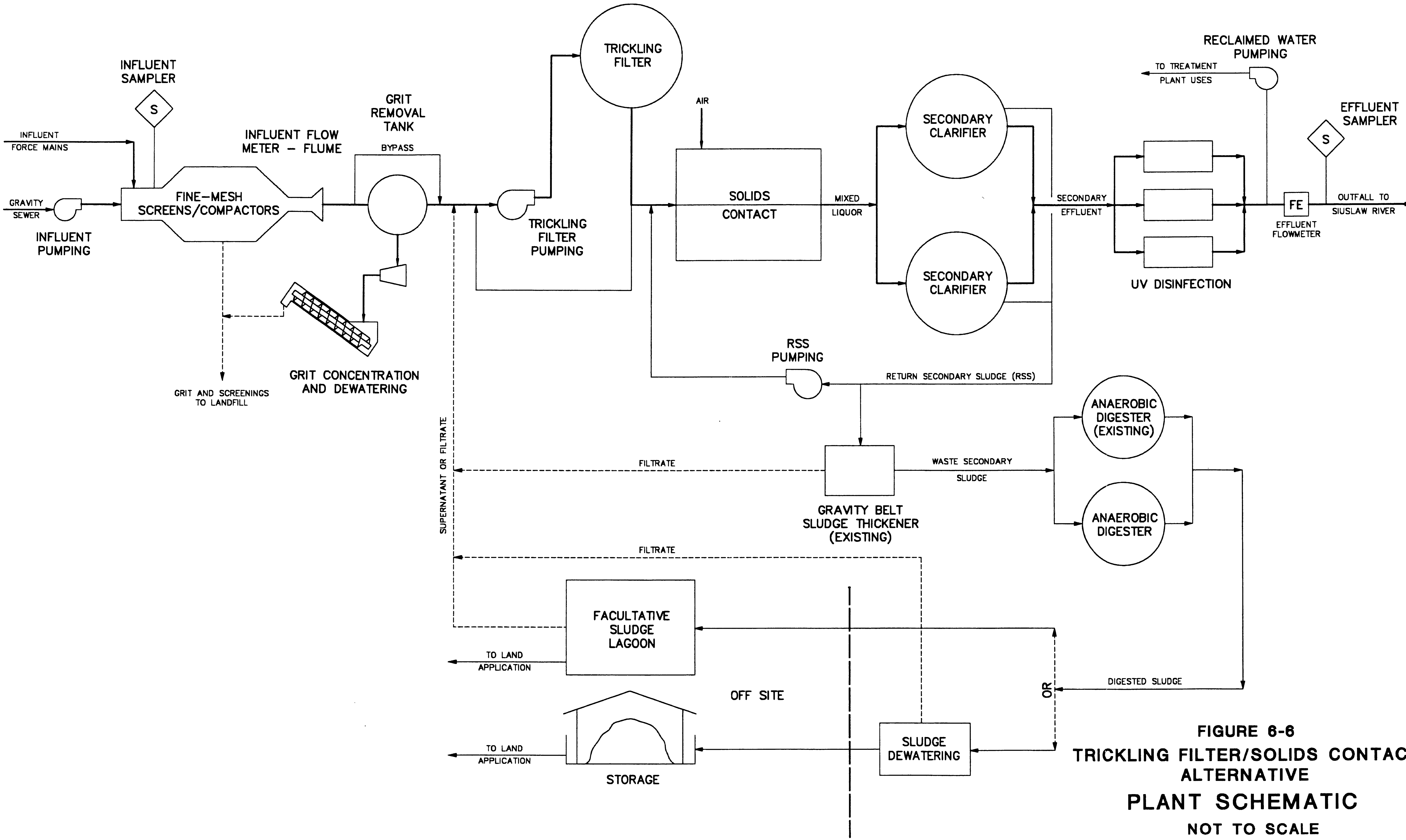

FIGURE 6-6
TRICKLING FILTER/SOLIDS CONTACT ALTERNATIVE
PLANT SCHEMATIC
NOT TO SCALE

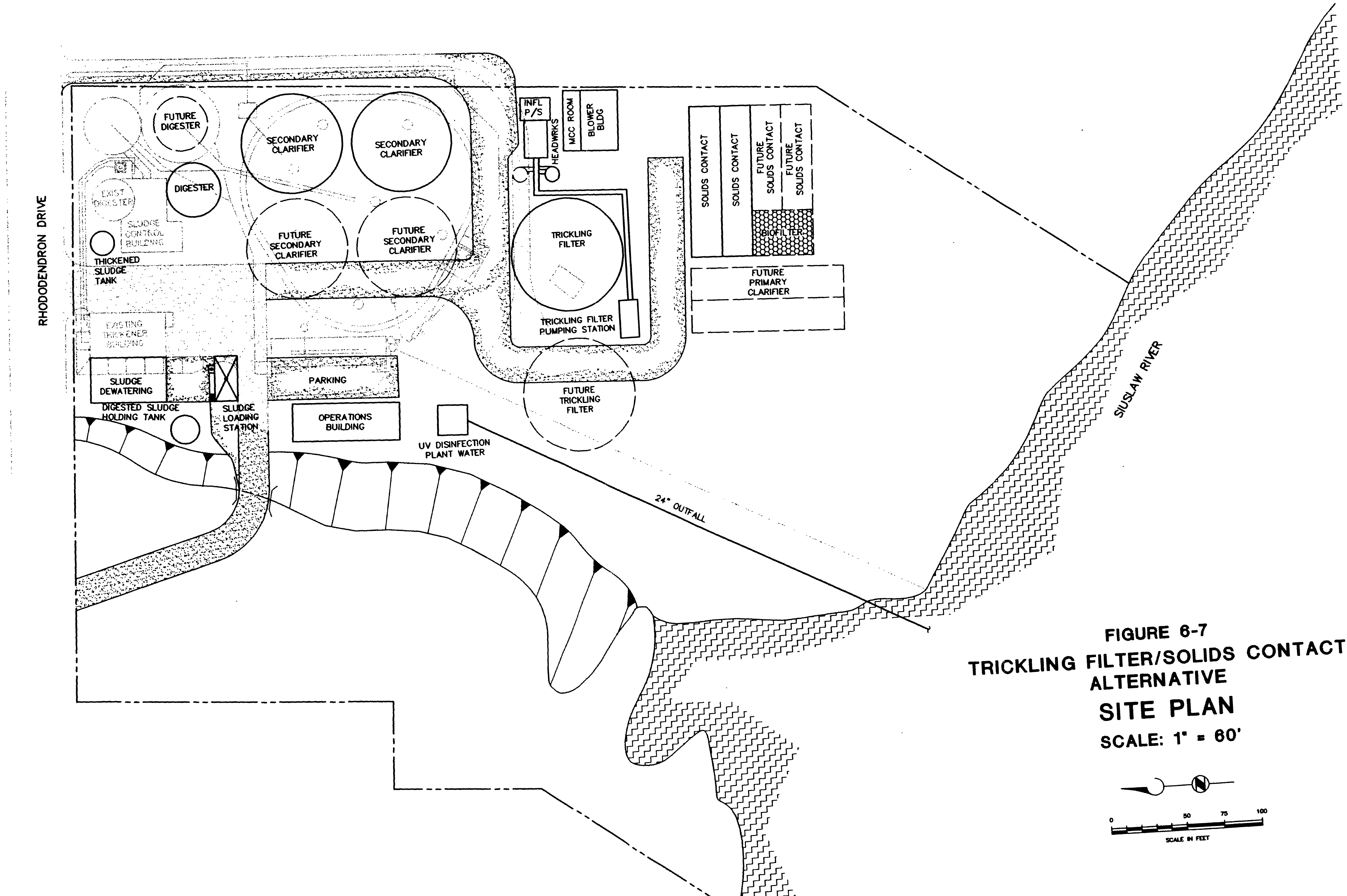

FIGURE 6-7

TRICKLING FILTER/SOLIDS CONTACT ALTERNATIVE

SITE PLAN

SCALE: 1" = 60'

aeration basin can be shut down, allowing construction of new secondary clarifiers in the location of the old aeration basin. Once the clarifiers are complete, the existing clarifiers can be removed allowing construction of a new digester.

Because the trickling filter is of much higher elevation than the other structures, it is placed as far north as possible on the currently vacant land. The more northerly location reduces the visibility from homes along the river, east and west of the plant. The aesthetics of the trickling filter are also improved by including a cover, which may be required for odor control.

Potential future expansions for the unit processes are shown in dashed lines on Figure 6-7. Two options are shown for expanding the secondary process. The process could be expanded directly by adding a trickling filter and increasing the volume of solids contact basin. Alternatively, primary sedimentation could be added, thus reducing the load to the secondary process. As with the activated sludge alternative, the layout can accommodate more than a doubling of the capacity provided in this phase.

Design Data

The design data for all of the unit processes in the TF/SC alternative are presented in Table 6-3. The values are those projected for the design year 2020. As under the activated sludge alternative, design data beyond the design year are not included.

Table 6-3. Design Data For TF/SC Alternative

Item	Value
Plant flow	
ADWF, mgd	1.9
Peak month, mgd	3.6
Peak day, mgd	5.1
PWWF, mgd	6.9
Plant load	
BOD average, ppd	5,300
BOD max month, ppd	7,000
SS average, ppd	3,800
SS max month, ppd	4,800
Influent Pumps	
Type: Self-priming[a]	
Number	3
Capacity each, mgd[b]	1.5
Screen	
Type: Fine-mesh in-channel	
Number	2

Item	Value
Opening size, inches	0.25
Capacity each, mgd	5.3
Emergency bypass bar rack	
Number	1
Opening size, inches	1
Capacity, mgd	6.9
Grit Removal	
Grit chamber: Induced vortex	
Number	2
Diameter, ft	10
Capacity each, mgd	7.0
Grit pump: Recessed impeller	
Grit separation: Cyclone	
Grit dewatering: Auger	
Trickling filter	
Number	1
Diameter, ft	75
Media depth, ft	16
Hydraulic load[c], gpm/sq ft	0.8
BOD load[c], ppd/1,000 cf	100
Interstage pumping	
Number of pumps	3
Capacity each, mgd	4.4
Aeration	
Basins	
Number	2
Width, ft	20
Water depth, ft	14
Length, ft	120
Volume each, 1,000 gallons	250
Blowers	
Type: Multistage centrifugal[a]	
Number	3
Capacity each, scfm	750
Secondary clarifiers	
Type: Flocculator, peripheral weir	
Number	2
Diameter, ft	62

Item	Value
Sidewater depth, ft	16
SOR at peak day, gpd/sq ft	845
SOR at PWWF, gpd/sq ft	1,143
RAS pumping (per clarifier)	
Number of pumps	2
Capacity each, gpm	600
Disinfection	
Type: Closed vessel, medium pressure[a]	
Number of trains	3
Capacity each, mgd	2.3
Lamps per train	8
Outfall	
Length	700
Diameter, inches	24
Diffuser length, ft	200
Number of diffuser ports	50
Sludge thickener (existing)	
Type: Gravity belt	
Number	1
Belt width, m	1
Capacity, lb/hr	800
Thickened sludge tank	
Number	1
Diameter, ft	16
Volume, gallons	22,000
Height, ft	15
Anaerobic digesters	
Type: Mesophilic, fixed submerged cover	
Number	2
Diameter, ft (exist/new)	30/36
Sidewater depth, ft (exist/new)	14/24
Volume, cubic ft (exist/new)	12,070/28,400
SRT at peak month, days	28
Digested sludge holding tank	
Number	1
Diameter, ft	19
Height, ft	15
Volume, gallons	33,000

Item	Value
Sludge dewatering[d]	
Type: Belt or centrifuge[a]	
Number	1
Capacity, lb/hr	1,900
Facultative sludge lagoon[d]	
Number	1
Area, acres	1.9
Depth, ft	12
Loading, lbVSS/1,000 sq ft/day	20

Notes: [a] Equipment type selection is preliminary for cost estimating purposes. Selection may change during predesign.

[b] Influent pump station receives flow from new interceptor only. All other flow is pumped to plant from collection system pump stations.

[c] Maximum month flow and load conditions assumed.

[d] Either sludge dewatering or an FSL would be provided, not both. These solids handling options are preliminary selections subject to change during predesign.

SBR ALTERNATIVE

Although the biological process for SBR is similar to activated sludge, the practical operation is quite different. Process changes are made by adjusting cycle times rather than by adjusting return sludge rates and tank volumes.

Plant Schematic

A schematic diagram of the SBR alternative is presented in Figure 6-8. In this alternative, the wastewater flows into the SBR and effluent is then decanted in batches to an equalization basin. It is then pumped through the disinfection system to the outfall. As plant flow varies, the cycle times would vary accordingly, as determined by the control module.

Two basins are provided. While one basin is quiescent for settling, the other accepts raw wastewater. Partial redundancy is provided in that the process can continue to operate to some degree with one basin out of service.

Site Plan

A proposed layout for the SBR alternative is shown on Figure 6-9. As with the other alternatives, the general placement of the major unit processes is constrained by the site configuration and placement of existing process units. For example, the SBR basins must be constructed away from

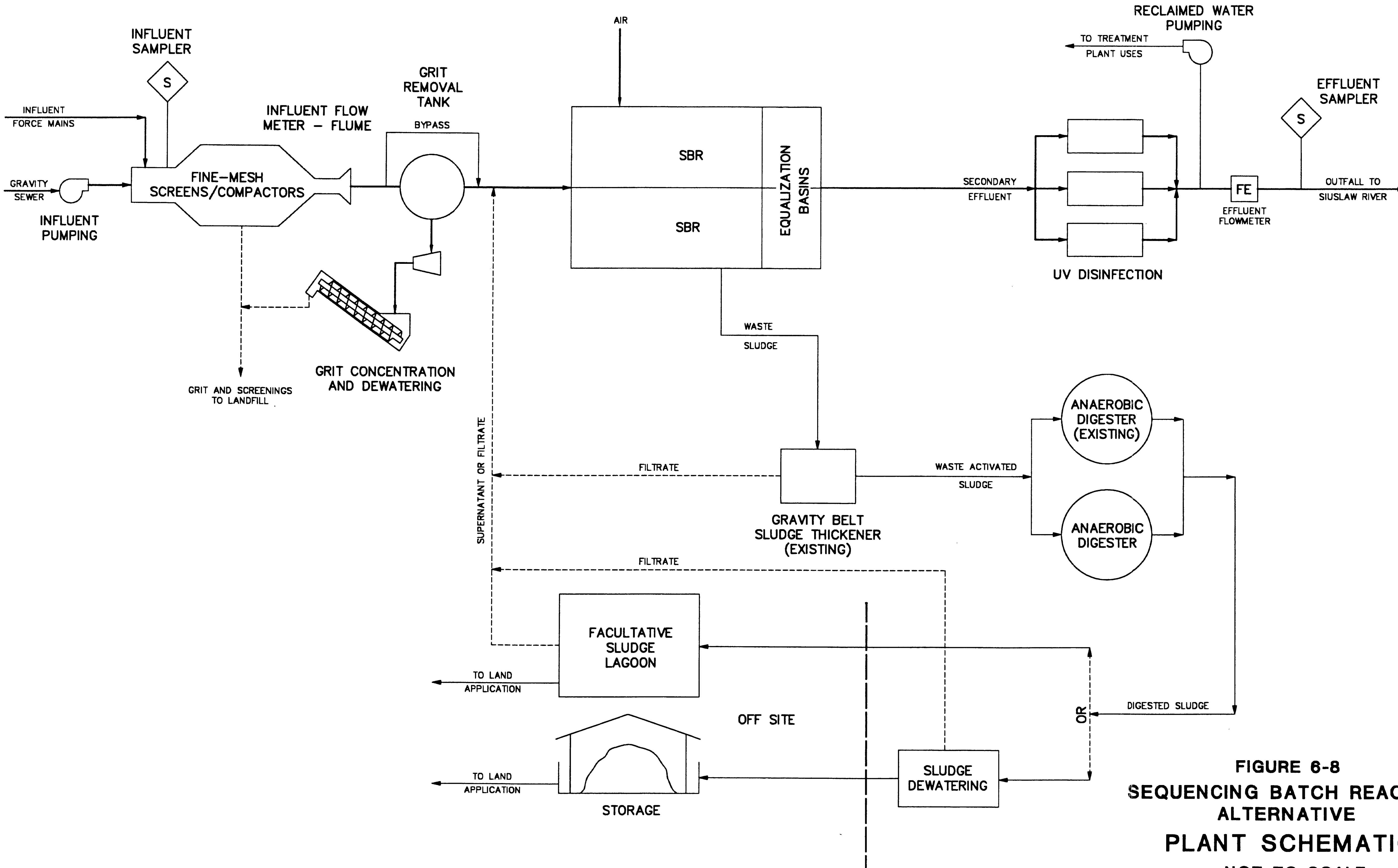

FIGURE 6-8
SEQUENCING BATCH REACTOR ALTERNATIVE
PLANT SCHEMATIC
NOT TO SCALE

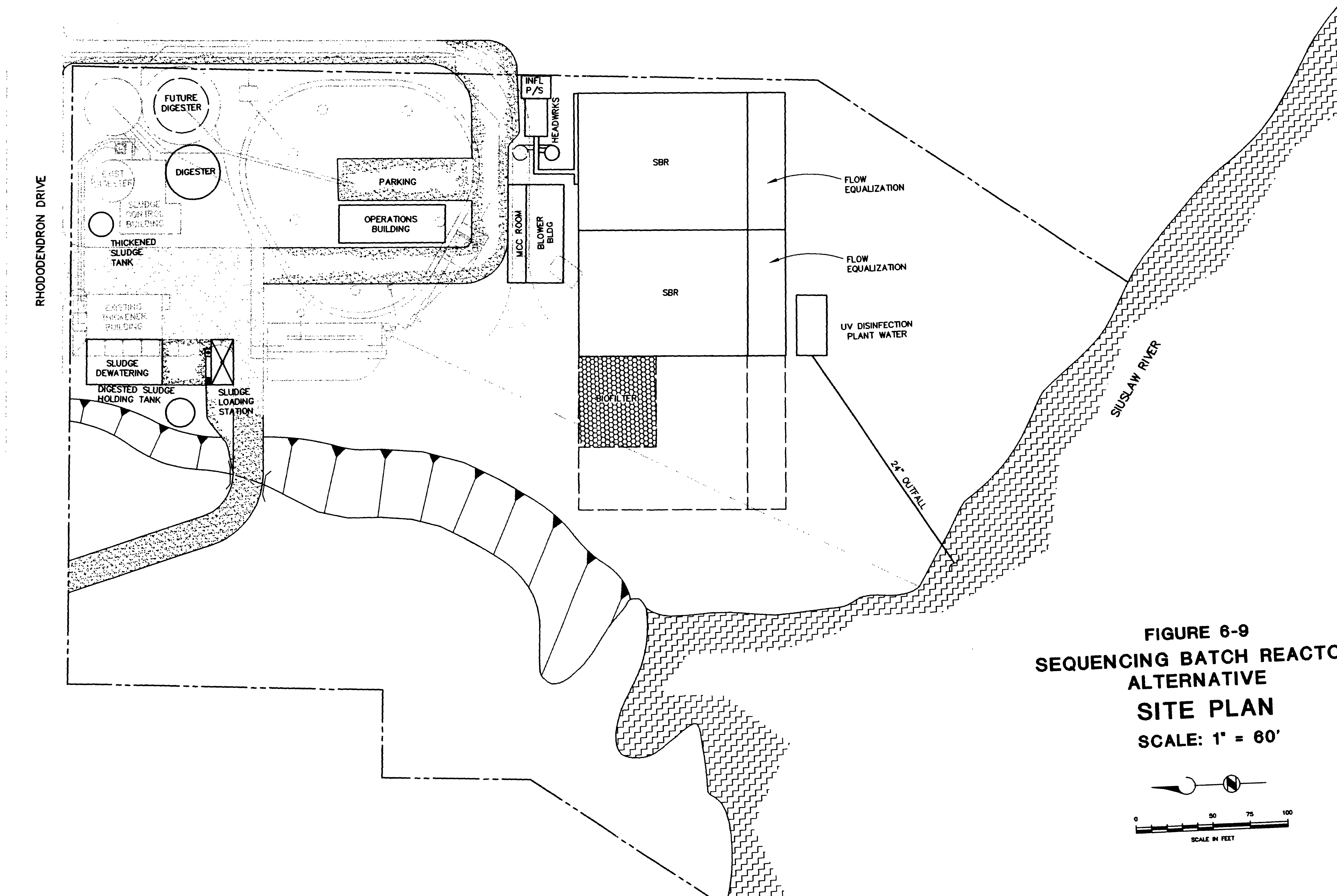

FIGURE 6-9
SEQUENCING BATCH REACTOR ALTERNATIVE
SITE PLAN
SCALE: 1" = 60'

the existing facilities to allow the existing plant to remain in service during construction. Once the SBR tanks and headworks are completed, the existing clarifiers can be removed allowing construction of a new digester.

Potential future expansions for the unit processes are shown in dashed lines on Figure 6-9. As with the activated sludge alternative, the layout can accommodate more than a doubling of the capacity provided in this phase.

Design Data

The design data for all of the unit processes in the SBR alternative are presented in Table 6-4. The values are those projected for the design year 2020. As under the other alternatives, design data beyond the design year are not included.

Table 6-4. Design Data For SBR Alternative

Item	Value
Plant flow	
ADWF, mgd	1.9
Peak month, mgd	3.6
Peak day, mgd	5.1
PWWF, mgd	6.9
Plant load	
BOD average, ppd	5,300
BOD max month, ppd	7,000
SS average, ppd	3,800
SS max month, ppd	4,800
Influent Pumps	
Type: Self-priming[a]	
Number	3
Capacity each, mgd[b]	1.5
Screen	
Type: Fine-mesh in-channel	
Number	2
Opening size, inches	0.25
Capacity each, mgd	5.3
Emergency bypass bar rack	
Number	1
Opening size, inches	1
Capacity, mgd	6.9

Item	Value
Grit Removal	
Grit chamber: Induced vortex	
Number	2
Diameter, ft	10
Capacity each, mgd	7.0
Grit pump: Recessed impeller	
Grit separation: Cyclone	
Grit dewatering: Auger	
Sequencing batch reactor	
Basins	
Number	2
Width, ft	92
Maximum water depth, ft	20
Bottom water level (decanted), ft	14
Length, ft	108
Volume each, 1000 gallons	1,500
Blowers	
Type: Multistage centrifugal[a]	
Number	3
Capacity each, scfm	3,700
Disinfection	
Type: Closed vessel, medium pressure[a]	
Number of trains	3
Capacity each, mgd	2.3
Lamps per train	8
Outfall	
Length	700
Diameter, inches	24
Diffuser length, ft	200
Number of diffuser ports	50
Sludge thickener (existing)	
Type: Gravity belt	
Number	1
Belt width, m	1
Capacity, lb/hr	800
Thickened sludge tank	
Number	1
Diameter, ft	16
Volume, gallons	22,000

Item	Value
Height, ft	15
Anaerobic digesters	
Type: Mesophilic, fixed submerged cover	
Number	2
Diameter, ft (exist/new)	30/36
Sidewater depth, ft (exist/new)	14/24
Volume, cf (exist/new)	12,070/28,400
SRT at peak month, days	28
Digested sludge holding tank	
Number	1
Diameter, ft	19
Height, ft	15
Volume, gallons	33,000
Sludge dewatering[c]	
Type: Belt or centrifuge[a]	
Number	1
Capacity, lb/hr	1,900
Facultative sludge lagoon[c]	
Number	1
Area, acres	1.9
Depth, ft	12
Loading, lbVSS/1,000 sq ft/day	20

Notes: [a] Equipment type selection is preliminary for cost estimating purposes. Selection may change during predesign.

[b] Influent pump station receives flow from new interceptor only. All other flow is pumped to plant from collection system pump stations.

[c] Either sludge dewatering or an FSL would be provided, not both. These solids handling options are preliminary selections subject to change during predesign.

CHAPTER 7

DEVELOPMENT OF SOLIDS MANAGEMENT OPTIONS

Solids management includes thickening, stabilization, and disposal of sludge produced in the biological treatment process. The quantity of solids produced in the biological treatment process is estimated at about 3,000 pounds per day. Assuming that the solids are 80 percent volatile and 55 percent reduced in the digestion process, this would result in production of about 1,600 pounds per day of digested sludge requiring disposal. Disposal is the most complex issue and the most difficult to resolve. The city currently has limited land available for sludge disposal. Although production of Class A sludge would increase disposal options, the additional cost or process requirements may not justify that option. In this discussion alternatives are broken down into two categories: production of Class A and Class B biosolids.

CLASS A BIOSOLIDS

As discussed in Chapter 5, sludge must meet Class A pathogen requirements to be land-applied without restriction. Although there are several methods of achieving Class A pathogen levels, many are better suited for larger plants or are prohibitively expensive. For this evaluation, Class A processes are categorized into two groups: processes utilized in conjunction with anaerobic digestion and the autothermophilic digestion process.

ANAEROBIC DIGESTION WITH ADDITIONAL TREATMENT

The plant currently uses anaerobic digestion to stabilize sludge, resulting in Class B biosolids. Under these alternatives, anaerobic digestion would continue to be used, with another process added to achieve Class A quality.

Anaerobic Digestion Improvements

To meet the increased loading projected for the future and to provide redundancy, a second anaerobic digester should be constructed and the existing digester should be refurbished. The new digester would be heated and mixed. A new boiler would be provided for digester and space heating. The boiler would operate on digester gas with oil as a standby fuel. The new digester would have either a fixed submerged or a floating cover. If a fixed cover were used, a separate digested sludge holding tank would be provided. Both digesters could then be fed continuously at a constant rate overflowing to the holding tank. Digested sludge could be withdrawn from the holding tank for hauling and/or dewatering as the operator's schedule dictated.

The existing digester will be emptied and cleaned when the new digester is operational. The upgrade would include new heating and mixing systems. Heat would be supplied by the boiler provided for the new digester. The inside of the tank would be thoroughly inspected and the appropriate structural repairs made.

The existing building will be evaluated for use as a digester control building for both digesters. The building could also house the standby engine generator set and maintenance shop if space permits. An alternative location for the engine generator would be the blower building.

A complete new gas management system would be provided, including controls for supplying digester gas to the new boiler, a waste gas burner, and all the required safety provisions for gas handling. Sufficient gas should be available to supply nearly all of the sludge heating requirements.

Additional Processing for Class A Biosolids

In the alternative development brainstorming session, it was agreed to evaluate pasteurization, irradiation, and composting as processes to be added to the existing digestion process.

Pasteurization is a sludge heating process in which the raw sludge is heated to 160 degrees F for 30 minutes. The process must take place upstream of anaerobic digestion or regrowth of pathogens occurs. Heating is normally accomplished with hot water and heat recovery heat exchangers. Additional tankage is necessary to provide the 30-minute detention time. The equipment is fairly complex and expensive. For a small plant, the complexity is greater than what operators are normally familiar with. As with any process in which sludge is heated, odor is a potential problem. Previous evaluations of this process have eliminated it based on the high construction and operational cost, potential odor problems, and lack of experience with the process in the United States. It is better suited to a larger plant where complex mechanical systems and large odor control facilities are already present.

Irradiation uses beta or gamma rays to disinfect the sludge. The process is currently used by the food industry to increase the shelf life of perishable foods. However, the equipment used in food irradiation is not well adaptable to sludge processing. Evaluations at other plants have eliminated this option on the basis of a high capital cost and lack of use in wastewater applications. Furthermore, public concern with radiation could make siting the facility in Florence difficult.

Composting is the aerobic thermophilic decomposition of organic material. In this process, dewatered digested sludge would be mixed with a bulking agent (for example, wood chips) to absorb water and aerate in windrows or static piles. The amount of bulking agent required depends mainly on the solids content in the sludge. For composting to proceed, the solids content of the mixture should be between 40 and 60 percent. If the sludge dewatering process produces a sludge with a solids content of 25 percent, the volume ratio of bulking agent to sludge would be roughly 2 to 1, depending on sludge and bulking agent characteristics. This would result in an average contribution of about 10 cubic yards per day to the composting process. Quantities of finished product would be less than this because bulking agent would be screened from the finished compost and returned to the process. The end product of composting is high quality and could be more acceptable to users than any other sludge product. Because the process produces odor and occupies a large area, a large, remote site with plenty of buffer area would be required. The process is labor intensive and has high operational costs. However, the type of equipment required is typical to municipal operations: blowers, trucks, and front end loaders, for example. Capital costs would be relatively low, although some type of structure would be required to shelter the compost from the rain. Availability of bulking agent would have a significant effect on the operating costs. Experience with other small plants indicates that composting is often the lowest cost and most practical method of achieving Class A pathogen reduction with anaerobically digested sludge. Composting should continue to be considered if an appropriate site becomes available.

AUTOTHERMOPHILIC AEROBIC DIGESTION (ATAD)

ATAD is a single process that stabilizes the sludge, reduces the vector attraction, and reduces the pathogens to a Class A level. In this process, thickened sludge is aerobically digested at a high rate in two tanks in series. The heat generated by the reaction raises the sludge temperature to about 140 degrees F. The tanks are insulated to help maintain this temperature.

The process has a detention time of about 6 days. This is about one-third the detention time that anaerobic digestion requires. Consequently, the tanks would be about one-third the size. Like any aerobic digestion process, energy consumption is high. However, the short detention time reduces the significance of the energy consumption.

The quality of the digested sludge is poorer than that of anaerobically digested sludge. Odors are very strong unless it is dewatered. Dewatering is also more difficult than for anaerobically digested sludge.

The most significant concern with the process is odor. Although odor control would be included with the process, the city cannot accept the risk of odor caused by process upset or odor control malfunction. Several homes are located adjacent to the plant site.

The capital cost of ATAD is generally somewhat lower than that of anaerobic digestion. However, including the cost of odor control and the fact that a major portion of the anaerobic digestion process is already in place in Florence, the capital cost of ATAD would not be lower.

Based on the odor concerns and the fact that the process does not utilize the existing anaerobic digester, ATAD was eliminated from further consideration.

CLASS B BIOSOLIDS

The city's existing anaerobic digestion system currently produces Class B biosolids. The city is able to dispose of the sludge on land despite the restrictions imposed on disposal of Class B sludge. However, if the city is to continue this strategy, some action must be taken to meet the requirements of increasing sludge production in the coming years. Options include: continuing to apply liquid sludge on private land, applying liquid on dedicated land, dewatering sludge to increase storage capacity, and construction of a lagoon for storage and treatment.

LAND APPLICATION OF ANAEROBICALLY DIGESTED LIQUID SLUDGE

The city's existing program utilizes this strategy on private land. Continuing this program would be the least cost alternative for sludge disposal for now. However, as sludge production increases, more land will soon be required. Additional private land is difficult to find and will require hauling liquid sludge greater distances. Eventually, the costs may become higher than those for other alternatives. Furthermore, reliability is poor. During wet weather sludge cannot be applied, resulting in the accumulation of excess solids in the treatment process. Applying sludge to this land also incurs the risk of contamination of watercourses. Application is also subject to the constraints of the landowner.

Another possible alternative for access to land for disposal is through the Federal Land Policy and Management Act of 1976. This act specifies that U.S. Forest Service and Bureau of Land Management lands may be used by municipalities for various purposes. Although initial discussions with the Forest Service indicate that the appropriate type of land may not be available in the Florence area, this option should be pursued further.

If the city were to buy land, sludge could be sprayed on that land with little risk. Liquid sludge could be spread at agronomic rates indefinitely. Special protection would be provided near any water bodies to reduce the risk of contamination.

STORAGE AND APPLICATION OF DEWATERED DIGESTED SLUDGE

This option would require that the city buy land to provide storage space. The advantages of dewatering the sludge are that hauling is much less expensive and storage is easier and requires less space. This option becomes more economically advantageous if sludge must be hauled over greater distances. Storage would eliminate the problem of accumulation of solids in the plant during inclement weather periods. An inexpensive structure would be required to shelter the stored sludge from the rain. Conventional agricultural equipment would also be necessary to apply dewatered sludge. This option should continue to be considered.

A patented variation of this process, called Centridry, produces sludge containing about 60 percent solids. This process provides the same advantages as conventional dewatering, except that the storage and hauling requirements are reduced even more. However, the equipment for this process is very expensive. Discussions with a manufacturer's representative indicate that the equipment cost for Florence would be more than two million dollars. The process was evaluated for a large plant in Vancouver, Canada, and even with the economies of scale was found to be uneconomical even though sludge hauling distances were over 100 miles.

FACULTATIVE SLUDGE LAGOON

A facultative sludge lagoon (FSL) provides an excellent means of long-term storage for liquid sludge. It also provides flexibility in maintenance of the digesters at the plant. If a digester must be emptied, the contents can be transferred to the FSL. Sludge removed from the FSL is of higher quality than freshly digested sludge. There are currently studies underway to determine whether air drying lagoon-treated sludge could meet Class A standards, although it is not now considered as an option for Class A biosolids.

Sludge is delivered to and from the FSL in a tank truck. It is removed from the FSL using a floating dredge.

An FSL provides flexibility in sludge disposal schemes. First, it provides about 2 years of sludge storage capacity, during which time no land disposal would be required. When land disposal recommences, the storage provided by the FSL allows the operator to work around long periods of poor weather, equipment breakdowns, or other constraints to land disposal. Liquid sludge could be land-applied at the FSL site, eliminating the need for additional hauling.

Disadvantages of an FSL include potential odor and insect nuisance problems, land area requirements, cost of construction, and potential resistance from the public. A major portion of the cost is from the liner required to eliminate leakage into the groundwater. The liner would be particularly important in the Florence area because of the sandy soils. The land area requirements would be greater than for dewatered sludge storage. A large buffer area would also be required.

Although some sludge lagoons constructed in the past have presented significant odor problems, proper design minimizes the odor potential. Criteria for design include:

- Sufficient depth for an adequate aerobic zone above the sludge storage (anaerobic) zone.
- Proper loading rate.
- Consideration of wind direction in pond layout to minimize wave action.
- Sufficient buffer area.

The large amount of rainfall along the coast poses another disadvantage for an FSL in that allowance must be made for the rainwater entering the FSL. To account for the additional water, the lagoon must be made deeper and more supernatant must be hauled back to the treatment plant. To minimize the impact of rainwater accumulation, the lagoon should be made as small as possible. By phasing the construction, a smaller lagoon could be built now, with provisions for expansion when needed. Much of the supernatant could be hauled on the return trips from hauling sludge to the lagoon. The supernatant would not require additional hydraulic capacity at the plant because hauling could be suspended during peak flow periods. Supernatant could also be irrigated on the land adjacent to the lagoon during the summer. A larger site would be advantageous in that it could accommodate more irrigation of supernatant. Application of supernatant would be limited to agronomic rates and would require harvesting to remove the accumulated nutrients. With summertime irrigation, extra trips (in addition to sludge-hauling trips) for hauling supernatant would probably be unnecessary. Alternatively, if a site is found reasonably close to the wastewater collection system, supernatant could be returned via a pipeline.

The FSL option should continue to be considered. Even if it is not economical at this time, it may become more so in the future if sludge disposal sites become more scarce.

SUMMARY AND RECOMMENDATIONS

Composting is the only option for producing Class A biosolids that has not been eliminated. The cost and labor efforts should be evaluated and compared with the Class B options. Composting will cost more than the Class B options, but provides more flexibility in sludge disposal. All of the Class B options should be evaluated further. Most likely, the recommended solids handling program will include a combination of several of the Class B options.

The one factor common to all the options recommended for further evaluation is the requirement for land. Acquisition of land would provide the city with the flexibility to pursue any combination of the recommended options as regulations, costs, and public response dictate. It would be very beneficial for the city to pursue acquiring a parcel in the range of 50 to 100 acres. Some criteria to consider in evaluating land are:

- Hauling distance from the plant and to other application sites
- Topography
- Access
- Distance from residents
- Watercourses, groundwater, and nearby water bodies
- Soil type

Land that is used for wastewater and sludge treatment or disposal purposes is eligible for State Revolving Fund loans. Given the high cost of other sludge treatment options, land acquisition will be an economical strategy as well as providing the flexibility discussed above.

Land acquisition also represents a better investment than capital equipment. While land at least retains and typically increases its value, equipment depreciates. For example, if the city buys land for liquid sludge disposal, sludge dewatering would be unnecessary, saving the cost of dewatering equipment. If the city's course of action changes in the future, the value of the land could be recovered by selling the land. On the other hand, dewatering equipment would have very little salvage value.

In conjunction with the purchase of land, the city will need to purchase sludge hauling equipment. Because it is likely that the city will continue applying liquid sludge to land for at least a portion of the sludge generated, a new 6,000 gallon tank truck should be purchased. The existing tank truck has a capacity of only 3,000 gallons, requiring twice as many trips. Furthermore, its reliability is questionable due to its age, high mileage, and heavy use. If sludge dewatering is employed, a dry box or dump truck will be necessary, as well as spreading equipment.

DEVELOPMENT OF COMPLETE SOLIDS HANDLING OPTIONS

There are many possible solids handling options utilizing different combinations of the processes recommended earlier in this chapter for further evaluation. Four major options have been developed for the detailed evaluation. A brief description of these options is presented below.

The four solids handling options are:

- ATAD with dewatering of digested sludge.
- Anaerobic digestion with dewatering of digested sludge.
- Anaerobic digestion with dewatering and composting of digested sludge.
- Anaerobic digestion with FSL storage.

These options are presented in Table 7-1 below with a listing of the major components of each option and the class of sludge produced.

Table 7-1. Solids Handling Options

Option	ATAD	Dewatering	Composting	FSL
Major components	ATAD Holding tank Dewater Storage Apply solid	Anaerobic digestion Dewater Storage Apply solid	Anaerobic digestion Dewater Compost Storage Apply/give away	Anaerobic digestion (Thicken) FSL Apply liquid Irrigate supernatant
Sludge class	A	B	A	B
Land area (process)	20 acres	20 acres	25 acres	50 acres
Land area (application)	50 acres	100 acres	25 acres	100 acres

A detailed evaluation of these options is presented in Chapter 8.

CHAPTER 8

EVALUATION OF ALTERNATIVES

In this chapter, the treatment alternatives developed in Chapters 6 and 7 are evaluated in detail. In this evaluation, both economic and noneconomic factors are considered.

ECONOMIC EVALUATION BACKGROUND

To make a valid comparison among alternatives, a present worth analysis is necessary in order to incorporate both capital and annual costs in the evaluation. In developing costs for the present worth analysis, many assumptions must be made to compensate for the lack of detail available during the facilities planning process. The analysis techniques and assumptions made are described below.

PRESENT WORTH ANALYSIS

In a present worth analysis, annual costs over the economic life of the alternative are brought from the future back to the present, discounted by an annual percentage rate called the discount rate. Once the annual costs are brought to the present as a single sum, they can be added to the capital cost to derive the total present worth. For this analysis, the discount rate is assumed at 8 percent. The analysis period, or economic life, is assumed to be 20 years. Salvage values, or the value at the end of the 20-year study period, are not considered in this analysis.

PRECISION OF COST ESTIMATES

The precision of a cost estimate is a function of the detail to which alternatives are developed and the techniques used in preparing the actual estimate. The American Association of Cost Engineers divides estimates into three basic categories:

1. Order-of-Magnitude Estimate. An order-of-magnitude estimate is made without detailed engineering data. Techniques such as cost-capacity curves, scale-up or scale-down factors, and ratios are used in developing this type of estimate. This type of estimate is normally accurate within +50 percent or -30 percent. That is, the final cost may be as much as 50 percent more or 30 percent less than the estimated amount. A relatively large contingency is normally included to reduce the probability of underestimating.

2. Budget Estimate. This estimate is prepared using process flow sheets, layouts, and equipment details. An estimate of this type is usually accurate within +30 percent and -15 percent.

3. Definitive Estimate. As the name implies, this estimate is prepared from well-defined engineering data, including construction plans and specifications. As a minimum, the data would include comprehensive plot plans and elevations, piping and instrument

diagrams, electrical diagrams, equipment data sheets and quotations, structural drawings, soil data and drawings, and a complete set of specifications. The definitive estimate is expected to be accurate within +15 percent and -5 percent.

The estimates presented in this document are order-of-magnitude estimates because the design has not been developed in sufficient detail for a more precise estimate. Although the final project cost may vary significantly from these estimates, the estimates are useful in evaluating alternatives because they are fairly accurate relative to each other.

BASIS FOR COSTS OVER TIME

Future changes in the costs of material, labor, and equipment will cause comparable changes in the costs presented in this analysis. However, because the relative economy of the alternatives should change only slightly with overall economic changes, the decisions based on the economic evaluation should remain valid.

Costs can be expected to undergo long-term changes in keeping with corresponding changes in the national economy. One of the best available indicators of these changes is the *Engineering News-Record* (ENR) construction cost index. It is computed from the prices for structural steel, Portland cement, lumber, and common labor, and is based on a value of 100 in the year 1913. Figure 8-1 shows the trend of the ENR index since 1980. The dashed portion of the line indicates expected future increases, based on the past trend.

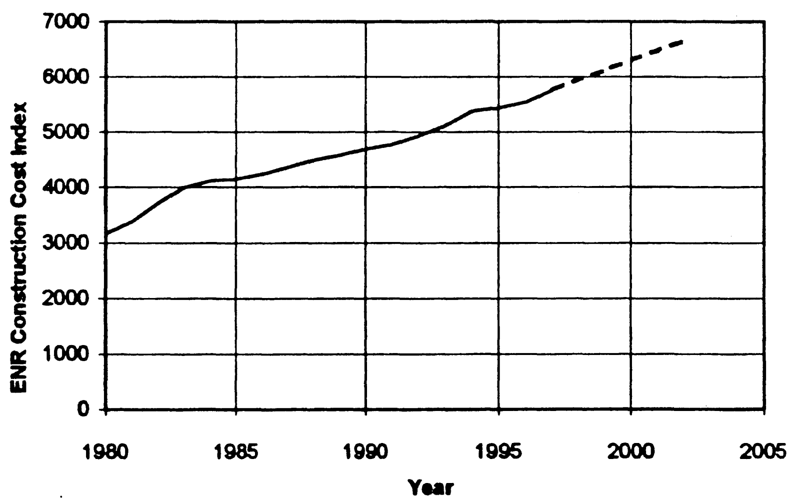

Figure 8-1. ENR Construction Cost Index Trend

The costs developed in this analysis are based on the current ENR 20-city index of 5800. The costs presented here may be related to those at any time in the past or future by applying the ratio of the then-prevailing cost index to 5800.

ENGINEERING AND ADMINISTRATIVE COSTS AND CONTINGENCIES

The cost of engineering services for major projects typically covers special investigations, a predesign report, surveying, foundation exploration, preparation of contract drawings and specifications, construction management, start-up services, the preparation of operation and maintenance manuals, and performance certifications. Depending on the size and type of project, engineering costs may range from 13 to 20 percent of the contract cost when all of the above services are provided. The lower percentage applies to large projects without complicated mechanical systems. The higher percentage applies to small, complicated projects and projects that involve extensive remodeling of existing plants.

The City of Florence has its own administrative costs associated with any major construction project. These include internal planning and budgeting, the administration of engineering and construction contracts, legal services, and liaison with regulatory and funding agencies. For a typical project of this size, the city's administrative costs will be about 4 percent of the contract cost. The total cost for engineering and administration is assumed to be 20 percent.

ECONOMIC COMPARISON OF LIQUID STREAM ALTERNATIVES

The three treatment alternatives developed in Chapter 6 are activated sludge, trickling filter/solids contact, and sequencing batch reactor. Construction cost breakdowns for each alternative are presented first, followed by annual costs. Then the construction and annual costs are combined in the present worth analysis.

CONSTRUCTION COSTS OF ALTERNATIVES

The construction costs for the alternatives, broken down by process area, are summarized in Table 8-1. Costs of engineering and administration are not included, as these costs do not affect the relative cost of one alternative compared to the others. Construction cost estimates for the components of these alternatives are based on costs of other similar installations, estimates of quantities of materials, and cost curves from various sources.

As indicated in the table, the construction costs for all three alternatives are very similar. Within the accuracy of this estimate, the cost totals for activated sludge and trickling filter/solids contact (TF/SC) are indistinguishable. The sequencing batch reactor (SBR) alternative is about 6 percent less costly. Although SBRs often have a significantly lower construction cost than the other alternatives in this flow range, only minor savings are indicated in this estimate. The unusually high cost of the SBR system is a result of the abnormally high biochemical oxygen demand loading at the Florence plant. The SBR, which is an extended aeration process, must utilize exceptionally large aeration basins and aeration equipment to treat the heavy organic load.

Table 8-1. Construction Cost Breakdowns for Liquid Stream Treatment Alternatives

Item		Costs, $1,000		
		A/S	TF/SC	SBR
Contractor indirects		469	469	469
Influent pumping		368	368	370
Yard development		384	373	373
Headworks		773	773	773
Odor control		237	237	237
Trickling filter		0	1,145	0
Aeration basins		866	434	1,631
Blower building		553	286	420
Secondary clarifiers		1,381	1,247	0
Yard piping		341	341	256
Flow equalization		0	0	160
Electrical/instrumentation		1,680	1,470	1,848
Disinfection		692	692	692
Outfall		558	558	558
Operations building		287	287	287
Subtotal		8,589	8,680	8,073
Bond @	1%	86	87	81
Contingency @	15%	1,288	1,302	1,211
Total construction cost		9,963	10,069	9,365

ANNUAL COSTS OF ALTERNATIVES

Estimated annual costs and the present worth of the annual costs are summarized in Table 8-2. Annual costs include electrical power consumption, labor, and chemical use. The major power-consuming processes are aeration and ultraviolet disinfection. Labor costs are estimated by assuming a number of shifts required to operate the plant and perform routine maintenance. Because the alternatives do not use chlorine for disinfection, chemical use is zero. Polymer use for sludge thickening is included in the solids handling cost estimate.

Table 8-2. Annual Costs for Liquid Stream Treatment Alternatives

Item	Costs, $1,000		
	A/S	TF/SC	SBR
Power, $1,000[a]	74	52	104
Labor[b]	374	331	331
Chemicals	0	0	0
Total annual cost	448	383	435
Present worth of annual cost[c]	4,394	3,755	4,271

Notes: [a] Power assumed at $0.05 per kWh.

[b] Labor assumed at $35 per hour, with supervisor at $45/hour.

[c] Present worth based on discount rate of 8% and 20 year life.

As expected, the low electrical power and labor requirements for TF/SC result in the lowest annual cost for this alternative. The computerized controls and lack of secondary clarifiers for the SBR result in low labor costs, but the extended aeration process of the SBR system consumes the highest amount of electrical power, resulting in a high annual cost. The efficient activated sludge aeration process uses less electrical power than the SBR. However, labor costs are higher because the significant flexibility offered by the activated sludge process requires more operator attention.

PRESENT WORTH COST OF LIQUID STREAM ALTERNATIVES

The total present worth cost of each alternative incorporates both the construction cost and the annual costs. By determining the present worth of the annual costs, they can be added to the construction cost, giving one value to form the basis for the economic comparison of the alternatives. These costs are presented in Table 8-3. The difference in total present worth between the lowest cost and highest cost alternative is only 5 percent. This difference is insignificant within the accuracy of this estimate.

Table 8-3. Present Worth Cost of Liquid Stream Alternatives

	Costs, $1,000		
Item	A/S	TF/SC	SBR
Construction cost	10,050	10,127	9,451
Present worth of annual cost[a]	4,394	3,755	4,271
Total present worth[a]	14,444	13,882	13,722

Note: [a]Present worth based on 8 percent discount rate over 20 years.

EVALUATION AND RANKING OF LIQUID STREAM ALTERNATIVES

The liquid stream treatment alternatives are activated sludge, TF/SC, and SBR. A brief evaluation of the alternatives relative to each of the ranking criteria, followed by the selection recommendation, is presented below.

ENVIRONMENTAL IMPACTS

Most of the environmental impact criteria are affected equally by each alternative. For example, all three alternatives would have an equivalent effect on water quality, air quality, solid waste generation, and historic preservation. Energy consumption is one criterion which distinguishes the alternatives. The SBR alternative consumes twice as much energy as TF/SC. Activated sludge energy consumption is midway between the other alternatives. The SBR alternative also requires more land closer to the river than do the other alternatives. For this criterion, activated sludge and TF/SC are ranked equal, with SBR ranked lower.

EASE OF IMPLEMENTATION

This factor refers to the ease of construction and start-up while maintaining the existing process in operation. The SBR alternative has a slightly greater ease of implementation because the entire process would be constructed away from the existing plant. However, the other alternatives present no significant difficulty because the headworks and biological treatment units would be constructed away from the existing plant. Once these units are in service, secondary clarifiers could be constructed without difficulty in the location of the existing aeration basin. Therefore, this factor is not considered to favor one alternative over another.

EASE AND RELIABILITY OF OPERATION

TF/SC and SBR are ranked equivalent with respect to ease of operation. Activated sludge requires more operator attention, particularly when flow and load conditions change. However, this is not considered a significant disadvantage because activated sludge is the process currently utilized and best understood by the city staff.

TF/SC is considered the most reliable process. The trickling filter handles flow and load variations well and is a simple process requiring little attention. The process is not dependent on continuous functioning of complex components. SBR is considered less reliable because the entire process relies on proper operation of the computerized control system, automatic valves, and the decant system. Failure of any of these components could have a major impact on treatment. Activated sludge is nearly as reliable as TF/SC. It is not vulnerable to failure of a single component, but does require more operator attention to optimize treatment. With respect to reliability, activated sludge and TF/SC are ranked equally, with SBR ranked lower.

PERMITS AND REGULATORY ASPECTS

The three alternatives are well-known and accepted by the regulatory agencies. All three alternatives are ranked equally with respect to this criterion.

FLEXIBILITY

Flexibility refers to both the flexibility in operation and future expansion. Activated sludge is the most flexible in operation. There are several modes of operation available to optimize treatment under various conditions. Sludge reaeration and step feed modes protect the solids inventory during peak flow periods. Biological selector modes can be used to improve sludge settling characteristics during low flow periods. Basins can be removed from service as flows and loads permit. SBR is also rather flexible. The timing of the sequence can be adjusted easily to optimize treatment under varying conditions. However, basins can not generally be removed from service on a long-term basis. TF/SC is less flexible; the entire filter is either used or bypassed. However, operational flexibility is less necessary because of the stability of the process. Activated sludge is ranked the highest in operational flexibility, with TF/SC and SBR ranked second.

With respect to construction and future expansion, activated sludge is the most flexible. Basins of the optimum size can be added in phases as increasing loads demand. For TF/SC and SBR, an entire new unit must be added when loads demand, resulting in paying for more excess capacity for the early years of the design period. This disadvantage is more significant for TF/SC because the excess capacity can lead to decreased treatment efficiency. Activated sludge is ranked the highest, with SBR second and TF/SC third.

AESTHETICS

The aesthetics criterion refers to visual and other effects (noise, odor, traffic) on nearby residents and the public. With respect to nonvisual effects, all three alternatives are considered equivalent, assuming that the trickling filter would be covered and provided with odor control; effects will be minimal. With respect to visual effects, activated sludge is ranked the highest. TF/SC is ranked second as a result of the high profile of the trickling filter. The top of the filter would be about 18 feet above grade with the cover reaching several feet above that. SBR is ranked third because the relatively large tanks would be situated close to the river. This location is visible from several homes as well as condominiums upstream along the river. The tanks would also have a greater impact on the view of river users and people in the sand dunes.

ECONOMICS

The budgetary cost estimates for the three alternatives were presented above and summarized in Table 8-3. The 1.5 percent difference between the present worth costs of TF/SC and SBR is insignificant within the accuracy of the estimate. The 6 percent difference between the costs of activated sludge and SBR is also of little significance. On the economic basis, TF/SC and SBR are ranked first, with activated sludge ranked lower.

SELECTION OF RECOMMENDED ALTERNATIVE

The rankings of the alternatives with respect to the criteria discussed above are summarized in Table 8-4. Criteria for which all three alternatives are considered equal are not included in the table.

Table 8-4. Summary of Treatment Alternative Rankings

	Alternative Ranking		
Criteria	**A/S**	**TF/SC**	**SBR**
Environmental impact	1	2	3
Reliability	1	1	2
Flexibility in expansion	1	3	2
Flexibility in operation	1	2	1
Aesthetics	1	2	3
Economics	2	1	1

As the table shows, the activated sludge alternative is ranked first in every category except cost. Although cost is considered one of the most important criteria, the cost differential between the alternatives is so small that ranking on the basis of cost should not be given much weight. Within the accuracy of the budgetary cost estimates, the difference between the alternatives is almost insignificant.

From a cost standpoint, a more significant criterion is flexibility in expansion. Providing more flexibility in expansion will afford the city definite cost savings in the future. Activated sludge provides the most flexibility.

Reliability and aesthetics are also considered very important. Past violations of the discharge permit have caused controversy within the city. It is crucial to the city that violations do not occur in the future. Providing the most reliable plant will ensure that violations of the permit do not occur. Aesthetics are important because the plant is located close to residences and recreational areas. Tourism represents a significant portion of the city's economy. A plant with the least aesthetic impact will have the least effect on tourism and will be the most easily accepted by stakeholders in the community.

Any of the three alternatives would provide a reliable, operator-friendly plant for a reasonable cost. Taking into account all the factors discussed above, activated sludge would provide the best fit for the city's needs. Consequently, activated sludge is the recommended alternative.

ECONOMIC COMPARISON OF SOLIDS HANDLING OPTIONS

Four major options were developed in Chapter 7 for detailed evaluation. An economic evaluation of these options are presented below.

CONSTRUCTION COSTS OF OPTIONS

The construction costs for the options are summarized in Table 8-5.

Construction cost estimates for the solids handling options have been developed in the same manner as described above for the liquid stream treatment alternatives. The price of land is assumed at 3,000 dollars per acre, based on preliminary investigations into availability of land.

The facultative sludge lagoon (FSL) is the lowest cost option by about 20 percent. Excluding the cost of land, composting is the most expensive option. However, because it is assumed that compost would require 25 percent as much land for application as would dewatered sludge, the total cost for composting is less than for dewatering. The reduced land requirement for compost results from the lack of restrictions on application of the Class A material, and the assumption that about half of the finished compost could be given to the public.

Table 8-5. Construction Costs for Solids Handling Options

Item	Costs, $1,000			
	ATAD	Dewatering	Composting	FSL
ATAD equipment, tanks	1,150	--	--	--
ATAD foundation (includes piles)	78	--	--	--
Feed and discharge pumps, piping	70	--	--	--
Convert exist digester to holding tank	100	--	--	--
Anaerobic digestion and holding tanks	--	1,483	1,483	1,483
Sludge dewatering	1,001	1,001	1,001	--
Dry box truck	60	60	60	--
Dewatered sludge storage	475	475	475	--
Manure spreader	72	72	72	--
Loader	100	100	100	--
Blower, air piping	--	--	10	--
Shredder	--	--	52	--
Chipper	--	--	30	--
Tank truck	--	--	--	100
Dredge	--	--	--	50
FSL	--	--	--	460
Supernatant irrigation system	--	--	--	50
Access road	50	50	70	100
Subtotal	3,156	3,241	3,353	2,243
Contingency @ 15 percent	473	486	503	336
Land	210	360	150	450
Total	3,839	4,087	4,006	3,029

ANNUAL COSTS OF OPTIONS

The estimated annual costs for the four solids handling options are summarized in Table 8-6. The assumption of round-trip hauling distance is critical to this analysis. As hauling distance is increased, the cost of the FSL option increases more rapidly because this option involves hauling liquid sludge, requiring more trips. Refer to the present worth comparison below for an estimate of the hauling distance at which FSL option and the dewatering option would break even.

Autothermophilic aerobic digestion (ATAD) is the only option with significant electrical power costs. ATAD is an aeration process which consumes a relatively large amount of energy. The other processes consume very little energy. Anaerobic digestion, on the other hand, produces digester gas that will be used for building heating, actually saving energy.

The most significant expense for the composting option is the labor required to mix the sludge with amendment, turn the piles, and screen the materials. It is assumed that the finished compost will be in sufficient demand by the public and that only half of the material will require land application.

Table 8-6. Annual Costs for Solids Handling Options

Item	Costs, $1,000			
	ATAD	Dewatering	Composting	FSL
Electrical power[a]	26	-2	2	2
Chemicals (polymer)	15	15	15	9
Labor for process[b]	38	38	93	6
Hauling to storage[c]	16	16	16	40
Application	21	21	11	53
Total annual cost	116	88	137	110
Present worth of annual cost[d]	1,140	865	1,341	1,082

Notes: [a] Electricity assumed at $0.05 per kWh. All options except ATAD include a $5,000 credit for anaerobic digester gas production.

[b] Labor assumed at $35 per hour.

[c] Hauling distance assumed at 20-mile round-trip.

[d] Present worth based on discount rate of 8 percent over 20-year period.

PRESENT WORTH COST OF SOLIDS HANDLING OPTIONS

The total present worth is the sum of the capital cost and the present worth of the annual costs. These costs are summarized in Table 8-7. ATAD and dewatering have about the same life cycle cost. Composting is more costly by about 7 percent. The FSL option is substantially less expensive in both capital and annual costs. The total present worth is about 80 percent that of the next most economical option. As mentioned above, this analysis is sensitive to hauling distance. As hauling distances become greater, the dewatering options become more favorable. Based on the assumptions made in this analysis, dewatering would become cost-effective if the distance to the application sites exceed 60 miles. This break-even distance could vary somewhat, depending on actual sludge production, truck capacity, labor rates, and other factors. However, for distances as short as 10 or 20 miles, the FSL is clearly the most cost-effective option. An additional economic advantage to the FSL option is that no land application would be required for the first two years of operation.

Table 8-7. Total Present Worth Costs for Solids Handling Options

Item	Costs, $1,000			
	ATAD	Dewatering	Composting	FSL
Construction cost	3,839	4,087	4,006	3,029
Present worth of annual cost	1,140	865	1,341	1,082
Total present worth[a]	4,979	4,952	5,347	4,111

Notes: [a] Present worth based on 8 percent discount rate and 20-year study period.

In this chapter the liquid and solids treatment alternatives developed previously are evaluated and ranked on the basis noneconomic factors as well as present worth cost. Noneconomic factors considered in this evaluation are environmental impacts, ease of implementation, ease and reliability of operation, regulatory aspects, flexibility, and aesthetics. The highest ranked alternatives are selected for the recommended plan.

EVALUATION AND RANKING OF SOLIDS HANDLING OPTIONS

The solids handling options are ATAD, dewatered digested sludge, composted digested sludge, and FSL. A brief evaluation of the alternatives relative to each of the ranking criteria, followed by the selection recommendation, is presented below.

ENVIRONMENTAL IMPACTS

Each of the options has fairly similar environmental impacts. They all require land for storage and application. The FSL would require more land for storage and fuel consumption for sludge hauling. The ATAD option would consume more energy than the other options. It would have a continuous power draw of about 60 horsepower as opposed to less than 5 horsepower for the other options.

EASE OF IMPLEMENTATION

The FSL option would have the greatest ease of implementation because all construction would take place at a remote site. The other three options would require a new dewatering facility at the existing treatment plant. Construction of this facility would cause some additional inconvenience to the plant operators. Construction of ATAD would cause even more disruption as the entire sludge digestion system at the plant would be replaced.

EASE AND RELIABILITY OF OPERATION

The FSL and dewatering options would have the greatest ease and reliability of operation. ATAD and composting would represent new processes for the operators. These processes are sensitive to temperature and other conditions and must be monitored closely. Failure of the composting process would not represent a major problem; sludge could still be applied to land, subject to Class B restrictions. An upset to the ATAD process would represent a major problem because the treatment plant would then be without any sludge stabilization process. Significant odors could result at the plant.

COMPLEXITY

ATAD and composting are more complex than simple dewatering or an FSL. However, ATAD is no more complex than anaerobic digestion, which is currently in use at the treatment plant. Although composting requires substantial labor and monitoring, it is a fairly simple process. The options are considered equivalent with respect to this criterion.

REGULATORY ASPECTS

The four options are well-known and accepted by the regulatory agencies. All four options are ranked equally with respect to this criterion.

FLEXIBILITY

The FSL option provides the greatest flexibility. An FSL provides about 2 years of storage, during which time the land application program can be developed. Liquid sludge can generally be applied to more types of sites than dewatered sludge. Furthermore, if sites which require dewatered sludge are obtained in the future, dewatering can be added at the FSL site. On the other hand, if dewatering is provided now and sites which accept dewatered sludge are not available, the cost of the dewatering facility cannot be recovered. Composting provides some added flexibility in that the product is more desirable and could be given to the public or used on city property in town.

AESTHETICS

ATAD would have the greatest aesthetic impact as a result of the odor potential at the treatment plant. Although odor control would be included, the potential for occasional problems exists as a result of process upset, odor control equipment failure, and exposure of sludge during transfer operations. Furthermore, the finished sludge would produce more odor than would sludge from the other options. An FSL would have an aesthetic impact, but it is assumed that the site would be remote and would have sufficient buffer to minimize the effect. Odor from an FSL is generally rather faint and musty. The aerobic layer on top of the lagoon prevents foul odors from escaping. Storage of dewatered solids would have a similar impact, but of a lesser extent. Composting could produce substantial odor. Remoteness of the site would be most crucial to this option.

ECONOMICS

The budgetary cost estimates for the four options were presented above and summarized in Table 8-7.

The FSL option represents considerable savings in capital cost. The cost is about 20 percent lower than that of ATAD, and 25 percent lower than the other options. The annual cost is lower than for all except dewatering. As discussed earlier in this chapter, the annual cost is sensitive to hauling distance. If an application site were located adjacent to the FSL, the annual cost would be less than for dewatering. Hauling distance would have to exceed 60 miles before the total present worth cost of the FSL would exceed that of the dewatering option.

SELECTION OF RECOMMENDED OPTION

The rankings of the options with respect to the criteria discussed above are summarized in Table 8-8. Criteria for which all three alternatives are considered equal are not included in the table. As discussed above, the FSL option has a substantially lower cost than the other options. Unless there were other overriding factors, cost alone would be a sufficient basis for recommending the