Town of Paradise
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# TOWN OF PARADISE
# WASTEWATER COLLECTION, TREATMENT, AND DISPOSAL
# PRELIMINARY DESIGN REPORT

## VOLUME 2

Nolte and Associates

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# CHAPTER I
# EXECUTIVE SUMMARY

# I. EXECUTIVE SUMMARY

The Town of Paradise is developing a wastewater management plan for the entire Town. The largest portion of the Town will be remaining on onsite wastewater systems. A relatively small portion of the Town will be connected to a sewer system and wastewater treatment plant. The purpose of this preliminary design report is to describe the engineering analysis of alternative wastewater collection, treatment, and disposal systems and to provide a recommendation of the best alternative for the Town of Paradise.

The report is divided into two volumes. Volume 1 contains a general overview of the recommended wastewater collection, treatment, and disposal plan and the financial analysis. Volume 2 contains details of the extensive evaluation that was undertaken to select the best apparent wastewater management alternative, background data, and cost estimates.

## A. PROJECTED SERVICE AREA

Criteria used in determining the boundary of the Town of Paradise sewer district service area were:

1. Current land use and zoning, including proposed updates to the General Plan.
2. Wastewater loading rates
3. Soils and soil conditions
4. Surface water quality
5. Septic tank failure and repair records
6. Property owners requests

The area of Town to be sewered is shown in Exhibit A. Characteristics of the sewer district include the high density commercial, industrial, and multi-family residential areas of the Town. The total service area for the formal sewer district comprises 1,665 net acres. Currently 1,100 onsite systems and 3,010 Equivalent Dwelling Units (EDU's) exist in the area to be sewered. At buildout, it is estimated that the service area will contain 7,800 EDU's. One EDU in the Town of Paradise has a wastewater flowrate of 200 gallons per day.

## B. WASTEWATER COLLECTION SYSTEM ALTERNATIVES

The alternatives considered for wastewater collection included conventional gravity sewers, septic tank effluent pump (STEP), septic tank effluent gravity (STEG), and a combination or hybrid system featuring conventional gravity sewers along the Skyway and STEP/STEG for the Clark Road areas. For comparison purposes, it was assumed in each alternative that all existing septic tanks in the service area would be replaced or abandoned. Criteria for selection of the best collection system included capital costs, operating costs, ease of installation, public acceptance, environmental impacts, aesthetics, and compatibility with water reuse options.

The recommended option is the hybrid collection system consisting of conventional gravity sewers for the Skyway area and a STEP/STEG system for the Clark Road, Buschmann, and Pearson/Elliott corridors. The hybrid system has the advantage of being a tailored sewer system for the particular terrain, type of development and potential for water reuse. The capital cost of the hybrid system is $12,443,000 which represents a savings of $4,350,000 compared to a conventional gravity collection system for the whole service area. The capital, operation and maintenance, and total present worth costs of the three each sewer system alternatives are presented in Table I-1. The cost of each sewer system includes onsite piping (laterals) to hook up all existing development from the house/business to the main sewer line. Reductions in capital costs are expected during final design when retention of some existing septic tanks and the use of effluent gravity systems can be optimized.

TABLE I-1

**TOWN OF PARADISE COLLECTION SYSTEM ALTERNATIVES TOTAL PRESENT WORTH[a]**

| Collection System Alternative | Capital Costs ($) | Operations & Maintenance Costs ($) | Present Worth ($) |
|---|---|---|---|
| Conventional Gravity System | 16,796,000 | 100,000 | 17,855,000 |
| STEP/STEG System | 11,797,000 | 164,000 | 13,534,000 |
| Hybrid System | 12,443,000 | 114,000 | 13,651,000 |

[a] Assumes 20 yr life cycle and 7% capital recovery.

## C. SEPTAGE HANDLING ALTERNATIVES

The septage handling alternatives considered for the Town of Paradise included land treatment and disposal (no treatment prior to land application), construction of an independent septage treatment facility (separate from the wastewater treatment plant), and co-treatment at the wastewater treatment plant. Land application without pretreatment is not recommended by regulatory authorities. Some type of stabilization process, such as liming or lagooning, is recommend to reduce the risk of disease transmission by pathogens contained in the septage. Implementation of a separate septage handling facility featuring composting, lagooning, or solar aquatics was determined to be far more expensive than sizing the proposed treatment plant to accommodate the septage.

The recommended septage handling alternative is co-treatment at the wastewater treatment plant. The beneficial uses of septage associated with land treatment and disposal can still be realized with co-treatment by stabilizing the septage with the wastewater sludge and using the combined residuals in a land application operation.

## D. WASTEWATER TREATMENT/DISPOSAL SYSTEM ALTERNATIVES

Combined flows of wastewater and septage will be treated to standards set by the Regional Water Quality Control Board (RWQCB) and disposed of in an environmentally safe manner. The average design flow for the first 20 years of operation is 0.90 mgd with an expected buildout average flow of 1.56 mgd (including 24,000 gpd of septage).

Sites evaluated for a Town of Paradise wastewater treatment plant included Elliot Spring, Upper Horning Ranch, Lower Horning Ranch, the Sanders Parcel (west of Highway 99), lower Skyway, and specific areas within the Town of Paradise. Discharge or reuse options included surface water discharge to Nugen Creek, irrigation reuse on Lower Horning Ranch and the Sanders Parcel, habitat wetlands on Lower Horning Ranch, and rapid infiltration (percolation basins) adjacent to Butte Creek and in the Town of Paradise.

Appropriate treatment operations and processes were evaluated within the categories of preliminary treatment, primary treatment, secondary treatment, advanced treatment, and sludge treatment and disposal. The secondary treatment systems that were evaluated included partial mix aerated ponds, oxidation ditch, sequencing batch reactor, wetlands, and overland flow. Appropriate wastewater treatment/disposal systems were developed for the sites under consideration and the applicable discharge requirements.

The recommended treatment/disposal system is overland flow at Upper Horning Ranch with discharge into Nugen Creek. The estimated capital cost for the treatment plant and the land is $5,376,000. A habitat wetland will be developed on Lower Horning Ranch at a cost of $875,000 to gain approval from the Regional Water Quality Control Board (RWQCB) for year-round discharge into Nugen Creek. Aerated ponds will be used for primary treatment and sludge storage. Sand filtration followed by ultraviolet light disinfection will be used to obtain the high effluent quality required prior to stream discharge. Sludge will be stabilized within the primary ponds. Every 3 to 5 years, the sludge will be dredged from the ponds and applied during the summer to land adjacent to the treatment plant.

## E. IN-TOWN WASTEWATER REUSE

To conserve potable water that is currently used for irrigation, an analysis was conducted of the potential for in-town water reuse. Reuse areas within the Town of Paradise were divided into categories of parks and playgrounds (50 acres) and landscape irrigation (87 acres). Landscape irrigation was determined to be the most cost effective, due to lower treatment standards required by the California Department of

Health Services (DHS). Based on large water demand and central location, the following sites were selected for construction of reclamation facilities and use of reclaimed water:

1. Paradise Cemetery
2. Tall Pines Golf Course
3. Proposed Expansion of Paradise Cemetery

Septic tank effluent from the Clark Road, Buschmann, and Pearson/Elliott corridors would be used as the influent wastewater to the reclamation plants. The estimated cost to construct the three reclamation facilities is $2,387,000. Construction of the most inexpensive of the three facilities, the Paradise Cemetery, would cost $631,000. For treatment and disposal, in-town reclamation exceeds the cost of the main treatment plant by 56% or $351/acre-ft. The operations costs also exceed the costs at the main plant by $111/acre-ft. Although the Town could save 230 acre-ft of potable supply, the high costs make it difficult to recommend in-town reuse at this point in time.

It is not uncommon for reclamation/reuse programs to subsidize the cost of reclamation especially in the early years of a program where the alternative water supply is relatively inexpensive. The PID charges for irrigation water are currently $89/acre-ft. Without the Town subsidizing the cost of reclaimed water, the price paid by the user would be $450/acre-ft. Although the current water prices cannot justify the conversion, future costs of developing new supplies, expected to be in the range of $1,750 to 2,800/acre-ft, may make reclamation desirable in the future.

## F. SUPPORT AND OPERATIONAL REQUIREMENTS OF THE RECOMMENDED PLAN

Operational requirements of the proposed sewer district include labor, equipment, energy, chemicals, and miscellaneous supplies. Staffing of the sewer district will include positions in administration, collection system maintenance, and treatment and disposal system operation. Administration of the district will require a district manager and a clerk typist. Collection system maintenance will require two maintenance personnel, a lead person and one helper. Operation and maintenance of the treatment plant and monitoring of the disposal system will require two operators, a lead operator and an operator/laboratory technician. The total annual cost for labor, equipment, energy, and miscellaneous supplies is estimated to be $364,000.

## G. FINANCIAL ALTERNATIVES

The capital costs of the recommended wastewater management plan is $20,921,000. To finance this cost it is proposed that a combination of grants, loans, and assessments be used. Grants from the Economic Development Administration, the Community Development Block Grant process, the State Water Resources Control Board, the Wildlife Conservation Board, and the Environmental Protection Agency are being pursued. A low interest loan from the State Water Resources Control Board (WRCB) is available based on the recently acquired Priority B ranking. Loans from the WRCB cannot exceed $20 million per project in any one year.

The capital cost of the collection, treatment, and disposal system will be spread over a buildout total of 7,800 EDU's and a 20 year capacity total of 4,400 EDU's. The average monthly cost for capital facilities will be $17.16 per EDU.

Operation and maintenance (O&M) costs will be spread over the initial 3,010 EDU's. Typical O&M cost per EDU will be $10.08 per month for collection, treatment and disposal.

# CHAPTER II
# INTRODUCTION

# II. INTRODUCTION

## A. BACKGROUND

The Town of Paradise is located in the foothills of the Sierra Nevada approximately 45 miles north of Marysville and 10 miles east of Chico (Figure II-1). The community is unsewered and all wastewater generated by the residents is treated and disposed of within onsite systems. The presence of such a large quantity of onsite systems within a relatively small area has raised concerns of possible surface water and groundwater quality degradation. To address the concerns, water samples from various locations throughout the Town are periodically collected and analyzed. As a result of the water quality monitoring program, it has been determined that onsite system failures leading to seepage of partially treated wastewater into surface waters of the Town may be occurring [2-1, 2-2, 2-3, 2-4]. To prevent widespread water quality problems, regulatory agencies overseeing wastewater disposal in the Town have instituted wastewater loading requirements. The loading requirements have effectively limited building density and precluded expansion of the small businesses that line the streets of the commercial district. Numerous engineering studies [2-1, 2-5, 2-6] have been commissioned and completed over the past 10 years to assess the extent of the problem and prescribe appropriate solutions.

## B. PURPOSE AND SCOPE

Nolte and Associates was retained by the Town of Paradise in November of 1991 to develop a management plan for an onsite district and to prepare a preliminary design report for a sewer collection system and wastewater treatment plant to serve the areas of Town not suited to onsite treatment. The Nolte and Associates project team consisted of experts in the fields of onsite systems, soil science, alternative collection systems, conventional collection systems, environmental assessment, and wastewater treatment and disposal methods.

In-depth surveys of soil types, water quality, and land use were completed and utilized to determine the boundaries of the onsite and sewer districts [2-4, 2-7]. After organization of the Onsite Wastewater Disposal Zone, an onsite manual was developed to ensure proper construction and effective operation of the onsite systems [2-8]. The sewer district was organized to serve the densely populated areas of Town, the commercial/industrial facilities, and the adjacent areas associated with onsite system failures. The collection, treatment, and disposal systems proposed to the Town included innovative ideas of utilizing existing septic tanks for settling prior to discharge to the main sewer, employing natural systems for wastewater treatment, incorporating wastewater reclamation and reuse into the Town's landscape irrigation system, and stream disposal for creation of wildlife habitat.

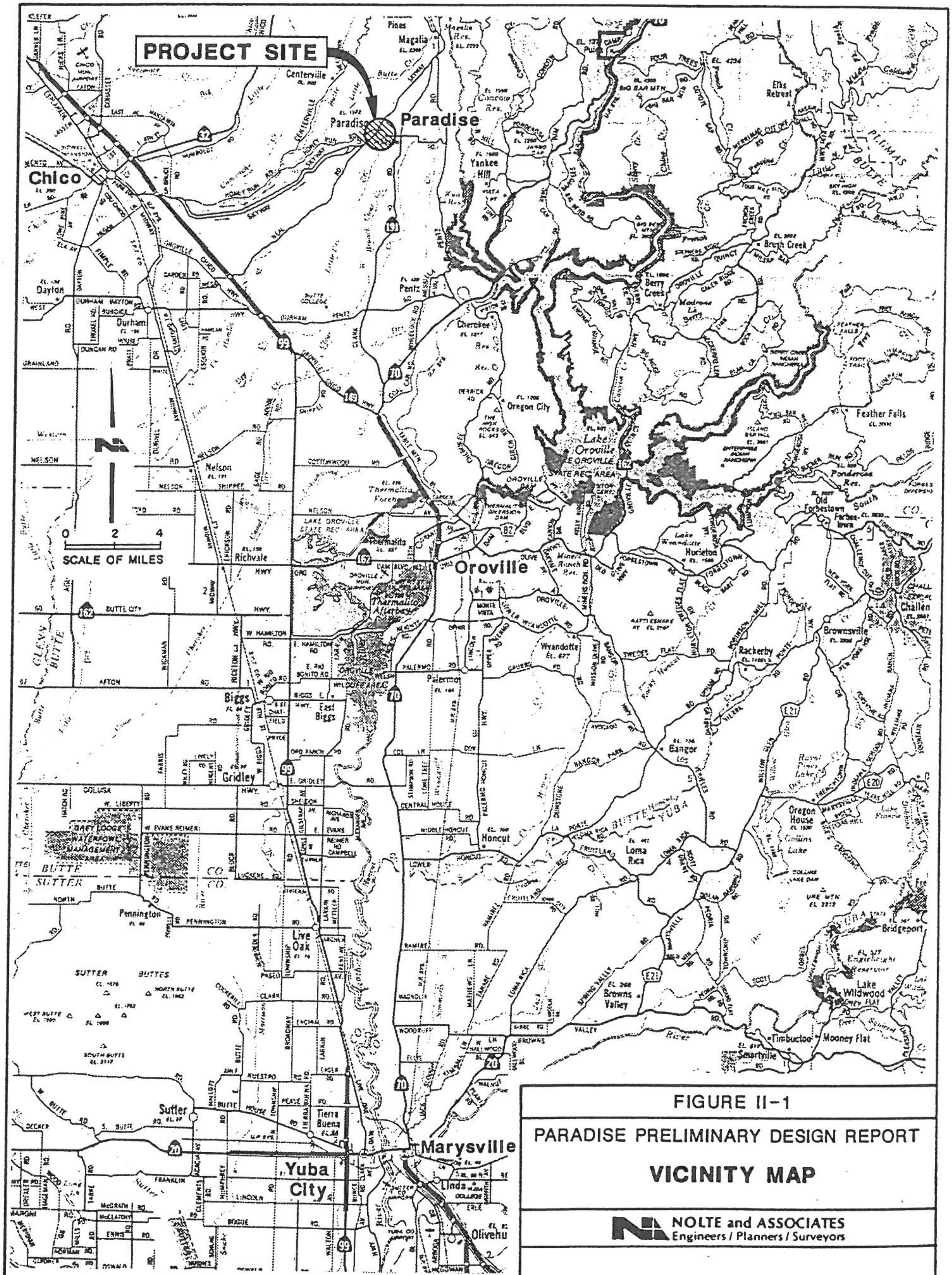


FIGURE II-1

PARADISE PRELIMINARY DESIGN REPORT

**VICINITY MAP**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

## C. REPORT ORGANIZATION

The Preliminary Design Report includes information for the proposed Town of Paradise Sewer District. Information pertaining to formation and management of the Onsite Wastewater Disposal Zone can be found in the *Manual for Onsite Treatment of Wastewater* [2-8]. The Preliminary Design Report is organized into two volumes to facilitate the review process. Volume 1 contains a description of the recommended wastewater collection, treatment, and disposal plan and the associated operational requirements. Possible funding sources for construction are presented along with the results of a rate study to determine connection charges and user fees. Volume 2 is organized into sections that correspond to the various activities that would be required to establish, operate, and maintain the sewer district: wastewater collection, septage handling, wastewater treatment/disposal and in-town wastewater reuse. Within each section of Volume 2, alternative methods of handling each activity are presented and evaluated according to economic and subjective criteria. Based on the evaluation results, the preferred alternative is described and recommended for incorporation into an overall Town of Paradise wastewater management plan. The appendixes to Volume 2 contains backup material that is relevant to preparation of the preliminary design report and operation of the sewer district.

## D. ECONOMIC ASSUMPTIONS

Preliminary cost estimates are used in the report to make economic comparisons between alternatives and to predict the final cost of the recommended system. The criteria and markups used to prepare the cost estimates are detailed below.

### 1. Life Cycle Analysis Criteria

a. Annual equipment maintenance equal to 2% of the capital cost.
b. Power costs of $0.10/kW-hr.
c. Capital recovery factor of 7%.

### 2. Markups

| | | |
|---|---|---|
| a. | Electrical facilities | 20% |
| b. | General contractor's overhead and profit | 15% |
| c. | Construction services and administration | 15% |
| d. | Contingency | 15% |

## E. ACKNOWLEDGEMENTS OF CONTRIBUTORS

Input and guidance received from Dan Cook, Project Manager for the Town of Paradise, and the Wastewater Steering Committee were integral to the completion of the Preliminary Design Report.

Nolte and Associates designed the wastewater treatment and disposal system and coordinated the preparation of the report. Several engineering firms under contract to Nolte and Associates were involved in the preparation of the Preliminary Design Report. Metcalf and Eddy coordinated the design of the collection system, contributed information regarding existing septage treatment and disposal, and participated in delineation of the area of service. North Star Engineering also participated in delineation of the area of service and i.e. Engineering designed the STEP collection system. Fieldman Rolapp and Associates investigated funding alternatives and prepared the rate study. Michael Brandman Associates performed biological surveys of the proposed collection, treatment, and disposal sites, reviewed existing environmental assessments, and prescribed additional investigations.

Key individuals involved in the preparation of this document include the following:

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- Frank Burton
- Bob Gearheart

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1979 *Water Quality Management Plan for Paradise and Magalia*, prepared for the Town of Paradise.

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1984 *Town of Paradise Wastewater Management Study, Supplementary Phase I Report*, prepared for the Town of Paradise.

2-4 Metcalf & Eddy
1992 *Town of Paradise, Water Quality Monitoring Summary Report*, prepared for the Town of Paradise.

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2-7 Wert & Associates, Inc.
1992 *Soils of Paradise and Their Ability to Treat Domestic Wastewater*, prepared for the Town of Paradise.

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1992 *Town of Paradise Onsite Wastewater Disposal Zone, Manual for the Onsite Treatment of Wastewater*, prepared for the Town of Paradise.

# CHAPTER III
# PROJECTED SERVICE AREA AND WASTEWATER CHARACTERISTICS

# III. PROJECTED SERVICE AREA AND WASTEWATER CHARACTERISTICS

The unique characteristics of the Town of Paradise environment result in the need for the application of different types of wastewater treatment systems. Some areas of Town, due to favorable soil conditions and low density zoning, are best suited to onsite systems. Other areas, due to unfavorable soil conditions and/or high wastewater loading rates, are not suited to onsite wastewater treatment. The areas determined to be unsuitable for onsite systems are being considered for sewer hookup to a central wastewater treatment facility. Based on land use, soil types, septic system failures, and wastewater loading rates, a formal sewer service area has been delineated for the Town of Paradise. The Town of Paradise environment, the proposed service area, and the projected characteristics of the wastewater from the service area are described in the following paragraphs.

## A. TOWN OF PARADISE ENVIRONMENT

Elements of the town environment described in this section include soils, groundwater, climate, surface water resources, land use, and population.

### 1. Soils

The soils of Paradise have been mapped in considerable detail by Wert and Associates in *Soils of Paradise and Their Ability to Treat Domestic Wastewater*, April 1992 [3-1]. A majority of the soils are of volcanic ash origin with embedded hard gravels and boulders. Volcanic mud flows and intermittent ash flows, which are collectively known as the Tuscan formation, underly the Town to a depth of approximately 1,000 ft. Most of the flows are relatively free of hard fragments and have weathered to produce a deep, well drained, clay soil known as the Aiken series. The Tuscan formation in its unweathered state can be difficult to excavate, requiring blasting or use of a rock saw. On broad ridges, the Aiken soil predominates. In swales, colluvium deposits have collected. Soils in swales typically have 2 to 5 ft of clay loam over a clay pan 2 to 3 ft thick. Below the clay pan there can be 10 to 30 ft of weathered Tuscan formation.

### 2. Groundwater

The average slope of the ground surface within the Town of Paradise is approximately 4%. Drainage is conveyed from the upper elevations of Paradise to the steep canyons south of town. Areas of Town exist where bedrock has caused water to collect. Old hand dug wells have tapped these areas for domestic water but the water supply is limited. Much of the ground surface consists of a permeable loam underlain with clay. Adequate gradient exists in most areas to move perched rainwater down-gradient on top of this clay layer. However, portions of Town with a gentle slope can have a prolonged temporary perched water table during the wet season.

There are approximately 200 private wells in town. During drought years, when water has been rationed by the Paradise Irrigation District (PID), homeowners use the well water to maintain their landscaping.

### 3. Climate

The climate of Paradise is typical of the Sacramento Valley with mild winters and hot dry summers. Temperatures can be as low as 32°F in winter and as high as 105°F in summer. The elevation of Paradise varies from 1,300 ft at the southern end of Town to 2,200 ft at the northern end. Average annual precipitation ranges from 40 in./yr in the lower elevations to 60 in./yr in the higher elevations.

### 4. Surface Water Resources

Water for the town is currently supplied by PID. The PID system includes a metered distribution with approximately 9,800 connections and two storage reservoirs, the Magalia and Paradise reservoirs. PID has water rights for 18,000 ac·ft of water per year, but storage capacity of only 14,140 ac·ft per year. PID currently has enough water to meet the needs of the Town until 1995. The district has explored three alternatives to meet the Town's future water demands:

a. Raise the Paradise Dam

b. Strengthen and raise Magalia Dam

c. Develop a new well

PID is pursuing the option of strengthening and raising Magalia Dam. The Division of Safety of Dams is currently questioning the Magalia Dam's ability to meet existing seismic requirements. It is possible that a project to strengthen the existing dam may be mandated.

The ability of the District to meet the Town's water needs is a function of the daily water usage. The District has encouraged conservation for many years. The goal of the District is an average annual water use of less than 250 gal/cap per day. During the drought of 1976-1977 water use ranged 175 to 225 gal/cap per day, but lately water use has exceeded the 250 gal/cap per day target. The immediate needs of the PID and the projects required to solve future water supply problems have not been resolved.

### 5. Land Use

An update of the General Plan for the Town of Paradise is currently underway. In the past, land use and zoning of Paradise have been dictated to a large extent by onsite wastewater disposal as influenced by soil types and related leach field characteristics. As outlined in the following section of this chapter, the service area for the collection system includes primarily the commercial, industrial, and multi-family residential zoned areas of town. A small amount of single family residential is included in the service area due to proximity to the sewered area and small lot size.

The residential character of the community is evident in that 85% of the Town is zoned for single family homes, and 6% is zoned for multi-family complexes. Commercial and industrial zoned land constitutes 6.5% of the total. Open space is not only reserved in the extensive rural residential zoning, but by resource conservation and community facilities that include the golf course, schools, hospital grounds and cemetery. About 30% of the land zoned for construction is vacant, and 24% is utilized in transportation thoroughfares. The occupied commercial and industrial land comprise about 2.5% or perhaps half of the net areas designated for those uses. There is still some land in agriculture, but the total acreage has decreased dramatically in recent years. At one time, Paradise was famous in the local region for apple orchards and vineyards.

### 6. Population

The population of the Town of Paradise, as estimated by the State Department of Finance for 1992, was 26,008. The historical annual growth rate for the Town from 1980 to 1990 was 1.3%. The average age of the population is 45.3 years with 26% of the population 65 years or older. The ethnic origin is 97% caucasian. There are estimated to be 11,483 housing units within the Town of Paradise with an average of 2.27 persons per household.

## B. SEWER DISTRICT SERVICE AREA

The need to create a "formal" service area as part of the implementation of a centralized wastewater treatment system was concluded in previous studies commissioned by the Town of Paradise [3-2, 3-3, 3-4]. The previous studies relied on land use designations and surface water quality issues as primary factors in determining where septic tank systems would be replaced by conventional sewers. Results of the studies were used as a baseline for establishing the boundary of the currently proposed service area.

### 1. Boundary Determination Criteria

Criteria used in determining the sewer district boundaries included: current land use and zoning designations, wastewater loading rates, soils and soil conditions, surface water quality, failure and repair records obtained from the county, and property owners requests.

a. Land Use and Zoning

The 1980 General Plan and Land Use Map for the Town of Paradise was used as the basis for the determination of projected land uses and densities. A windshield survey (drive-by survey of the Town to identify structures and determine occupancy) was conducted by Quad Consultants in 1992 as part of the General Plan

Update [3-8]. This survey was examined to develop a wastewater loading map, in gallons/acre-day. An overlay of land use, soils conditions, and loadings was used to further evaluate the proposed sewer district boundary.

The Draft 1992 General Plan update was recently made available and has been compared to the proposed sewer district boundary. The proposed general plan land use designations specifically refer to the potential sewers in determining land use and densities. A summary of the sewer dependent land use types and their estimated wastewater loading rates are presented in Table III-1.

TABLE III-1

**LAND USE TYPES IDENTIFIED IN THE DRAFT GENERAL PLAN TO BE DEPENDENT ON SEWERS**

| Land use Category | Residential Density (units/acre) | Loading Rate (gallons/acre-day) |
|---|---|---|
| Town Residential | 2 - 5[a] | 400 - 1000 |
| Multi-Family Residential | 5 - 10[b] | 825 -1,650 |
| Central Commercial | N/A | 2,000 |
| Town Commercial | N/A | 2,000 |
| Light Industrial | N/A | 2,000 |

a Five units/acre in areas zoned Town Residential will require sewers.

b 10 units/acre in areas zoned Multi-Family Residential will require sewers.

b. Wastewater Loading Rates

Wastewater loading rates were determined by an extensive review of PID records during the winter months augmented by site specific studies of metered water use. The wastewater generation rates associated with residential uses are listed in Table III-2. The current and projected residential wastewater generation rates were plotted on base maps of the Town and compared to the threshold loading rate of 900 gallons/acre-day. The threshold rate was based on the maximum acceptable nitrogen loading rates determined by Ryder and Associates in 1985 [3-3]. Areas outside of the proposed sewer district were also analyzed in terms of the threshold loading rate. Several factors were analyzed to determine the feasibility and need to connect these areas to the formal system, as described in more detail in a separate report prepared by NorthStar Engineering (*Remote Cluster Systems for the Town of Paradise*).

TABLE III-2

**TOWN OF PARADISE RESIDENTIAL WASTEWATER GENERATION RATES**

| Single Family Residential | Multi-Family Residential | Mobile Home Park |
|---|---|---|
| 200 gallons/residence per day[a] | 165 gallons/residence per day | 125 gallons/residence per day |

[a] Represents one equivalent dwelling unit (EDU)

c. Soils and Soil Conditions

The soils of Paradise are described in detail in *Soils of Paradise, and Their Ability to Treat Domestic Wastewater* prepared by Wert and Associates [3-1]. The report and the associated soils map detail the soil types and conditions found in Paradise and their ability to treat wastewater. In general, the Aiken soils which comprise approximately 67% of the Town, accept and treat domestic wastewater very effectively. However, the installation of septic systems within the Town is hindered in some areas by the presence of shallow groundwater and limited space in which to place an effective system. Ground disturbance (cuts and fills), over-covering, setbacks from waterlines and streams, and topography all limit the available area for installation.

d. Surface and Groundwater Quality

Degradation of surface water quality within the Town of Paradise has been documented by the Regional Water Quality Control Board (RWQCB) and various consultants [3-5, 3-6, 3-7]. Bacterial indicators of human waste have been found in surface water samples. Bacteria detected in the Town of Paradise surface water include total and fecal coliform and fecal streptococcus.

The bacteriological results of the sampling program are indicative of marginal surface water quality. In the most recent round of testing, fecal coliform exceeded the Basin Plan standard of 200 MPN/100 mL at 14 of 22 sampling stations [3-7]. The most significant degradation of surface water quality was found in the Middle Honey Run Basin and the Pearson Basin. However, due to the limited number of samples collected, there is no conclusive link between the fecal contamination and septic tank effluent [3-7].

Groundwater quality was also investigated for bacterial contamination, but the results were not indicative of widespread fecal pollution [3-7]. The small concentrations of bacteria detected within some wells may be related to a poor sanitary seal or long periods of non-use. Groundwater quality is considered to be good and there is no strong evidence that groundwater quality has been impacted by septic tank effluent.

e. Property Owners Requests

Several property owners have expressed interest in obtaining sewer capacity and service. Most notable are the land owners associated with the proposed development of the golf course area and the area between the golf course and Buschmann Road (the Moe West project). Both of the projects are consistent with the Paradise General Plan and have been in the discussion stage for several years. The owners of the Cypress Convalescent Hospital, located north of Wagstaff on Clark Road, have also expressed interest in a sewer hookup.

f. Septic System Failure and Repair Records

Currently, Town of Paradise wastewater is treated and disposed of by approximately 11,800 residential and 400 commercial septic tank and leachfield systems. Of these systems, roughly 39% are 10 years old or less, 24% range in age from 11 to 20 years, 20% are 21 to 30 years old, and 17% are greater than 30 years old.

A detailed analysis of septic system failures during 1990 and 1991 was undertaken through investigating the records of the Environmental Health Department and interviewing sanitarians. The results of the analysis reflected a Town-wide average failure rate of 1% (or roughly 100 systems) per year. Unfortunately, the location of these failures was not readily correlated with physical factors such as soil type or depth to groundwater and could not be considered in delineating the sewer service area.

### 3. General Boundary Description

A map of the service area boundaries is included as Exhibit A. The description of the sewer district boundary is divided into the following corridors: Skyway (Town limits to North of Wagstaff), Upper Clark Road (Buschmann to North of Wagstaff), Lower Clark Road (Town limits to Buschmann), Buschmann Road, and Pearson/Elliott.

a. Skyway (Town Limits to North of Wagstaff)

The Skyway corridor is bounded to the south by the Town limits. The northwesterly boundary of the corridor extends to the rear of parcels fronting on Skyway, between Bille Road and Wagstaff Road. The Northerly boundary includes the currently zoned community-commercial property north of Wagstaff Road and the eastern boundary follows the abandoned railroad right of way.

The northwesterly boundary of the Skyway corridor generally follows the zoning line that separates single family residential from commercial/multi-family. Some existing single family residences are included within the corridor due to the inconsistency between the zone and the current land use. In addition to the property clearly located within the boundaries described above, Skyway includes the existing apartment project and commercial uses in the "island" between the divided roadway. At owner request, a large undeveloped parcel south of Skyway is also included. The owner is anticipating the construction of a single family residential subdivision of approximately 4 units per acre.

b. Upper Clark Road (Buschmann to North of Wagstaff)

The northern Clark Road corridor is contiguous to the Pearson/Elliott area and the Moe West project. The easterly boundary from Buschmann to the north follows the zoning line between single family and commercial/multi-family and extends one or two parcels deep from Buschmann Road to Elliott Road. The boundary was extended along Elliott to include the existing multi-family projects in the area.

The zoning line between single family and commercial/multi-family is followed from Elliott north to Wagstaff. The Country Oaks Subdivision has been excluded from the sewer district because it is new and meets the current onsite standards. It is recommended that the zoning/general plan be amended to reflect single family for this parcel. The boundary on the west side of Clark between Wagstaff and Elliott essentially follows the zoning line between single family and commercial/ multi-family residential. The mobile home parks contiguous to the original boundary were added.

An area between Copeland Road and the existing commercial area is indicated in the Draft General Plan as Town Residential. This area has been included in the proposed sewer district. The principal additions to the sewer district north of Wagstaff consist of the Cypress Acres Convalescent Hospital, Pine Springs Mobile Home Park, and the Apple Village Mobile Home Park. Inclusion of Cypress Acres was at the request of the owners. The Apple Village Mobile Home Park was included based on the density, extensive soil disturbance during construction, overcovering of soil with impervious surfaces, and the lack of alternative sites for onsite disposal. Pine Springs Mobile Home Park was included for similar reasons.

c. Lower Clark Road (Town Limits to Buschmann Road)

The southern Clark Road corridor consists primarily of the Paradise Industrial Park, the previously mentioned Moe West property, the Tall Pines golf course, and other commercial and multi-family parcels. Vineyard Acres Mobile Home Park, currently under development by Gary Guardino, has been included in the district because connection to the sewer is a development requirement. The southern Clark Road corridor area is the most difficult to serve by the sewer district, because all wastewater must be pumped to a sewer main on Buschmann Road.

d. Buschmann Road

Buschmann Road corridor is bounded by Buschmann and Pearson Roads. The area contains a variety of land uses, including a Little League ball park, two schools, a park, a medical center, and single family homes. The single family residential areas were not included in the sewer district, but all of the other areas have been included. Portions of the Buschmann Road corridor are subject to high groundwater.

e. Pearson/Elliott

The Pearson/Elliott area is generally bounded by Pearson Road to the south and Elliott Road to the north. Outside of these general boundaries, the corridor includes the high school and the multi-family residential units along Maxwell Road. Most of the Pearson/Elliott area was included in the sewer district because it is either zoned or developed as multi-family or other high wastewater flow uses. Some pockets of single family development exist in the area and were omitted from the sewer district designation. Areas of high groundwater and areas within impacted basins were included in the sewer district.

The gross acreages of the proposed sewer district associated with the various land uses identified in the Paradise General Plan are presented in Table III-3. The total service area comprises 1,665 acres of which 37% is dedicated to commercial/industrial properties and 20% to multi-family residential.

## C. WASTEWATER CHARACTERISTICS

A summary of the wastewater characteristics used in the preliminary design of the recommended treatment/disposal system is presented in Table III-4. Design flowrates for the Town of Paradise wastewater treatment plant were based on predicted flows from the sewer system and predicted septage loads from septic tank pumping. Wastewater flows from the sewer system were estimated by the number of equivalent dwelling units (EDU's) in the sewer district service area. Approximately 3,010 EDU's presently exist within the service area.

GP RELATIONSHIP

The treatment plant will be constructed to handle wastewater flows occurring during the first 20 years of operation. If population growth in the sewer district increases at approximately 2% per year for 20 years, 4,400 EDU's will be contributing wastewater at a predicted rate of 200 gpd/EDU in the year 2014. The contribution of wastewater from the sewer system will therefore be 0.88 mgd. The total volume of septage predicted to be received at the plant in the year 2014 is 0.024 mgd (0.022 mgd from septic tanks in the onsite district and other areas of Butte County and 0.002 mgd from STEP systems). The average dry weather flow (ADWF) for the first 20 years of operation of the Town of Paradise wastewater treatment plant will be 0.90 mgd (wastewater flow rates plus septage). Peak dry weather flow (PDWF) is predicted

TABLE III-3

**TOWN OF PARADISE PROPOSED SEWER DISTRICT SERVICE AREA**

| Land Use Category | Residential Density (Units/Acre) | Population Density (Persons/ Dwelling Unit) | Gross Acres in Sewer District |
|---|---|---|---|
| Agricultural Residential | 1 | 2.36 | 24 |
| Suburban Residential | 1-2 | 2.36 | 333 |
| Town Residential | 2-5 (sewered) | 2.36 | 222 |
| Multi-Family Residential | 5 to 10 | 1.92 | 313 |
| Central Commercial | N/A[a] | N/A | 102 |
| Town Commercial | N/A | N/A | 349 |
| Community Service | N/A | N/A | 56 |
| Recreational | N/A | N/A | 68 |
| Public Institutional | N/A | N/A | 99 |
| Light Industrial | N/A | N/A | 99 |

[a] N/A - Not Applicable

to be 2.2 mgd, based on an overall peaking factor of 2.44. Peak wet weather flow (PWWF) of 2.5 mgd was calculated from the sum of the PDWF and estimated infiltration rates.

Flowrates occurring at Town buildout will be approximately 1.6 mgd (ADWF) and 3.9 mgd (PWWF). The buildout flowrates were estimated based on maximum densities as allowed by zoning category and a water use of 200 gpd/EDU.

Wastewater quality was determined using a mass balance prepared from the expected concentrations and flowrates of the various waste streams entering the treatment plant. Approximately one half of the sewer district service area will be hooked up to conventional gravity sewers and the other half will utilize STEP systems. Step system effluent is less concentrated than conventional sewer effluent due to settling of solid particles in the septic tank. The concentrations of $BOD_5$, TSS, nitrogen, and phosphorus associated with wastewater from the conventional sewer system, wastewater from the STEP systems, septage from conventional septic tanks, and septage from STEP systems are listed in Table III-4. The treatment plant design concentrations were calculated to be 310 mg/L $BOD_5$ and 530 mg/L TSS.

## D. EXPECTED WASTEWATER DISPOSAL REQUIREMENTS

Effluent quality objectives were derived based on proposed wastewater disposal/reuse options and correspondence with the Regional Water Quality Control Board (RWQCB). The disposal/reuse options under consideration, surface water discharge (Hamlin Slough through Nugen Creek), rapid infiltration, and agricultural reuse are described in Chapter VI of Volume 2. The likely wastewater disposal requirements used in the evaluation and selection of appropriate wastewater treatment processes, are enumerated in Table III-5.

TABLE III-4

**PROJECTED WASTEWATER CHARACTERISTICS FOR THE TOWN OF PARADISE THROUGH DESIGN YEAR 20**

| Wastewater Component | Wastewater Characteristics | | | | |
|---|---|---|---|---|---|
| | Flow (mgd) | $BOD_5$ (mg/L) | TSS (mg/L) | Total N (mg/L) | Total P (mg/L) |
| Conventional Sewer Effluent | 0.44 | 220 | 220 | 40 | 8 |
| STEP Effluent | 0.44 | 150 | 40 | 45 | 8 |
| Septage from Conventional Septic Systems | 0.022 | 5,000 | 15,000 | 600 | 150 |
| Septage from STEP Systems | 0.002 | 5,000 | 15,000 | 600 | 150 |
| ADWF (combined flows) | 0.90 | 310 | 530 | 57 | 12 |
| PDWF (PF=2.44) (combined flows) | 2.2 | ---- | ---- | ---- | ---- |
| PWWF (combined flows) | 2.5 | ---- | ---- | ---- | ----- |

TABLE III-5

**LIKELY WASTEWATER DISPOSAL REQUIREMENTS FOR THE TOWN OF PARADISE WASTEWATER TREATMENT PLANT**

| Disposal Alternatives | Effluent Limitations | | | | |
|---|---|---|---|---|---|
| | $BOD_5$ (mg/L) | TSS (mg/L) | Coliform[a] (MPN/100 mL) | Chlorine Residual (mg/L) | Un-ionized[b] Ammonia (mg/L) |
| Surface Discharge | 10 | 10 | $\leq 23$ | <0.1 | <0.01 |
| Rapid Infiltration | 30 | 30 | -- | -- | -- |
| Agricultural Reuse | 40 | -- | $\leq 23$ | -- | -- |

[a] Total Coliform

[b] Nitrified Effluent

## REFERENCES


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1992 *Soils of Paradise and Their Ability to Treat Domestic Wastewater*, prepared for the Town of Paradise.

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# CHAPTER IV
# WASTEWATER COLLECTION SYSTEM ALTERNATIVES

# IV. WASTEWATER COLLECTION SYSTEM ALTERNATIVES

The Town of Paradise sewer district consists of approximately 1,420 lots, of which 1,100 are currently improved. The service area is comprised of multi-family, residential, and commercial land use. A considerable portion of the service area is zoned commercial. However, due to the inherent restrictions of onsite wastewater treatment and disposal, development of the commercial lots has been limited. The construction and operation of a central wastewater treatment facility that services the proposed sewer district will result in business expansion and reduce water quality problems associated with onsite system failures.

An evaluation of the collection system alternatives considered for the Town of Paradise sewer district is presented in the following chapter. The evaluation and recommendation of the most appropriate system was based on capital costs, operations and maintenance costs, and suitability for the Town.

## A. COLLECTION SYSTEM ALTERNATIVES

The collection system design analysis was conducted to determine the best means of conveying the collected wastewater to the treatment plant. The collection system options evaluated were conventional gravity sewers, septic tank effluent pump (STEP) and septic tank effluent gravity (STEG) systems, and a hybrid system of conventional gravity and STEP/STEG. For each of the three options, a system layout, as well as capital and operations and maintenance costs, were developed. Existing zoning maps were used to determine the size of the sewer mains in various tributary areas. The wastewater unit flowrates and design flowrates for the collection system are presented in Table IV-1. The zoning clarifications are based on the existing Town of Paradise General Plan. Actual land use and zoning classifications based on the Draft 1992 General Plan are summarized in Table IV-2.

### 1. Conventional Gravity System

A conventional gravity system may be defined as a set of collection sewers that convey wastewater by gravity, as opposed to a pressure system that incorporates pumping. The conventional gravity system is the most widely used method of collecting wastewater. The traditional municipal system provides collector sewers in the public right of way with service laterals to each property line. The individual homeowner is normally responsible for constructing a connection (lateral) from the property line to the plumbing in the house. For Paradise, the district will pay for the lateral from the house or business to the sewer. A typical gravity system house connection detail is shown as Figure IV-1. Conventional gravity systems are designed for peak flow rates giving them the capacity to carry the maximum rate of wastewater flow that is anticipated to be generated. Conventional gravity systems must also be designed to maintain a minimum scouring velocity (the flowrate that keeps solids in suspension and prevents deposition that might clog the pipe) over a wide range of flows.

## TABLE IV-1

## WASTEWATER UNIT FLOW RATES

| Item and Zoning Classification | Allowable Density | Unit Flow Rate | Design Flowrate[c] (gpd/acre) |
|---|---|---|---|
| Residential Flow Rates: | | | |
| Single Family (S-F) | 0.25 acre minimum lot | 200 gpd/du[a] | 800 |
| Multi-Family (M-F) | 7 du/acre[b] | 165 gpd/du | 1,155 |
| Multi-Family Professional (M-F-P) | 10 du/acre | 125 gpd/du | 1,250 |
| Community Facilities, Mobile Home Parks (C-F) | ----- | 125 gpd/du | Varies |
| Rural Residential (R-R-3) | 3 acre lot minimum | 200 gpd/du | 70 |
| Planned Development (P-D) | ----- | 165 gpd/du | Varies |
| Commercial Flow Rates: | | | |
| Neighborhood Commercial (N-C) | ------ | 2,000 gpd/acre | 2,000 |
| Community Commercial (C-C) | ------ | 2,000 gpd/acre | 2,000 |
| Central Business (C-B) | ------ | 2,000 gpd/acre | 2,000 |
| Industrial Services (I-S) | ------ | 2,000 gpd/acre | 2,000 |

[a] gpd/du = gallons per day/dwelling unit
[b] du/ac = dwelling units/acre
[c] gpd/ac = gallons per day/acre

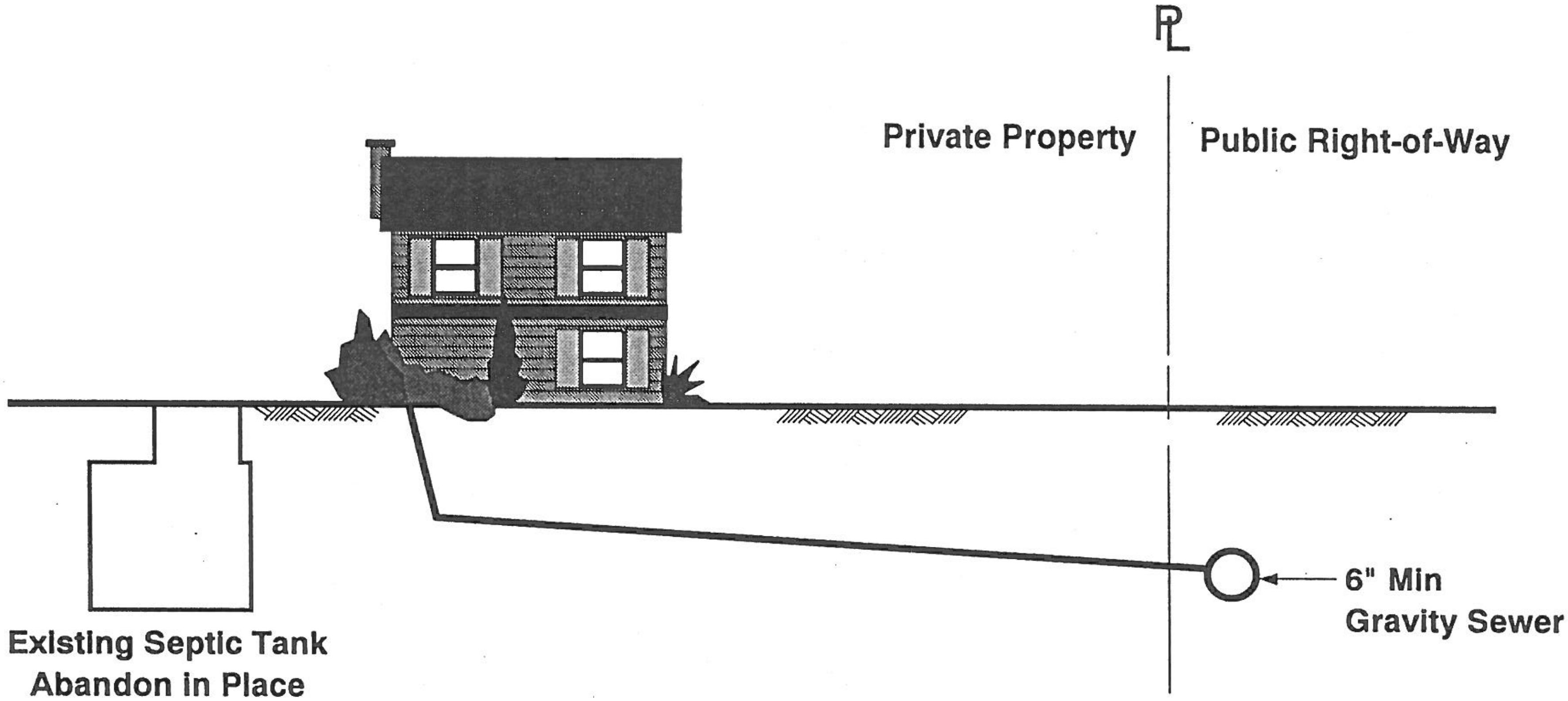


FIGURE IV-1

PARADISE PRELIMINARY DESIGN REPORT

**TYPICAL GRAVITY SYSTEM HOUSE CONNECTION DETAIL**

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Metcalf & Eddy

a. Suitability

With the sloping topography in the Town of Paradise, a gravity type sewer is a logical solution for much of the wastewater collection system. With the exception of some of the areas on the far western reaches of the system (areas that "fall away" from Skyway) and localized areas that are lower than the main thoroughfares, the majority of the sewer service area may be served by gravity sewers. Because of steepness of the natural grade, most of the mains may be laid at slopes greater than minimum required for scour velocity. The greater slope also provides for additional capacity in the pipelines, resulting in a reduction in typical pipeline diameters.

TABLE IV-2

**EXISTING LAND USE WITHIN THE TOWN OF PARADISE SEWER DISTRICT SERVICE AREA**

| Zoning Classification | Area (acres) |
|---|---|
| Single Family (AR, SR, TR) | 579 |
| Multi-Family (MR) | 313 |
| Commercial (CC, TC) | 451 |
| Community Facilities (CS, R, PI) | 223 |
| Industrial Services (LI) | 99 |
| TOTAL AREA | 1,665 |

b. Design Criteria

The design criteria for the conventional gravity system alternative were selected based on historical experience in similar foothill communities and suitability for the Town of Paradise. The criteria are summarized in Table IV-3. For purposes of this study, the design of a gravity sewer system was based on a 50-year life. Buildout flow projections were derived by estimating the flow (based on the unit flows presented above) for each subarea according to its zoning classification. At buildout it is assumed that the entire sewer service area will be developed in accordance with its maximum permissible density. This assumption is conservative because the likelihood that all of these areas will be built according to present zoning is unlikely. At startup the total system flow will be much smaller, but because of the available slope, the anticipated velocity will be sufficient for scouring settled solids. The pipes were designed to flow 80% full at peak flows, and sizes were computed using Manning's formula with a constant roughness coefficient. Peaking factors were taken as an average of 3.0 times the average daily flow rate for residential flows, and 2.0 times the average daily flow for commercial flows [4-1].

Inflow and infiltration (I/I) was assumed to be minimal for several reasons. Piping will be gasketed or glued and manhole barrels are to be gasketed as well. Groundwater contact is expected to be minimal or non-existent based on topography and initial soils study information. Roof drain connections will be prohibited and there will not be any cross connections. During the wet season there will be some inflow through the manhole covers. For this study, 500 gpd/in-mile was used for the average infiltration rate. Average and peak flows for various subareas are summarized in Table IV-4.

TABLE IV-3

**CONVENTIONAL GRAVITY SYSTEM DESIGN CRITERIA**

| Item | Parameter |
|---|---|
| Minimum pipe size | 6 in. |
| Minimum Slope (ft/ft): | |
| 6 in. | 0.005 |
| 8 in. | 0.004 |
| 10 in. | 0.0028 |
| 12 in. | 0.0020 |
| Manning Coefficient, n | 0.013 |
| Pipe Materials | Plastic |
| Minimum Cover | 3 ft |
| Manhole Spacing (Maximum) | 500 ft |
| Cleanout Spacing | at terminus |

TABLE IV-4

## BUILDOUT WASTEWATER FLOWS IN A CONVENTIONAL GRAVITY SYSTEM FOR THE TOWN OF PARADISE SEWER DISTRICT

| Subarea | Average Flow (gpd) | Peak Flow (gpd) | Infiltration/ Inflow (gpd) | Total Peak Flow (gpd) |
|---|---|---|---|---|
| Upper Clark | 506,000 | 1,262,000 | 40,000 | 1,302,000 |
| Lower Clark | 404,000 | 958,000 | 15,000 | 973,000 |
| Upper Skyway | 605,000 | 1,385,000 | 29,000 | 1,414,000 |
| Lower Skyway | 51,000 | 270,000 | 5,400 | 275,000 |
| TOTAL FLOWS | 1,566,000 | 3,875,000 | 97,800 | 3,964,000 |

Sewer mains and laterals installed in 1974 as part of the Skyway Assessment District have been incorporated into the preliminary design. There exists currently approximately 765 ft of 8 in. and 10 in. sewer main and roughly 100 laterals. The adequacy of the 8 in. main to carry buildout sewage flows and depth underground to serve the area will be further evaluated in the final design process. A schematic of the gravity collection system is shown as Figure IV-2.

Lift stations are planned to "lift" flows for those areas in the collection system that cannot be served by gravity. Design criteria for the small lift stations (typically, less than 100 gpm) are as follows: two submersible pumps, on rails for easy removal, placed in a precast manhole near the low point of the localized region that needs to be pumped. The sites may need to be fenced for security and public safety. All of the controls can be mounted on a pedestal that can be telemetered back to a centralized station to signal an emergency. Alternatively, the pump and motor controls may be mounted in the top of the manhole so that the entire station is below grade. A package station may be used for each of these lift stations.

A large pump station is anticipated at the bottom of Clark Road to pump all of the wastewater collected from the areas below Buschmann Road back up the hill. This is considered a large station (and therefore denoted a pump station as opposed to a lift station) which will require a custom design. It is anticipated that the average flow rate will be 865,000 gpd (600 gpm) at a total dynamic head (TDH) of approximately 360 ft (300 ft static head plus 60 ft of friction loss).

The Clark Road pump station will consist of three two-stage non-clog pumps that are sized to handle 300 gpm each. There will be an external structure to house the pumps as well as a generator for emergency power outages. The building will incorporate ventilation systems as well as lighting and other amenities. The site

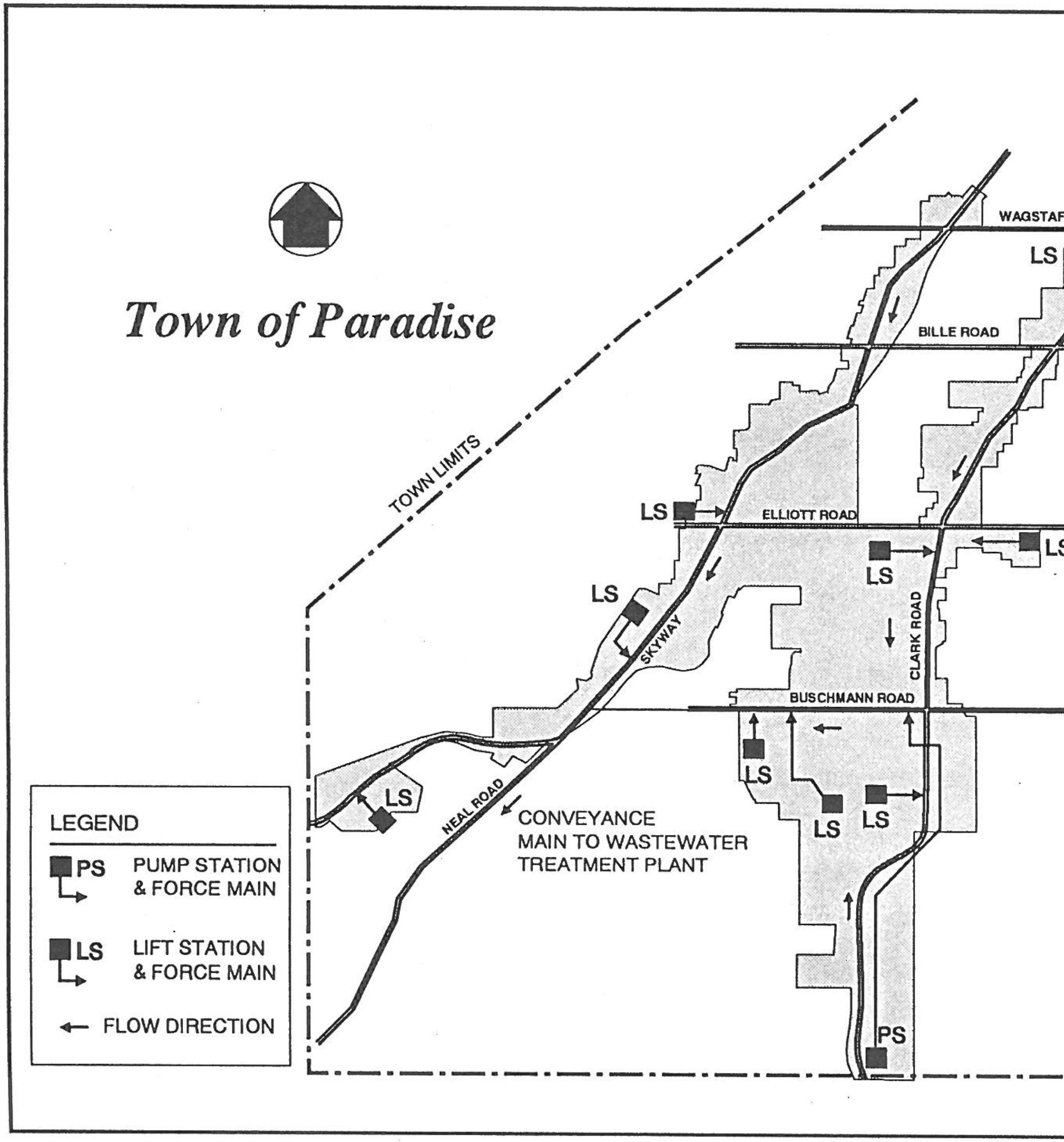


FIGURE IV-2

PARADISE PRELIMINARY DESIGN REPORT

**GRAVITY SYSTEM SCHEMATIC**

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M&E Metcalf & Eddy

should be approximately 40 by 60 ft and a fence and an all-weather access road should be constructed.

Additional easements are required throughout the system. Most of the mains will be placed in the public right of way; however where it is necessary to cross private property, a permanent utility easement will be needed. In some areas a temporary construction easement will also be required. It is anticipated that a 10-foot wide strip will be taken for the permanent and temporary construction easements. Additional area may be needed depending on construction methods.

c. Preliminary Cost Estimate

Unit cost assumptions for the conventional gravity system are presented in Table IV-5. Construction costs are included in Table IV-6. A contingency of 15% is added to cover unaccounted for items because the estimates are based on a preliminary design level of quantities. The costs for Construction Management, Administration, and Legal Issues (15%) is intended to cover the costs that occur during the post-award and construction periods of the project.

Construction costs presented in Table IV-6 represent a comprehensive figure including elements of work from each building or house. The lateral lengths are based on an average of 100 ft from the dwelling unit to the main in the street. The entire cost of the lateral will be considered a sewer district cost. Construction costs are based on published estimating guides as well as from discussions with local contractors regarding their recent experience with construction in the area [4-2]. The preliminary cost of \$1.00/ft$^2$ for easements and right of way acquisition is based on average market value of property within the Town of Paradise. Final costs will be calculated at 60% of market value for the permanent easements and 20% of market value for the temporary construction easements.

Surplus soil produced from the construction of the collection system will be used as engineered fill for the embankments at the treatment plant site. Surface restoration costs include replacement of the existing surface, either pavement or soil, to a condition equal to or better than existing. The paving costs are higher than average for the portions of the system along Clark Road where Caltrans requires special construction materials and techniques. An average cost of \$3.75/ft$^2$ is used for surface restoration to account for the high cost associated with stricter trench restoration requirements. A chip seal coating will be applied when the construction is complete.

Operations and maintenance costs of the conventional gravity collection system are presented in Table IV-7. Maintenance costs of the gravity sewers are estimated to be \$0.25/lf. The cost to maintain the force mains is \$1.25/lf. Force mains are smaller in diameter than the gravity pipes and thus clog more frequently and require more labor for servicing. Lift and pump station maintenance is estimated to require 3.5 hours per week. Energy costs are based on the estimated number of hours per day of lift and pump station operation.

TABLE IV-5

**COST ASSUMPTIONS FOR CONVENTIONAL GRAVITY SYSTEM**

| Item | Unit Cost ($) |
|---|---|
| Capital Unit Costs[a]: | |
| House Laterals, 4 in. | 12.00/lf |
| Gravity Sewers, PVC pipe | |
| 6 in. | 30.00/lf |
| 8 in. | 35.00/lf |
| 10 in. | 40.00/lf |
| 12 in. | 45.00/lf |
| Force Mains, PVC pipe | |
| 4 in. | 12.00/lf |
| 6 in. | 17.00/lf |
| Manholes | 2,100/ea |
| Terminal Cleanouts | 700.00 |
| Lift stations | 70,000/ea |
| Pump station | 325,000/ea |
| Paving/surface restoration | $3.75/ft^2$ |
| Easements[b] | $1.00/ft^2$ |

[a] Unit costs for gravity sewer pipe and force main include excavation, backfill and compaction, pipe materials, testing, and all appurtenant equipment necessary for proper installation and functioning of the system. The unit cost does not include surface restoration or any of the appurtenances listed separately in the table.

[b] Actual easement costs will vary with the property value.

TABLE IV-6

**CONVENTIONAL GRAVITY COLLECTION SYSTEM**
**FOR THE TOWN OF PARADISE**
**PRELIMINARY COST ESTIMATE**

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| 6 in. Gravity Sewer | 30.00/lf | 122,600 | 3,678,000 |
| 8 in. Gravity Sewer | 35.00/lf | 19,800 | 693,000 |
| 10 in. Gravity Sewer | 40.00/lf | 3,850 | 154,000 |
| 12 in. Gravity Sewer | 45.00/lf | 15,850 | 713,000 |
| 4 in. Force Main | 12.00/lf | 7,650 | 92,000 |
| 6 in. Force Main | 17.00/lf | 10,750 | 183,000 |
| Manholes | 2,100/ea | 477 | 1,002,000 |
| 4 in. Laterals - Public R/W (1,460 lots) | 22.00/lf | 56,800 | 1,250,000 |
| 4 in. Laterals - Private R/W (1,100 lots) | 12.00/lf | 66,000 | 792,000 |
| Lift Stations | 70,000/ea | 11 | 770,000 |
| Pump Station (Clark) | 325,000/ea | 1 | 325,000 |
| Air Release/Vacuum Valve | 3,000/ea | 1 | 3,000 |
| Paving/Surface Restoration | 3.75/ft$^2$ | 578,000 | 2,168,000 |
| Seeding & Sodding | 1.50/ft$^2$ | 205,000 | 308,000 |
| Abandonment of Existing Septic Tanks | $300/ea | 1,100 | 330,000 |
| Subtotal | | | 12,461,000 |
| Contingency (15%) | | | 1,869,000 |
| Subtotal | | | 14,330,000 |
| Erosion Control | | | 67,000 |
| Mobilization/Demobilization | | | 130,000 |
| Easements | | | 78,000 |
| Subtotal | | | 14,605,000 |
| (Continued) | | | |

TABLE IV-6

## CONVENTIONAL GRAVITY COLLECTION SYSTEM FOR THE TOWN OF PARADISE PRELIMINARY COST ESTIMATE

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| (Continued) | | | |
| Construction, Management, Administration, and Legal (15%) | | | 2,191,000 |
| TOTAL COST | | | 16,796,000 |

TABLE IV-7

## CONVENTIONAL GRAVITY COLLECTION SYSTEM PROJECTED OPERATION AND MAINTENANCE COSTS

| Description | Cost ($) |
|---|---|
| Gravity Sewers | 40,000 |
| Force Main Maintenance | 23,000 |
| Lift Stations and Pump Station | |
| Power | 21,000 |
| Maintenance | 15,000 |
| Annual Operations and Maintenance (O&M) | 100,000 |
| PRESENT WORTH OF ANNUAL O&M | 1,059,400 |

## 2. STEP/STEG System

STEP is an acronym for Septic Tank Effluent Pump. The septic tank acts as a primary clarifier. Heavy solids sink to the bottom to form a sludge layer and floatable material rises to form a scum layer. Rather than discharging to an individual drainfield, the septic tank effluent is collected and conveyed to a facility for treatment. A pump is located at each tank, or group of tanks, to convey the effluent under pressure to the treatment facility. The pumping system extracts water from the relatively clear layer found between the sludge and the scum layers in the tank. A screened vault within the tank or external pump basin further reduces solids allowing the use of high-head, low-flow submersible effluent pumps that can operate over a wide range of flow and head conditions. The typical effluent quality of a screened STEP system is approximately 130 mg/L to 150 mg/L $BOD_5$ and 30 mg/L to 50 mg/L TSS. A typical STEP system house connection detail is shown in Figure IV-3.

A STEG (Septic Tank Effluent Gravity) system functions much the same as a STEP system but without the need for the pump. STEG system tanks are located above the hydraulic gradeline of the sewer so the effluent can flow from the tank by gravity. A typical STEG system house connection detail is shown in Figure IV-4.

### a. Suitability

While the ground surface of Paradise generally slopes toward the south, there are many local areas that have adverse grade conditions. Adverse grade can make a conventional gravity sewer more expensive to install and can lead to the installation of lift stations. The amount of shallow rock and its rippability is also unknown at this time. Sewer lines servicing STEP or STEG systems are much smaller than conventional gravity lines which reduces excavation requirements. The smaller lines make the STEP and/or STEG system advantageous to the conventional gravity system in certain locations of Town.

### b. Design Criteria

The design flow assumptions used for the STEP/STEG system are the same as those used for the conventional gravity system. As a conservative measure, all of the septic tanks were assumed to require pumps to convey the effluent to the pipelines.

The pipes in the STEP system were sized to limit the velocities to 5 ft/sec or less. This maximum velocity is used because the headloss will begin to increase rapidly for velocities greater than 5 ft/sec. In some areas, due to the existing ground slope, the pipeline will not be under pressure and will flow by gravity even though the line is a pressure conduit. The minimum pipe size used was 2 inches

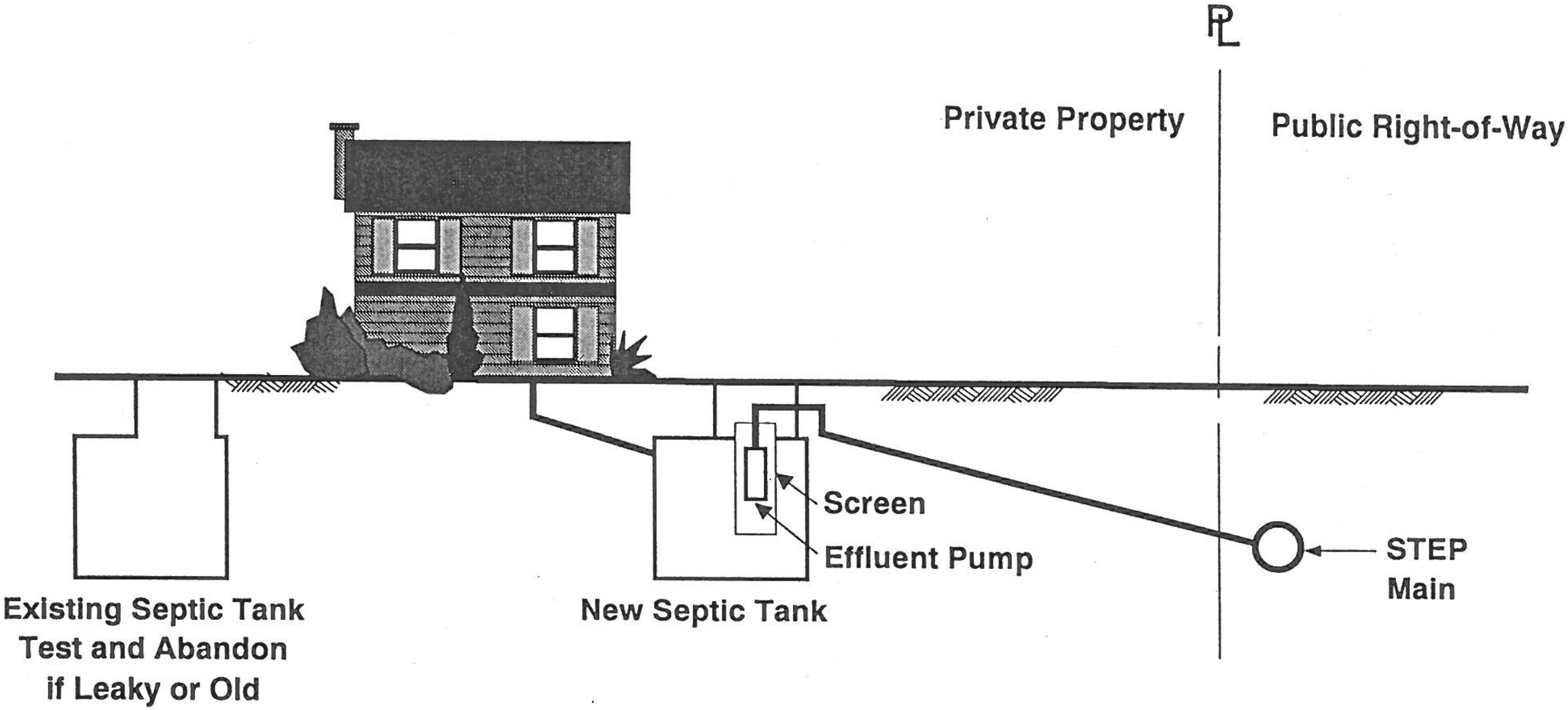


FIGURE IV-3

PARADISE PRELIMINARY DESIGN REPORT

**TYPICAL STEP SYSTEM**
**HOUSE CONNECTION DETAIL**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

M&E Metcalf & Eddy

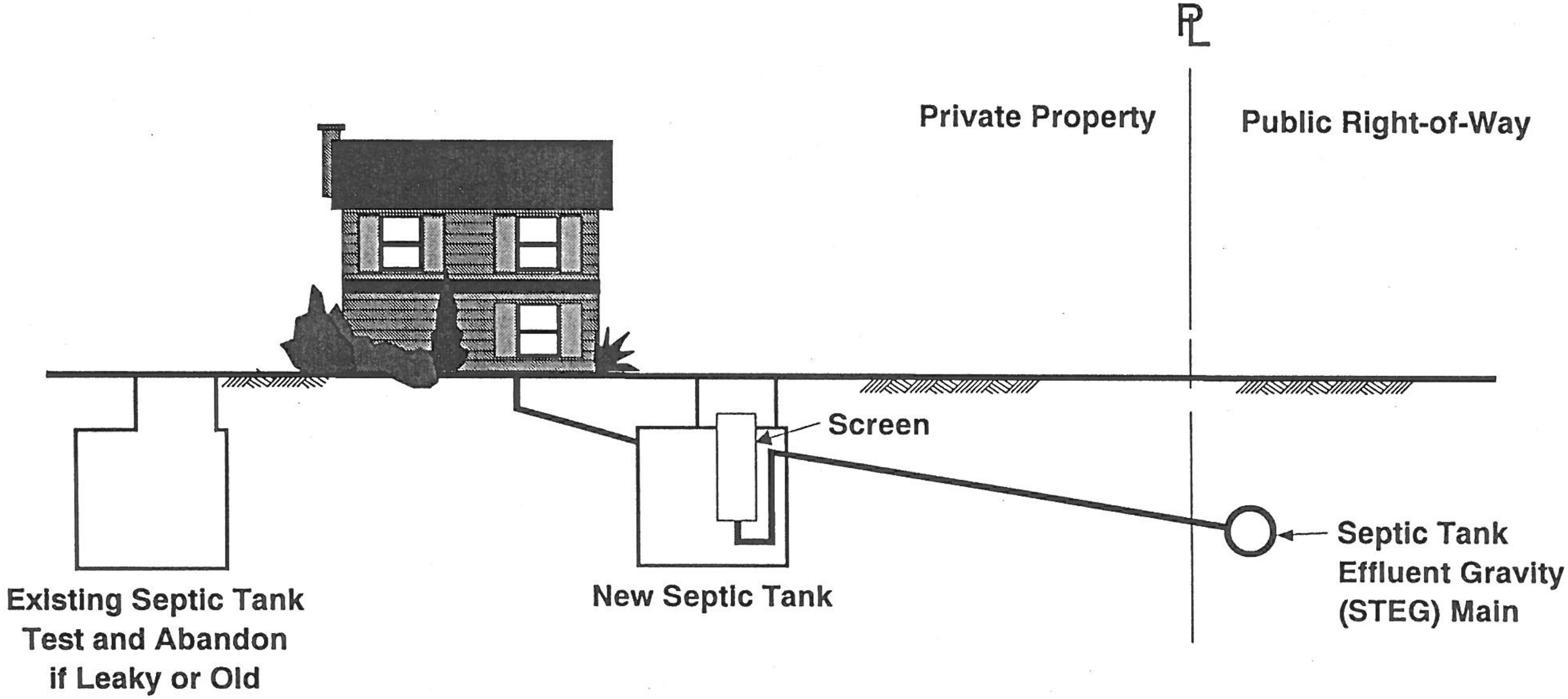


FIGURE IV-4

PARADISE PRELIMINARY DESIGN REPORT
**TYPICAL STEG SYSTEM HOUSE CONNECTION DETAIL**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

Metcalf & Eddy

in diameter, based on maintenance requirements. Headloss was calculated using the Hazen-Williams equation.

For STEG systems, the pipelines can be installed at smaller slope than conventional gravity sewers due to the lack of solids and scum in septic tank effluent. Self-cleaning scouring velocities are therefore not required in STEG systems. This results in shallower lines and a reduction in installed cost when compared with conventional gravity systems. A schematic of the STEP/STEG system is shown as Figure IV-5.

(1) <u>Wastewater Flow Characteristics</u>: The following criteria were used to determine the wastewater flowrates for the STEP/STEG system.

(a) Average flowrates are the same for conventional gravity or STEP/STEG collection systems. Flowrates based on zoning are summarized in Table IV-1. Flowrates for various areas of the sewer district are summarized in Table IV-8.

(b) Non-residential flows for existing units were converted to EDU's (Equivalent Dwelling Units) by using the total average daily flow from the water records and dividing by 200 gpd (one single family household). To determine the total flow at buildout, each parcel area was approximated and multiplied by the corresponding flow from Table IV-1 and then converted to an EDU for use in sizing the pipelines.

(c) Peaking factors were calculated by converting all the flows to EDU's and then using the Battelle Laboratories equation:

$$\textit{Peaking Factor} = \frac{18 + \sqrt{\frac{Population}{1000}}}{4\sqrt{\frac{Population}{1000}}}$$

Because the STEP/STEG system essentially functions as a pressure conduit, no infiltration/inflow (I/I) was assumed. Care must be taken during construction to insure that the tanks are watertight and that existing plumbing to the tank is watertight.

(d) Startup Assumptions: Because the STEP/STEG system has no gross solids, low velocities due to lower flows at startup were not a consideration.

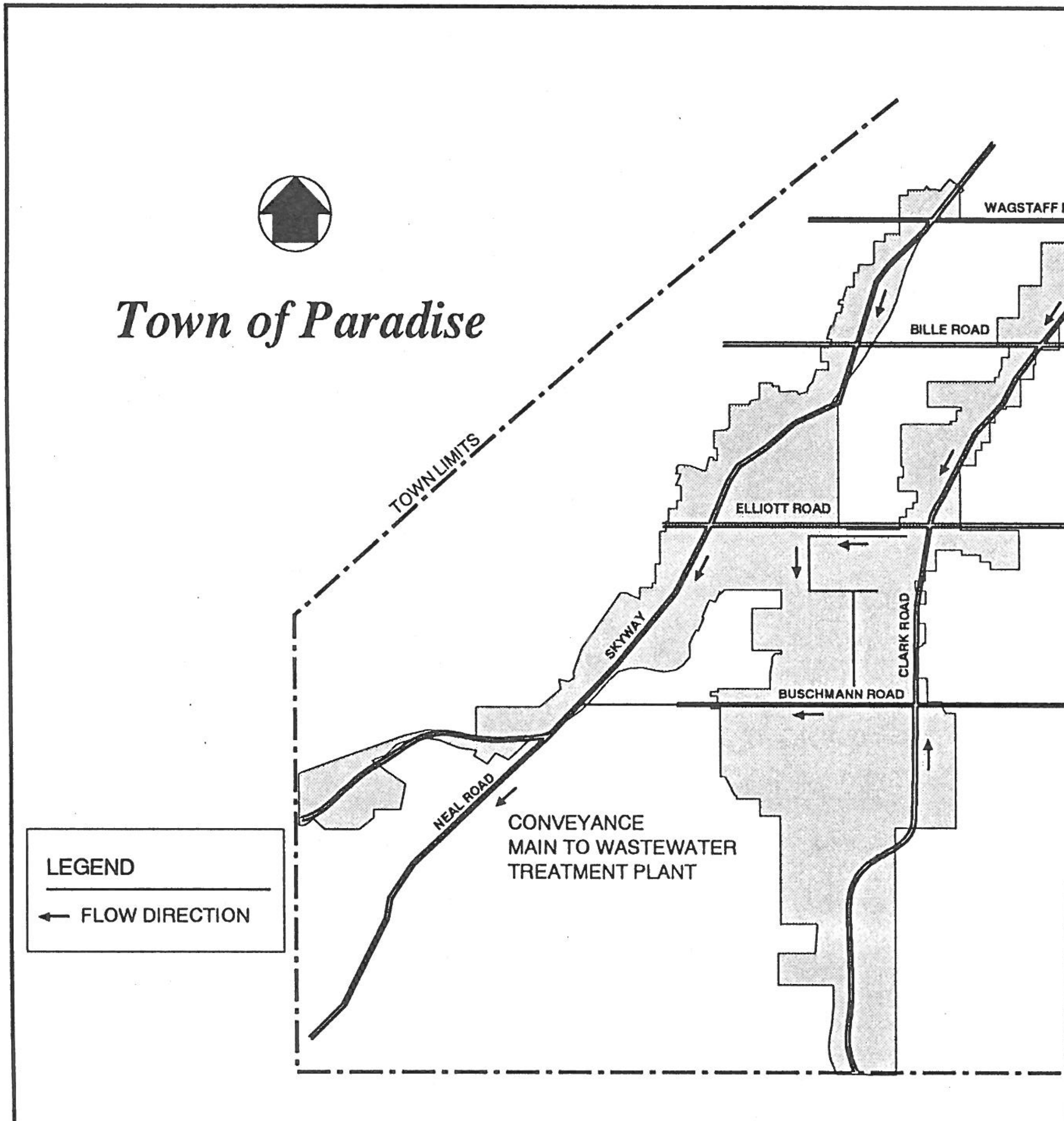


FIGURE IV-5

PARADISE PRELIMINARY DESIGN REPORT

**STEP SYSTEM SCHEMATIC**

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Metcalf & Eddy

(e) Buildout Assumptions: The STEP/STEG system pipelines were sized to handle the peaks flows predicted for the sewered area when the area is totally developed.

TABLE IV-8

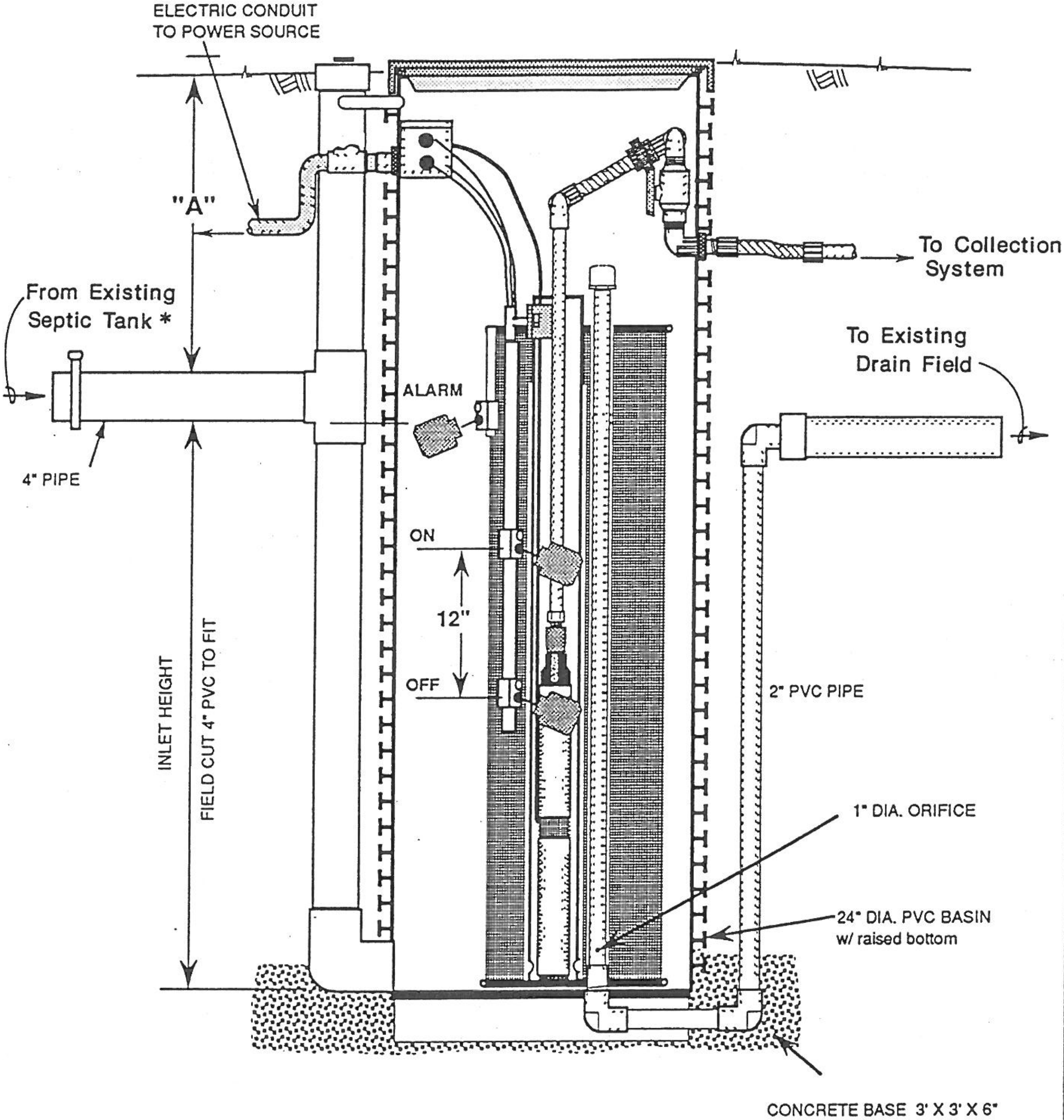
**STEP SYSTEM EXISTING AND BUILDOUT AVERAGE DAILY FLOWS FOR THE TOWN OF PARADISE SEWER DISTRICT**

| Subarea | Existing Flows (gpd) | Average Buildout Flows (gpd) |
|---|---|---|
| Upper Clark | 322,000 | 506,000 |
| Lower Clark | 32,000 | 404,000 |
| Upper Skyway | 224,000 | 605,000 |
| Lower Skyway | 24,000 | 51,000 |
| TOTAL FLOWS | 602,000 | 1,566,000 |

(2) Pipeline Design Criteria: The maximum cut for the STEP/STEG pipelines will likely be about 5 to 6 ft. Generally, it becomes more cost effective to use pumps when the pipeline depth is greater than 6 ft. As stated earlier in this chapter, many areas will be able to flow into the pipeline by gravity. The exact number of STEG installations would be determined during final design.

Existing septic tanks for single family dwellings and older commercial units will probably be abandoned in favor of new tanks to insure that no I/I is introduced into the system through leaking tanks. The existing tanks will be inspected and tested and retained if they are not leaky and are deemed suitable. Suitability factors include age, materials of construction, and current condition. Newer tanks may be left in place and a small package external pump basin used to keep the onsite facilities in service while the pressure sewer main and treatment facilities are being constructed. A typical external pump basin for a small installation is shown in Figure IV-6.

Air release/vacuum valve installations will require that the air be "scrubbed" of hydrogen sulfide prior to being released. The typical installation releasing small amounts of air will use carbon filters while the larger installations can make use of soil filters to clean larger amounts of air more economically.




* Existing tanks must be tested and found to be fully useable to be retained.

FIGURE IV-6

PARADISE PRELIMINARY DESIGN REPORT.

**EXTERNAL PUMP BASIN**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

Metcalf & Eddy

Where STEP/STEG systems are combined with conventional gravity sewers, the effluent will be aerated to increase the dissolved oxygen content and prevent corrosion. This can be accomplished by installing a static aerator that makes use of the elevation difference between the STEP/STEG system and the gravity sewer system. Another alternative is to line affected manholes and select corrosion resistant pipeline materials. If the STEP/STEG system is flowing by gravity and the pipes are less than full, wastewater will gain dissolved oxygen through surface aeration as it travels down the pipeline.

(3) STEP Pump Design Criteria: The pumps designed to serve single family dwellings would be flow restricted to limit the output to a maximum flow of 10 gpm. The pump would be capable of pumping 5 gpm against a TDH of 160 ft. Pumps designed for commercial and multi-family installations will be capable of pumping 20 gpm against a TDH of 105 ft. Both pumps will be vertical turbines made of stainless steel and plastic and use 1/2 hp motors. All materials will be capable of sustained operation in a septic atmosphere.

c. Easements

During the final design phase of the STEP/STEG system, each owner of existing residential, multi-family, commercial, or industrial installations will be interviewed to find the location of their septic system and asked to sign a right of entry agreement to allow access for construction and maintenance. Because the design of the STEP/STEG system allows it to follow the contour of the ground, mainline easements will be very rare. However, an easement will be included for each pump tank.

d. Preliminary Cost Estimate

Cost assumptions for the STEP/STEG system are included in Table IV-9. The preliminary cost estimate for the STEP/STEG system is presented in Table IV-10. There is a potential for retention of 65% of the existing septic tanks if a STEP system is utilized. However, for this report it was assumed that all septic tanks will be replaced. The cost estimate also includes a conservative assumption of 100% STEP whereas up to 40% of the systems may be able to be STEG. All of the pipelines were assumed to be in paved roadways.

TABLE IV-9

## COST ASSUMPTIONS FOR THE STEP/STEG SYSTEM

| Item | Unit Cost ($) |
|---|---|
| STEP/STEG sewers, PVC pipe: | |
| 2 in. Onsite Laterals (in asphalt) | 9.75/lf |
| 2 in. Onsite Laterals (no asphalt) | 7.50/lf |
| 2 in. | 10.50/lf |
| 3 in. | 11.25/lf |
| 4 in. | 12.00/lf |
| 6 in. | 17.00/lf |
| 8 in. | 19.50/lf |
| 10 in. | 23.00/lf |
| 12 in. | 27.50/lf |
| 15 in. | 34.50/lf |
| Air/Vacuum Release Stations | 3,000/ea |
| Onsite Installations: | |
| Septic Tank Installed | 1,500.00 |
| Electrical | 150.00 |
| Equipment | 800.00 |
| Equipment Installation | 175.00 |
| Contractors Overhead and Profit | 525.00 |
| Paving/surface restoration | 3.75/$ft^2$ |

TABLE IV-10

**STEP/STEG COLLECTION SYSTEM FOR THE TOWN OF PARADISE PRELIMINARY COST ESTIMATE**

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| 2 in. STEP/STEG Sewer | 10.50/lf | 62,840 | 660,000 |
| 3 in. STEP/STEG Sewer | 11.25/lf | 15,850 | 178,000 |
| 4 in. STEP/STEG Sewer | 12.00/lf | 6,900 | 83,000 |
| 6 in. STEP/STEG Sewer | 17.00/lf | 16,500 | 280,000 |
| 8 in. STEP/STEG Sewer | 19.50/lf | 13,050 | 254,000 |
| 10 in. STEP/STEG Sewer | 23.00/lf | 9,850 | 227,000 |
| 12 in. STEP/STEG Sewer | 27.50/lf | 6,170 | 170,000 |
| 15 in. STEP/STEG Sewer | 34.50/lf | 4,500 | 155,000 |
| 2 in. Laterals - Public R/W | 9.75/lf | 56,800 | 554,000 |
| 2 in. Laterals - Private R/W | 7.50/lf | 44,000 | 330,000 |
| 4 in. Laterals - Private R/W | 12.00/lf | 22,000 | 264,000 |
| Residential or Small Commercial Onsite Installation, 1 EDU or Less | 3,150/EDU | 717 | 2,259,000 |
| Commercial, Industrial,Multi-family Onsite Installation, 1 to 5 EDU's (Pump tank) | 3,500 per Connection | 153 | 536,000 |
| Commercial, Industrial, Multi-family Onsite Installation, 1 to 5 EDU's (Septic tank) | 600/EDU | 399 | 239,000 |
| Commercial, Industrial, Multi-family Onsite Installation, Greater than 5 EDU's (Pump tank) | 4,000 per Connection | 98 | 392,000 |
| Commercial, Industrial, Multi-family Onsite Installation, Greater than 5 EDU's (Septic tank) | 400/EDU | 2,095 | 838,000 |
| Paving/Surface Restoration | 3.75/ft$^2$ | 230,000 | 862,000 |
| (Continued) | | | |

TABLE IV-10

**STEP/STEG COLLECTION SYSTEM FOR THE TOWN OF PARADISE PRELIMINARY COST ESTIMATE**

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| (Continued) | | | |
| Abandonment of Existing Septic Tanks | 300/ea | 1,100 | 330,000 |
| Subtotal | | | 8,611,000 |
| Contingency (15%) | | | 1,292,000 |
| Subtotal | | | 9,903,000 |
| Erosion Control | | | 25,000 |
| Mobilization/Demobilization | | | 130,000 |
| Easements | | | 200,000 |
| Subtotal | | | 10,258,000 |
| Construction Management, Administration, and Legal (15%) | | | 1,539,000 |
| TOTAL COST | | | $11,797,000 |

Operations and Maintenance costs of a STEP/STEG System for the Town of Paradise are presented in Table IV-11. An all STEP/STEG effluent collection system would require two person-years to operate and maintain 1,100 connections based on experience with other STEP systems such as Montesano, WA. The majority of the time spent will likely be inspecting new installations added to the system.

The additional cost of pumping sludge from the septic tanks has been estimated at $200/EDU on a 7 year pumping cycle to allow for the increased accumulation in some commercial tanks as opposed to a 10 year cycle on all residential units.

(1) Replacement Costs: Pump life is assumed to be 10 years. The cost of pump replacement is approximately $300 per pump.

(2) Power Costs: The average pump will operate 20 min/day. The 1/2 hp pump will draw approximately 10 amps at 120 volts. The monthly power consumption per EDU will be approximately 12 kWh. At $0.10 per kWh, this is a cost of $1.00/month.

TABLE IV-11

**STEP/STEG SYSTEM**
**PROJECTED OPERATION AND MAINTENANCE COSTS**

| Description | Value |
|---|---|
| Labor Call Outs/Valve Maintenance | $60,000/yr |
| Septic Tank Emptying | $74,000/yr |
| Pump Replacement | $26,000/yr |
| Power | $4,000/yr |
| Annual Operations and Maintenance (O&M) | $164,000 |
| PRESENT WORTH OF ANNUAL O&M | $1,737,000 |

### 3. Hybrid Collection System

A hybrid system is defined as a combination of the technologies described above to serve the Town of Paradise sewer district. For purposes of this report, conventional gravity, STEG, and STEP systems were applied to various areas of the sewer district to produce an economical wastewater collection solution.

#### a. Suitability

The topography within the Paradise Sewer Service area contains some areas that slope away from the sewer mainlines and therefore will require lift stations to provide sewer service by conventional means. These areas are prime candidates for a combination of STEG and STEP systems.

#### b. Design Criteria

The design criteria for the hybrid system includes guidelines for both conventional gravity or STEP/STEG systems. In areas where adverse grade would require the depth of the gravity sewer system to be greater than 8 ft, in areas of hard rock, in areas requiring lift stations or individual pumps, a STEP system will be considered. Hydraulic flows used for this alternative are the same as the conventional gravity and STEP/STEG alternatives.

#### c. Other Considerations

The use of STEP/STEG collection system along the Clark Road corridor reduces the cost of potential wastewater treatment for reclamation. Septic tank effluent is similar to what is commonly known as "primary effluent" at many wastewater treatment plants. The wastewater is relatively free of gross solids and scum, therefore preliminary treatment to remove screenings, grit, and scum is not required. Primary settling facilities and solids handling are also not required. This attribute of the STEP/STEG system will be considered in the analysis of collection system alternatives.

d. Preliminary Cost Estimate

For ease of presentation, the preliminary cost estimate for the hybrid system was divided into two tables representing the two main sections of the service area, Skyway and Clark Road. Table IV-12 includes the cost of the conventional gravity and STEP systems proposed for Skyway. Table IV-13 includes the cost of the STEP/STEG systems proposed for Upper Clark, Lower Clark, and Buschmann. The total cost for the hybrid collection system is presented in Table IV-14. Projected operations and maintenance costs of the hybrid system are included in Table IV-15.

TABLE IV-12

**CONVENTIONAL GRAVITY/STEP FOR SKYWAY**
**PRELIMINARY COST ESTIMATE**

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| 6 in. Gravity Sewer | 30.00/lf | 49,200 | 1,476,000 |
| 8 in. Gravity Sewer | 35.00/lf | 7,300 | 256,000 |
| 12 in. Gravity Sewer | 45.00/lf | 9,050 | 407,000 |
| 4 in. Force Main | 12.00/lf | 1,550 | 19,000 |
| Manholes | 2,100.00/ea | 142 | 298,000 |
| Cleanouts | 700/ea | 44 | 31,000 |
| 4 in. Laterals - Public R/W | 22.00/lf | 23,200 | 510,000 |
| 4 in. Laterals - Private R/W | 12.00/lf | 25,860 | 310,000 |
| Lift Station | 70,000.00/ea | 1 | 70,000 |
| Air Release/Vacuum Valve | 3,000.00/ea | 1 | 3,000 |
| 2 in. STEP Sewer | 10.50/lf | 1,440 | 15,000 |
| 2 in. Laterals - Public R/W | 9.75/lf | 760 | 7,000 |
| 2 in. Laterals - Private R/W | 7.50 | 760 | 6,000 |
| 4 in. Laterals - Private R/W | 12.00 | 380 | 5,000 |
| (Continued) | | | |

TABLE IV-12

## CONVENTIONAL GRAVITY/STEP FOR SKYWAY PRELIMINARY COST ESTIMATE

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| (Continued) | | | |
| Residential or Commercial Onsite Installation, 1 EDU or less | 3,150/EDU | 19 | 60,000 |
| Paving/Surface Restoration | 3.75/ft$^2$ | 292,260 | 1,096,000 |
| Landscape Repair | 40,000/ls | 1 | 40,000 |
| Abandonment of Existing Septic Tanks | 300/ea | 450 | 135,000 |
| Subtotal | | | 4,744,000 |
| Contingency (15%) | | | 712,000 |
| Subtotal | | | 5,456,000 |
| Erosion Control | | | 44,000 |
| Mobilization/Demobilization | | | 80,000 |
| Easements | | | 48,000 |
| Subtotal | | | 5,628,000 |
| Construction Management, Administration, and Legal (15%) | | | 844,000 |
| TOTAL COST | | | $6,472,000 |

TABLE IV-13

## STEP/STEG COLLECTION SYSTEM FOR UPPER CLARK, LOWER CLARK, AND BUSCHMANN PRELIMINARY COST ESTIMATE

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| 2 in. STEP/STEG Sewer | 10.50/lf | 32,990 | 346,000 |
| 3 in. STEP/STEG Sewer | 11.25/lf | 12,400 | 140,000 |
| 4 in. STEP/STEG Sewer | 12.00/lf | 2,400 | 29,000 |
| 6 in. STEP/STEG Sewer | 17.00/lf | 6,400 | 109,000 |
| 8 in. STEP/STEG Sewer | 19.50/lf | 4,600 | 90,000 |
| 10 in. STEP/STEG Sewer | 23.00/lf | 5,700 | 131,000 |
| 12 in. STEP/STEG Sewer | 27.50/lf | 6,170 | 170,000 |
| 2 in. Laterals - Public R/W | 9.75/lf | 33,600 | 328,000 |
| 2 in. Laterals - Private R/W | 7.50/lf | 26,000 | 195,000 |
| 4 in. Laterals - Private R/W | 12.00/lf | 13,000 | 156,000 |
| Residential or Small Commercial Onsite Installation, 1 EDU or Less | 3,150/EDU | 273 | 860,000 |
| Commercial, Industrial, Multi-family Onsite Installation, 1 to 5 EDU's (Pump Tank) | 3,500 per Connection | 46 | 161,000 |
| Commercial, Industrial, Multi-family Onsite Installation, 1 to 5 EDU's (Septic Tank) | 600/EDU | 121 | 73,000 |
| Commercial, Industrial, Multi-family Onsite Installation, Greater than 5 EDU's (Pump Tank) | 4,000 per Connection | 58 | 232,000 |
| Commercial, Industrial, Multi-family Onsite Installation, Greater than 5 EDU's (Septic Tank) | 400/EDU | 1,440 | 576,000 |
| Paving/Surface Restoration | 3.75/ft$^2$ | 106,000 | 398,000 |
| Landscape Repair | 1.00/ft$^2$ | 45,000 | 45,000 |
| Abandonment of Existing Septic Tanks | $300/ea | 650 | 195,000 |
| (Continued) | | | |

TABLE IV-13

## STEP/STEG COLLECTION SYSTEM FOR UPPER CLARK, LOWER CLARK, AND BUSCHMANN PRELIMINARY COST ESTIMATE

| Description | Unit Cost ($) | Quantity | Total ($) |
|---|---|---|---|
| (Continued) | | | |
| Subtotal | | | 4,234,000 |
| Contingency (15%) | | | 635,000 |
| Subtotal | | | 4,869,000 |
| Erosion Control | | | 25,000 |
| Mobilization/Demobilization | | | 130,000 |
| Easements | | | 168,000 |
| Subtotal | | | 5,192,000 |
| Construction Management, Administration, and Legal (15%) | | | 779,000 |
| TOTAL COST | | | $5,971,000 |

TABLE IV-14

## HYBRID COLLECTION SYSTEM PRELIMINARY COST ESTIMATE

| Description | Total ($) |
|---|---|
| Skyway Area, Conventional Gravity | 6,472,000 |
| Clark Road Area, STEP/STEG | 5,971,000 |
| TOTAL | 12,443,000 |

TABLE IV-15

HYBRID COLLECTION SYSTEM
PROJECTED OPERATIONS AND MAINTENANCE COSTS

| Description | Cost ($) |
|---|---|
| Gravity Sewer Maintenance | 17,000 |
| STEP/STEG Labor Call Outs/ Valve Maintenance | 35,000 |
| Septic Tank Emptying | 44,000 |
| Pump Replacement | 16,000 |
| STEP/STEG Power | 2,000 |
| Annual Operations and Maintenance (O&M) | 114,000 |
| PRESENT WORTH OF ANNUAL O&M | 1,208,000 |

## B. EVALUATION OF COLLECTION SYSTEM ALTERNATIVES

The collection system alternatives for the Town of Paradise sewer district were evaluated based on criteria related to the unique setting of the Town and the costs of construction and operations and maintenance.

### 1. Engineering Evaluation

Collection system alternatives were evaluated based on each system's characteristics and applicability to the unique features and constraints of the Paradise area. Each alternative system has individual characteristics which dictate its proper usage under a given set of local requirements. The relative merits of each alternative system and typically applied combinations of systems have been simplified and tabulated in Table VI-16. The following is a discussion of the various alternatives and their practical application to the Paradise sewer service area.

TABLE IV-16

## ENGINEERING EVALUATION OF ALTERNATIVE SEWERS [4-3][a]

| Sewer Type | Ideal Topography | Construction Cost in Rocky, High Ground Water Sites | Sulfide Potential | Minimum Slope or Velocity Required | Operations & Maintenance Requirements | Power Requirements |
|---|---|---|---|---|---|---|
| STEG | downhill | moderate | high | no | low-moderate | none |
| STEP | uphill | low | high | no | moderate-high | low |
| Conventional | downhill | high | moderate | yes | low | none |
| STEG- STEP | undulating | low-moderate | high | no | moderate | low |

a. Topography

The topography of the Paradise service area is very hilly and undulating with multiple ridges and drainages. The placement of major transportation corridors (Skyway and Clark Road) on ridgelines complicates the layout of gravity collection systems. In this type of terrain, the cost of conventional sewers is increased by the need for multiple lift stations. Although STEG systems are less expensive to install than conventional sewers, the need for multiple lift stations and pumping of septic tanks will also greatly increase STEG costs. The STEG approach using variable-grade sewers can reduce the number of lift stations by following natural drainage courses. STEP systems are applicable to any adverse or undulating grade as they can follow natural grades at minimum depths. STEP pumps are applicable at total dynamic heads up to 300 ft.

b. Geology/Hydrology

Where rocky soil or high groundwater conditions exist, the cost of conventional sewers increases rapidly. Excavation, trench dewatering, imported backfill and compaction requirements can significantly increase the installation cost. Long-term pipe deterioration in areas of high groundwater can lead to excessive infiltration resulting in increased conveyance and treatment plant costs. The use of older septic tanks and house laterals with STEP and STEG sewers in high ground water areas may allow excessive infiltration/inflow (I/I) into the system. The Paradise collection system service area has several localized areas of shallow soil or high groundwater which may increase trenching and installation costs. In general, the lower Clark Road and Neal Road areas have very shallow soils. Sloping beds of the Tuscan mudflow, locally referred to as "lava cap," are found at or near the surface in these areas. A basaltic outcropping which runs parallel to and east of Skyway will present localized trenching problems for east-west sewer lines. This outcropping, commonly called "post rock" is exposed in road cuts along Elliott Road and Pearson Road.

Areas of high groundwater have been documented within the low lying drainages. STEP and STEG sewers require less excavation and become more cost-effective under these conditions.

c. Climate

In warmer climates, conventional sewers can develop odor and corrosion problems associated with high concentrations of sulfides. Mean annual temperature for the Town of Paradise is approximately 60°F with summer daytime temperatures typically ranging between 85 and 100°F. Potential odors of hydrogen sulfide, mercaptans, and other toxic gases will need to be controlled at transitions (changes in type of collections systems, manholes) and at air release valves.

Along Skyway, sulfide concentrations should not pose a significant problem for conventional gravity sewers under open channel flow conditions. Sufficient oxygen should be present in the system to inhibit the formation of hydrogen sulfide. Sulfide control measures will be required at all transition points from STEP and variable-grade STEG sewers to gravity interceptors where a STEP/STEG pipeline residence time of 30 minutes or greater is anticipated. Sulfide control to prevent corrosion will also be necessary at receiving manholes constructed of concrete. Air or chemical oxidants should be introduced to the STEP\STEG line upstream of the convergence or the manholes lined with a corrosion-resistant material. The sulfate content of the water supply in Paradise is low, so the potential for hydrogen sulfide generation will probably also be low.

d. Population Density, Growth and Development

Conventional sewers are generally advantageous in highly developed areas with high population densities. In low-density areas, the cost per connection to conventional sewers significantly increases. Paradise has a relatively high density of development along the Skyway corridor. The Clark Road corridor, in general, is of a lower density than Skyway. The density differences and the presence of commercial establishments along Skyway result in the buildout to initial design flow ratios being small for Skyway (3) and large for the Clark Road area (7).

The Skyway area with its high degree of development and low flow ratio, is an appropriate area for the application of conventional gravity sewers. The Clark Road area with a lower development density and larger flow ratio is more amenable to the implementation of STEP/STEG systems. There are additional considerations in the recommendation of STEP/STEG systems for the Clark Road corridor. Septic tank replacement and pump vault installation in areas of high commercial development can be difficult. STEG systems, because of their relative freedom from minimum velocity requirements, can handle a wide variance between initial and ultimate design flows.

e. Operation and Maintenance

Conventional sewers require considerable efforts in routine inspection and maintenance, including the flushing and cleaning of solids from the pipes and periodic repairs to manholes and other structures. STEG system operational & maintenance consists primarily of septic tank pumping and occasional mainline flushing. The majority of the maintenance work required on STEP systems is electrically related. Routine inspection and maintenance is required for proper operation of pumps, float switches, air release valves, and electrical control panels.

f. Power

Conventional gravity and STEG systems do not require power for operation where appropriate topography exists. Pressure sewers are subject to the reliability of residential power supplies. STEP systems generally accommodate lengthy power outages because of the inherent excess capacity of each septic tank. Septic tank effluent can flow by gravity into the existing leachfield if it is left intact.

g. Treatability

Septic tank effluent transported by STEG and STEP systems is quite amenable to aerobic biological treatment. Because of reduced I/I in both systems and lower peak flows realized with septic tanks, the treatment facility may be designed with a reduced hydraulic capacity. The minimal concentration of grease, grit, and settleable solids in the effluent may permit elimination of preliminary grit removal, screening and primary treatment systems. Corrosion resistant construction materials, odor control, and immediate oxygen demand requirements must be considered during the design of treatment facilities for these types of wastewaters.

h. Easements

Minimizing the number of lift stations will require the purchasing of back-lot easements for conventional gravity collection. Easement negotiations and access restrictions can limit the pipeline routes which are the least cost. Pressure sewers have a distinct advantage over gravity sewers; the hydraulic gradient can be overcome by the addition of energy from pumps.

i. Treatment/Reuse Considerations

The importance and long-term availability of water resources must also be considered in the selection of a collection system for the Town of Paradise. California has experienced several years of drought and the Paradise Irrigation District has investigated several costly alternatives for augmenting their water supply. These include raising the elevation of the dam at Magalia Reservoir and the installation of deep groundwater wells. Ultimately, this could lead to significant increases in the price of water. As potable water costs increase, the implementation of a wastewater reclamation and reuse program for the Town of Paradise will become more attractive. In-town reuse of wastewater for landscape irrigation at the Tall Pines Golf Course and the Paradise Cemetery is discussed in detail in Chapter VII of Volume 2. The incorporation of STEP/STEG systems in the Clark Road corridor will provide primary treatment and thus reduce costs of the proposed reclamation facilities.

### 2. Subjective Evaluation

Relative characteristics of the collection system alternatives are summarized and presented in Table IV-17. Further discussion of the characteristics are included in the following paragraphs.

TABLE IV-17

SUBJECTIVE EVALUATION OF ALTERNATIVE SEWERS

| Sewer Type | Disruption | | Safety | Noise | Aesthetics | Odors | Constructability |
|---|---|---|---|---|---|---|---|
| | Public | Private | | | | | |
| STEG | Low | Low | High | Low | Good | Low | Good |
| STEP | Low | High | High | Low | Good | Moderate | Moderate |
| STEG-STEP | Low | Moderate | High | Low | Good | Low-Moderate | Good |
| Conventional | High | Low | Moderate | Moderate | Good | Moderate | Moderate-Difficult |

#### a. Disruption

Disruption as it applies to the Paradise Wastewater Project, was defined as inconveniences to the Town residents and businesses during installation of the sewer or its operation and maintenance. Public property disruption would apply during construction in public right of ways such as roads. This type of disruption would manifest itself as traffic delays, detours, loss of access to business and dusty roads. Private property disruption would apply during construction on private property or along easements. This type of disruption would manifest itself as interruption of facilities, noise, landscape removal, and dust.

The STEP/STEG sewer would, in general, be less disruptive on public right of ways than conventional sewer construction. This is because of the reduced width and depth of the sewer trench, resulting in smaller excavation equipment and less soil to be hauled off. However, the STEP/STEG sewer would be considered to be more disruptive on private property. This is because a relatively large excavation must be made to accommodate the new septic tank (if needed) or auxiliary pump vault.

#### b. Safety

Safety during construction of the sewer is of the utmost importance. Deep trenches and poor soil stability have led to serious injuries during the installation of conventional sewers. Conventional gravity sewers in Paradise will occasionally require sewer lines deeper than 5 ft because of the need to maintain gravity flow. Some lines will be installed as deep as 16 ft below ground surface. The California Occupational Health and Safety Administration requires that any trench over 5 ft deep be shored or sloped to provide adequate soil stability.

The STEP/STEG sewer is not constrained by the minimum slope requirements of the gravity sewer and can typically be installed with a minimum cover of 3 ft of soil. STEP/STEG sewers take advantage of gravity when it is available, and use pumps when it is not available, thereby minimizing the depth of the sewer. The relative safety of STEP/STEG is therefore high compared to conventional gravity.

STEP/STEG sewers are usually less than 4 in. diameter pipe which results in a narrow trench typically less than 1 ft wide. However, conventional gravity sewers are usually between 6 in. and 12 in. in diameter resulting in a trench width up to 2-1/2 ft.

c. Noise

Typically STEP/STEG sewers are installed with trenching equipment that is self-powered. The noise associated with trenching equipment would be less than that of a backhoe or large excavator required for the installation of conventional gravity sewer lines. The occurrence of volcanic "cap rock" or "post rock" may require blasting to install conventional gravity sewers in certain areas.

STEP system have internal pumps located inside the septic tank, or a specially designed pump vault. The pumps are designed to be quiet and are also dampened by the soil and tank surrounding the pump. Therefore, noise from STEP system pumps would be low to inaudible.

d. Aesthetics

In general, conventional sewers are located beneath the ground surface, therefore the sewers are not visible. Small lift stations will be located within oversized manholes and therefore will also be unobtrusive. The pump station at the lower end of Clark Road will include an above ground structure for instrumentation and auxiliary power and will be designed to be pleasing architecturally.

STEP/STEG sewers have a manhole riser for cleaning the tank as well as an electric panel for pump controls. These items can be painted or positioned to blend with the homeowners' landscape, thereby minimizing the aesthetic impacts.

e. Odors

Sewage conveyance systems, by their very nature, have the potential to emit offensive odors. Once waste is flushed from the home, there should not be any odors detected from a properly operating system. Odor problem areas are typically found at the upstream side of inverted siphons, at pump stations for conventional gravity systems, and at air release valves for STEP/STEG sewers. Manholes on gravity systems can also release odors.

f. Constructability

In general, conventional sewers have been in use for centuries. Contractors have installed thousands of miles of pipe through various terrain under all types of conditions. The STEP/STEG sewers are more recent in development. Their use in the United States is limited to the last 10 to 15 years and subsequently the number of experienced contractors and design engineers is relatively small. There are approximately 37 STEP systems in California. The installation of the STEP/STEG pipelines is quite simple but difficulties can arise in the on-lot installation of the septic tank and pump appurtenances. Conventional sewers do not have septic tanks and only require pipeline installation. Construction difficulties can arise when conventional sewers are installed in deep trenches with high groundwater or with rocky soil. Blasting is often required when conventional sewers are installed in areas of shallow soil.

### 3. Cost Evaluation

a. Construction Cost

The construction costs for the all conventional gravity, all STEP/STEG, and hybrid collection systems are summarized in Table IV-18.

TABLE IV-18

**COLLECTION SYSTEM CAPITAL COSTS**

| Description | Cost ($) |
|---|---|
| Conventional Gravity | 16,796,000 |
| STEP/STEG | 11,797,000 |
| Hybrid | 12,443,000 |

b. Operations and Maintenance Costs

The annual operations and maintenance costs for the conventional gravity, STEP/STEG, and hybrid collection systems are summarized in Table IV-19.

TABLE IV-19

COLLECTION SYSTEM OPERATIONS AND MAINTENANCE COSTS

| Description | Cost ($/yr) |
|---|---|
| Conventional Gravity | 100,000 |
| STEP/STEG | 164,000 |
| Hybrid | 114,000 |

c. Total Present Worth

Total present worth of each of the collection system alternatives was calculated using the capital costs and the annual O&M costs presented previously in this chapter. A comparison of the total present worth costs is included in Table IV-20. Within the context of a present worth analysis, the STEP/STEG and the hybrid systems are approximately equal. the Skyway corridor, however, is better suited for conventional gravity sewers than STEP/STEG sewers due to the density of commercial development and favorable terrain.

TABLE IV-20

COLLECTION SYSTEM TOTAL PRESENT WORTH COSTS

| Description | Cost ($) |
|---|---|
| Conventional Gravity | 17,855,000 |
| STEP/STEG | 13,534,000 |
| Hybrid | 13,651,000 |

## C. RECOMMENDED COLLECTION SYSTEM ALTERNATIVE

The recommended collection system alternative for the Town of Paradise sewer district is the hybrid system. Pipeline layout is presented as Exhibit B (Figures IV-7 through IV-13). The hybrid system was selected based on low construction costs, low operations and maintenance costs, and suitability to the varying terrain and land use of the Town of Paradise. Conventional gravity is more appropriate than STEP/STEG systems along Skyway due to the level of development of the area, including many small commercial establishments, and the topography. STEP/STEG is more appropriate for the Clark Road area due to the lower density of development, the ability to cluster several commercial units (such as at Safeway), the variable grade, and the potential for wastewater reclamation.

### 1. Total Capital Costs of the Recommended Collection System

Total capital costs of the recommended collection system will include construction of the hybrid system and the purchase of miscellaneous equipment for sewer system maintenance. The required accoutrements for sewer maintenance may include sewer cleaning equipment, vehicles, supplies, safety equipment, and spare parts. A hydroflusher or a backhoe should be contracted out initially and then purchased at a later date if the need arises. An estimate of the miscellaneous equipment needed for the hybrid system is presented in Table IV-21. The total capital costs of the recommended system is presented in Table IV-22.

TABLE IV-21

MISCELLANEOUS EQUIPMENT FOR THE HYBRID COLLECTION SYSTEM

| Description | Cost ($) |
|---|---|
| Vehicles (2) | 20,000 |
| Safety Equipment | 8,000 |
| Sewer Cleaning Equipment | 10,000 |
| Supplies | 5,000 |
| Spare Parts | 3,000 |
| Tools | 5,000 |
| TOTAL COST | 51,000 |

TABLE IV-22

TOTAL CAPITAL COSTS OF THE HYBRID COLLECTION SYSTEM

| Description | Cost ($) |
|---|---|
| Hybrid Collection System | 12,443,000 |
| Miscellaneous Equipment | 51,000 |
| TOTAL COST | 12,494,000 |

### 2. Wastewater Conveyance Pipeline

The wastewater collected from the Skyway and Clark corridors will be routed down Neal Road to the proposed treatment facility. The conveyance pipeline will be a 12 in. diameter gravity line with maximum manhole spacing at 1,000 ft. Transmission to the treatment plant will begin at Skyway and Neal Road and will continue along the Neal Road right of way for approximately 16,600 ft. The turnoff to the wastewater treatment plant will follow the PG&E gas line easement for 7,000 ft to Upper Horning Ranch. A 12 ft wide, asphalt paved access road to the wastewater treatment plant will also be constructed along the PG&E easement. The estimated costs of installing the conveyance pipeline and constructing the access road are presented in Table IV-23.

TABLE IV-23

**WASTEWATER CONVEYANCE PIPELINE**
**PRELIMINARY COST ESTIMATE**

| Description | Quantity | Unit Cost ($) | Total ($) |
|---|---|---|---|
| 12 in. Pipe - Along Neal Road | 16,600 lf | 45 | 747,000 |
| 12 in. Pipe - Along Gasline Easement | 7,000 lf | 35 | 245,000 |
| Manholes | 24 | 2,100 | 50,000 |
| Manhole Lining | 24 | 700 | 17,000 |
| Paving/Surface Restoration | 41,500 ft$^2$ | 2.50 | 104,000 |
| WWTP Entrance Road | 84,000 ft$^2$ | 2.75 | 231,000 |
| Hydroseeding | 70,000 ft$^2$ | 0.15 | 10,000 |
| Subtotal | | | 1,404,000 |
| Contingency (15%) | | | 211,000 |
| Subtotal | | | 1,615,000 |
| Erosion Control | | | 6,000 |
| Mobilization/Demobilization | | | 80,000 |
| Subtotal | | | 1,701,000 |
| Construction Management, Administration, and Legal (15%) | | | 255,000 |
| TOTAL COST | | | 1,956,000 |

## REFERENCES


4-1 Metcalf & Eddy
1991 *Wastewater Engineering - Treatment, Disposal, and Reuse,* McGraw-Hill Publishing Company.

4-2 Fitzgerald, W.
1992 Personal Communication with Bill Fitzgerald of Frank Green Construction.

4-3 Water Pollution Control Federation
1985 *Alternative Sewer Systems*, Manual of Practice No. FD-12, Water Pollution Control Federation.

# CHAPTER V
# SEPTAGE HANDLING ALTERNATIVES

# V. SEPTAGE HANDLING ALTERNATIVES

## A. SEPTAGE CHARACTERISTICS AND VOLUMES

### 1. Characteristics

Septage, for the purpose of this report, is defined as the anaerobically digested sludge, scum and liquid pumped from a septic tank. Septage generally has high concentrations of grease and grit and emits a highly offensive odor. The characteristics of septage will vary depending on origin whether a kitchen garbage disposal is used, frequency of septic tank pumping, etc. Typical characteristics of septage are shown in Table V-1.

Septage samples collected from the Sewage Commission Oroville Region (SCOR) sewage treatment plant in Oroville were analyzed and found to contain biochemical oxygen demand, suspended solids, and volatile suspended solids at concentrations of 4,200 mg/L, 22,200 mg/L, and 14,000 mg/L, respectively. This is generally consistent with typical values presented by EPA and Metcalf & Eddy [5-1, 5-2].

TABLE V-1

**TYPICAL CHARACTERISTICS OF SEPTAGE[a]**

| Parameter | Range (mg/L) | Typical (mg/L) | EPA Mean (mg/L) |
|---|---|---|---|
| Total Solids | 5,000-100,000 | 40,000 | 38,800 |
| Suspended solids | 4,000-100,000 | 15,000 | 13,330 |
| Volatile suspended solids | 1,200-14,000 | 7,000 | 8,700 |
| $BOD_5$ at 20°C | 2,000-30,000 | 6,000 | 5,000 |
| Chemical oxygen demand | 5,000-80,000 | 30,000 | 42,900 |
| Total Kjeldahl nitrogen (TKN as N) | 100-1,600 | 700 | 680 |
| Ammonia, $NH_3$, as N | 100-800 | 400 | 160 |
| Total phosphorus as P | 50-800 | 250 | 250 |

[a] Adapted from Table 3-17, Metcalf & Eddy, *Wastewater Treatment*, [5-2].

Heavy metals are another environmentally important constituent of septage. Table V-2 contains values presented by EPA as typical metals concentrations for municipal septage. No comprehensive studies of metals concentrations have been performed for septage in Butte County. However, metals were analyzed in the highly concentrated sludge from the septage drying ponds at the Neal Road Landfill. The sludge was found to be suitable for disposal in the landfill.

TABLE V-2

**TYPICAL SEPTAGE METAL CONCENTRATIONS [5-3]**

| Metal | Range (mg/L) | EPA Mean (ug/L) |
|---|---|---|
| Aluminum (Al) | 2.0-200.0 | 50.0 |
| Arsenic (As) | 0.03-0.5 | 0.1 |
| Cadmium (Cd) | 0.05-10.8 | 0.5 |
| Chromium (Cr) | 0.30-3.0 | 1.0 |
| Copper (Cu) | 0.30-34.0 | 8.5 |
| Iron (Fe) | 3.0-750.0 | 200.0 |
| Mercury (Hg) | 0.0002-4.0 | 0.1 |
| Manganese (Mn) | 0.50-32.0 | 5.0 |
| Nickel (Ni) | 0.20-28.0 | 1.0 |
| Lead (Pb) | 1.50-31.0 | 2.0 |
| Selenium (Se) | 0.02-0.3 | 0.1 |
| Zinc (Zn) | 33.0-153.0 | 50.0 |

### 2. Volumes

Septage volumes for the Town of Paradise were derived from Butte County records, population data, and disposal site records [5-4, 5-5, 5-6, 5-7]. The Town of Paradise generates approximately 30% of the total septage produced in Butte County. This amounted to 1.8 million gallons in 1990 and approximately 1.7 million gallons in 1991.

The proposed onsite district includes septage generated from both the Town of Paradise and the upper ridge area. The volume of septage expected is 2.4 million gallons per year.

## B. EXISTING TREATMENT AND DISPOSAL METHODS

The current method of disposal for septage from the Town of Paradise is to haul septage to the Neal Road Landfill (NRLF) for discharge to lagoons designated for septage only. When the septage is dried, it is scraped from the lagoon and buried in the landfill. Neal Road Landfill handles approximately 80% of the total septage generated in Butte County.

Disposal of septage to the NRLF presently costs $19.35 per 1,000 gallons. This includes approximately $6.85 for Neal Road Landfill Company to cover operation and maintenance, and $12.50 is collected by the county to cover other related cost such as monitoring and closure. The county presently has awarded a contract for the design of new lined Class II septage ponds. The approximate cost of new ponds is $750,000. Currently, no projections for the actual effect of these costs on current tippage fees for NRLF have been calculated by Butte County.

If a growth rate of 2% is considered for septage volume production in Butte County and a 7% interest rate is applied to the present worth of construction, the additional cost of the new ponds translates to approximately $12.95 per 1,000 gallons. This value also assumes no reserve funds are available to defer the construction cost and that the Town of Paradise continues septage disposal at NRLF. Therefore, the cost of disposal at the NRLF is expected to rise considerably.

The only other septage disposal sites in Butte County are located in Oroville and in Gridley. Both of these sites receive septage exclusively from their respective service areas. The septage received at these two sites is placed in sludge drying beds and stockpiled after drying. The SCOR facility in Oroville charges $14.55 per 1,000 gallons and the Gridley facility charges $7.50 per 1,000 gallons.

It should be noted that the existing ponds at the Neal Road Landfill are currently scheduled for closure in 1992. The planned lined ponds referenced above will occupy land to the south of the existing pond sites. However, the county presently has an extension of their use-permit to research the possibility of combining resources with the Town of Paradise.

## C. SEPTAGE TREATMENT AND DISPOSAL ALTERNATIVES

There are numerous alternatives for receiving, treating and disposing septage. In general, methods for septage treatment and disposal fall into three major categories:

- Land treatment and disposal.
- Independent facilities for treatment and disposal.
- Co-treatment at a wastewater treatment plant.

### 1. Land Application Alternatives

Septage applied to land can be stabilized, dewatered, or both, or can be applied without any pretreatment under certain conditions. Properly managed land application is relatively simple, economical, and can make beneficial utilization of the nutrient value of septage. Land application, according to the U.S. EPA is the most frequently used technique for septage disposal in the U.S. today.

Land application should continue to be a very common means of disposal, although Federal and State regulations are placing additional restrictions on its use, particularly with regard to pathogen control in agricultural land application. The health aspects of land application of septage will be discussed in a subsequent section.

All land disposal alternatives require analyses of soil characteristics, seasonal groundwater levels, neighboring land use, potential water quality impacts, and public access restriction such as signs and fences. There are three basic methods of land application for septage disposal: a) Surface application; b) Subsurface incorporation; and, c) Burial. These methods are described briefly as follows, and are summarized in Table V-3.

a. Surface Application

(1) Spray Irrigation: Spray irrigation of septage necessitates storing septage in a lagoon before disposal. Portable pipes and large nozzle guns as shown in Figure V-1 are used rather than fixed or solid set sprinklers. Because the septage must be pumped at 80 to 100 psi through 3/4 to 2 in. nozzle openings, a screening device at the lagoon's pump suction is mandatory to prevent clogging of the distribution nozzles. Spray irrigation also offers the greatest potential for offensive odors; thus a well-located site is important.

(2) Ridge and Furrow Irrigation: This method has been used to dispose of sludges on relatively level land, usually limited to 1.5% slopes. Although this method can be used to distribute septage to row crops during their growth, care should be taken to ensure these crops are not for human consumption. This method is illustrated in Figure V-1.

(3) Land Spreading: Land spreading has been the most commonly used technique of land application in the U.S. This very simple method involves spreading septage directly to the soil as the pumping truck slowly traverses the disposal field. Operation and maintenance requirements are relatively

TABLE V-3

**LAND DISPOSAL CONSIDERATIONS FOR APPLICATION OF SEPTAGE [5-3] [a]**

| Land Disposal Method | Characteristics | Advantages | Disadvantages |
|---|---|---|---|
| A. Surface application | | | |
| Spray irrigation | Large nozzle orifices recommended: irrigation lines to be drained after irrigation season | Can be used on steep or rough land | High power requirements; odor problems; possible pathogen dispersal<br><br>Storage lagoon needed for pathogen destructin and when ground is wet or some odor |
| Ridge and furrow | Land preparation | Lower power requirements than spray irrigation; can be used in furrows, on crops not grown for human consumption | Limited to 1.5% slopes; storage lagoon; some odor |
| Hauler truck spreading | Larger volume trucks require floatable tires; 500 to 2,000 gallon trucks ok; 800 to 3,000 gallon capacity | Same truck can be used for transport and disposal | Some odor immediately after spreading; storage lagoon; limited to 8% slopes |
| Farm tractor with tank wagon spreading | Requires additional equipment | Frees hauler truck during high usage periods | Some odor immediately after dispersal; storage lagoon; limited to 8% slopes |

(Continued)

TABLE V-3

**LAND DISPOSAL CONSIDERATIONS FOR APPLICATION OF SEPTAGE [5-3] [a]**

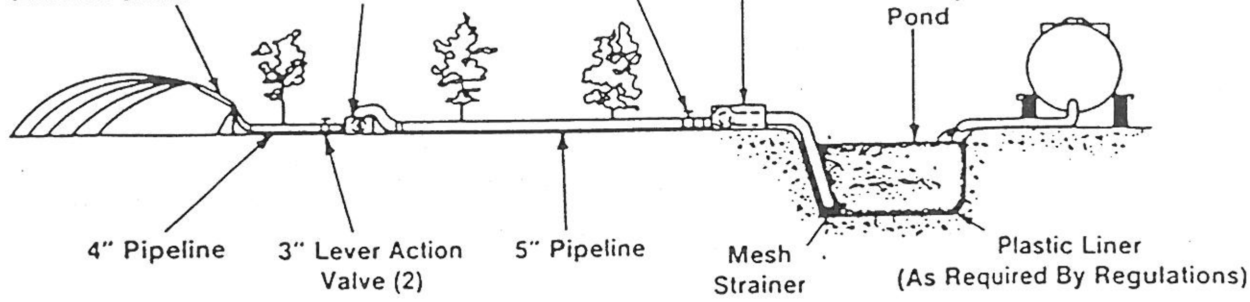
| Land Disposal Method | Characteristics | Advantages | Disadvantages |
|---|---|---|---|
| (Continued) | | | |
| Overland flow | Use on sloping ground with vegetation | Can be applied from ridge roads, suitable for emergency operation | Difficult to get uniform distribution; extensive site preparation; slopes limited to <8% |
| B. Subsurface application | | | |
| Tank truck with plow-furrow-cover (PFC) | Single plow mounted on truck; not usable on wet or frozen ground | Minimal odor; storage lagoon optional for pathogen control | Limited to 8% slopes; longer time needed for disposal operation than for surface disposal |
| Farm tractor with PFC | Septage discharge into furrow behind single plow; septage spread in narrow swath and immediately plowed; not usable on wet or frozen ground | Minimal odor; storage lagoon optional for pathogen control | Limited to 8% slopes; more time needed for application than in surface disposal |
| Sub-sod injection (SS) | Septage placed in opening created by tillage tool; not usable in wet, frozen, or hard ground | Injector can be mounted on rear of some trucks; minimal odor; storage lagoon optional for pathogen control | Limit land to 8% slopes; more time needed for application than in surface disposal keeps vehicles off area for 1 to 2 weeks after injection |
| (Continued) | | | |

TABLE V-3

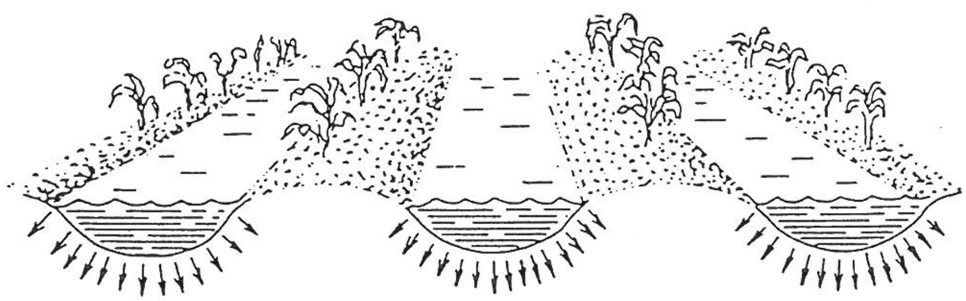
## LAND DISPOSAL CONSIDERATIONS FOR APPLICATION OF SEPTAGE [5-3] [a]

| Land Disposal Method | Characteristics | Advantages | Disadvantages |
|---|---|---|---|
| (Continued) | | | |
| C. Burial | | | |
| Trench | New trenches opened when old ones filled; long-term land commitment after operations end | Simplest operation, no slope limits; no climatological limits | Odor problems; high groundwater restrictions; vector problem |
| Lagoon | Sludge bucketed out to landfill from bottom of lagoon; settled water usually flows to percolation/infiltration beds | No slope limits; no climatological limits | Odor problems; high groundwater restrictions; vector problem |
| Sanitary landfill | Septage mixed with garbage at controlled rates; possible leachate and collection requirements | No topographic limits; simple operation | Odor problems; rodent and vector problems; limited to areas with less than 35 inches yearly rainfall or have leachate collection or be isolated from groundwater |

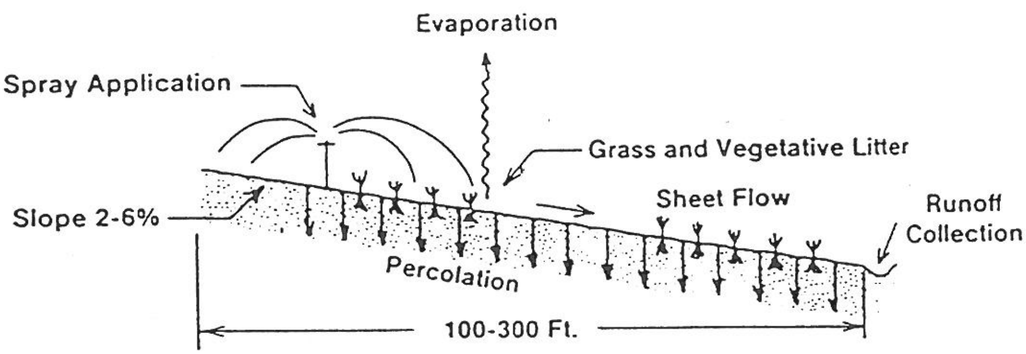
[a] Assumes a moderately drained soil, nitrogen loading requirements as limiting factor, and use of holding tanks during inclement weather.




LIQUID SLUDGE SPREADING SYSTEM IN FOREST LAND UTILIZING TEMPORARY STORAGE PONDS



RIDGE AND FURROW IRRIGATION METHOD FOR APPLYING SEPTAGE TO LAND




OVERLAND FLOW METHOD OF APPLYING SEPTAGE TO LAND

Source: US EPA [5-1]

FIGURE V-1

PARADISE PRELIMINARY DESIGN REPORT

**METHODS FOR LAND APPLICATION OF SEPTAGE**

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very low. The hauler truck that pumps the septic tank is frequently the vehicle that applies the septage to the land. A typical layout of a site used for landspreading of septage is shown in Figure V-2. As with all methods of land application, setbacks are regulated.

Storage is necessary immediately prior to and/or after precipitation to prevent runoff of contaminated water. Also, studies have shown that levels of certain bacteria and viruses in sludge are reduced during storage. (See Table V-5). With a storage facility, disposal can be performed by the hauler truck or by a tank wagon, usually pulled by a farm tractor. The choice is one of economics. A larger operation may choose to have its trucks on the road with septage spreading performed by a separate crew, thus freeing the more expensive tank truck to perform cleanout functions. A smaller septage hauler may prefer to use one vehicle to perform both tasks, thus leveling the workload by spreading septage during slack hauling periods. In some instances, soil conditions may require the use of floatation-type tires that are not suitable for long-distance highway use. This would dictate the use of separate collection and spreading vehicles.

Land spreading is best suited to land slopes of less then 8% with strict runoff controls. Other requirements include interim storage facilities, crop management techniques, odor control procedures,and loading criteria. Loading criteria generally are determined by agricultural considerations that result in the limiting of toxic organics and heavy metals.

(4) Overland Flow: This method was studied as part of an overall septage-sewage and septage-sewage-sludge treatment system at the Brookhaven National laboratory in Upton, New York. The overland flow field, as part of the meadow-marsh-pond treatment system was planted with reed canary grass and has a slope of 3%. Although experiments at the Brookhaven National Laboratories have been discontinued, the development of the technique, in combination with the marsh-pond system, has shown promise. An illustration of this method is shown in Figure V-1.

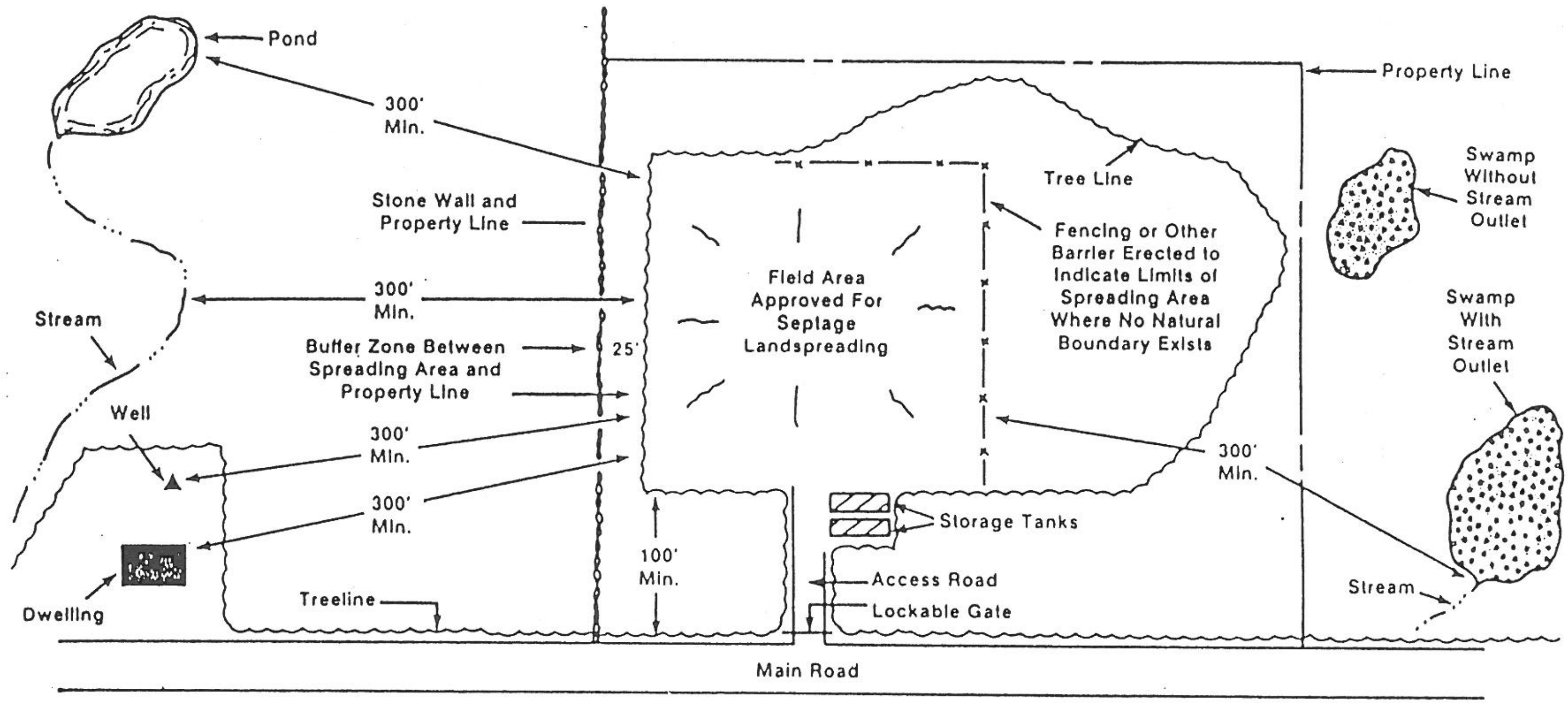
b. <u>Subsurface Incorporation</u>

Subsurface incorporation techniques have gained acceptance as an alternative for disposal of liquid sludge and to some extent, septage.

The three basic approaches to subsurface incorporation are:

- Incorporate using a farm tractor and tank trailer with attached injection equipment.

- Incorporate using a special purpose tank truck with subsurface injection equipment.




Source: US EPA [5-1]

FIGURE V-2

PARADISE PRELIMINARY DESIGN REPORT

**TYPICAL SEPTAGE DISPOSAL SITE**

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- Incorporate using tractor-mounted, subsurface injection equipment in conjunction with a central holding facility and flexible "umbilical cord". Liquid sludge is continually pumped from the hold tank to the injection equipment.

The following incorporation techniques offer better odor and pest control than surface spreading and reduce the risk of inadvertent exposure of humans to pathogens. Specialized equipment is generally required, depending on the method of subsurface disposal practiced. Two of these techniques are illustrated in Figure V-3.

(1) Plow-Furrow-Cover (PFC): A typical setup for implementing this method consists of a moldboard plow with furrow wheels and colters. The colter blade is used to slit the ground ahead of the plow. Septage is applied to the land in a narrow furrow 6 to 8 in. deep and is immediately covered by the following plow.

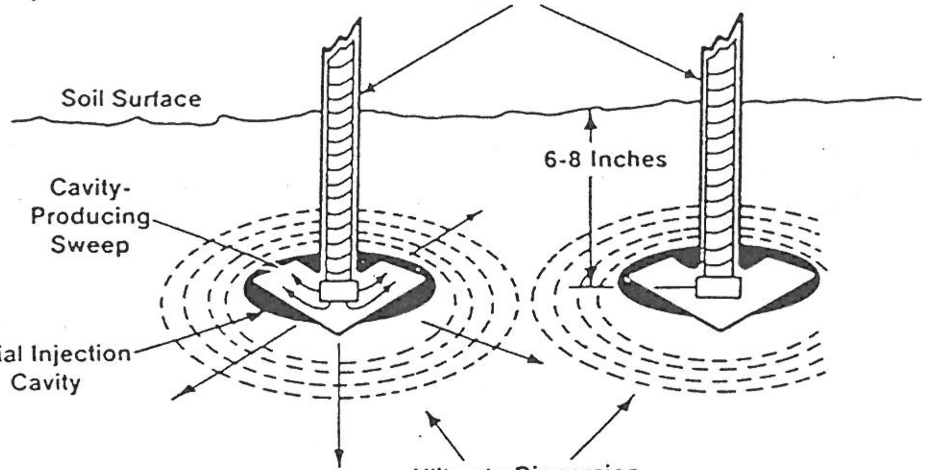
(2) Subsurface Injection: This technique employs a device that injects either a wide band or several narrow bands of septage into a cavity 4 to 6 in. below the surface. Rollers then force the injection swatch closed.

(3) Terreator: This is a patented device that drills a 3.75 in. hole with an oscillating chisel point. A curved tube places the septage as deep as 20 in. below the surface at a rate of 2 gallons per linear foot.

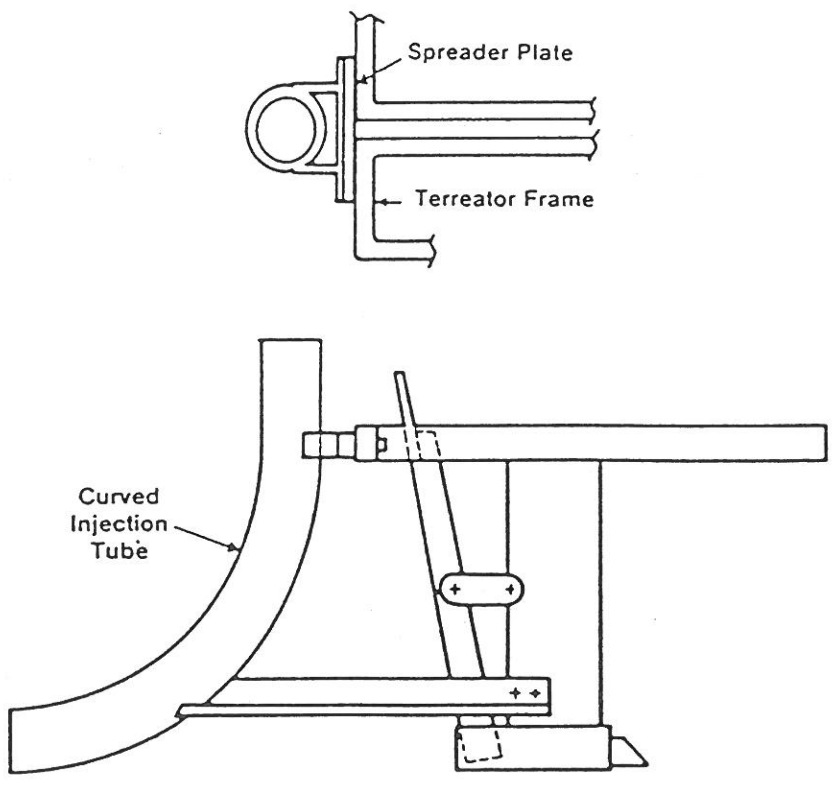
c. Burial

Burial methods include disposal in holding lagoons, trenches, and sanitary landfills. Foul odors are inherent to all of these operations until a final cover of soil is placed over the applied septage. Site selection and management practices are particularly important, not only for odor control, but also to minimize potential groundwater and surface water pollution. Although burial methods are not a means of agricultural usage of septage, it is addressed here to complete the discussion of land application options for septage disposal. Also, this is the current method of septage disposal for the Town of Paradise.

(1) Trenches: Disposing septage in trenches is similar to disposing septage in lagoons, except that trenches are usually a smaller scale alternative. Septage is placed sequentially in one of many trenches in small lifts, 6 to 8 in., to minimize drying time. When a trench is filled with septage, 2 ft of soil should be placed as a final covering, and a new trench opened. Sufficient room must be left between trenches for movement of heavy equipment. The trench-and-fill technique is often used at sanitary landfills. An alternate management technique allows a filled trench to remain uncovered to permit as many solids as possible to settle, as well as liquids to evaporate and leach out. Then the solids as well as some bottom and sidewall material are removed to the landfill as cover and the trench is reused.




**SUBSURFACE SOIL INJECTION**




**TERREATOR APPARATUS FOR SUBSURFACE INJECTION**

FIGURE V-3

PARADISE PRELIMINARY DESIGN REPORT

**METHODS FOR SUBSURFACE INJECTION OF SEPTAGE**

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(2) Lagoons: These are usually a maximum of 6 ft deep, allow no effluent or underdrain system, and require small (6 to 12 in.) incremental lifts and sequential loading of lagoons for optimum drying. After drying, solids can be scraped out and disposed in a sanitary landfill and the lagoon used for further applications, or 2 ft of soil may be placed over the solids as a final cover. Odor problems may be reduced by placing the lagoon inlet pipe below the liquid level and have water available for haulers to immediately wash spills into the lagoon inlet pipe.

(3) Sanitary Landfills: Leachate production and treatment and odor are the main problems to be addressed when a sanitary landfill accepts septage. For moisture absorption, a recommended ratio is 10 gallons of septage to each cubic yard of solid wastes. A 6 in. earth cover should be applied daily to each area that is dosed with septage and a final cover of 2 ft within one week after placement of the final lift. Generally, this in not an economical method of disposal and is not normally recommended.

d. Guidelines for Agricultural Use of Septage

Sewage sludge has been used for centuries as a soil amendment and fertilizer. Early use practices were concerned mainly with the transmission of intestinal diseases to the population due to the high incidence of pathogenic bacteria and intestinal parasites in sludge and in untreated sewage. More recently, concerns have been raised regarding the accumulation of certain metals and toxic organic chemicals in the soil and vegetation where sludge is applied.

Sewage sludge has many characteristics which make it a valuable agricultural supplement and soil conditioner. Sludge contains a fair amount of nitrogen, phosphorus, and micronutrient elements. It can make the soil more friable, enhance tilth, and increase pore space and water holding capacity. However, sludge also contains pathogens and toxic substances which present hazards to public health and the environment.

The design requirements and constraints associated with land disposal of septage are closely related to sewage sludge and are dependent on the type of crop grown, soil condition, and the septage characterization, including pathogens, organics, N, Cd, Pb, Zn, Cu and Ni. Consideration must be given to stabilization and additional pathogen reduction before surface application of septage to land.

The constraints discussed below are mostly based on federal regulations presented in 40 CFR 257, *Criteria for Classification of Solid Waste Disposal Facilities and Practices* [5-8]. State and local requirements are discussed individually.

(1) Control of Disease Transmission: The natural digestion process in a septic tank does not always result in a pathogen free material. Untreated septage contains a variety of potential pathogens, including bacteria, protozoa, parasites, and viruses. For this reason, care must always be taken in handling and disposal of septage.

Pathogenic organisms found in septage are discharged by humans who are infected or carriers of a particular disease. The usual bacteriological pathogenic organisms that may be excreted by man cause diseases of the gastrointestinal tract such as typhoid and paratyphoid fever, dysentery, diarrhea, and cholera. Viral pathogens include polio virus and hepatitis A.

Federal and state regulations now require that septage applied to the land or incorporated into the soil must be treated by a "process to significantly reduce pathogens" (PSRP) prior to application or incorporation, unless public access to the facility is restricted for at least 12 months, and unless grazing by animals whose products are consumed by humans is prevented for at least one month. Aerobic digestion, air drying, anaerobic digestion, composting, lime stabilization, or other techniques that provide equivalent pathogen reduction are acceptable PSRP's. These treatment processes are discussed in a subsequent chapter. Septage is further required to be treated by a "process to further reduce pathogens" (PFRP) prior to application or incorporation if crops for direct human consumption are grown within 18 months subsequent to septage application or incorporation where contact between the septage applied and the edible portion of the crop is possible. Acceptable PFRP's include beta or gamma ray irradiation, pasteurization, or other equivalents, after a PSRP process. The state guidelines for use of disinfected and undisinfected sludge are summarized in the following section on "Recommended Practices to Control Disease Transmission".

The potential for groundwater contamination by land treatment disposal of septage can be minimized by proper design and management techniques. It is important to demonstrate to the public that every managerial precaution has been taken, and that the chance of contamination is extremely remote.

Evidence that pathogens are reduced when septage is exposed to atmospheric conditions is based on work by the Metropolitan Sanitary District of Greater Chicago and others. As shown in Table V-4, only 1% of the original coliforms survived after 7 days. The number of days of storage required in a laboratory study for reduction of several viruses and bacteria to 99.9% from the original values at various temperatures is presented in Table V-5.

TABLE V-4

**FECAL COLIFORM COUNTS OF STORED DIGESTER SUPERNATANT EXPOSED AT ATMOSPHERIC CONDITIONS [5-9]**

| Days | Fecal Coliform Counts (per 100 ml) | Percent Survival |
|---|---|---|
| 0 | [a]800,000 | 100.00 |
| 2 | [b] 20,000 | 2.50 |
| 7 | 8,000 | 1.00 |
| 14 | 6,000 | 0.75 |
| 21 | <2,000 | <0.25 |
| 35 | <20 | <0.01 |

[a] Fecal coliform count just before lagooning.
[b] Fecal coliform count after lagooning.

TABLE V-5

**LABORATORY STUDY ON NUMBER OF DAY'S STORAGE REQUIRED FOR 99.9 PERCENT REDUCTION OF VIRUS AND BACTERIA IN SLUDGE [5-10]**

| Organism | Number of Days at | | |
|---|---|---|---|
| | 39°F | 68°F | 82°F |
| Poliovirus 1 | 110 | 23 | 17 |
| Echo virus 7 | 130 | 41 | 28 |
| Echo virus 12 | 60 | 32 | 20 |
| Coxsackie virus A9 | 12 | -- | 6 |
| Aerobacter aerogenes | 56 | 21 | 10 |
| *Escherichia coli* | 48 | 20 | 12 |
| Streptococcus faecalis | 48 | 26 | 14 |

Pathogens are removed in the soil by various mechanisms, predominately filtration, soil inactivation, and die-off. The distance traveled by pathogens is usually restricted to several feet from point of application, unless runoff or channeling occurs.

The disposal of raw sludge on agricultural lands without treatment is not recommended in the guidelines. Partially digested septage may be applied if some preventive measures are followed, such as lagooning or immediate liming of septage before land disposal.

(2) <u>Recommended Practices To Control Disease Transmission</u>: The California DHS recommends the following practices for handling sewage sludge as well as septage.

(a) <u>Use of Treated but Undisinfected Sludge</u>: Sludge which has been effectively stabilized but which is undisinfected may be applied to land used for the production of a wide range of food chain crops; however, undisinfected sludge contains large numbers of pathogenic organisms, such as salmonella bacteria, parasitic worm eggs and viruses. These organisms persist for long periods in soil and on vegetation and may cause disease when ingested. Therefore, strict sanitary precautions are necessary when using undisinfected sludges. Sludge treated by a stabilization process may be applied to land used for the production of processed food crops, orchards and vineyards, and animal feed other than that consumed by milking animals, provided that the heavy metal limits are met. The following precautions should be observed:

(1) Public access should be prevented for 12 months.

(2) Grazing by animals whose products are consumed by humans should be prevented for one month after sludge application.

(3) If pasture is subsequently converted into a dairy pasture, grazing by milking animals should be prevented for a least 12 months after last sludge application. Where the milk is unpasteurized, no grazing should be allowed.

(4) There should be no planting of unprocessed food crops for three years after sludge application. A longer waiting period is necessary in humid climates.

(b) <u>Use of Disinfected Sludge</u>: Sludge treated by a disinfection process (except thermophilic composting) or stabilized sludge treated by a supplementary disinfection process, may be applied to land used for the production of any crop without observing the precautions cited above for undisinfected sludge.

Because of the uncertain effectiveness of thermophilic composting in pathogen destruction, sludge disinfected by thermophilic composting should not be applied to land used for grazing of milking animals or for production of unprocessed food crops.

(c) Application Practices: The following precautions should be observed to minimize development of nuisances, sludge residues on crops, and public and worker exposure to the sludge.

(1) Where liquid sludge is employed, the sludge should be incorporated into the soil within 48 hours after application. If application is by spraying, the public should be protected from the sludge spray.

(2) Sludge applied to orchards and vineyards should be treated by air drying or composting and should be incorporated into the soil. Sludge should not be applied immediately preceding or during the fruit harvesting period.

(3) Sludge should not be applied directly to any growing food chain crop, except hay production on properly cropped pasture.

In spite of all the above precautions, the use of sludge on unprocessed food crops such as salad vegetables and root crops may not be desirable. Even through the pathogens may be destroyed, sludge is objectionable to many persons on aesthetic grounds. As discussed under the heading "Heavy Metals in Septage", leafy vegetable and root crops are cadmium accumulators which presents an additional health hazard.

(3) Nutrients in Septage: Nutrients in septage, specifically nitrogen and phosphorus, are of concern due to the potential for nitrate groundwater contamination and for surface water eutrophication. Nitrogen and phosphorus are also of interest with respect to specific loading rates as they apply to the land treatment of septage.

Nitrogen is the nutrient in septage that is required in the largest amounts by potential crops selected for the disposal site. However, N application in excess of the amount required for crops results in the potential for nitrate ($NO_3$) contamination of groundwater supplies. Elevated $NO_3$ levels in water supplies could result in health risks for infants and livestock. Because nitrogen requirements vary significantly from crop to crop, and due to the fact that some nitrogen may carry over from year to year, close monitoring of nitrogen application is required. Depending on application techniques, significant nitrogen loss can occur through ammonia volatilization.

The amount of fertilizer recommended for different crops is determined by the nutrients required for optimum yield. The amounts of nitrogen, phosphorus, and potassium required to obtain a given crop yield have been determined experimentally for different crops and soil types in each region of the country. A variety of crops that might be grown on sites where septage has been applied, along with their respective nutrient requirements are listed in Table V-6. For all crops, yield potential and soil fertility are controlled by such factors as the amount and distribution of rainfall; soil physical properties (drainage, crusting, water-holding capacity, and compaction); length of growing season; available heat units; and incidence of weed, insect, and disease problems. These factors are integrated with the available nutrients to determine the yield level observed for each crop.

The crops selected essentially dictate the scheduling and methods of application. Because septage application rates are typically controlled by the nitrogen required by the crop, crops requiring large amounts of nitrogen (e.g., corn, forages, sorghum) will minimize the amount of land required and the operation costs. However, corn and sorghum actively grow from May to November, thereby limiting the time available for septage applications to a few months (i.e., the non-growing season) Although forage crops, legumes, and grasses consume large quantities of nitrogen and permit access during most of the growing season, surface application of septage is feasible only after crops have been mown and baled for animal feed.

As with agronomic crops, the harvesting of a forest stand removes the nutrients accumulated during growth. However, the amounts removed annually in forest harvesting are generally lower than in agronomic crop harvesting. Uptake by vegetative cover will affect the uptake of N; i.e., plush understory vegetation markedly increases N uptake. Forest systems also rely on soil processes (denitrification) to minimize nitrate leaching into groundwater. Average annual uptake of nitrogen for several forest species is listed in Table V-7. In general, nutrient loadings on forested lands should be less than those on agricultural sites. No annual limitations are set for cadmium, as no food-chain crops are grown. Lifetime metal limits used for agricultural sites are suggested for forested land. These limits are designed to minimize metal toxicity to trees and allow growth of other crops if the area were cleared at a future date.

TABLE V-6

## ANNUAL NITROGEN, PHOSPHORUS, AND POTASSIUM UTILIZATION BY SELECTED CROPS[a]

| Crop | Nitrogen (lb/acre) | Phosphorus (lb/acre) | Potassium (lb/acre) |
|---|---|---|---|
| Corn | 240 | 44 | 199 |
| Wheat | 186 | 24 | 134 |
| Oats | 150 | 24 | 125 |
| Barley | 150 | 24 | 125 |
| Alfalfa | 450 | 35 | 398 |
| Orchard Grass | 300 | 44 | 310 |
| Tall Fescue | 135 | 29 | 153 |
| Bluegrass | 200 | 24 | 149 |

a Values reported above are from reports by the Potash Institute of America and are for the total above-ground portion of the plants. Where only grain is removed from the field, a significant proportion of the nutrients is left in the residues. However, because most of these nutrients are temporarily tied up in the residues, they are not readily available for crop use.

TABLE V-7

## ESTIMATED ANNUAL NITROGEN UPTAKE BY FOREST SPECIES [5-11] [a]

| | Tree Age (years) | Average Annual Nitrogen Uptake (lb/acre) |
|---|---|---|
| Hybrid Poplar[b] | 4 to 5 | 268 |
| Douglas Fir Plantation | 15 to 25 | 178 |
| Eucalyptus | n/a | 200 |
| Pulpwood (Slash Pine) | n/a | 150 |

a Uptake rates shown are for wastewater-irrigated forest stands.

b Short-term rotation with harvesting at 4 to 5 years; represents first growth cycle from planted seedlings.

(4) Heavy Metals in Septage: Metal contamination may result from one or more of the following sources:

(1) Household chemicals that contain trace concentrations of heavy metals.

(2) Leaching of metal from household piping.

(3) Contamination of septage in hauler trucks from a previous industrial waste load.

Research studies done in the U.S. and Europe and data compiled by the U.S. EPA demonstrated that the metal concentrations in septage are considerably less than those typically observed in domestic sewage sludge. However, the level of heavy metal concentration is still of particular significance when consideration is given to application of septage to land.

The lifespan of an application system is limited, based on the cumulative amounts of lead (Pb), copper (Cu), nickel (Ni), zinc (Zn), and cadmium (Cd) applied to the soil. Maximum application loadings suggested by the California DHS are listed in Table V-8. It should be noted that those loadings are cumulative loadings and are a function of the cation exchange capacity of the soil. When one of the trace elements is loaded to its maximum allowable limit, septage and/or other sludge disposal at the site should be terminated.

TABLE V-8

**RECOMMENDED MAXIMUM CUMULATIVE APPLICATION OF HEAVY METALS TO AGRICULTURAL LANDS [5-12]**

| | Soil Cation Exchange Capacity (meq/100g) | | |
|---|---|---|---|
| | 0-5 | 5-15 | >15 |
| Metal | Maximum cumulative addition of metal (lb/acre) | | |
| Zinc | 223 | 446 | 892 |
| Copper | 112 | 223 | 446 |
| Nickel | 45 | 89 | 178 |
| Lead | 357 | 714 | 714 |
| Cadmium | 4 | 9 | 18 |

In particular, health risks associated with cadmium (Cd) are an additional constraint that limits the rate at which septage can be applied to land used for crop production. Cadmium contained in the diet accumulates in the kidneys and may cause a chronic disease called proteinuria (increased excretions of protein in the urine). It is difficult to predict the effect of septage application of Cd on the human diet for the following reasons:

(1) Crops vary markedly in Cd uptake (e.g., leafy vegetable are significantly higher in Cd than cereal crops).

(2) Cd uptake by crops is dependent on soil properties and the amount of Cd applied.

(3) The Cd content of the current human diet is not accurately known and varies with each individual's diet preferences.

(4) Projected increase in dietary Cd are influenced by the amount of cropland affected, the properties of sludge and septage applied, types of crops grown, and soil properties.

The EPA "criteria" specify the limits for annual amounts of Cd applied to different crops, as given in Table V-9. It is also required that the septage and soil mixture pH be maintained at 6.5 or above.

TABLE V-9

ANNUAL CADMIUM LIMITS SPECIFIED
BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY [5-8]

| Type of Crop | Cadmium Limit (lb/acre) |
|---|---|
| Tobacco, root crops, leafy vegetables | 0.45 |
| Other food chain crops (e.g., corn, small grains, forages) | 0.45 |
| Animal feed only | None[a] |

[a] A facility plan must be prepared showing the distribution of the animal feed to preclude human consumption.

(5) Governmental Regulations: In general, governmental regulations apply equally to septage and sewage sludge. Government documentation which refers to treatment and/or disposal of sewage sludge can be utilized as a guideline for appropriate treatment/disposal of septage.

(a) Federal Regulations: The U.S. EPA is authorized to issue comprehensive septage and wastewater sludge management guidelines and regulations. Currently, the EPA is in the process of promulgating new regulations regarding sludge reuse and disposal.

(b) State Regulations: Chapter 15 of the California Administrative Code titled "Discharge Of Waste To Land" imposes restrictions on both municipal sludge and septage disposal; and the two are treated as equals.

Under provisions of Chapter 15, septage is classified as a "designated waste" and further defined as "non-hazardous waste which consists of or contains pollutants which, under environmental conditions at the waste management unit (landfill), could be released in concentrations in excess of applicable water quality objectives, or which could cause degradation of waters of the state".

The regulations require that non-hazardous designated waste shall only be discharged at Class II waste management units. The Neal Road Landfill is currently planning to upgrade the site to comply with Chapter 15 changes as required by the Central Valley RWQCB.

The California DHS has published guidelines and recommended practices for land application of sewage sludge. These can be found in Appendix D.

(c) Local Regulation: Two Butte County departments issue regulations for septage disposal. The Department of Health regulates the haulers and the disposal sites, and the Planning Department approves zoning for disposal sites.

Butte County has a Solid Waste Management Plan which is actually a planning tool. The Planning Commission issues permits for septage disposal facilities and relies on the Health Department to regulate and require health compliance. The Health Department of Butte County strictly adheres to the guidelines and recommended practices of the State of California, DHS.

## 2. Independent Treatment of Septage

### a. Composting

Composting is an alternative septage disposal technique offering good bactericidal action and a 25% reduction in organic carbon. This process of stabilizing organic matter is achieved through aerobic thermophilic decomposition. The septage is transformed into a humus like material that can be used as a soil conditioner. This method of sludge disposal has been successfully demonstrated in numerous cities in the U.S. and Canada. Composting characteristics of septage have been found to be the same as sewage treatment plant sludge.

In aerobic composting, septage is mixed with dry organic matter for moisture control and for easier air penetration by increasing the porosity of the septage so that aerobic conditions can be maintained. Bulking agents added to the septage can be woodchips, sawdust, bark chips, etc. This method may be of particular interest to the Town of Paradise as a means to help solve another solid waste disposal concern in the form of yard waste. To comply with AB 939, the town must reduce the volume of yard waste (lawn clippings, shrub and tree trimmings) that is hauled to the landfill. By using the shredded tree trimmings as the dry addition to the septage, the yard waste disposal volume would be reduced at the same time eliminating the need to purchase an additive. In addition, utilizing the compost product as a resource can result in significant environmental and economic benefits. Aerobic composting is generally recognized as superior to anaerobic composting because it provides better odor control, higher temperatures for pathogen control and requires shorter periods for stabilization.

(1) Process Stages: There are three stages in composting. In the initial stage, temperatures increase from cryophilic (41°F to 50°F) to mesophilic (50°F to 104°F) regions. Active composting, the second stage, can begin within days and operates in the thermophilic (104°F to 176°F) region, which tends to be self limiting because of competing mechanisms. When there is an abundance of substrate, bacterial populations increase, thereby raising temperatures. Temperatures above 140°F inhibit microbial growth, thereby lowering the population and thus lowering the temperatures to the point where optimum renewed growth can occur. The third stage is substrate limiting. This curing stage operates under two successive temperature regions (104°F to 50°F) and cryophilic (50°F to 41°F).

(2) Design: Composting sites should have ample room for movement of heavy equipment and should have a receiving tank to equalize septage as well as to collect leachate and surface runoff water. Primary screening for removal of larger unwanted material is advised. After the septage is mixed with the dry organic matter, the compost is shaped into windrows, cubes, or hemispheres. Moisture level is controlled by either adjusting the dry, organic material/septage ratios or by aeration.

Pile aeration can be achieved by natural draft, mechanical mixing, forced (bottom) aeration, or turning over the compost.

Composting is generally classified into three types of operations, which differ primarily by the aeration mechanism they employ. Each method is described briefly in the following sections.

(a) Windrow Composting: In the windrow process, the septage and bulking agent are stacked in long parallel rows called "windrows". The cross-section of the windrows is either trapezoidal or triangular, depending on the equipment used for mixing and turning the compost material.

Convective air movement within the windrows is essential for providing oxygen for the microorganisms. The heat produced by the aerobic reactions warms the air in the windrow, causing it to rise, producing a natural chimney effect. To expose all the organisms within the pile to oxygen, it must be turned, varying from once a day to several times per week. This method is highly equipment and labor intensive.

A variation of the windrow process, the Lebo process, is perhaps the first composting process designed specifically for the treatment of septage. The Lebo system is in operation in South Tacoma, Bremerton and several other towns in Washington. A patented preaeration process is used before septage is sprayed on piles of sawdust, wood shavings, or other dry organic material. A 1 to 2 in. application is covered with additional sawdust, and front-end loaders form the mixtures into piles to minimize heat loss. Alternating layers of septage-sawdust are used until the pile height reached 8 to 10 ft. Pile configuration is generally square with a flat tip to prevent excessive heat loss. Natural draft aeration, possible because the mixture is bulky, eliminates the need for turning or forced aeration. The 50 to 60% moisture content material is said to attain a pile temperature of 150°F.

Provisions for the collection of leachate are necessary because the material is relatively wet. The leachate may be collected and recycled, or if the site is located at the wastewater treatment plant, the leachate may be discharged with the liquid waste stream.

(b) Aerated Static Pile Composting: The aerated static pile system was developed by the U.S. Department of Agriculture to eliminate many of the land requirements associated with windrow composting, and to allow for the composting of raw sludge.

Also called the Beltsville System, the method consists of a 6 in. perforated pipe, with 0.25 in. holes placed on the ground as a base for the compost pile. A 12 in. thick layer of woodchips is placed on the pipe and acts as an absorbent for liquids, helps prevent clogging of the holes, and allows air circulation below the raw material mixture. A front-end loader is used to blend the building agent and raw sludge in appropriate proportions. The mixture is then placed on the base as shown on Figure V-4. The pile is then covered with a 12 in. layer of screened compost to provide insulation (minimizing loss of generated heat) and to prevent odors from escaping. Vacuum and forced air is alternately applied to maintain oxygen concentrations between 5 and 15%. A three week composting period is usually provided followed by a four week curing period. Screening to recover woodchips can take place just prior to or after the curing process.

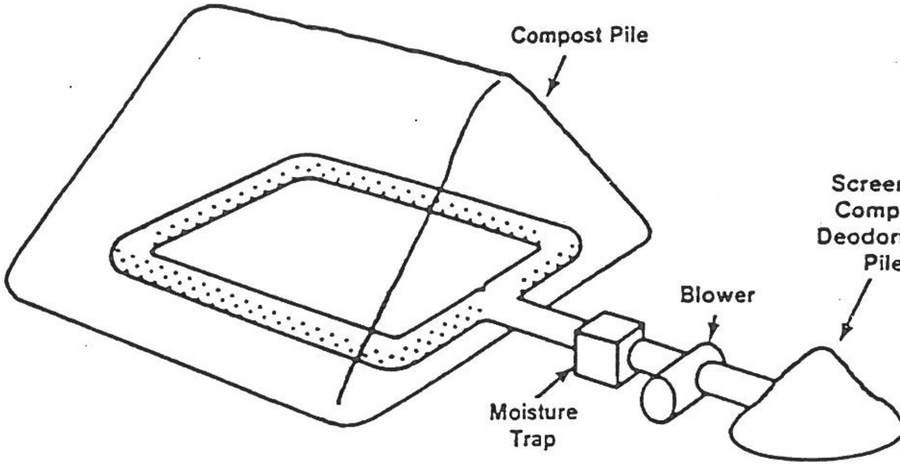
Studies indicate that the process is capable of producing a stabilized compost product when appropriate ratios of liquid waste and organic bulking agents are achieved. Approximate volumetric requirements for the total compost pile are listed in Table V-10.

TABLE V-10

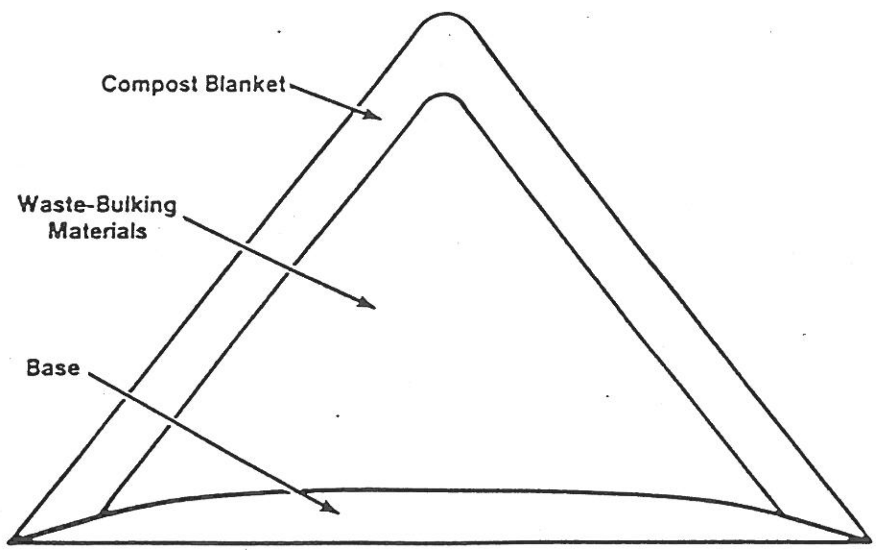
**AERATED STATIC PILE COMPOSTING**
**VOLUMETRIC REQUIREMENTS PER 1000 GALLONS SEPTAGE [5-1]**

| Purpose | Additive | Volume(yd$^3$) |
|---|---|---|
| Base | Woodchips | 7 |
| Absorbent Organic Mixture | Woodchips<br>Sawdust<br>Compost | 9.7<br>9.7<br>4.2 |
| Insulation Blanket | Compost | 10 to 20 |

(c) Mechanical Composting: The mechanical composting method is substantially different from other methods. Instead of a batch mode of composting, mechanical composting is a continuous process. Organic material and the bulking agent are introduced daily into the influent end of the reactor. Mixing to ensure adequate aeration can be done by tumbling, by movement with an endless belt that lifts and drops the material, or by movement with an auger. Additional aeration is provided by externally supplying air to refuse and wastewater sludge. Application to septage composting is limited by the size of available equipment, which is generally applicable only to facilities handling greater than 30,000 gal of septage per day.




General Layout




Blanket and Base — Woodchips & Previously Composted Material

Bulking Material — Woodchips, Sawdust and Previously Composted Material

Septage Pile Dimensions
9 ft. High
15 ft. Diameter
12 in. Base
18 in. Blanket

Cross Section

Source: US EPA [5-1]

FIGURE V-4

PARADISE PRELIMINARY DESIGN REPORT

**FORCED AERATION STATIC PILE COMPOSTING SYSTEM**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

(3) Process Considerations: Composting represents the combined activity of a succession of mixed populations of bacteria, actinomycetes, and other fungi associated with a diverse succession of environments. The principle factors that affect the biology of composting are moisture, temperature, pH, nutrient concentration, and availability and concentration of oxygen. Generally recommended operating parameters for septage composting are presented on Table V-11.

TABLE V-11

**OPERATIONAL PARAMETERS FOR SEPTAGE COMPOSTING [5-1]**

| Parameter | Optimum Range | Control Mechanisms |
|---|---|---|
| Moisture Content | 40-60% | Pretreatment of septage by dewatering to 10-20% solids<br><br>Addition of bulking material (woodchips, sawdust), 3:1 bulking agent; dewatered septage (by volume) |
| Oxygen | 5-15% | Periodic turning/natural convection (windrow, Lebo composting)<br><br>Forced aeration (static pile)<br><br>Mechanical agitation with compressed air (mechanical) |
| Temperature activity (must reach) | 130°-150°F | Natural result of biological activity in piles |
| pH | 5-8 | Generally occurring in septage, no adjustment necessary |
| C/N Ratio | 20:1 to 30:1 | Addition of bulking material |

(4) Moisture: Organic decomposition is dependent upon moisture. The lowest moisture content at which bacterial activity takes place is from 12 to 15%; however, less than 40% may limit decomposition. The optimum moisture content is in the range of 50 to 60%. Beyond 60%, the proper structural integrity will not be obtained.

Normally the moisture content of septage is in excess of 90%. In order to optimize the composting process, septage should be dewatered and/or blended with a bulking agent, whichever is more economical.

(5) Temperature: For the most efficient operation, composting processes depend on temperatures of from 130° to 150°F but not above 176°F. High

temperatures are also required for the inactivation of human pathogens in the sludge. Moisture content, aeration rates, size and shape of pile, atmospheric conditions, and nutrients affect the temperature distribution in a compost pile. For example, temperature elevation will be less for a given quantity of heat released if excessive moisture is present, as heat will be carried off by evaporation. On the other hand, low moisture content will decrease the rate of microbial activity and thus reduce the rate of heat evolution.

(6) pH: The optimum pH range for growth of most bacteria is between 6 and 7.5, and between 5.5 and 8.0 for fungi. The pH varies throughout the pile and throughout the composting operation, but is essentially self-regulating. A high initial pH resulting from the use of lime for dewatering will solubilize nitrogen in the compost and contribute to the loss of nitrogen by ammonia volatilization. It is difficult to alter the pH in the pile for optimum biological growth, and this has not been found to be an effective operation control.

(7) Nutrient Concentration: Both carbon and nitrogen are required as energy sources for organism growth. Thirty parts by weight of carbon (C) are used by microorganisms for each part of nitrogen (N); a C/N ratio of 30 is, therefore, most desirable for efficient composting, and C/N ratios between 25 and 35 provide the best conditions. The carbon considered in this ratio is biodegradable carbon. Lower C/N ratios increase the loss of nitrogen by volatilization as ammonia, and higher values lead to progressively longer composting times as nitrogen becomes growth-rate limiting. No other macro-nutrients or trace nutrients have been found to be rate-limiting in composting municipal wastewater sludge.

(8) Oxygen Supply: Optimum oxygen concentrations in a composting mass are between 5 and 15% by volume. Increasing the oxygen concentration beyond 15% by air addition will result in a temperature decrease because of the greater air flow. Although oxygen concentrations as low as 0.5% have been observed inside windrows without anaerobic symptoms, at least 5% oxygen is generally required for aerobic conditions.

b. Lime Stabilization of Septage

Lime stabilization is a very simple technology that consists of adding lime to septage in sufficient quantities to maintain a pH greater than 12 for a minimum of 30 minutes. The high pH is not conducive to microorganism survival. Keeping the pH high for longer than 30 minutes has been found to correlate well with the dewaterability and odor conversion of the septage. As long as the high pH is maintained, the septage will not putrefy, cause odors, or pose a health hazard.

Lime stabilization may be followed by a dewatering step, or the stabilized liquid septage may be spread on the land directly. Because lime stabilization does not destroy the organics necessary for bacterial growth, the septage must be disposed of before the pH drops significantly or it can become reinfested and putrefy.

Lime addition to septage may reduce nitrogen concentration through volatilization of ammonia if conditions permit this stripping, often enabling greater quantities of stabilized septage to be applied per unit of land area, because such applications are often limited by nitrogen loading. Lime stabilization is, therefore, only a temporary stabilization which enables further handling and disposal to take place prior to the onset of destabilization. The design objective is to maintain pH above 12 for about 2 hours and to provide enough residual alkalinity so that the pH does not drop below 11 for at least 14 days to ensure pathogen destruction, thereby allowing sufficient time for disposal or use without the possibility of renewed putrefication.

c. Chlorine Oxidation (*Purifax*™)

The BIF-Purifax ™ process utilizes chlorine gas in solution to oxidize various types of waste sludges, including septage. Chlorine oxidation stabilizes sludges and septage both by reducing the number of organisms present and by making organic substrates less suitable for bacterial metabolism and growth.

The Purifax™ process involves oxidation of several septage constituents with high dosages of chlorine gas, which is applied directly to the septage in an enclosed reactor for a short time. Because of the reaction of chlorine gas with the septage, significant quantities of hydrochloric acid are formed, and the stabilized septage has low pH (about 2). The reactor vessel is moderately pressurized (30 to 40 psi) to ensure more complete absorption of the chlorine gas as well as adequate chlorination penetration into the larger particles in the sludge. At these pressures, the gases formed are supersaturated in the treated septage. When discharged from the reactor vessel at atmospheric pressure, these gases come out of solution as fine bubbles that float the septage solids. The process is followed by dewatering, generally on sand beds.

Chlorine oxidation, like lime stabilization, does not completely destroy organic matter or solids during septage treatment. It can, however, produce a relatively biologically stable end product, which is dewaterable and which does not have an offensive odor. Because chlorine reactions with sludge and septage are very rapid, reactor volumes are relatively small; therefore, compared with biological digestion processes, Purifax™ system sizes are generally smaller, and capital costs may be lower, depending on the site specific circumstances. In addition, Purifax™ systems can be run intermittently (unlike biological processes) so long as sufficient storage volume is available both upstream and downstream of the reactor. As a result, operating costs are more directly dependent on septage production rates. Septage treatment facilities utilizing Purifax™ include Babylon, New York; Ventura, California; Putnam, Connecticut; and Bridgeport, Connecticut.

Chlorine dosages vary from 700 to 3,000 mg/L, depending on the solids content of the septage. BIF recommends approximately 6 lbs chlorine for 1,000 gal septage (for a suspended solids concentration of 1.2%).

Equipment consists of a "disintegrator" to reduce particle size, a recirculation pump, two reactor tanks, a chlorine eductor, a pressure control pump, a chlorinator, an influent feed pump and a flow meter.

d. Anaerobic Stabilization

Anaerobic stabilization or digestion is a biological process in which organic matter is decomposed in the absence of molecular oxygen. This stabilization process can proceed in airtight tanks or anaerobic and facultative stabilization ponds. Only limited data exist on anaerobic digestion of septage at independent septage treatment facilities, although anaerobic digestion of septage at a treatment plant (co-treatment) has been well documented, therefore correlations can be made.

Anaerobic digestion is classified by the EPA as a "Process to Significantly Reduce Pathogens". Certain pathogenic bacteria have been shown to be removed at 85 to nearly 100%. The pH in an anaerobic digester should be maintained in the range of 6.6 to 7.6 to provide a proper growth environment for methane-forming organisms. Therefore, lime, soda ash, sodium bicarbonate, etc. should be provided as a means to adjust the pH as required. A mixing method (draft tubes or mechanical mixers) is very important in achieving optimum process performance. Heating is required to maintain temperatures at a constant value because even slight temperature changes of 2 degrees can be sufficient to cause an upset.

The limitations of anaerobic digestion include the relatively high capital cost, sensitivity to upset, monitoring requirements, poor quality supernatant (high oxygen demand and high concentration of nitrogen and suspended solids), and a relatively long detention time (10-30 days, heated) required for stabilization.

e. Aerobic Digestion

Compared with anaerobic stabilization, aerobic processes are easier to operate and maintain, have lower capital costs, and produce an odorless, biologically stable residual that dewaters easily. Cell matter is oxidized to carbon dioxide, water and other inert materials. The EPA qualifies aerobic digestion as a Process to Significantly Reduce Pathogens.

Conventional aerobic digesters are open-topped tanks or earthen basins and are affected by ambient temperatures. Mixing and aeration requirements can be provided by either mechanical mixers or diffusers.

Two major problems associated with aerobic digestion are odors and foaming. In pilot studies, it was found that odors were reduced after approximately 3-4 days of aeration, and that foaming would dissipate after about 10 days of aeration.

Solid retention time ranges from 20-40 days. Temperature, pH, total solids, volatile solids, dissolved solids, settleable solids, $BOD_5$, and alkalinity must be monitored regularly for process control of aerobic digestion.

Long detention times and relatively high capital and operating costs make this process less desirable when compared to land treatment or lagooning.

f. Lagoons

Lagoons are easy and inexpensive to construct and operate. Properly designed lagoons perform consistently and can be operated year-round.

The simplest septage lagoon systems consist of two earthen basins arranged in series. The first, or primary, lagoon receives raw septage. It may be lined or unlined, depending on the geological conditions of the site and governmental regulations. The supernatant from the primary lagoon, which has undergone some clarification and possibly anaerobic digestion, is drawn off into the second lagoon, or percolating pond, where it is allowed to infiltrate into the ground. It is also possible to have multi-celled lagoon systems with either surface discharge or land application of effluent.

Where groundwater separation distances or geological conditions are unfavorable, septage lagoons should be lined to avoid infiltration. The liner should be impermeable to liquids, durable, and able to withstand heavy equipment used for cleaning and removal of accumulated solids. Concrete, asphalt, or clay liners are recommended over membranous rubber or plastic liners due to the limited ability of the rubber and plastic to withstand the stresses of heavy equipment and their susceptibility to laceration, abrasion, or puncture from sharp objects such as stones, tree branches, or roots. Lagoons are normally built above grade with earthen embankments to minimize construction costs.

A septage receiving facility should be employed at the site to minimize the odors associated with septage. Typically, this would consist of a concrete chamber with a tight-fitting hatch or manhole designed to allow the septage to be discharged below the liquid level of the primary lagoon. The pH in a septage lagoon must be maintained at 8.0 or greater to control odors. This is usually accomplished by adding lime to the septage before it is discharged to the lagoon (i.e., add bag of lime to septage in hauler truck) or as it is discharged (i.e., add lime to receiving chamber).

A major operating consideration with this septage disposal method is the accumulation of suspended solids. Solids will eventually accumulate in the primary lagoon to the point where the lagoon no longer acts as a clarifier. If solids accumulate in the percolating pond the infiltrative surface may become clogged and no longer accept effluent. For this reason, it is recommended that two parallel systems be constructed to allow for draining, solids drying, solids removal, and resting in alternate lagoons. Solids disposal then becomes a concern. This has previously been discussed in the sections on land disposal.

A percolating pond can be used to receive the supernatant from lagoons which, in turn, is allowed to infiltrate into the ground, undergoing further treatment before entering the groundwater table. The outlet from the lagoon should be designed to prevent floatable materials, grease, and algae from overflowing into the percolating pond. This can be done by submerging the outlet pipe or by using a baffle structure.

The most serious environmental consideration with lagoon systems is the potential for groundwater contamination. Little control is available concerning the application rates of nitrogen, phosphorous, organics, pathogenic bacteria and viruses, and potential heavy metals. Studies in New England recommend using percolation beds rather than percolation ponds. Percolation beds are constructed using alternating layers of fine sand and coarse gravel. The thick layers of sand (1.5 to 3 ft) increases removal of bacteria and other pollutants.

g. Biological Secondary Treatment Processes

Because the basic composition of septage is similar to domestic wastewater, it is reasonable to assume that processes used in treating wastewater should be suited to the treatment of septage. The same basic principles of design apply, with adjustments being made to account for higher organic and solids loadings.

For the Town of Paradise, it is not cost effective to construct separate biological treatment facilities for septage if wastewater treatment facilities are being constructed nearby. If biological treatment processes are considered the best option for septage treatment, then co-treatment with the domestic wastewater stream is the recommended alternative.

h. Solar Aquatic System

The solar aquatic system consists of a series of translucent cylindrical tanks which contain a progression of living organisms. The process equipment is housed in a greenhouse. It is a system that minimizes sludge residue and avoids expensive chemicals.

Ecological Engineering Associates (EEA), of Marion, Massachusetts, was established in 1988 to commercialize solar aquatic technology. EEA acquires the necessary permits, designs, builds, and operates the septage treatment facility on a long term basis. Prototypes recently constructed in Harwich, Massachusetts, and Providence, Rhode Island have provided positive results.

The Solar Aquatic Septage Treatment system proposed for the Town of Paradise would be a privately owned and operated facility with a capacity of 10,000 gpd. The facility would be comprised of a receiving station, a headworks building housing microscreens and a primary clarifier, two equalization tanks, a covered sludge dewatering and composting bed, and the greenhouse system. An earth filter, drawing air from the equalization and sludge stabilization tanks and grit removal area, would provide odor control. A shed would house equipment and another building would provide space for employees.

In the 10,900 $ft^2$ greenhouse, septage would flow through a series of translucent fiberglass tanks, secondary settling, sand filtration, an artificial marsh filled with reeds and other water plants, and second set of translucent tanks, a second stage marsh, and sand filtration. Effluent would be disinfected by UV light.

EEA, as owner and operator of the facility, reserves the right to reject septage showing indications of toxicity or any prohibited wastes. The Town of Paradise would be responsible for disposing of grit, screening, and harvested plant material at the Neal Road Sanitary Landfill.

## 3. Co-Treatment of Septage with Wastewater

### a. Feasibility of Co-Treatment

The similarity in the characteristics of septage and municipal wastewater makes co-treatment an attractive method of septage treatment and disposal. Septage can be disposed of in a treatment facility by adding it to the liquid stream or the sludge stream. In either case, a properly designed septage handling facility, including screening, degritting, and equalization is recommended.

The quantity of septage that a plant can handle is governed by two major factors: 1) quantity and nature of flow and 2) the aeration capacity and solids handling capacity of the plant.

It has already been determined that the Chico wastewater treatment plant will not accept septage from the Town of Paradise. However, with current plans to construct a new wastewater treatment plant (WWTP) for the town, these facilities can be designed to accept septage.

### b. Modes of Septage Addition

Septage is about 50 times as concentrated as domestic sewage in terms of organic and solids loading. Generally, septage can be dumped into an upstream sewer, or directly discharged into various unit processes within the WWTP. Adding septage to the sewer can create maintenance problems such as deposits in the sewer, increased corrosion of sewer pipes and odor problems at downstream locations.

(1) Addition of Septage to the Liquids Stream: The preferred method of septage addition to most plants is continuous feed at a rate proportional to sewage flow. In this way it is possible to introduce septage into the sewage flow stream at considerably higher flow rates than that possible with slug loading. To ensure continuous controlled addition of septage, equalization and metering facilities are required. Such facilities could be part of a septage receiving station at the headworks for the WWTP and should include provisions for mixing, odor control, and controlled rate feeding of septage. Bar screens and grit chambers are also recommended to protect the primary and/or secondary unit processes.

Continuous feed of septage after receiving station flow equalization provides better control of hydraulic and organic loading on primary and secondary process units, which improves overall performance of the treatment processes and ensures more uniform effluent quality.

If the WWTP is an extended aeration system, the septage would be added directly to the aeration basin without primary clarification. The septage may be mixed with the sludge recycle stream entering the aeration basin to ensure a well mixed influent. Septage pretreatment in the form of screening and degritting is required prior to septage addition to the secondary biological treatment process. The pretreatment of septage can be handled at the receiving facility, and is described in a later section.

(2) Addition of Septage to the Solids Stream: Based on the concept that septage is essentially a mixture of settled sludge and raw sewage, with very high solids content, it is logical to consider the option of treatment with primary and/or secondary sludges.

Addition of septage to the sludge stream, as opposed to the liquid stream, will have less impact on forward flow treatment processes. This is true because only the return flows, such as digester supernatants, thickener overflows, and dewatering filtrates, are recirculated through the major liquid treatment processes. In contrast, during liquid stream addition of septage, both the direct septage input and return-flow impacts may be significant.

Septage could be added to the sludge stream of the WWTP at several points. It is generally recommended that septage be chemically conditioned or biologically stabilized (aerobic or anaerobic digestion) prior to dewatering and ultimate disposal. However, in cases where sludge is to be buried or disposed of at a landfill, it may be more feasible to add septage directly to the thickening or dewatering processes.

## D. SEPTAGE RECEIVING STATION

Regardless of the ultimate treatment and disposal option chosen for septage, a well designed receiving station is an important element. The primary functions of the receiving station are: 1) transferral of septage from the hauler trucks, 2) preliminary treatment of septage (i.e., grit removal and screening), and 3) storage and equalization of septage flows.

The overall design of the receiving station will vary depending on the ultimate treatment/disposal method, however, several fundamental design elements are discussed below. Figure V-5 contains illustrations of several pretreatment options.

### 1. Dumping Station

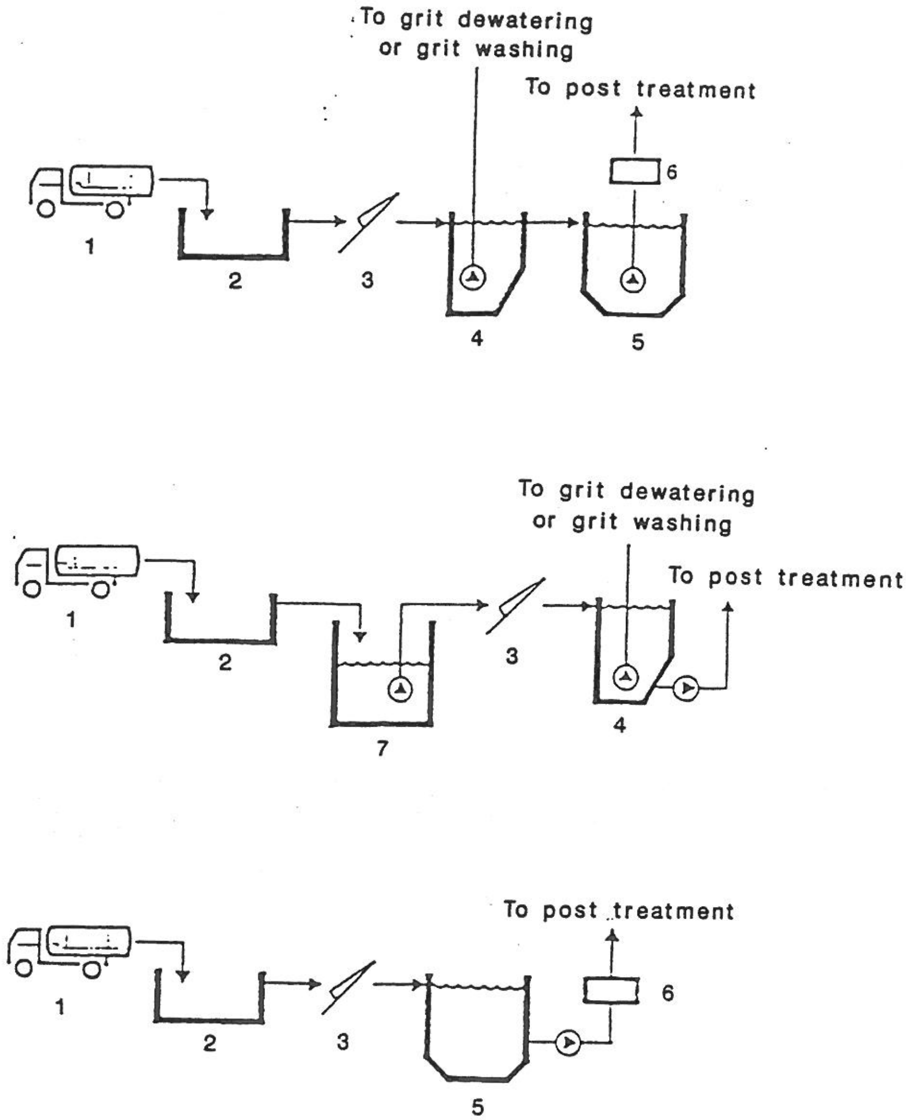
The dumping station is the initial point of reception of septage at the receiving facility. The basic layout should provide a sloped ramp to tilt the truck for drainage and facilitate hosing down of spillage. Access to the manhole would be locked to the public, but a key would be provided to local haulers. A computerized actuated dumping station, as illustrated in Figure V-6, is a more costly alternative but would facilitate monitoring and billing operations. Haulers would gain access to dumping facility by inserting a "credit card" issued by the district.

## 2. Screening

Septage will generally contain various forms of untreatable debris such as rags, plastics, sticks and stones. Such debris is separated from the liquid septage by a coarse bar screen. A mechanically cleaned bar screen is desirable for septage handling facilities. All metal parts coming into contact with septage should be constructed of stainless steel.

## 3. Grit Removal

In septage, grit consists of material such as sand, gravel, cinders and food particles that become enmeshed in organic matter and grease, making separation difficult. Two general types of grit chambers are the horizontal flow type and the aerated type. For the most part, the same design criteria applied to sewage are appropriate for septage except there is a need for longer detention times. For co-treatment, if the wastewater treatment-facility does not include grit removal, there is no need to construct a separate grit removal chamber just for the septage.




1 Tanker vehicle
2 Receiving facility
3 Mechanically cleaned bar rack
4 Grit removal
5 Balancing tank/sludge storage
6 Grinding
7 Pumping station

FIGURE V-5

PARADISE PRELIMINARY DESIGN REPORT

**OPTIONS FOR PRETREATMENT OF SEPTAGE**

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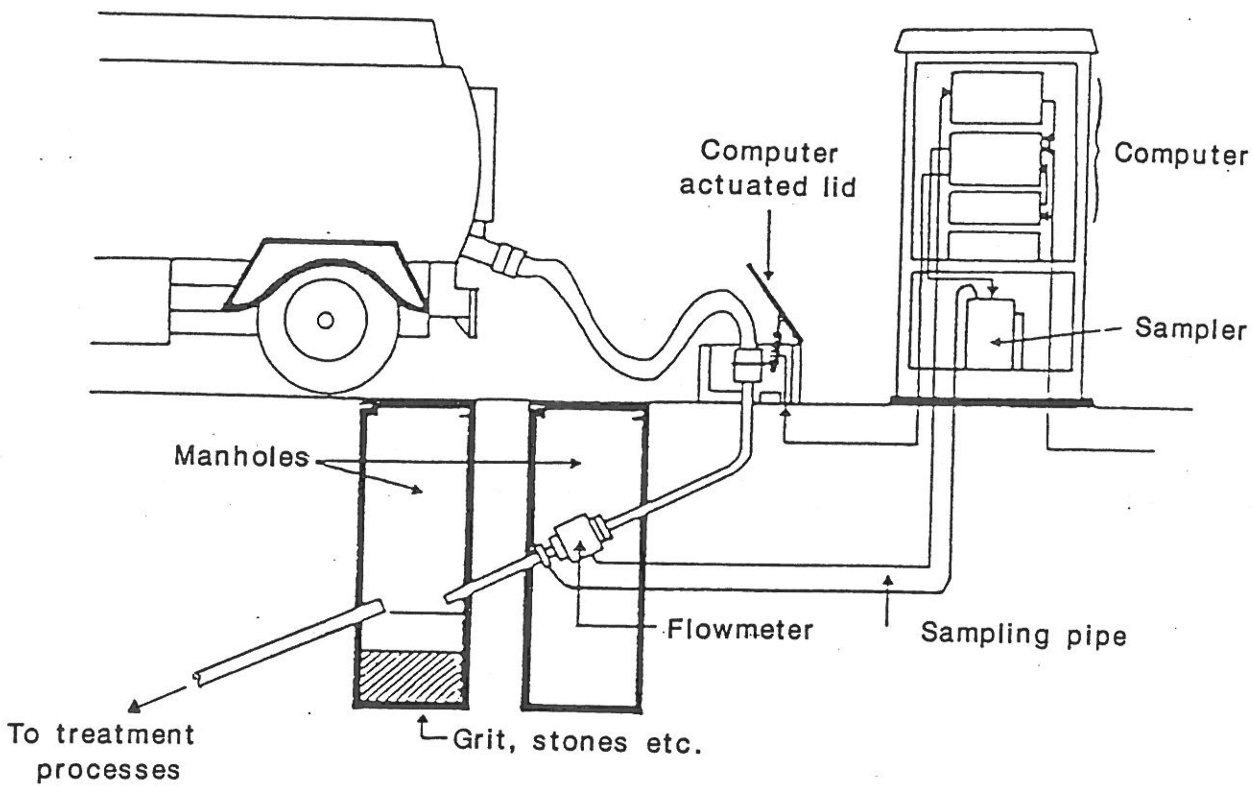


FIGURE V-6

PARADISE PRELIMINARY DESIGN REPORT

**POSSIBLE RECEIVING STATION DESIGN**

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### 4. Storage and Equalization

Septage holding basins can be used to provide for storage, equalization, mixing, and/or aeration of the septage prior to further treatment. In certain co-treatment applications, the holding facilities are necessary to allow proper metering of septage addition to downstream treatment processes to prevent shock loading. If a pond system is the chosen treatment alternative, then the septage can be added directly to the system at the headworks without metering.

### 5. Odor Control

Site selection in a well-ventilated area, downwind from existing or projected population centers is the most desirable means to control odor problems. Technologies for odor control include chemical scrubbers, filters, combustion, and biological processes. Some consideration of odor control devices must be given for future residential growth around a site.

## E. RECOMMENDED ALTERNATIVE

Land application without pretreatment is not recommended by regulatory authorities. Some type of stabilization process, such as lining or lagooning, is recommended to reduce the risk of disease transmission by pathogens contained in the septage. Of the independent septage treatment processes, composting is the most attractive alternative. Yard waste generated in the Town could be used as a bulking agent and in-turn, alleviate the Town's volume of yard waste to be disposed of in the Neal Road Landfill. However, plans are currently being developed for construction of a Butte County composting facility which will accept yard waste from the Town of Paradise. The costs to construct a separate composting facility for sludge or septage are evaluated in Chapter VI of Volume 2. Based on the evaluation, it appears that the cost of constructing a separate septage treatment facility will exceed the incremental cost of sizing the proposed wastewater treatment facility to accommodate the septage.

Since composting of yard waste will be undertaken by Butte County and that construction of a separate composting facility from the main wastewater treatment plant would be very expensive, co-treatment of septage with wastewater appears to be the most attractive option for the Town of Paradise. Co-treatment can be very efficient and effective, as long as the wastewater treatment process selected is amenable to the shock loading of a septage receiving station. The potential beneficial uses of septage would also not be sacrificed by co-treatment. Septage can be stabilized along with the wastewater sludge and then used in either a composting or land application system.

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# CHAPTER VI
# WASTEWATER TREATMENT/DISPOSAL ALTERNATIVES

# VI. WASTEWATER TREATMENT/DISPOSAL ALTERNATIVES

Wastewater treatment and disposal alternatives for the Town of Paradise are described and evaluated in the following chapter. A wide range of treatment processes and disposal methods were proposed by the Town staff and wastewater steering committee for review and are included in the discussion. In reviewing and selecting alternatives, importance was placed on efficiency of operation, minimum capital costs, and innovative technologies.

## A. DESCRIPTION OF THE ALTERNATIVE SELECTION PROCESS

The chapter is organized sequentially according to the major steps in the wastewater treatment/disposal system selection process. A flow chart depicting the stages of evaluation and selection is presented as Figure VI-1.

The available treatment and disposal sites, the proposed treatment plant components, and the approved disposal/reuse options were all evaluated prior to combining the most compatible to produce a treatment/disposal system alternative. To screen the lengthy list of treatment plant components, the various processes under consideration were analyzed within the categories of preliminary treatment, primary treatment, secondary treatment, advanced treatment, disinfection, and biosolids handling. Processes obviously not suited for the Town of Paradise application were eliminated from further discussion during this stage of evaluation.

A comparison of the selected treatment/disposal system alternatives was initiated prior to finalizing definitive information regarding wastewater flowrates and quality. As a result wastewater characteristics were assumed so that a direct comparison between the alternatives could be made. Wastewater characteristics assumed for the purposes of evaluation are listed in Table VI-1. The best apparent treatment/disposal system alternative was selected based on a comparison of the estimated capital and operation and maintenance (O&M) costs and an analysis of various subjective criteria such as regulatory approval, site limitations, and environmental impacts.

When the actual wastewater characteristics (based on area of service for the collection system) were predicted, the design of the recommended treatment/disposal system was refined. The updated preliminary design (presented at the end of the chapter) therefore more accurately represents the capital costs of the recommended treatment/disposal system. The wastewater characteristics used in preliminary design of the recommended alternative presented in Table VI-2.

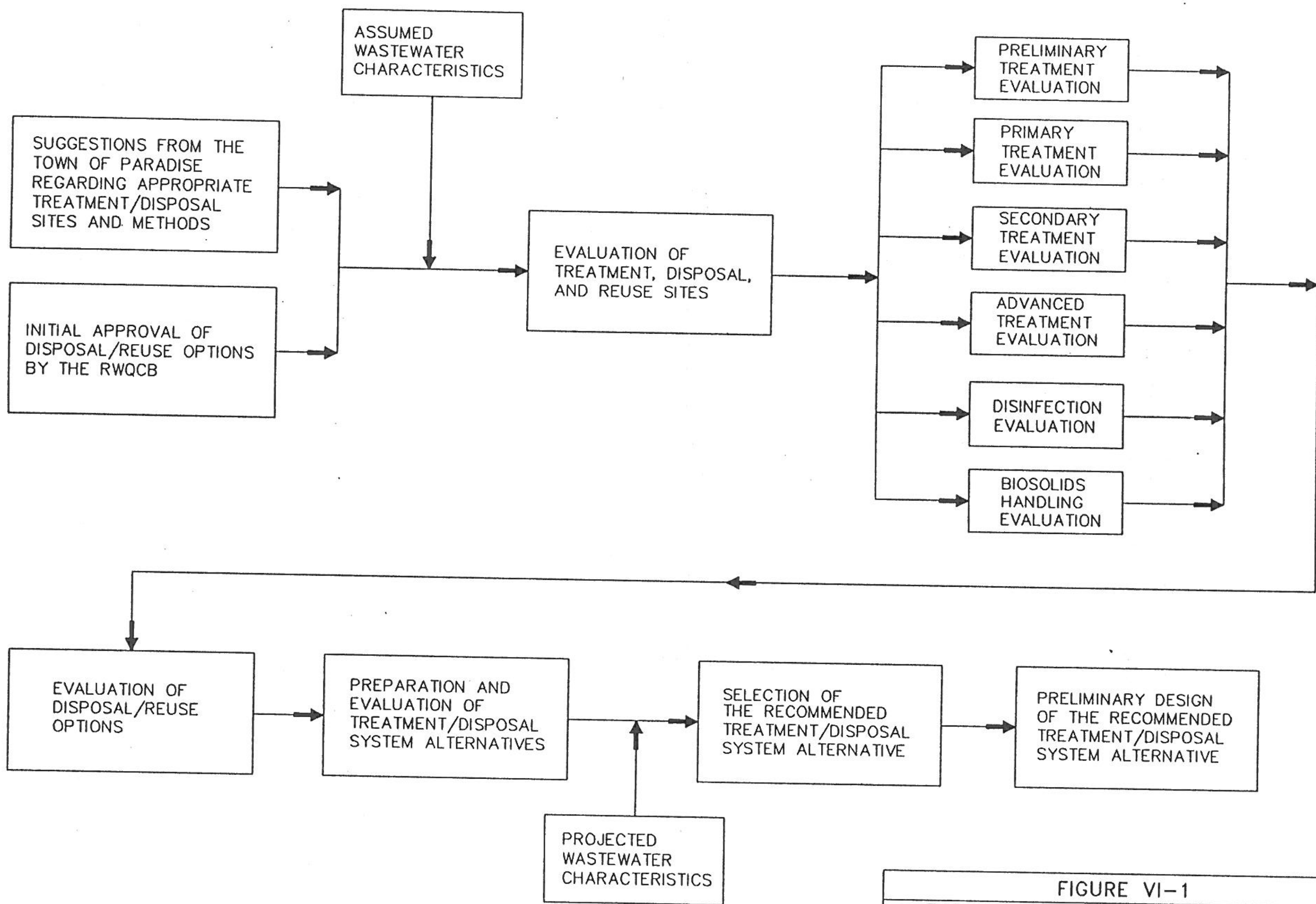


FIGURE VI-1

PARADISE PRELIMINARY DESIGN REPORT

WASTEWATER TREATMENT/DISPOSAL SYSTEM SELECTION PROCESS

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

TABLE VI-1

## WASTEWATER CHARACTERISTICS USED IN THE EVALUATION OF TREATMENT/DISPOSAL SYSTEM ALTERNATIVES

| Wastewater Component | Characteristics | | | | |
|---|---|---|---|---|---|
| | Flow (mgd) | $BOD_5$ (mg/L) | TSS (mg/L) | Total N (mg/L) | Total P (mg/L) |
| Conventional Sewer Effluent | 0.632 | 250 | 250 | 40 | 8 |
| Small Diameter Sewer Effluent | 0.211 | 150 | 50 | 45 | 8 |
| Septage | 0.007 | 5,000 | 15,000 | 600 | 150 |
| Combined Flows (First 20 Years) | 0.850 | 264 | 322 | 46 | 9 |
| Combined Flows (Town Buildout) | 1.76 | 264 | 322 | 46 | 9 |

TABLE VI-2

## WASTEWATER CHARACTERISTICS USED IN THE PRELIMINARY DESIGN OF THE RECOMMENDED TREATMENT/ DISPOSAL SYSTEM ALTERNATIVE

| Wastewater Component | Characteristics | | | | |
|---|---|---|---|---|---|
| | Flow (mgd) | $BOD_5$ (mg/L) | TSS (mg/L) | Total N (mg/L) | Total P (mg/L) |
| Conventional Sewer Effluent | 0.435 | 220 | 220 | 40 | 8 |
| STEP | 0.435 | 150 | 40 | 45 | 8 |
| Septage | 0.022 | 5,000 | 15,000 | 600 | 150 |
| STEP Septage | 0.002 | 5,000 | 15,000 | 600 | 150 |
| Combined Flows (First 20 Years) | 0.90 | 310 | 530 | 57 | 12 |

## B. WASTEWATER TREATMENT, DISPOSAL, AND REUSE SITES

There are several candidate sites in the Paradise area for wastewater treatment, disposal, and reuse. A brief description of each site's topography, geology, hydrology, and availability are presented in the following paragraphs. The sites under consideration include Elliot Spring, Upper Horning Ranch, Lower Horning Ranch, Nugen Creek, Sanders Parcel, Skyway, a gravel tailings area adjacent to Butte Creek, and the Town of Paradise.

### 1. Elliot Spring

Elliot Spring is under consideration as a wastewater treatment plant site. The area is owned by the Horning Family and is located on Neal Road approximately 4 miles south of the Town of Paradise (Figure VI-2). Proximity to Neal Road is the major advantage of Elliot Spring. Septage haulers and materials suppliers could quickly and easily deliver their loads to a treatment facility at this location. The elevation of the site is approximately 950 ft and the site grade averages 6%. About 100 acres of the site are appropriate for construction. Drainage from the site is directed into Nugen Creek which flows through Nugen Canyon to Lower Horning Ranch.

Shallow (less than 1 ft deep), rocky soils exist at the Elliot Springs site. A geotechnical survey of the Elliot Springs was completed for the 1989 Kennedy/Jenks/Chilton study [6-1]. The site is characterized by very hard volcanic agglomerate cap rock overlain by a thin layer of fine-grain soils. The upper surface of the volcanic agglomerate is weathered, especially where the bedrock is mantled by topsoil. The moderate weathering is present to 0.5-1 ft below the soil, but heavy equipment such as a D-9 or a D-10 would be required for excavation. The underlying metavolcanic rock would be difficult to excavate even with heavy-duty equipment.

The area is characterized by oak vegetation communities. No rare, endangered, or threatened plant species were found on the site during a botanical survey completed by Barbara Castro in 1990 [6-2]. However, minor populations of two plant species which are listed on the California Native Plant Society watchlist and three natural plant communities which are declining in area within California were identified on the site. Michael Brandman and Associates recently conducted a field reconnaissance to characterize the general biological resources of the site (Appendix A). Though no sensitive species were found, habitats were identified that could potentially support sensitive plant and wildlife species, including several vernal pools and freshwater seeps. The wetland areas are considered to be sensitive habitats by the California Department of Fish and Game and should be avoided during construction.

### 2. Upper Horning Ranch

Upper Horning Ranch site is under consideration as a site for a wastewater treatment plant. The site is owned by the Horning family and is located approximately 1.3 miles

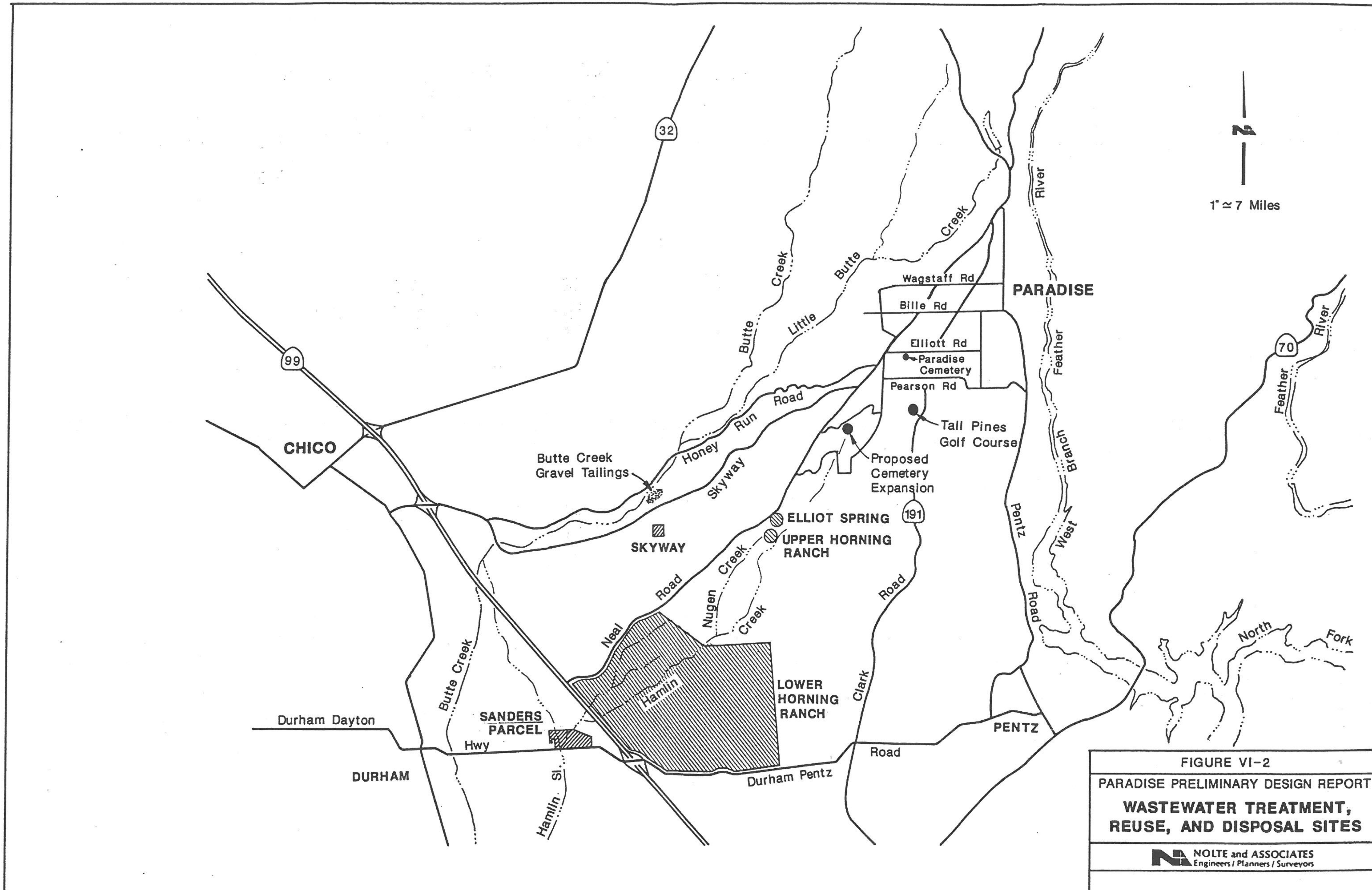


FIGURE VI-2

PARADISE PRELIMINARY DESIGN REPORT

**WASTEWATER TREATMENT, REUSE, AND DISPOSAL SITES**

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south southwest of the Elliot Spring site (Figure VI-2). Access to the site is along a Pacific Gas and Electric (PG&E) gas pipeline easement that traverses a ridge from Neal Road to Lower Horning Ranch. Approximately 200 acres are appropriate for construction. The elevation of the site ranges from 700 to 800 ft and the site grade averages 2%. Drainage is directed into a tributary of Nugen Creek. Site soils are 1 to 2 ft deep and contain less surface rock than found in the soils at the Elliot Spring site. Oak trees, grasses, and other herbaceous plants comprise the vegetation of the area.

### 3. Lower Horning Ranch

Lower Horning Ranch is under consideration as a site for wastewater treatment, treated wastewater storage, agricultural reuse of wastewater, land application of sludge, and creation of a habitat wetlands. The lower ranch is bordered by Highway 99 to the west, Durham Pentz Road to the south, and Neal Road to the north (Figure VI-2). The site consists of transition land between the bluffs of the Sierra foothills and the Sacramento Valley. Many small streams drain the property, the largest of which is Hamlin Creek. All of the streams discharge into Hamlin Slough west of Highway 99.

The soils of Lower Horning Ranch are shallow and cobbly. Soil depth ranges from 4 to 20 in. with an underlying layer of bedrock and hard volcanic mudflows. Weathering of the bedrock is slight and limited to near-surface materials. Vegetative communities of the site were surveyed by Michael Brandman and Associates (Appendix A). The primary communities identified were disturbed non-native grassland and patches of blue oak savannah. Much of the open grassland in the southern and southwestern sections of the ranch is characterized by vernal pool and vernal swale habitat areas. Open riparian woodland, comprised of sycamore, cottonwood, and oak, exists along Hamlin Creek.

### 4. Nugen Creek

Nugen Creek is being considered for "Category A" (as designated by the Regional Water Quality Control Board, RWQCB) discharge of treated effluent from a wastewater treatment plant located at Elliot Spring or Upper Horning Ranch. Nugen Creek is an ephemeral stream which flows only during and shortly after rainstorms. The creek begins at Elliot Spring and runs through Nugen Canyon to Lower Horning Ranch (Figure VI-2). On Lower Horning Ranch, Nugen Creek combines with Hamlin Creek before emptying into Hamlin Slough. Watershed area of the creek is approximately 1,400 acres. Approval for the discharge of treated wastewater is expected from the Regional Board based on high effluent standards and transformation of the "not naturally" perennial creek to a perennial creek.

### 5. Sanders Parcel

The Sanders Parcel is under consideration for the location of a wastewater treatment plant, treated wastewater storage, and agricultural reuse of wastewater. The parcel is owned by the Sanders Family and is located west of Highway 99 and north of the Durham Oroville Highway (Figure VI-2). Approximately 270 acres are available at the site. Hamlin Slough runs through the western half of the parcel and that area has been classified by the Federal Emergency Management Agency (FEMA) as a 100 yr flood zone. Soils information for the site is limited. Maximum soil depth is about 3 ft and the soil quality is better than found on the Lower Horning Ranch. However, heavy clay soils and a perched water table have been observed in some locations. The parcel is being used presently as rangeland, but rice has been successfully cultivated on the site in the past.

### 6. Skyway

Skyway is under consideration as a wastewater treatment plant site. The treatment plant would be located between Skyway and Neal Roads just south of the Southern Pacific Railroad tracks (Figure VI-2). Donald Swartz is the owner of the property and the 6,400 acre Swartz Ranch which surrounds the selected site. Swartz Ranch is currently slated for residential and commercial development. Soils of the treatment plant site are shallow (less than 1 ft), hard, gray, tuff-breccia (mudflow). Drainage of the site is toward the southwest. Treated wastewater from Skyway would be piped under the railroad tracks and Skyway Road to a disposal area at Butte Creek. Rapid infiltration within gravel tailings adjacent to the creek would be utilized for final treatment and disposal.

### 7. Gravel Tailings Area Adjacent to Butte Creek

The gravel tailings area selected for rapid infiltration is located northwest of the proposed Skyway treatment plant site (Figure VI-2). Approximately 20 acres of gravel tailings on the south side of Butte Creek (just downstream of the Butte Creek Gaging Station) would be the most convenient for treatment. Subsurface drainage from the rapid infiltration area would be into Butte Creek. Butte Creek is a perennial stream with a discharge ranging from 109 to 621 $ft^3/s$ [6-3]. The Alms Estate owns the 20 acre gravel tailings area. The estate also owns the area of Skyway just above the gravel tailings and is involved in development of that parcel.

"Evaporation ponds" for disposal of septic tank effluent are currently in use at the south edge of the selected 20 acre tailings area. Unfortunately the ponds do not hold water and it is unclear how much treatment the wastewater is receiving. The water disappears very quickly, an indication that the nearby gravel beds may be too porous to ensure adequate treatment and that hydraulic short circuiting is occurring. Due to the fact that Butte Creek is used for many types of recreational activities and residences are present on the north side of the creek, the RWQCB may not approve the use of the site for rapid infiltration. In addition to the water quality issues, vegetative growth in the tailings provides important wildlife habitat along the creek. Residents of the area are opposed to destruction of the habitat and have successfully prevented projects in the past.

## 8. Town of Paradise

There are a number of sites within the Town of Paradise that are appropriate for wastewater reuse and disposal. The in-town reuse options associated with landscape irrigation were identified in Technical Memorandum 8.4-2 and are described further in Chapter VII. To implement in-town reuse, wastewater would be "scalped" from the sewer system upstream of the main treatment plant. The wastewater would then be treated to Department of Health Services (DHS) standards for landscape irrigation and applied to the Paradise Cemetery and the Tall Pines Golf Course (Figure VI-2). Upstream reuse of wastewater would reduce organic loadings at the main treatment plant and would reduce the volume of wastewater to be disposed of during the reclamation season.

Several areas of Paradise have been identified as potential rapid infiltration basins or community drainfields. It has been suggested that large scale wastewater treatment could be implemented within the town by utilizing recirculating sand filters for treatment and these geologic formations for disposal. Regulatory approval for this type of disposal would be difficult to obtain. The RWQCB is concerned about applying large quantities of wastewater to a relatively small area. To protect underlying groundwater, the current hydraulic loading requirement for leachfield disposal (900 gallons/acre·day based on nitrogen limitations) would apply to the rapid infiltration basins and community drainfields. The limitation on hydraulic loading translates into very large area requirements. Purchase of the disposal areas, if they are available, may be cost prohibitive at an estimated $50,000/acre.

Due to the uncertainty of town or regulatory acceptance of in-town reuse or community drainfields, the preliminary designs for the treatment/disposal system were based on the entire wastewater flow from the town delivered to the treatment plant. If in the future the Town of Paradise decides to implement either one of the options, savings may be realized in terms of operations and maintenance or capital costs of the proposed treatment plant.

## C. TREATMENT PLANT COMPONENTS

The individual treatment plant components determined to be appropriate for the Town of Paradise wastewater are described in the following paragraphs. The components are grouped according to the type of sequential treatment process they represent, i.e., preliminary treatment, primary treatment, secondary treatment, advanced treatment, disinfection, and biosolids handling. Design criteria for each component were based on the assumed initial (0.85 mgd) and buildout (1.76 mgd) flow conditions. Unit process alternatives are evaluated on the basis of life cycle costs and specific recommendations.

### PRELIMINARY TREATMENT

Preliminary treatment involves wastewater screening, degreasing, and grit removal. Effective preliminary treatment is critical to ensure adequate downstream unit process operation, good plant aesthetics, and minimal nuisance problems. Preliminary treatment facilities would be sized and constructed for the ultimate flow conditions at the onset of operation.

#### 1. Screening

Process description, design criteria, and system costs are detailed as follows for the screening component of preliminary treatment.

a. Process Description

The first treatment step required for raw wastewater is screening. Screening is the process of removing coarse materials from the wastewater that arrives at the treatment plant from the main sewer interceptor.

b. Design Criteria

A 1 ft wide self-cleaning bar screen, installed in a concrete channel, would be required to screen the Town of Paradise wastewater. A 9 in. Parshall flume would follow the screen to provide influent flow metering. The screen would be designed for the buildout treatment plant capacity (1.76 mgd). Wastewater would flow through the influent channel at a depth of approximately 3 ft during peak flows at buildout. The screen would be continuously cleaned and material removed by the screen would be deposited in a storage bin and periodically disposed of in a solid waste landfill.

Self-cleaning screens are designed for minimum maintenance and can generally be left unattended for several days. Energy requirements for automatic screens are very low. A bypass channel with a manually cleaned bar rack would be provided to allow for periodic maintenance of the mechanical screen and to serve as a hydraulic bypass in the event of screen failure when the plant is unattended.

The predesign estimate of screening volumes is presented in Table VI-3. A summary of design criteria is found in Table VI-4. Material estimates are provided for septage and wastewater screening. Septage screening would be accomplished at a septage receiving station and would produce screening volumes at roughly 3% of the original septage volume [6-4]. Assuming that the screenings are dewatered to 60% water content, roughly 50 $ft^3$/day of screenings would be removed from the septage. Screenings from domestic wastewater have been found to range from 0.5 to 5 $ft^3$ per million gallons of wastewater [6-5]. Screenings production would be about 4 $ft^3$ per day from Paradise wastewater. The present worth costs for the wastewater screening facilities are summarized in Table VI-5.

TABLE VI-3

**DAILY VOLUME OF SCREENINGS FOR DISPOSAL**

| Parameter | Value |
|---|---|
| From Wastewater | 4 $ft^3$ |
| From Septage | 50 $ft^3$ |
| Total Volume of Screenings | 54 $ft^3$ |

TABLE VI-4

**WASTEWATER SCREENING FACILITY PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| No. of Automatic Bar Screens | 1 |
| Width | 1.0 ft |
| Maximum Depth of Flow | 3 ft |
| Clear Opening Between Bars | 0.625 in. |
| No. of Manual Cleaned Bar Screens | 1 |
| Width | 1.0 ft |
| Maximum Depth of Flow | 3 ft |
| Clear Opening Between Bars | 1.0 in. |
| Screenings Storage | 5.0 $yd^3$ |
| Parshall Flume Size | 9 in. |
| Capacity of the Parshall Flume | 5.5 mgd |

TABLE VI-5

## WASTEWATER SCREENING FACILITIES[a] PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 93,000 | | 1 | 93,000 |
| Labor | | 4,000 | 10.594 | 42,000 |
| Power/fuels | | 200 | 10.594 | 2,000 |
| Equipment Maintenance | | 800 | 10.594 | 8,000 |
| TOTAL PRESENT WORTH | | | | 145,000 |

[a] Facilities costs for septage screening are included in the costs of the septage receiving station.

### 2. Grit/Grease Removal

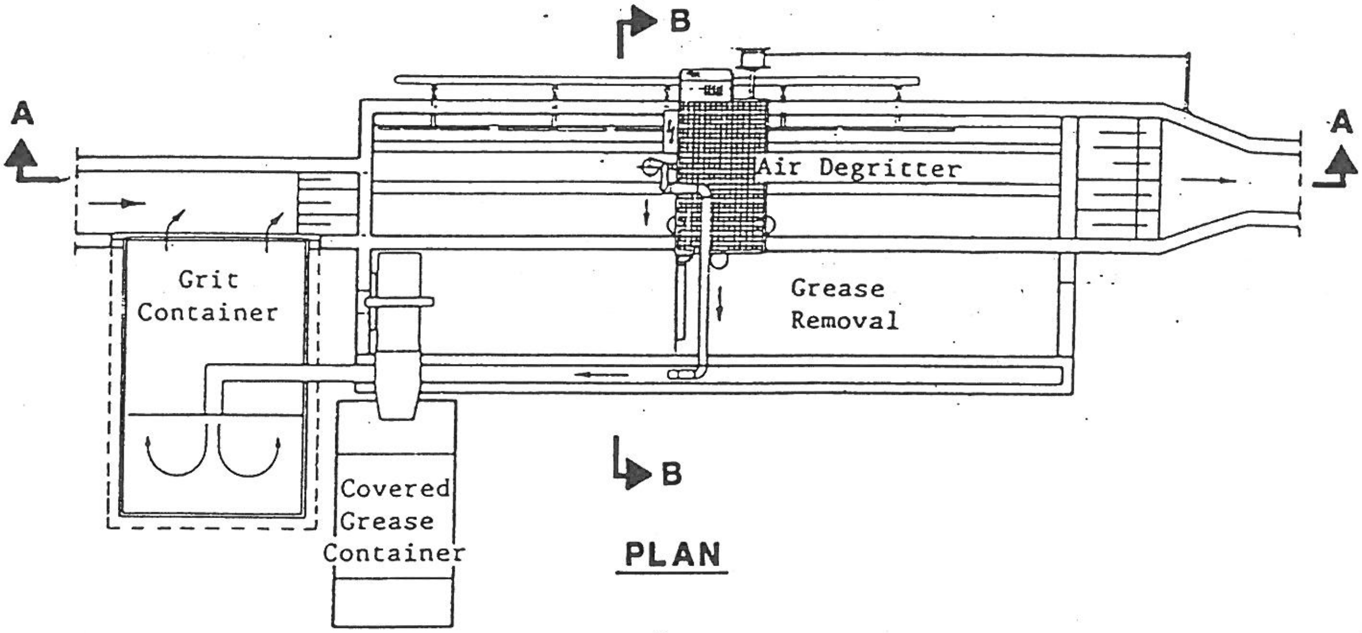
The removal of grit and grease is necessary prior to secondary treatment by activated sludge. Design criteria and costs for this unit process are discussed below.

a. <u>Process Description</u>

Grit and grease removal is employed after raw wastewater screening. Grit is any material with a specific gravity substantially greater than the putrescible solids in the incoming screened wastewater and may include eggshells, bone chips, seeds, coffee grounds, etc. Grit is separated from the waste stream to protect plant equipment and piping from scour and abrasion and to prevent deposition of these materials in aeration chambers or other reactors.

b. <u>Design Criteria</u>

Degritting at Paradise would be accomplished simultaneously with degreasing operations. Screened wastewater and septage would pass into parallel channels in a process which provides aerated grit removal and simultaneous grease and oil removal (Figure VI-3). Grease is skimmed from the wastewater as it passes quiescently through a rectangular concrete channel. In an adjacent rectangular channel, air is entrained in the water through diffusers in a manner which causes the water to spiral. Grit settles out of the water column into a trough at the bottom of the chamber and a grit pump is used to transport the grit to a storage

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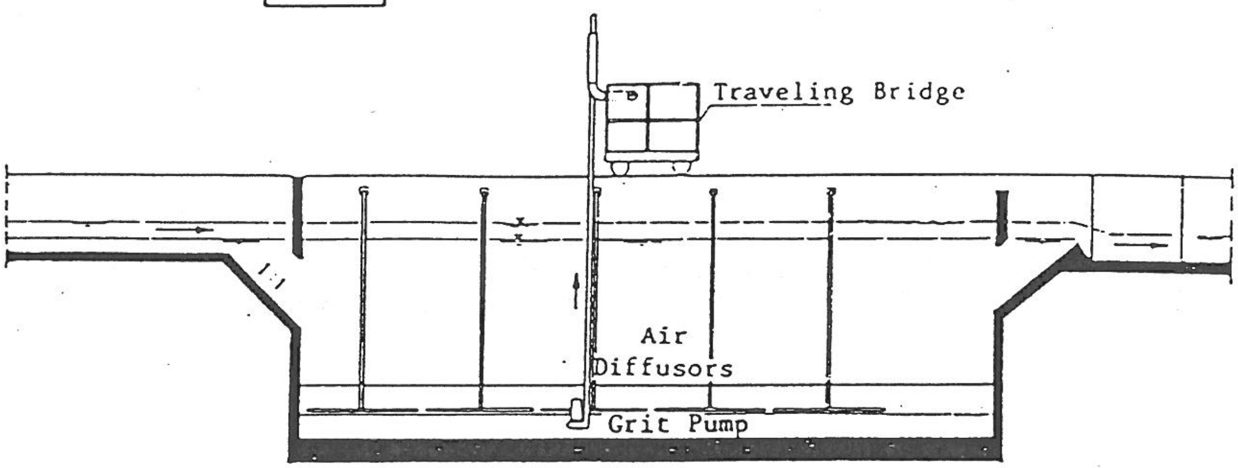
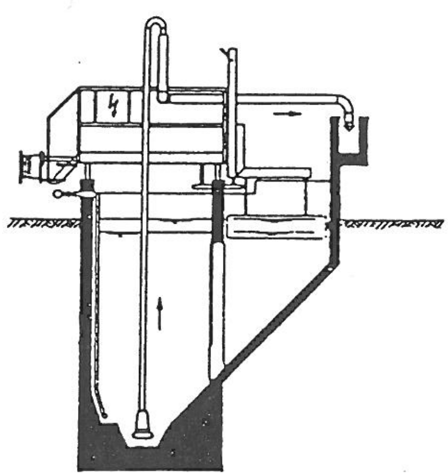



SECTION A-A



SECTION B-B

FIGURE VI-3

PARADISE PRELIMINARY DESIGN REPORT

**GRIT/GREASE REMOVAL**

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Source: Schrieber Corp.

container. The grit is dewatered prior to disposal at a landfill. Grease and other floatable materials (scum) are skimmed from the influent, stored in a grease container, and then incinerated, recycled, disposed of in a landfill, or processed with the waste sludge from the plant. Preliminary design criteria for the grit and grease removal facilities are shown in Table VI-6.

Preliminary estimates of grit and grease removal quantities are shown in Table VI-7. Grit quantities are estimated to be about 25 $ft^3$ per million gallons (Mgal) of septage and about 2 $ft^3$ per million gallons of raw wastewater. Grease quantities are estimated at 8,000 mg/L for septage [6-4] and 150 mg/L for wastewater. Qasim [6-6] suggests that 17-110 lb/Mgal of scum is removed from wastewater by skimming. Approximately 25% of the septage scum should be removed in the grease channel. The present worth costs for the degrit/degrease facility are summarized in Table VI-8.

## PRIMARY TREATMENT

Primary treatment involves the settling of solid matter from the wastewater stream. Primary settling can be accomplished on raw wastewater as well as screened and degritted wastewater. The solid matter removed during sedimentation represents a large percentage of the suspended solids and organic matter of the wastewater. Efficiently designed and operated primary sedimentation tanks can remove 50 to 70% of the suspended solids and 25 to 40% of the incoming $BOD_5$ [6-5]. The removal of solids and BOD during primary treatment results in reduced organic loadings and reduced aeration requirements during secondary treatment.

For the Town of Paradise application, primary treatment would only be required prior to secondary treatment by natural systems. Either a settling pond or a primary clarifier is recommended and both types of sedimentation facilities are described and evaluated in the following paragraphs.

### 1. Settling Ponds

The type of settling pond under consideration is a partial mix aerated pond with a short detention time (approximately 2 days). Partial mix aerated ponds with a much longer detention time (approximately 15 days) are commonly used for secondary treatment (refer to the secondary treatment section of this chapter). The main advantage of using a settling pond for primary treatment over a primary clarifier is that aerobic decomposition of organic matter occurs in the upper layer of the pond while anaerobic digestion of sludge occurs on the pond bottom.

TABLE VI-6

## GRIT/GREASE REMOVAL FACILITY PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Grit Channel | |
| Minimum Detention Time | 7 min |
| Length | 47 ft |
| Width | 5 ft |
| Sidewall Depth | 10 ft |
| Volume | 2,068 $ft^3$ |
| Grit Pump (No. and power) | 1 - 2.3 hp |
| Aeration | |
| Blowers (No. and power) | 2 - 2 hp |
| Capacity | 61 cfm |
| Discharge Pressure | 3.8 psi |
| Air Required | 61 cfm |
| Air Supplied | 122 cfm |
| Grit Classifiers (No. and power) | 1 - 1 hp |
| Size | 12 in. |
| Grease Channel | |
| Length | 47 ft |
| Width | 5 ft |
| Sidewall Depth | 10 ft |
| Surface Area | 215 $ft^2$ |
| Grease Hoist Motor | 0.5 hp |

TABLE VI-7

## DAILY QUANTITIES OF GRIT AND GREASE FOR DISPOSAL

| Parameter | Value |
|---|---|
| Grit | |
| From Wastewater | 2 $ft^3$ |
| From Septage | 0.2 $ft^3$ |
| TOTAL | 2.2 $ft^3$ |
| Grease | |
| From Wastewater | 100 lb |
| From Septage | 200 lb |
| TOTAL | 300 lb |

TABLE VI-8

## DEGRIT/DEGREASE FACILITIES PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($/yr) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 265,000 | | 1 | 265,000 |
| Labor | | 7,400 | 10.594 | 78,000 |
| Power/fuels | | 2,500 | 10.594 | 26,000 |
| Equipment Maintenance | | 2,200 | 10.594 | 23,000 |
| TOTAL PRESENT WORTH | | | | 392,000 |

a. Process Description

Partial mix aerated ponds are characterized by a surface aerobic zone, an anaerobic bottom zone, and an intermediate zone that is partly aerobic and partly anaerobic (Figure VI-4). The surface aerobic zone is maintained by floating aerators designed to mix and aerate the top 6-10 ft of the pond. Within the aerobic zone, bacteria consume and degrade the organic matter present in the wastewater. Bacterial waste products, bacterial cells, and inorganic particles settle to the bottom of the pond. The accumulated sludge receives additional treatment and digestion by anaerobic bacteria that reside in the bottom zone.

The anaerobic treatment and compaction result in a very slow buildup of sludge. Sludge removal from partial mix aerated ponds may only be required every 3 to 5 years. The sludge that is finally removed from the pond is stabilized and appropriate for land application or composting with other organic material. Partial mix aerated ponds must be fairly deep (approximately 10-20 ft) to store accumulated sludge, to establish the distinctive layers, and to provide a sufficiently long detention time for treatment.

Primary treatment in a settling pond is very reliable and simple to achieve. Good settling will occur as a result of the 2 day detention time and, as long as aeration is maintained, there should not be any odor problems. Operations and maintenance requirements of the system are minimal. Aerators require only periodic maintenance and sludge removal is infrequent. Construction of settling ponds can be difficult and expensive if suitable soils for excavation are not available, however.

Settling ponds in a wastewater treatment operation for the Town of Paradise would be used to reduce organic loadings and provide flow equalization prior to natural systems treatment. Primary treatment at the initial flowrates would be accomplished in a 0.8 acre pond. Approximately 100,000 $ft^3$ of sludge (at 10 percent solids) would be removed from the pond after 3 years. To provide treatment during the draining and dredging phase of operation, a second pond of the equal size will be constructed. When plant expansion occurs in 20 years, an extra pond (same size as the first two ponds) would be added to accommodate the additional wastewater flow. Sufficient area for settling pond construction is available at Elliot Spring, Upper Horning Ranch, or the Lower Horning Ranch.

b. Design Criteria

Preliminary design criteria for the settling ponds are presented in Table VI-9. At the initial flowrates, one 15 ft (3 ft of freeboard) deep settling pond with a volume of 1.8 Mgal would be utilized for primary treatment. A pond of this size would provide 2.1 days of detention at onset of operation and 1.0 days after 3 years of sludge accumulation. A second pond of equal volume would be provided for use while the first pond is out of service during sludge removal. Approx-

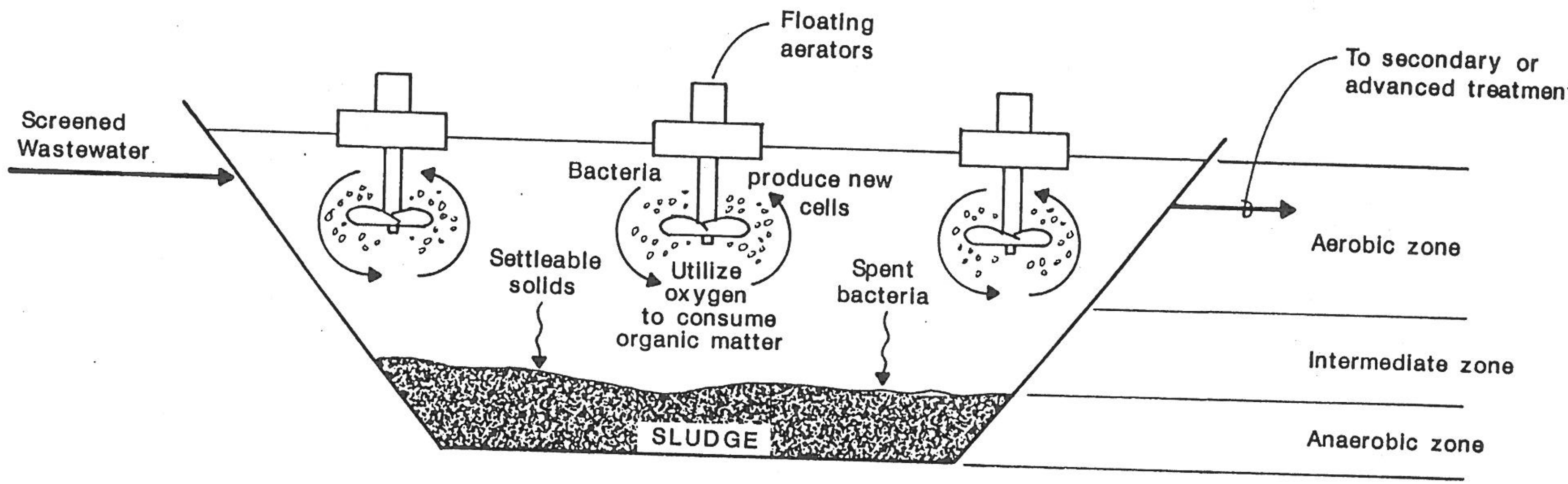


FIGURE VI-4

PARADISE PRELIMINARY DESIGN REPORT

**SCHEMATIC REPRESENTATION OF A PARTIAL MIX AERATED POND**

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imately 34% of the incoming $BOD_5$ would be removed in the settling pond resulting in an effluent $BOD_5$ of approximately 175 mg/L. To maintain aerobic conditions in the surface layer of the pond, five 10 hp floating aerators would be required. At plant expansion, a third pond (same volume as first two ponds) would be constructed and another five 10 hp aerators purchased. An outflow weir would be constructed in each pond to control discharges and an aerator bay with hoist would be provided to facilitate aerator removal from the settling ponds. The present worth costs for primary treatment in a settling pond are presented in Table VI-10.

TABLE VI-9

**PRIMARY SETTLING POND**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Volume (operational) | 1.78 Mgal |
| Depth (operational) | 12 ft |
| Freeboard | 3 ft |
| Width (approximate) | 110 ft |
| Length (approximate) | 300 ft |
| Sideslopes | 2:1 |
| Initial Detention Time | 2.1 days |
| Aerators (No. and power) | 5 - 10 hp |

TABLE VI-10

**PRIMARY SETTLING POND**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Initial Construction | 497,000 | | 1 | 497,000 |
| Labor | | 13,300 | 10.594 | 141,000 |
| Power | | 32,700 | 10.594 | 346,000 |
| Equipment Maintenance | | 1,000 | 10.594 | 11,000 |
| TOTAL PRESENT WORTH | | | | 995,000 |

## 2. Primary Clarifier

Primary clarifiers have relatively short detention times (1.5 to 3 hrs) compared to a settling pond (2 days). Sludge is removed continuously from the primary clarifier and must be digested either by pond storage or in a mechanical digester prior to disposal.

### a. Process Description

Primary clarifiers are used to separate gross solids from essentially raw wastewater that has been screened and degritted. In Paradise, wastewater would enter a 40 ft diameter tank and would be allowed to become relatively quiescent. Grease and scum in the wastewater would float to the top of the tank and be collected by surface skimmers. Approximately 60% of the suspended solids in the wastewater and 30% of the $BOD_5$ would settle to the bottom of the tank and be collected by mechanical scrapers.

Primary clarifiers may be sensitive to shock hydraulic loading from infiltration during storm events into the collection system or other peak conditions. Properly designed clarifiers for peak loading conditions and careful construction in the collection system virtually eliminates the potential for upset. Primary clarifiers are a very reliable means of reducing the solids loading on other treatment processes that may be sensitive to excess solids. Secondary and polishing treatment system costs can be reduced by removal of solids from the wastestream. Primary clarifiers will not normally generate serious odors provided the raw wastewater is not septic. Odors can be mitigated by locating primary treatment systems away from populated regions and by frequently removing sludge.

Primary treatment would be required prior to application of the wastewater to a natural systems area. Settling in a primary clarifier would effectively remove solids from the waste stream and provide a steady source of solids for a composting operation and/or beneficial land application. Assuming that 60% of the suspended solids are removed by primary sedimentation and that the solids concentration of primary sludge is about 4%, 1400 lbs or approximately 4100 gallons per day of primary sludge would be generated initially. About twice as much sludge would be generated at buildout. The sludge removed from the primary clarifier must be stabilized in a sludge storage pond or digester prior to disposal.

b. Design Criteria

Initially, one 40 ft diameter primary clarifier would be constructed. An additional 40 ft clarifier would be constructed in approximately 20 years as flows from Paradise increase. Specific design criteria for the primary system are shown in Table VI-11. The present worth costs for this alternative are summarized in Table VI-12.

TABLE VI-11

**PRIMARY CLARIFIER**
**PRELIMINARY DESIGN CRITERIA**

| Paramenter | Value |
|---|---|
| Primary Clarifiers | |
| Number | 1 |
| Diameter | 40 ft |
| Sidewall Depth | 10 ft |
| Hydraulic Loading | 690 gpd/$ft^2$ |
| Peak Hydraulic Loading | 1,210 gpd/$ft^2$ |
| Detention Time at Average Loading | 2.6 hrs |
| Sludge/Scum Pumps | |
| Type | Progressive Cavity |
| Number | 3 |
| Capacity, each | 40 gpm |

TABLE VI-12

**PRIMARY CLARIFIER
PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 301,000 | | 1 | 301,000 |
| Labor | | 7,000 | 10.594 | 74,000 |
| Power | | 1,400 | 10.594 | 15,000 |
| Equipment Maintenance | | 1,500 | 10.594 | 16,000 |
| TOTAL PRESENT WORTH | | | | 406,000 |

### 3. Recommended Primary Treatment Option

Of the secondary treatment options being considered for the Town of Paradise, primary settling would only be required prior to natural systems treatment. Both a settling pond and a primary clarifier would provide the necessary treatment level for this application. A summary of the capital costs, operations and maintenance costs, and total present worth of the two primary treatment options is presented in Table VI-13. The settling pond system would be significantly more expensive than the primary clarifier. However, the primary clarifier costs do not include the cost of constructing a sludge storage basin (estimated to be $1,456,000 in the Biosolids Handling section of this report) or a digester for sludge stabilization (estimated to be $1,929,000). The settling pond becomes much more attractive when the added benefits of sludge storage, maintenance of aerobic conditions, and flow equalization within the settling pond are considered. Therefore, settling ponds are the recommended primary treatment option.

TABLE VI-13

**SUMMARY OF PRIMARY TREATMENT OPTIONS**

| Option | Capital Costs ($) | Annual Costs ($/yr) | Present Worth ($) |
|---|---|---|---|
| Primary Clarifier | 301,000 | 9,900 | 406,000 |
| Settling Pond | 497,000 | 47,000 | 995,000 |

## SECONDARY TREATMENT

The additional treatment of wastewater after primary settling is commonly referred to as secondary treatment. In general, biological processes are used in secondary treatment to further reduce the organic matter and suspended solids content of the wastewater.

There are numerous types of secondary treatment processes. The three types under consideration for Paradise are conventional pond systems, conventional activated sludge systems, and natural systems. Within each of these broad categories, there are many designs that have been developed for specific applications. The most appropriate designs have been evaluated for Paradise and are presented in the following paragraphs.

### 1. Conventional Pond Treatment

The pond systems evaluated for Paradise include partial mix aerated ponds as the main treatment method. Use of ponds alone would be applicable if the wastewater was stored and used for irrigation of an agricultural enterprise. If the treated wastewater is discharged to Nugen Creek, higher treatment standards would apply and dissolved air flotation (DAF) would be required to remove algae.

#### a. Partial Mix Aerated Ponds

Partial mix aerated ponds would be used to reduce $BOD_5$ to a minimum of 30-40 mg/L. At this treatment level, the only wastewater disposal option available would be storage and agricultural reuse for feed, fiber, and seed crops.

(1) Process Description: The process of wastewater treatment in a partial mix aerated pond system was described previously under primary treatment. The main difference between the two applications is detention time. In secondary treatment the ponds are designed to consistently reduce the $BOD_5$ content to less than 40 mg/L, where in primary treatment the main purpose is to encourage settling of the inorganic solids and somewhat reduce the organic loading to subsequent secondary treatment processes. Much longer detention times are required to meet the secondary discharge limitations. Unfortunately, long detention times can mean increased algae growth, especially in warm sunny climates, which results in high effluent suspended solids.

As mentioned previously, pond treatment is very reliable and involves minimal operation and maintenance. The major operational expense is the power required to run the aerators 24 hours per day. Despite these advantages, there is a significant and serious problem with the use of ponds for the Town of Paradise wastewater, that being the lack of suitable soils for construction. Approximately 7 ft of soil must be excavated to construct the

15 ft ponds and surrounding berms. Less than 1 ft of soil exists at the Elliot Spring site.

Kennedy/Jenks/Chilton recommended pond treatment at Elliot Spring and conducted a geotechnical survey to determine the feasibility of excavation [6-1]. The survey team detailed the extensive site work that would be necessary to excavate the ponds and construct the berms. The site work included stripping, processing, and stockpiling all soils from the pond area. As an alternative to excavation, the survey team suggested the construction of a series of ponds in the upper reaches of the drainage way. A large dike at the downhill side of each pond would be used to contain the water. Both of the recommended construction options would be very expensive to implement. A more practical solution would be to construct the ponds in an area that contains more soil, however, all of the sites under consideration for the Paradise treatment plant have shallow soils. The Lower Horning Ranch and the Sanders Parcel may have a slight advantage over Elliot Spring due to the additional soil depth of 1 to 2 ft.

At the initial flowrates, three 15 ft deep ponds in series with a total surface area of less than 6 acres would be required to satisfy the 40 mg/L $BOD_5$ limitation. When plant expansion occurs, another two ponds would be required which would bring the total treatment plant area to 10 acres. There is ample space for the treatment ponds at all three of the sites under consideration. However, there may be a major advantage in using either the Lower Horning Ranch or Sanders Parcel over Elliot Spring due to the excavation considerations. The total amount of sludge removed from the three ponds would be approximately 276,000 $ft^3$ (10% solids concentration) every 5 years during the initial phase of operation. Sludge removal in the second and third ponds would probably not be required as frequently as in the first pond. Algae growth will occur in the ponds, but the presence of algae in the secondary effluent should not be a problem if the wastewater is used for agricultural irrigation.

(2) Design Criteria: Preliminary design criteria for secondary treatment by partial mix aerated ponds are presented in Table VI-14. At the initial flowrates, three ponds operated in series would be required to achieve the treatment goals. The ponds were designed to achieve 85% $BOD_5$ removal (264 mg/L to 40 mg/L). Each pond would have a volume of approximately 5 Mgal and a detention time of 5.8 days. Due to the long detention time and resulting algae production, effluent suspended solids would be in the range of 40 to 100 mg/L. When the plant expands, two more ponds (each pond having a volume of 5.5 Mgal and a detention time of 6 days) would have to be constructed to treat the additional flow. The new ponds would be operated in series prior to joining the original treatment stream in the third pond. Outflow weirs would be placed in each pond to maintain a constant water level in the ponds and to control discharges. Aerator bays

with hoists would be provided to facilitate removal of the aerators for maintenance. The present worth costs for secondary treatment in partial mix aerated ponds at Lower Horning Ranch or the Sanders Parcel are presented in Table VI-15.

b. Partial Mix Aerated Ponds Followed by Dissolved Air Flotation

Algae growth in treatment ponds is a common problem in the sunny, warm areas of California. If discharge to Nugen Creek is chosen as the disposal option after pond treatment, suspended solids concentrations will have to be reduced to 15 mg/L. Dissolved air flotation (DAF) would be an effective method of removing algae and other suspended solids from the wastewater prior to stream disposal.

TABLE VI-14

**PARTIAL MIX AERATED PONDS**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| No. of Ponds in Series (required for initial flowrates) | 3 |
| Volume (each pond) | 5 Mgal |
| Hydraulic Residence Time (each pond) | 5.8 days |
| Depth (operating) | 12 ft |
| Freeboard | 3 ft |
| Width (approximate) | 165 ft |
| Length (approximate) | 465 ft |
| Pond No. 1: | |
| $BOD_5$ Loading Rate | 1870 lb/day |
| Aerators (No. and power) | 7 - 10 hp |
| Pond No. 2: | |
| $BOD_5$ Loading Rate | 900 lb/day |
| Aerators (No. and power) | 4 - 10 hp |
| Pond No. 3: | |
| $BOD_5$ Loading Rate | 440 lb/day |
| Aerators (No. and power) | 4 - 7.5 hp |

TABLE VI-15

## PARTIAL MIX AERATED POND SYSTEM (LOWER HORNING RANCH OR SANDERS PARCEL) PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 2,269,000 | | 1 | 2,269,000 |
| Labor | | 21,800 | 10.594 | 231,000 |
| Power | | 91,500 | 10.594 | 969,000 |
| Equipment Maintenance | | 2,800 | 10.594 | 30,000 |
| TOTAL PRESENT WORTH | | | | 3,499,000 |

(1) <u>Process Description</u>: The treatment processes utilized in partial mix aerated ponds have been described in a prior section of this chapter. DAF is used after pond treatment to aerobically separate suspended solids, particularly algae, from wastewater. High pressure air is dissolved into a small stream of effluent and then the pressurized air/water mix is released into the center of a tank through which the wastewater flows. In the tank, the mixture is subject to approximately atmospheric pressure conditions and the dissolved air forms minute bubbles which rise to the surface carrying solids. Skimmers at the surface direct the solids to holding bins for disposal.

DAF systems are known to perform as well as or better than filtration for the removal of algae from pond water. In Paradise, a DAF unit would be utilized to remove algae from pond effluent prior to advanced treatment and discharge to Nugen Creek. Algae can have a negative effect on advanced treatment and disinfection by clogging filters and shielding bacteria.

DAF units require a significant energy input to inject pressurized air into the wastewater and to continuously skim solids off of the top and bottom of the tank. Operation of DAF systems is relatively complex and requires a higher degree of operator training compared to secondary ponds. The advantage of operational simplicity associated with pond treatment may be compromised if a DAF system is installed.

Area requirements for the DAF system are minimal (0.05 acres). The total area required for the combined pond/DAF treatment systems is approximately the same as the area required for the pond system alone, 10 acres. The appropriate sites for the operation are Elliot Spring and Lower Horning Ranch. Float generation would be approximately 335 lbs of dry solids or 1000 gallons of DAF skimmings per day (assuming the average suspended solids in the pond effluent are 50 mg/L and that the solids concentration of the float is 4%). Disposal of the float would be accomplished by discharging the solids to drying beds.

(2) Design Criteria: The size and features of the ponds required for treatment are identical to those described in the section on pond treatment alone. For the DAF facility, one 28 ft diameter DAF unit would be required initially to treat the pond effluent. An additional 28 ft unit would be constructed as wastewater flows from Paradise increase. Specific design criteria for the dissolved air flotation system are shown in Table VI-16. The present worth costs for secondary treatment in partial mix aerated ponds followed by DAF are presented in Table VI-17.

TABLE VI-16

**DISSOLVED AIR FLOTATION UNITS**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Dissolved Air Flotation Tanks (No.) | 1 |
| Diameter | 28 ft |
| Sidewall Depth | 10 ft |
| Skimmer Drive Unit | 0.5 hp |
| Pressurization Pump | 25 hp |
| Hydraulic Loading (Rise Rate) | 1 gpm/ft$^2$ |

TABLE VI-17

**PARTIAL MIX AERATED PONDS<br>FOLLOWED BY DISSOLVED AIR FLOTATION<br>PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| A. Lower Horning Ranch Site | | | | |
| Construction | 2,546,000 | | 1 | 2,546,000 |
| Labor | | 33,800 | 10.594 | 358,000 |
| Power | | 108,500 | 10.594 | 1,149,000 |
| Chemicals | | 5,000 | 10.594 | 53,000 |
| Equipment Maintenance | | 4,500 | 10.594 | 48,000 |
| TOTAL PRESENT WORTH | | | | 4,154,000 |
| B. Elliot Spring Site | | | | |
| Construction | 3,604,000 | | 1 | 3,604,000 |
| Labor | | 33,800 | 10.594 | 358,000 |
| Power | | 108,500 | 10.594 | 1,149,000 |
| Chemicals | | 5,000 | 10.594 | 53,000 |
| Equipment Maintenance | | 4,500 | 10.594 | 48,000 |
| TOTAL PRESENT WORTH | | | | 5,212,000 |

c. Summary of the Conventional Pond Treatment Options

Secondary treatment in a partial mix aerated pond is a viable option for the Town of Paradise, with or without dissolved air flotation. DAF would be required if pond treatment and stream discharge are part of the chosen treatment/disposal alternative because the strict disinfection limits would not be met without algae removal. If stream discharge is not a part of the chosen treatment/disposal alternative, the treated wastewater will have to be stored and reused which will not require DAF.

## 2. Conventional Activated Sludge Treatment Options

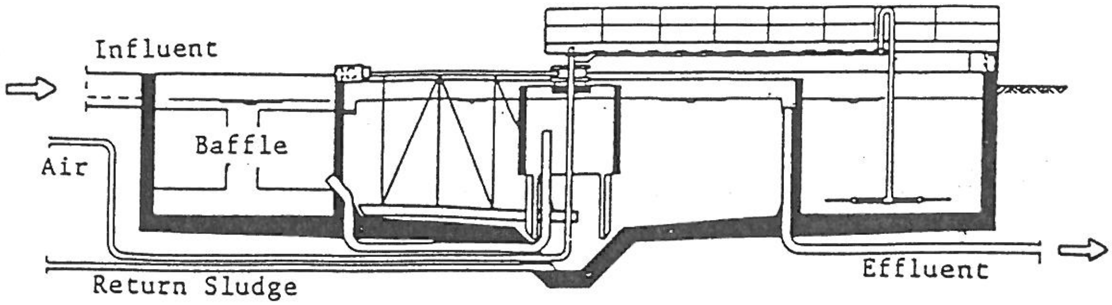
Activated sludge systems are popular unit processes for secondary treatment. An activated sludge treatment system uses a culture of biological organisms such as bacteria and protozoa to consume organic material and suspended solids in the wastewater. Air is added to the wastewater to maintain the aerobic (oxygenated) atmosphere the organisms require for life. After the organisms have consumed most of the organic matter in the wastewater, the mixed liquor is settled out of the waste stream in a clarifier and returned to the treatment vessel. The resulting clarified effluent is then ready for advanced treatment and/or disinfection. A by-product of the treatment process is wastewater sludge, which consists largely of the cell tissue of spent organisms. The wastewater sludge from an extended aeration system is a stable product which can be disposed of in any one of a number of ways, as discussed further in this chapter. Two variations of the activated sludge process are an oxidation ditch or sequencing batch reactor. These options are analyzed in the following paragraphs.

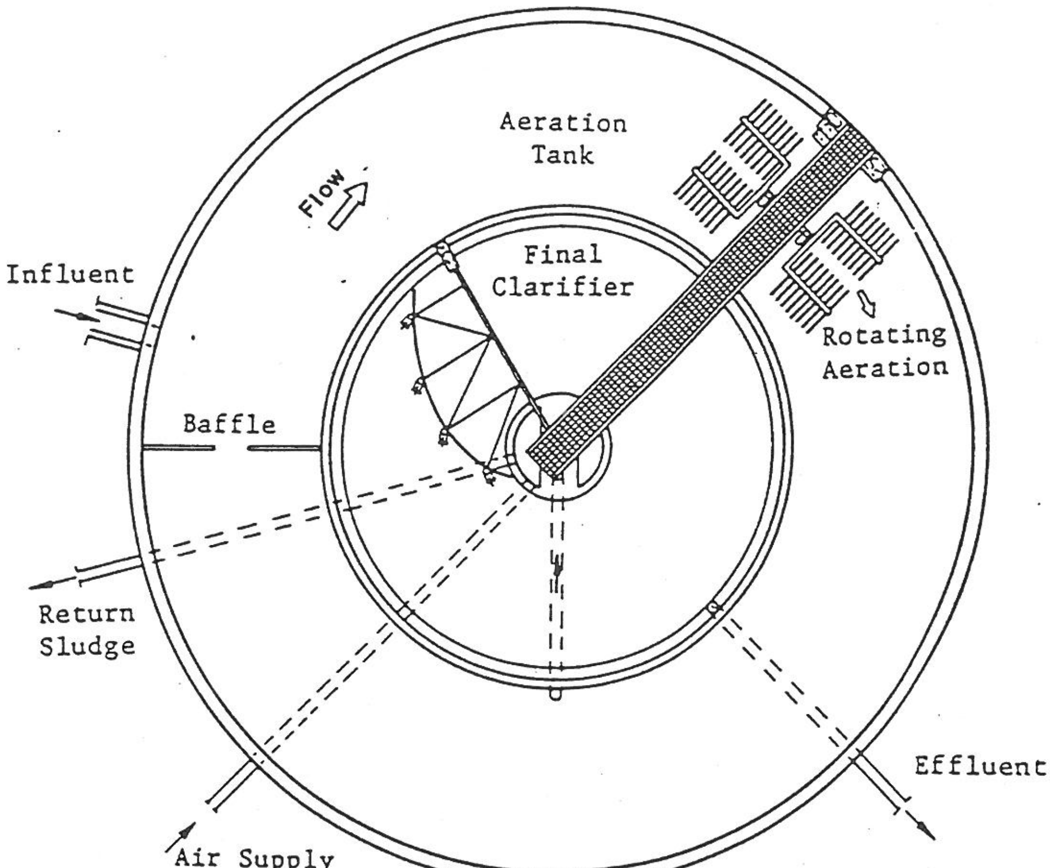
### a. Oxidation Ditch

The oxidation ditch is a reliable treatment process employed by many small communities to achieve a high-quality secondary effluent. Design criteria and construction costs for this alternative are highlighted below.

(1) Process Description: An oxidation ditch treatment plant is a variation of the extended aeration activated sludge treatment process. Oxidation ditches consist of a continuously recirculating closed loop reactor to which screened, degritted, and degreased wastewater is applied. Typically, air is entrained in the loop at one or more locations and the wastewater is propelled around the loop at velocities of up to 2 ft/sec. The wastewater is subjected to periodic aerobic and anoxic cycles. Typical detention times of 24 hours or longer may be used in the design of oxidation ditches. Effluent is drawn from the ditch and clarified. Sludge from the clarifier is returned to the oxidation ditch and periodically wasted as in other activated sludge processes. A diagram of a typical oxidation ditch plant is shown in Figure VI-5.

Generally oxidation ditches produce a high quality nitrified secondary effluent and a relatively stable sludge at reasonable cost. Advantages of an oxidation ditch include elimination of separate primary treatment, reduction of sludge digestion, and relatively easy operation and maintenance. Oxidation ditches can withstand shock loadings better than high rate activated sludge plants and can provide some degree of flow equalization. At Paradise where advanced treatment of wastewater and potential nitrogen limitations may occur, the oxidation ditch allows for flexibility of operation to provide nutrient removal.




SOURCE: Schreiber Corp.

FIGURE VI-5

PARADISE PRELIMINARY DESIGN REPORT

**DIFFUSED AIR OXIDATION DITCH**

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Two possible oxidation ditch configurations for Paradise include a "race track" aeration basin layout with brush aerators or a circular loop aeration basin with rotating diffused air aeration as manufactured by the Schreiber Corporation. For purposes of this alternative analysis, the diffused air oxidation ditch configuration has been evaluated.

(2) Design Criteria: Dual oxidation ditches would be provided at the Elliot Spring or Skyway treatment sites for the ultimate flow. Efficient bubble diffuser aeration facilities sized conservatively for strong septage inflows would be provided. The aeration system would be provided with flexibility to allow reduction of operating costs when loadings on the plant are low. Automatic aeration control would allow the plant to perform optimally even when unattended. Initial construction would include pretreatment facilities, a single aeration channel, and two clarifiers. Spare mechanical components and aerators would be provided as a backup in the event of mechanical failure. Ultimate construction would involve installation of a second aeration channel to treat total future flows. Specific design criteria are presented in Table VI-18. The entire plant at buildout can be contained on less than 5 acres of land.

The Paradise oxidation ditch would produce about 1900 dry pounds of waste sludge per day or about 28,000 gallons of sludge at 0.8% solids. At buildout the volume of sludge would approximately double to 3900 dry pounds per day. Capital and operation and maintenance costs for a diffused air oxidation ditch are summarized in Table VI-19.

TABLE VI-18

**DIFFUSED AIR OXIDATION DITCH**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Aeration Tanks (No.) | 1 |
| Diameter | 140 ft |
| Sidewall Depth | 14 ft |
| Aeration Volume | 176,000 $ft^3$ |
| Organic Loading, $BOD_5$ | 12 lb/1,000 $ft^3$-day |
| F/M Ratio | 0.05/day |
| Avg Hydraulic Residence Time | 39 hrs |
| MCRT | 25 days |
| MLSS | 4,000 mg/L |
| Spare Drive, Mech., (No.) | 1 |
| Blowers (No.) | 4 |
| Peak $O_2$ Demand | 8,600 lb/day |
| $O_2$ Capacity | 19,600 lb/day |
| Total Power | 200 hp |
| Output at 7 psi, each | 975 scfm |
| Clarifiers (No.) | 2 |
| Diameter | 60 ft |
| Sidewall Depth | 14 ft |
| Overflow Rate at Average Flow (with one clarifier out of service) | 300 gpd/$ft^2$ |
| RAS Pumps (No.) | 2 |
| Total Power | 4 hp |
| WAS Pumps (No.) | 1 |

TABLE VI-19

**DIFFUSED AIR OXIDATION DITCH**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 2,164,000 | | 1 | 2,164,000 |
| Labor | | 38,000 | 10.594 | 403,000 |
| Power/fuels | | 44,000 | 10.594 | 466,000 |
| Equipment Maintenance | | 11,500 | 10.594 | 122,000 |
| TOTAL PRESENT WORTH | | | | 3,155,000 |

b. <u>Sequencing Batch Reactor</u>

A sequencing batch reactor (SBR) is a relatively new technology that is typically proprietary in nature. An SBR is considered frequently for small wastewater flows where a high-quality effluent is desired under a variety of loading conditions. A description of the SBR system and design criteria is included as follows.

(1) <u>Process Description</u>: An SBR is a fill-and-draw, extended aeration, activated-sludge treatment system. The treatment provided by an SBR is comparable to that provided by an oxidation ditch activated-sludge system. Aeration and sedimentation/clarification are accomplished in both systems. However, in oxidation ditch systems, the processes occur simultaneously in separate tanks. In a SBR operation, the processes are carried out sequentially in the same tank. A schematic representation of a sequencing batch reactor system is presented in Figure VI-6.

All SBR systems have five steps that are carried out in sequence: fill, react, settle, draw, and idle. Sludge wasting usually occur during the settle or idle phases. Mixed liquor remains in the reactor during all cycles, thereby eliminating the need for separate secondary sedimentation tanks and a return activated-sludge (RAS) system.

An SBR wastewater treatment system offers several advantages to the Town of Paradise. A construction cost savings is realized over an oxidation ditch activated sludge system because, treatment and sedimentation occurs within

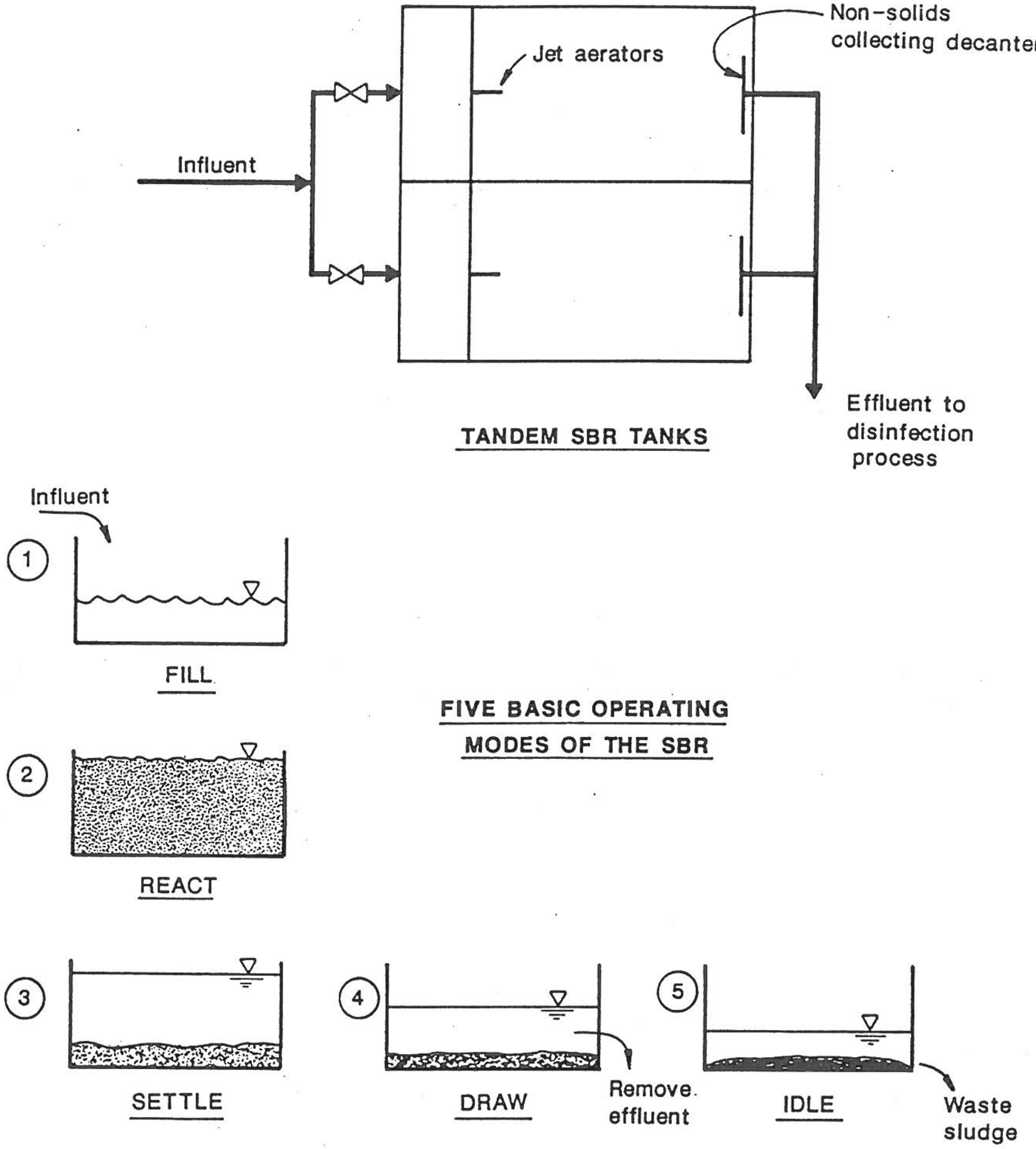


FIGURE VI-6

PARADISE PRELIMINARY DESIGN REPORT

**SEQUENCING BATCH REACTOR FLOW SCHEMATIC AND OPERATING MODES**

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the same basin, eliminating the need for separate clarifiers. The tanks can also be constructed above grade to minimize excavation of the rocky soil. A typical arrangement makes effective use of common walls which reduces concrete requirements.

The SBR operating strategy offers attractive treatment flexibility. By modifying the reaction times, the SBR can be operated to achieve any combination of carbon oxidation, nitrogen reduction, and phosphorous removal. Negative aspects regarding use of an SBR for the Town of Paradise include operational difficulties due to shockloading at the septage receiving station and seasonal fluctuations in wastewater and septage quality.

(2) Design Criteria: The SBR design criteria presented in Table VI-20 was provided by Transenviro, Inc. Environmental Engineers of Irvine, California and Fluidyne Corporation of Cedar Falls, Iowa.

The proposed SBR facility would be equipped with two basins each having a capacity of 51,200 $ft^3$ and an aerobic sludge storage basin. Each SBR basin would be furnished with a surface skimmer, two 75 hp blowers, floor-mounted, non-clog membrane fine bubble diffusers, and a 1 hp sludge contacting/wasting pump. The sludge storage basin, sized for 15 days detention, would be fitted with supernatant decanting equipment and two 40 hp blowers.

Influent to the two basins would be controlled by a cycle control center. A cycle time of 4 hours is anticipated under normal conditions, however, it would be a simple procedure to alter cyclic sequences to effect operational savings should less than design load conditions occur.

To accommodate the flows anticipated at town buildout, two additional SBR basins, of the same volumetric capacity as the first basins, and another sludge storage basin would have to be constructed. The present worth costs of initial construction, power, equipment maintenance, and labor for the SBR option are presented in Table VI-21.

c. Recommended Activated Sludge Treatment Option

A summary of the capital costs, operations and maintenance costs, and total present worth of the two activated sludge options is presented in Table VI-22. The present worth of an oxidation ditch treatment system at Paradise is estimated to be about 5% more than a sequencing batch reactor. At the planning

TABLE VI-20

## SEQUENCING BATCH REACTOR PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Number of Basins | 2 |
| Volume (each basin) | 350,000 gal |
| Basin Dimensions | 40 ft x 80 ft |
| Water Depth | 15 ft |
| Normal Cycle Operation: | |
| Cycles/Day (each basin) | 6 |
| Fill-Aeration Time | 2 hrs |
| Fill-Settle Time | 1 hr |
| Skim-Idle Time | 1 hr |
| Total Cycle Time | 4 hrs |
| Organic Loading Rate | 25 lb $BOD_5$/1,000 $ft^3$-day |
| Sludge Age | 16 days |
| Hydraulic Residence Time | 20 hrs |
| F/M Ratio | 0.113/day |
| Sludge Production | 1,900 lb/day |
| Aeration System: | |
| Aeration Period | 12 hrs/day |
| Peak Standard Oxygen Demand (each basin) | 640 lb/hr |
| Air Delivery | 2,600 scfm |
| Blowers (No. and total power) | 3-60 hp (2-Duty, 1-Standby) |

TABLE VI-21

## SEQUENCING BATCH REACTOR PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 1,863,000 | | 1 | 1,863,000 |
| Labor | | 38,000 | 10.594 | 403,000 |
| Power | | 60,000 | 10.594 | 636,000 |
| Equipment Maintenance | | 10,500 | 10.594 | 111,000 |
| TOTAL PRESENT WORTH | | | | 3,013,000 |

level, a cost difference of 5% is suggestive but not necessarily conclusive as to the best treatment alternative. A non-economic comparison of the two alternatives for Paradise is therefore helpful in evaluating the best suited activated sludge treatment system.

Some non-economic considerations for SBR versus oxidation ditch systems are enumerated in Table VI-23. Sludge produced by oxidation ditches is somewhat more stabilized than sludge produced by an SBR. The more stable sludge is less odorous and may be more beneficial for disposal alternatives such as composting. SBR operation is more flexible in terms of adaption to different treatment requirements and more efficient with respect to the number of pumps and other structural components included in the design. However, SBR's require more complex operating algorithms and therefore more operator attention for daily fluctuations in wastewater volume or strength. The oxidation ditch considered for Paradise is easily expanded by adding a concrete ring around the clarifier. The oxidation ditch and the SBR use high efficiency diffused air aeration to conserve energy, can be operated to provide nutrient removal, can be left unattended, and can be designed to provide automatic process adjustment when unattended. Despite the slightly higher cost, an oxidation ditch is recommended over an SBR because of the system's proven technology, expandability, and reliability.

TABLE VI-22

## SUMMARY OF ACTIVATED SLUDGE OPTIONS

| Option | Capital Costs ($) | Annual Costs ($/yr) | Present Worth ($) |
|---|---|---|---|
| Oxidation Ditch | 2,164,000 | 93,500 | 3,155,000 |
| Sequencing Batch Reactor | 1,863,000 | 108,500 | 3,013,000 |

TABLE VI-23

## COMPARISON OF OXIDATION DITCH AND SEQUENCING BATCH REACTOR OPTIONS

| | Oxidation Ditch | SBR |
|---|---|---|
| Advantages | Proven technology | Good settling sludge |
| | Handles load fluctuations | Large surface area for settling |
| | Well stabilized sludge | Easily adapted for nutrient removal |
| | Easily Expanded | |
| Disadvantages | Occasional sludge settling problem | Decant mechanism is critical, relies on a programmable computer |
| | More equipment to maintain | Load fluctuations may cause operational problems |
| | | Less stabilized sludge |
| | | New technology |
| | | Scum removal problem |

### 3. Natural Systems Treatment Options

Natural systems are wastewater treatment processes that utilize natural components to achieve treatment with a minimum of external energy input. Natural systems are usually less labor intensive than conventional treatment systems and are more aesthetically pleasing. Many of the systems attract and support wildlife.

The types of natural systems evaluated for the Town of Paradise include free water surface wetlands, overland flow, submerged bed wetlands, and a combined system of overland flow and free water surface wetlands. A description of the treatment systems and an assessment of their suitability for the Town of Paradise are presented in the following paragraphs.

#### a. Free Water Surface Wetlands

Free water surface wetlands are constructed wetlands designed to take advantage of the water treatment functions of natural wetlands systems. In a free water surface wetland, the water surface is above ground (as opposed to submerged bed wetlands where the water surface is below ground) and thus exposed to atmospheric conditions. The presence of a free water surface leads to improved oxygen transfer and increases the habitat value of the system by attracting waterfowl and aquatic organisms.

(1) Process Description: Wastewater treatment in a free water surface wetlands is achieved by the same processes which occur in a natural wetland. Solids removal occurs by filtration through plant stems and settling in the quiescent waters. The plant stems also provide attachment sites for bacteria that consume the soluble organic matter in the wastewater. Nitrogen removal occurs as a result of nitrification/denitrification and plant uptake.

A schematic diagram of a free water surface treatment wetlands is presented as Figure VI-7. Wetlands cells are graded flat or to a slight slope to ensure slow and constant movement of the wastewater. A dense stand of wetland vegetation (usually bulrush or cattail) is planted within the cells. Wastewater enters one end of the long, narrow cell and treatment occurs as the wastewater slowly moves to the other end of the cell. Depth of water in the wetlands is usually less than 24 in. Oxygenation is accomplished through absorption at the water surface and by transfer through the roots of the wetland vegetation.

Free water surface wetlands function reliably and effectively in the removal of BOD, suspended solids, and nitrogen. Microbial activity slows down during cold periods, but the wetland systems are sized accordingly to provide the necessary detention time and loading area. The winter temperatures at the Paradise treatment site would not be a limiting factor for the implementation of a free water surface wetland system.

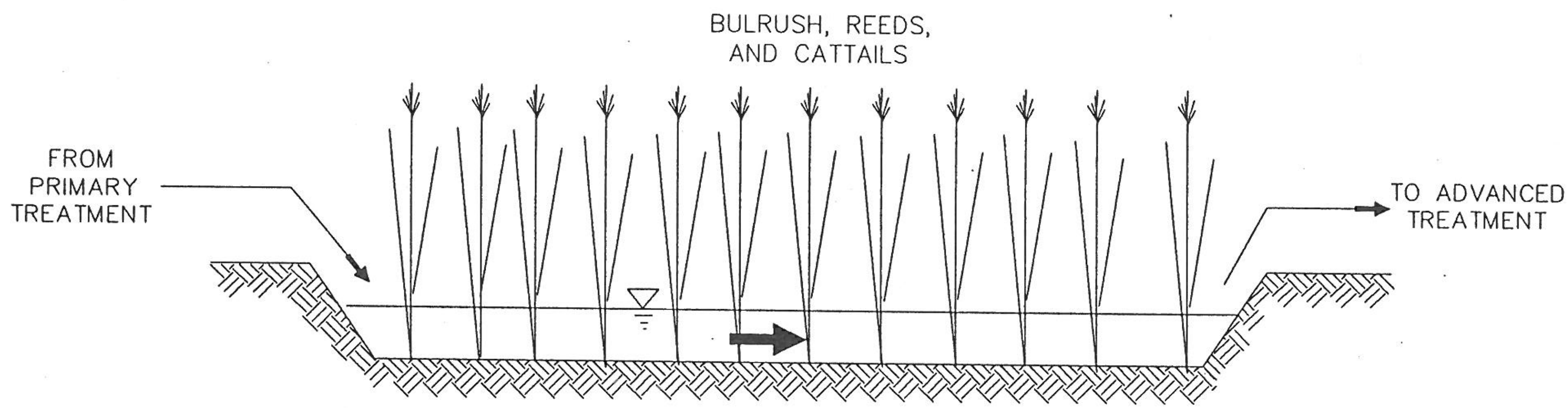


FIGURE VI-7

PARADISE PRELIMINARY DESIGN REPORT

FREE WATER SURFACE WETLANDS

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Odors are not a problem if the wetland is designed for adequate oxygen transfer and if long detention times are avoided. The primary maintenance activity is harvesting the wetlands vegetation, either mechanically or by burning, to maintain the system hydraulics. Harvesting should only be necessary every 5 years and the mechanically harvested plant material will be the only significant amount of solids produced as a byproduct of the treatment process.

Wastewater should be degreased, degritted, and settled (primary treatment) prior to entering a treatment wetlands. The wetlands system for the Town of Paradise would be located on Lower Horning Ranch and would comprise 27 acres initially and 55 acres at town buildout. There is limited area on Horning Ranch that is suitable for wetlands construction, either due to shallow, rocky soils or steep terrain. The area of Lower Horning Ranch most suitable (relatively deep soil) for placement of a natural treatment system is fairly steep, but the wetland cells could be constructed in terrace-style parallel to the contours.

(2) Design Criteria: Preliminary design criteria for a Town of Paradise wetlands treatment system are presented in Table VI-24. At the initial flow-rates, 27 acres of wetlands (five wetland cells) would be required for treatment. At buildout, four additional cells (total of 28 acres) would be constructed to treat the expected volume of wastewater. The detention time during the winter months would be approximately 15 days at a water depth of 1.5 ft. Effluent structures would be placed in each wetland cell so the depth of water in the cell could be adjusted. A pump station may be required at the collection point to transfer the wetlands effluent to wastewater filters for advanced treatment. The present worth costs for secondary treatment in a free water surface wetland are presented in Table VI-25.

b. Overland Flow

Treatment at an overland flow site is achieved as wastewater is discharged through sprinklers or gated distribution pipe over vegetated hill slopes. The wastewater is treated as it flows over the slope in a thin sheet. Water tolerant grasses are planted on the hillslopes which provide some cover habitat for terrestrial organisms and songbirds.

(1) Process Description: The mechanisms of treatment utilized in overland flow are filtration as the wastewater flows through the vegetation, sedimentation on the slopes, and bacterial degradation of organic matter. The bacteria that consume the organic matter are naturally occurring and reside in the soil or are attached to the grass stems. Distribution of the wastewater in a thin sheet over the slopes results in good oxygen transfer from the atmosphere and good contact between the wastewater and the micro-

TABLE VI-24

## FREE WATER SURFACE WETLANDS PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Hydraulic Loading Rate | 0.032 Mgal/acre-day |
| $BOD_5$ Loading Rate | 48 lb/acre-day |
| Winter Operation: | |
| Hydraulic Residence Time | 3.2 days |
| Water Depth | 0.33 ft |
| Summer Operation: | |
| Hydraulic Residence Time | 15 days |
| Water Depth | 1.5 ft |
| Area Required for Initial Flowrate | 27 acres |
| Number of Wetland Cells | 5 |
| Dimensions of Each Cell (approximate) | 100 ft x 2320 ft |
| Additional Area Required for Buildout Flowrate | 28 acres |
| Number of Additional Wetland Cells | 4 |
| Dimensions of Each Cell (approximate) | 100 ft x 3060 ft |

TABLE VI-25

**FREE WATER SURFACE WETLANDS**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 1,774,000 | | 1 | 1,774,000 |
| Labor | | 35,500 | 10.594 | 376,000 |
| Power | | 6,500 | 10.594 | 69,000 |
| Equipment Maintenance | | 3,000 | 10.594 | 32,000 |
| TOTAL PRESENT WORTH | | | | $ 2,251,000 |

organisms in the soil. Perennial, water tolerant grasses are planted on the slopes to provide support medium for the microorganisms, to minimize erosion, and to take up nutrients from the wastewater.

A schematic diagram of an overland flow system is presented in Figure VI-8. Overland flow slopes must be carefully graded to produce a smooth surface and a slope of 2-8%. Wastewater is discharged at the top of the slope and collected in a ditch at the bottom of the slope. Wastewater is applied to the slopes for 6 to 12 hours per day. During the remaining hours of the day, the slopes are regenerated by letting the ground dry and absorb oxygen.

Overland flow treatment is effective for the removal of suspended solids and BOD. Nitrogen removal through nitrification/denitrification is dependent on the BOD/nitrogen ratios of the wastewater, but is typically very good. Cold temperatures and freezing conditions can reduce operational performance, but the winter temperatures of Paradise treatment site should not pose a problem. Extremely heavy rainfall can also have a negative effect on operation, particularly on the removal of suspended solids.

Operations and maintenance costs of an overland flow site may only be slightly higher than a wetlands treatment area when considered on an annualized basis. However, much more attention is required for overland flow on a day-to-day basis due to maintenance of the distribution system and more frequent vegetation removal. Sprinklers, as opposed to gated pipes, are the preferred distribution method because they produce an even flow of wastewater over the slopes. Periodic cleaning and repairing of the sprinkler heads will be necessary to prevent operational problems. Mowing of the slopes may be necessary a few times per year or monthly, depending on

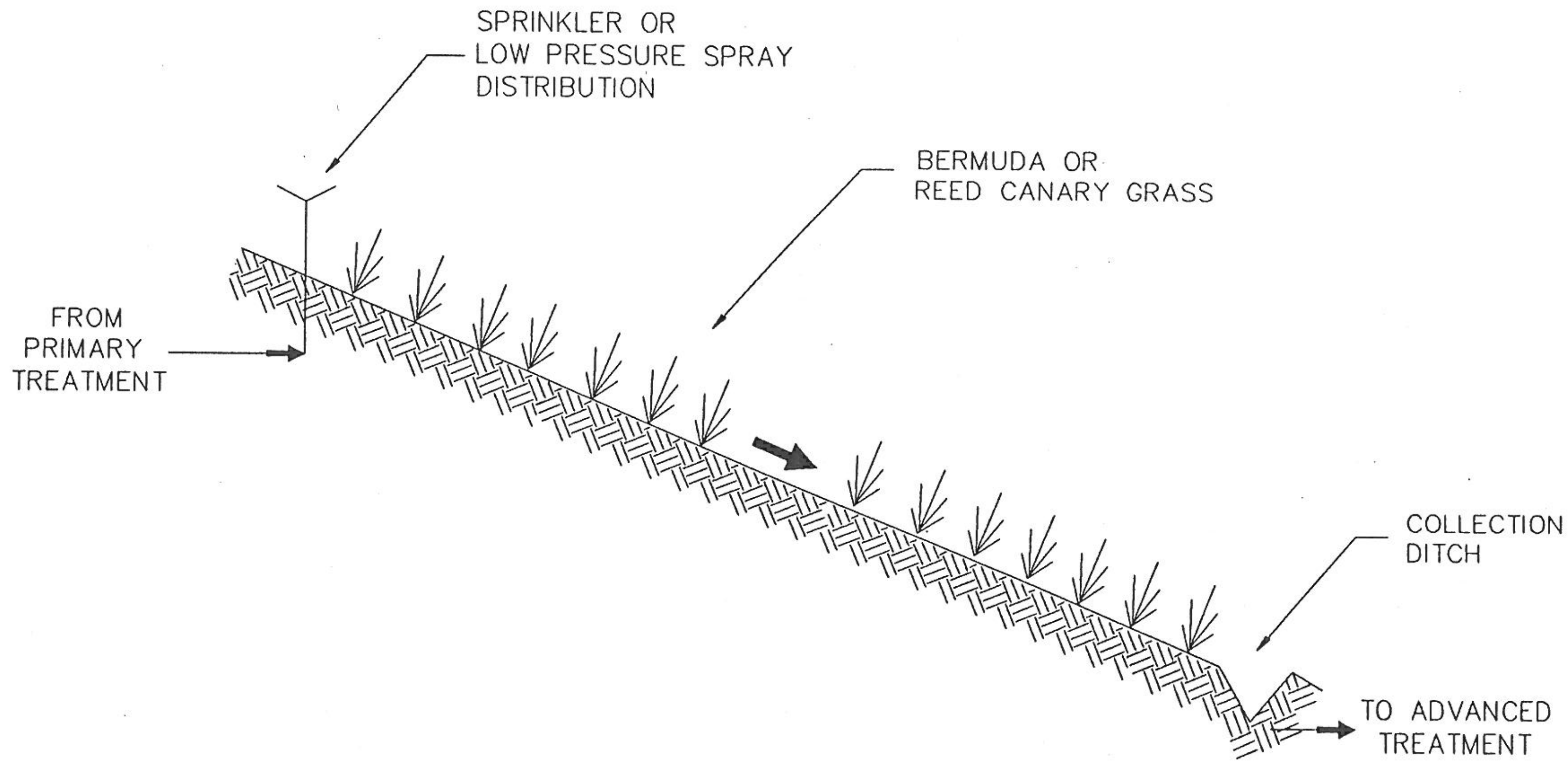


FIGURE VI-8

PARADISE PRELIMINARY DESIGN REPORT

OVERLAND FLOW

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grass growth and treatment performance. The cut grass can be composted, landfilled, or used as feed for sheep, horses, or beef cattle.

Wastewater should be at least screened or settled prior to application to an overland flow site. Appropriate sites for overland flow treatment exist at Lower Horning Ranch, Upper Horning Ranch and Elliot Spring. Approximately 19 acres will be required for treatment at the initial flowrates and an additional 20 acres will be required at buildout. A 20% allowance is included in the area estimations to ensure that the required treatment area will be available when a portion is out of service for drying and mowing. There are 39 acres of appropriate slope available at the Lower Horning Ranch site, but considerable earthwork will be required to construct the desired width and length and to direct drainage to a central location for collection prior to advanced treatment. Construction of an overland flow system at the Elliot Spring site or Upper Horning Ranch may require the importation of a significant amount of soil and the removal of oak trees.

(2) Design Criteria: Preliminary design criteria for a Town of Paradise overland flow treatment system are presented in Table VI-26. At the initial flowrates, 19 acres of overland flow slopes would be required to reduce the $BOD_5$ content to 15 mg/L. The slope length required to achieve this level of treatment is 150 ft. At buildout, 20 additional acres would be added to the system to treat the expected flowrates. Pressure required to operate the sprinkler system would be supplied by an irrigation booster pump. A strainer would be installed in-line after the booster pump to remove any solids remaining in the wastewater that could clog the sprinkler heads. The collection ditches would be lined to prevent grass growth and sluggish flowrates in the channels. Purchase of a tractor and mower would be necessary to accomplish the routine maintenance of the overland flow site. After treatment, the overland flow effluent would be transported to the advanced treatment facilities via a collection pump station. The present worth costs for secondary treatment by overland flow are presented in Table VI-27.

c. Submerged Bed Wetlands

A submerged bed wetlands is a wetland system with a subsurface water flow. Treatment is accomplished as the wastewater flows through a gravel bed that is planted with emergent vegetation. Limited habitat value is associated with a submerged bed wetlands, because there is no free water surface to attract waterfowl and aquatic organisms.

(1) Process Description: Submerged bed wetlands typically consist of a lined bed filled with approximately 2-3 ft of gravel. Wastewater flows just below the surface of the gravel and is treated by the same treatment processes described for a free water surface wetlands; filtration, sedimentation,

TABLE VI-26

**OVERLAND FLOW TREATMENT**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Application Rate | 2.1 $ft^3$/ft-hr |
| Application Period | 12 hrs/day |
| Slope Length | 150 ft |
| $BOD_5$ Loading Rate | 81 lb/acre-day |
| Area Required for Initial Flowrate | 19 acres |
| Additional Area Required for Buildout Flowrate | 20 acres |

TABLE VI-27

**OVERLAND FLOW**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| A. Lower Horning Ranch | | | | |
| Construction | 1,448,000 | | 1 | 1,448,000 |
| Labor | | 37,700 | 10.594 | 399,000 |
| Power | | 23,000 | 10.594 | 244,000 |
| Equipment Maintenance | | 5,800 | 10.594 | 61,000 |
| TOTAL PRESENT WORTH | | | | 2,152,000 |
| B. Elliot Spring or Upper Horning Ranch | | | | |
| Construction | 1,957,000 | | 1 | 1,957,000 |
| Labor | | 37,700 | 10.594 | 399,000 |
| Power | | 23,000 | 10.594 | 244,000 |
| Equipment Maintenance | | 5,800 | 10.594 | 61,000 |
| TOTAL PRESENT WORTH | | | | 2,661,000 |

microbial degradation, and plant uptake. Emergent vegetation such as cattails, tules, or reeds are planted in the gravel bed. In a submerged bed wetlands, roots of the emergent vegetation extend into the path of the wastewater flow and supply oxygen for treatment. The plant roots, along with the gravel, also serve as attachment sites for the bacteria that consume organic matter in the wastewater. A schematic representation of a submerged bed wetlands is presented as Figure VI-9. The major difference between submerged bed wetlands and free water surface wetlands is the absence of a free water surface. Subsurface flow can be considered an attribute if the wetland is located in a densely populated area because the potential for odors and mosquito problems is reduced significantly.

Submerged bed wetlands function effectively and reliably for the removal of BOD, suspended solids, and nitrogen. However, treatment effectiveness can be significantly reduced if wastewater surfaces. To prevent surfacing, uniform distribution of wastewater over the cross section of the gravel bed must be addressed during system design. Uniform distribution results in utilization of the entire treatment area and prevents the buildup of organic matter in one area which might lead to odor problems and clogging. The total area required for treatment is based on winter temperatures due to the decrease in microbial activity that occurs in cold weather.

The maintenance requirements for a submerged bed wetlands are minimal. Periodic harvesting of plant material is not necessary. The emergent vegetation does not remove a significant amount of nutrients from the wastewater and thus decomposition of the plant material within the wetlands will not add an appreciable nutrient load. Another benefit of submerged bed wetlands is the elimination of mosquito habitat. Mosquitos cannot hatch and develop without standing water.

Wastewater should be at least screened and settled prior to entering a submerged bed wetlands. The most appropriate site for a submerged bed wetland is on the Lower Horning Ranch. Approximately 22 acres of wetland will be required for treatment at the initial flowrates with an additional 24 acres required at plant expansion. Excavation to the required 2.5 to 3 ft depth may be difficult to complete, due to the limited amount of soil on the site.

(2) <u>Design Criteria</u>: Preliminary design criteria for a Town of Paradise submerged bed wetlands are presented in Table VI-28. At the initial flowrates, 22 acres of submerged bed wetlands would be required for treatment (15 cells). At buildout, 15 more cells (24 acres) would be constructed to treat the expected wastewater flows. An automatic strainer would be placed in-line after the primary settling facilities to prevent the carryover of any large solids into the flow distribution system. A pump may be required at the collection point to transfer the wetlands effluent to the advanced treatment area. The present worth costs for secondary treatment by a submerged bed wetlands are presented in Table VI-29.

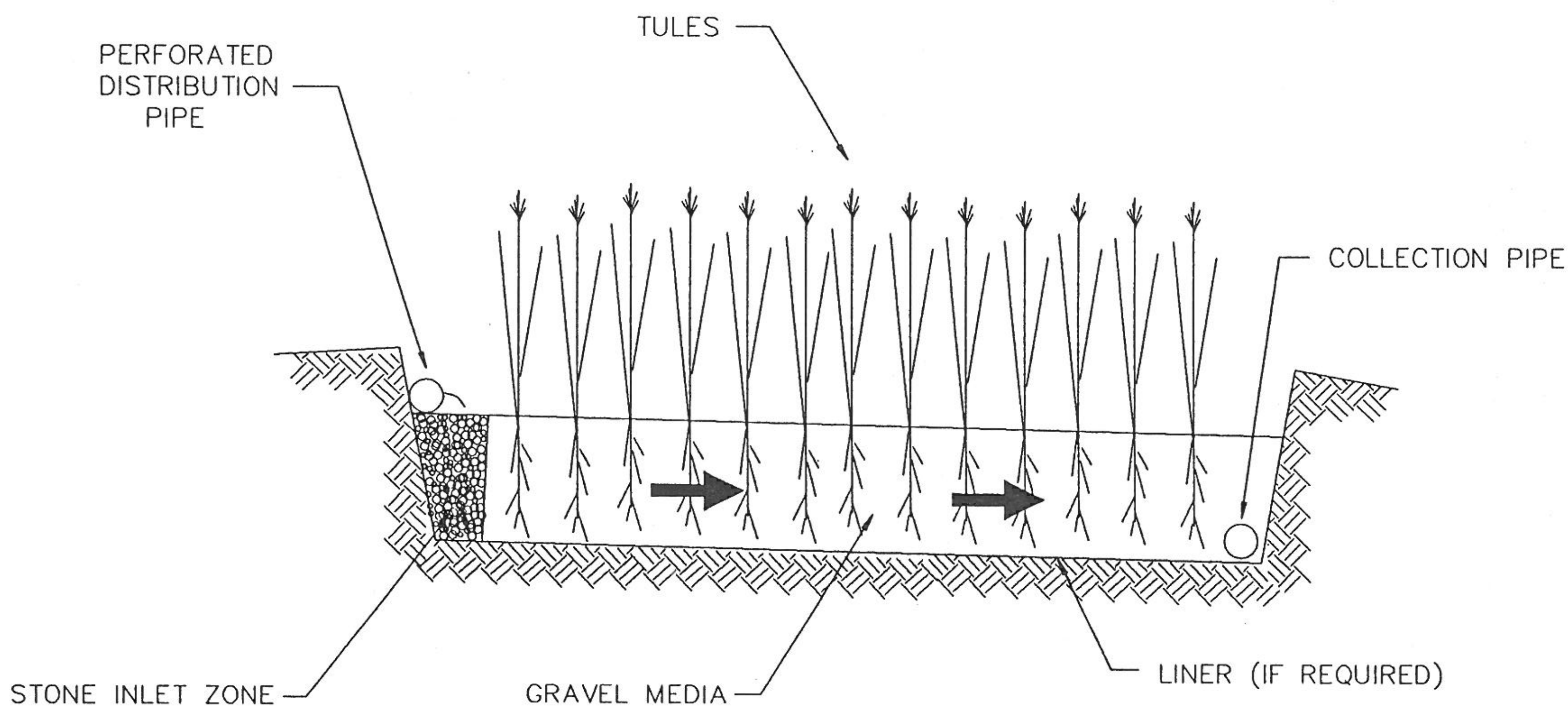


FIGURE VI–9

PARADISE PRELIMINARY DESIGN REPORT

SUBMERGED BED WETLANDS

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TABLE VI-28

**SUBMERGED BED WETLANDS**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Hydraulic Loading Rate | 0.038 Mgal/acre-day |
| Hydraulic Residence Time | 20.4 days |
| Water Depth | 2.4 ft |
| $BOD_5$ Loading Rate (wetlands surface) | 56 lb/acre-day |
| $BOD_5$ Loading Rate (wetlands cross section) | 1401 lb/acre-day |
| Area Required for Initial Flowrate | 22 acres |
| Number of Wetland Cells | 15 |
| Dimensions of Each Cell (approximate) | 60 ft x 1065 ft |
| Additional Area Required for Buildout Flowrate | 24 acres |
| Number of Additional Wetland Cells | 15 |
| Dimensions of Each Cell (approximate) | 60 ft x 1165 ft |

TABLE VI-29

**SUBMERGED BED WETLANDS**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 2,997,000 | | 1 | 2,997,000 |
| Labor | | 27,400 | 10.594 | 290,000 |
| Power | | 6,500 | 10.594 | 69,000 |
| Equipment Maintenance | | 3,400 | 10.594 | 36,000 |
| TOTAL PRESENT WORTH | | | | $ 3,392,000 |

d. Overland Flow Followed by a Free Water Surface Wetlands

Utilizing a combined system of overland flow and free water surface wetlands would take advantage of the major treatment benefits of both systems. BOD removal would occur primarily during overland flow treatment. A small polishing wetlands, constructed downstream of the overland flow area, would be utilized to remove residual suspended solids. Wildlife habitat value of the overland flow system would be enhanced by the establishment of a nearby wetlands.

(1) Process Description: The overland flow and free water surface wetlands treatment mechanisms were described in previous sections of this chapter. A combined system is proposed to capitalize on the excellent suspended solids removal capabilities of the wetlands. Periodic treatment upsets, consisting of discharges of high solids content effluent, have been recorded by operators of existing overland flow treatment areas. A wetlands constructed to treat the overland flow effluent would minimize the effects of these periodic upsets on the advanced treatment facilities.

Combining overland flow and wetlands treatment would ensure a consistent quality effluent from the natural systems treatment area. Initial area requirements for the combined system would be approximately 19 acres. An additional 21 acres would be required at plant expansion. The total area required for overland flow followed by a small free water surface wetlands is approximately the same area necessary for treatment by overland flow alone.

(2) Design Criteria: Preliminary design criteria for a Town of Paradise combined overland flow/free water surface wetlands treatment system are presented in Table VI-30. Overland flow would be used to reduce the $BOD_5$ concentration to 30 mg/L. Reduction to the necessary 15 mg/L would occur in a wetland sized to provide a 1 day detention time at a water depth of 1 ft. Initially, 17 acres of 150 ft length overland flow slopes would be required for treatment. The initial polishing wetland would be 2.6 acres (3 cells). At plant expansion, an additional 18 acres of overland flow and 2.8 acres (3 cells) of wetlands would have to be constructed to treat the expected increase in flows. Specific equipment required for operation of the treatment systems were detailed in the previous sections on overland flow and free water surface wetlands treatment. The present worth costs for secondary treatment by overland flow followed by a free water surface wetlands are presented in Table VI-31.

e. Recommended Natural Systems Treatment Option

A summary of the capital costs, operations and maintenance costs, and total present worth of the five natural systems options is presented in Table VI-32. Submerged bed wetlands would be the most expensive option. The high present worth is due to the large initial capital costs of gravel, excavation, and distribution piping. The present worth of a free water surface wetlands system is slightly higher than overland flow.

TABLE VI-30

**OVERLAND FLOW FOLLOWED BY FREE WATER SURFACE WETLANDS PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Overland Flow: | |
| Application Rate | 2.3 $ft^3/ft \cdot hr$ |
| Application Period | 12 hrs |
| Slope Length | 150 ft |
| $BOD_5$ Loading Rate | 87 lb/acre-day |
| Area Required for Initial Flowrate | 17 acres |
| Additional Area Required for Buildout Flowrate | 18 acres |
| Free Water Surface Wetlands: | |
| Hydraulic Loading Rate | 0.05 Mgal/acre-day |
| $BOD_5$ Loading Rate | 82 lb/acre-day |
| Hydraulic Residence Time | 1 day |
| Water Depth | 1 ft |
| Area Required for Initial Flowrate | 2.6 acres |
| Number of Wetland Cells | 3 |
| Dimensions of Each Cell (approximate) | 60 ft x 635 ft |
| Additional Area Required for Buildout Flowrate | 2.8 acres |
| Number of Additional Wetland Cells | 3 |
| Dimensions of Each Cell (approximate) | 60 ft x 680 ft |

TABLE VI-31

**OVERLAND FLOW FOLLOWED BY A FREE WATER SURFACE WETLANDS PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Initial Construction | 1,636,000 | | 1 | 1,636,000 |
| Labor | | 33,600 | 10.594 | 356,000 |
| Power | | 24,000 | 10.594 | 254,000 |
| Equipment Maintenance | | 5,800 | 10.594 | 61,000 |
| TOTAL PRESENT WORTH | | | | 2,307,000 |

TABLE VI-32

**SUMMARY OF NATURAL SYSTEMS TREATMENT OPTIONS**

| Option | Capital Costs ($) | Annual Costs ($/yr) | Present Worth ($) |
|---|---|---|---|
| Free Water Surface Wetlands (Lower Horning Ranch) | 1,774,000 | 45,000 | 2,251,000 |
| Overland Flow (Lower Horning Ranch) | 1,448,000 | 66,500 | 2,152,000 |
| Overland Flow (Elliot Spring or Upper Horning Ranch) | 1,957,000 | 66,500 | 2,661,000 |
| Submerged Bed Wetlands (Lower Horning Ranch) | 2,997,000 | 37,300 | 3,392,000 |
| Overland Flow Followed by a Free Water Surface Wetlands (Lower Horning Ranch) | 1,636,000 | 63,400 | 2,307,000 |

However, the capital costs of a wetlands system are much higher than overland flow due to the construction techniques that must be employed to create a wetlands in rocky soil. Considerable excavation and grading will be necessary to construct terraced wetlands cells on the rocky hillslopes.

Overland flow followed by a small free water surface wetland will produce a more consistent effluent quality to the advanced treatment facilities than overland flow treatment alone. However, the fluctuations in suspended solids concentration that may occur in overland flow effluent are not extreme enough to cause downstream filter upsets and any labor or power savings realized by a reduction in filter backwashing are probably not significant enough to warrant construction of a polishing wetlands.

Overland flow without a polishing wetlands is the most cost effective natural system treatment option. The present worth of overland flow (at Lower Horning Ranch) is less than the other natural systems options due to significantly lower capital costs. Reliability and effectiveness of overland flow as a treatment method is enhanced by use of the existing topography and geology at all of the sites under consideration. The existing slope is advantageous for overland flow, so a minimum of earthwork and soil disturbance would be required. The shallow soils, an impediment to the cultivation of many plants, are conducive to the establishment and support of grasses.

Though the capital costs of overland flow systems at Elliot Spring and Upper Horning ranch appear to be higher than the Lower Horning Ranch, there are additional considerations regarding the sites that will be evaluated later in this chapter. The primary consideration is that locating a treatment plant at Lower Horning Ranch would entail piping wastewater approximately 3.5 miles from Neal Road to Lower Horning Ranch. Pipeline costs will greatly exceed the $500,000 (as highlighted in Table VI-32) additional expense to construct overland flow slopes at the Elliot Spring or Upper Horning Ranch sites. A further discussion of these options is included in Part E of this chapter.

## ADVANCED TREATMENT

Permit requirements for the proposed Paradise wastewater treatment plant effluent will include a final effluent total coliform level of less than 23 MPN per 100 mL for discharge to Nugen Canyon. The Inland Surface Waters Plan also sets stringent biotoxicity and heavy metals limitations for surface water discharges. Filtration will further remove suspended solids (which can contain heavy metals) from the secondary effluent. Filtration has the added benefits of making the disinfection process and overall treatment plant performance more reliable.

Upflow continuous backwash, traveling bridge, and deep bed filters are suitable for filtration of Town of Paradise secondary influent. The continuous backwash and traveling bridge filters return waste backwash at low enough rates such that equalization and repumping of the waste backwash water would not be required. The deep bed filter is a conventional gravity flow filter for which waste backwash handling facilities would be required. In addition, the deep bed filter is more costly to construct because of the deep media bed (4 to 6 ft) and the large backwash pumps that are required for operation. Given the high cost of deep bed filters, they will be eliminated from further consideration for the Town of Paradise.

### 1. Upflow Continuous Backwash Filter

The upflow continuous backwash filter is becoming increasingly popular in wastewater reclamation applications. A description of the unit and a discussion of specific design criteria are provided below.

#### a. Process Description

The upflow continuous backwash filter operates in an upflow mode with simultaneous continuous backwash occurring. For reference, the Dynasand™ filter is a continuous self-cleaning, upflow, deep bed granular-medium filter. The filter medium is cleaned continuously by recycling the sand internally through an airlift pipe and sand washer. The regenerated sand is redistributed on top of the sand bed allowing for a continuous uninterrupted flow of filtrate and reject water. In the Dynasand™ filter, the liquid to be filtered is introduced into the bottom of the filter where it flows upward through a series of riser tubes and is distributed evenly into the sand bed through the open bottom of an inlet distribution hood. The influent flows upward through the downward moving sand bed. The clean filtrate exits from the sand bed, overflows a weir and is discharged from the filter. Simultaneously the sand bed, along with the accumulated solids, is drawn downward into the suction of an airlift pipe which is positioned in the center of the filter. A small volume of compressed air is introduced into the bottom of the airlift. The sand, dirt, and water are transported upward through the pipe at a rate of about 200 gpm/ft$^2$. The impurities are scoured loose from the sand during this violently turbulent upward flow. Upon reaching the top of the airlift, the dirty slurry spills over into the central reject compartment. By setting the filtrate weir above the reject weir, a steady stream of clean filtrate flows upward, countercurrent to the sand, through a washer section. The upflow liquid carries away the dirt particles, the sand is not carried out of the filter. A process flow schematic for this filter option is shown in Figure VI-10.

Advantages of these filters include high solids loading capacity, low backwash return rates, and simple operation. These filters have a good track record for filtering secondary effluent and would be appropriate for the Paradise treatment plant. Although there are other manufacturers of upflow filters, the units are not equal in construction and performance to the Dynasand™ filter and therefore, only the Dynasand™ unit would be recommended.

b. Design Criteria

The filtration system will be designed for an equalized wastewater flow rate of 1.0 mgd (1.2 peaking factor). Equalization facilities would be provided following secondary treatment and prior to filtration. The equalization facility would consist of a concrete basin with pumping facilities and controls to provide a constant flow output. For the proposed application of filtering suspended solids to improve disinfection, a filtration rate of 5 gpm/$ft^2$ at peak flow will provide a good quality effluent. The filter media and filtration equipment would be contained in a concrete basin. The filters are manufactured in 50 $ft^2$ modules with two hexagonal modules in a basin. The continuous backwash will consume approximately 5 to 10% of its daily flow for backwashing. An air compressor is provided with the unit for the backwash operation. Typical design media depth for the Dynasand™ filter is 1 meter (3.28 ft) with a design headloss of 2 ft. Typical design criteria for this filter are summarized in Table VI-33.

The filters would operate in the continuous contact filtration mode. In this mode, chemicals such as alum and polymer would be added (if needed) prior to a rapid mixer. Effluent would then enter the filter without a separate flocculator. Contact flocculation occurs in the lower levels of the filter media.

Chemical addition facilities would be provided as a safeguard for occasions when secondary effluent quality deteriorates. Chemical filter aids should not be required for normal operation. The chemical feed facilities would consist of a liquid polymer dilution and mixing system. Liquid alum would be fed neat with a mechanical diaphragm chemical metering pump. Liquid polymer would be provided in 55 gal drums. Liquid alum would be purchased bulk and stored in two 3,000 gal FRP storage tanks. Capital, O&M, and present worth costs for the upflow filter installation, including chemical feed facilities are summarized in Table VI-34.

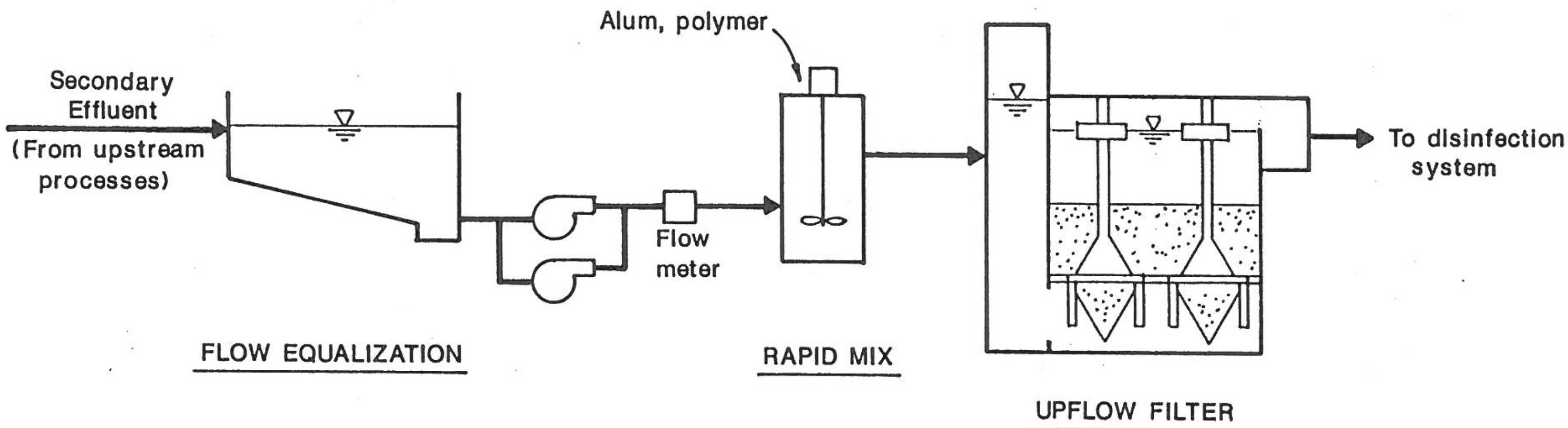


FIGURE VI-10

PARADISE PRELIMINARY DESIGN REPORT

**UPFLOW CONTINUOUS BACKWASH FILTRATION SYSTEM**

**FLOW SCHEMATIC**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

TABLE VI-33

## UPFLOW CONTINUOUS BACKWASH FILTER SYSTEM PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Flow Equalization: | |
| Capacity (working volume) | 200,000 gal |
| Detention Time at 0.85 mgd | 5.6 hours |
| Working Depth | 6 ft |
| Rapid Mix | |
| Number of Chambers | 1 |
| Volume of Chamber | 200 gal |
| Detention Time at 1.0 mgd | 15 seconds |
| Velocity Gradient | 750 $seconds^{-1}$ |
| Filtration: | |
| Type | Upflow, Continuous Backwash |
| Number of Cells | 4 |
| Number of Basins | 2 |
| Cell Size | 50 $ft^2$ |
| Total Filter Area | 200 $ft^2$ |
| Media Characteristics: | |
| Depth | 1 meter |
| Sand Diameter | 1.4 mm |
| Uniformity Coefficient | 1.5 |
| Filtration Rate: | |
| Maximum Equalized Flow | 3.5 $gpm/ft^2$ |
| Maximum Equalized Flow with 1 Basin Out of Service | 7.0 $gpm/ft^2$ |
| Airlift Compressor: | |
| (Continued) | |

TABLE VI-33

**UPFLOW CONTINUOUS BACKWASH FILTER SYSTEM**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| (Continued) | |
| Type | Two-stage reciprocating |
| Number | 2 |
| Capacity | 100 scfm |
| Pressure | 125 psi |
| Motor Size | 30 hp |
| Backwash Rate | 200 gpm/$ft^2$ |
| Chemical Feed Facilities: | |
| Alum | |
| Storage Tanks | |
| Number | 2 |
| Type | FRP |
| Capacity, Each | 3,000 gal |
| Dose | 30-100 mg/L |
| Metering Pumps | |
| Number | 2 (1 standby) |
| Type | mechanical diaphragm |
| Polymer | |
| Storage (liquid) | bin or drums |
| Dose | 1-5 mg/L |
| Metering Pumps | |
| Number | 2 |
| Type | automatic dilution system |
| Control | flow paced |

TABLE VI-34

**UPFLOW CONTINUOUS BACKWASH FILTER**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 1,655,000 | | | 1,655,000 |
| Power | | 9,000 | 10.594 | 95,000 |
| Chemicals | | 6,000 | 10.594 | 64,000 |
| Equipment Maintenance | | 11,000 | 10.594 | 117,000 |
| Labor | | 11,000 | 10.594 | 117,000 |
| TOTAL PRESENT WORTH | | | | 2,048,000 |

## 2. Traveling Bridge Filter

Many reclamation plants in Southern California utilize traveling bridge filters. Design criteria for this filtration option are enumerated below along with a description of equipment components.

### a. Process Description

Traveling bridge filters operate in the downflow mode and consist of multiple filter cells and a traveling bridge hood assembly for backwashing. The filter cells and traveling bridge are mounted in a concrete basin. The filter operates with a relatively shallow depth of media relying primarily on surface filtration. During filter backwash, the bridge travels across the filter sequentially backwashing one filter cell at a time. In this way, the backwash wasting rate is limited to a low flow which can be wasted directly to the headworks of the treatment plant without the need for backwash equalization facilities. There are several reputable manufacturers of traveling bridge filters which provides the opportunity for good competition in a bidding situation.

The traveling bridge filter includes more moving mechanical parts than the upflow filter. However, the operation of the filter is straightforward and operators are able to maintain the filter mechanical parts without the need for special training or sophisticated equipment. The traveling bridge filter would be suitable for the Paradise treatment plant. A process flow schematic for this option is shown in Figure VI-11.

b. Design Criteria

The filtration system will be designed for an equalized wastewater flow rate of 1.0 mgd (1.2 peaking factor). For the proposed application, a filtration rate of 2 gpm/ft$^2$ at peak flow will provide a good quality effluent. Typical design media depth for traveling bridge filters is 11 to 24 in. with a design headloss of 2.0 feet. The filter media and filtration equipment would be contained in an uncovered concrete basin. The continuous backwash will consume approximately 3 to 5% of its daily flow for backwashing.

Because the traveling bridge filter has a shallower depth of media, the continuous contact filtration mode is not appropriate. A separate flocculator would be provided upstream of the filter to assist in agglomeration of particles prior to filtration. In this mode, chemicals such as alum and polymer would be added (if needed) prior to a rapid mixer. Effluent would then enter a separate 2-stage flocculator designed to produce a velocity gradient of 80 sec$^{-1}$ in the first chamber and 40 sec$^{-1}$ in the second chamber. The chambers would be plumbed such that the units may be operated in series or parallel. In this manner, one of the chambers can be removed from service for maintenance. Design criteria for the traveling bridge filter system are summarized in Table VI-35.

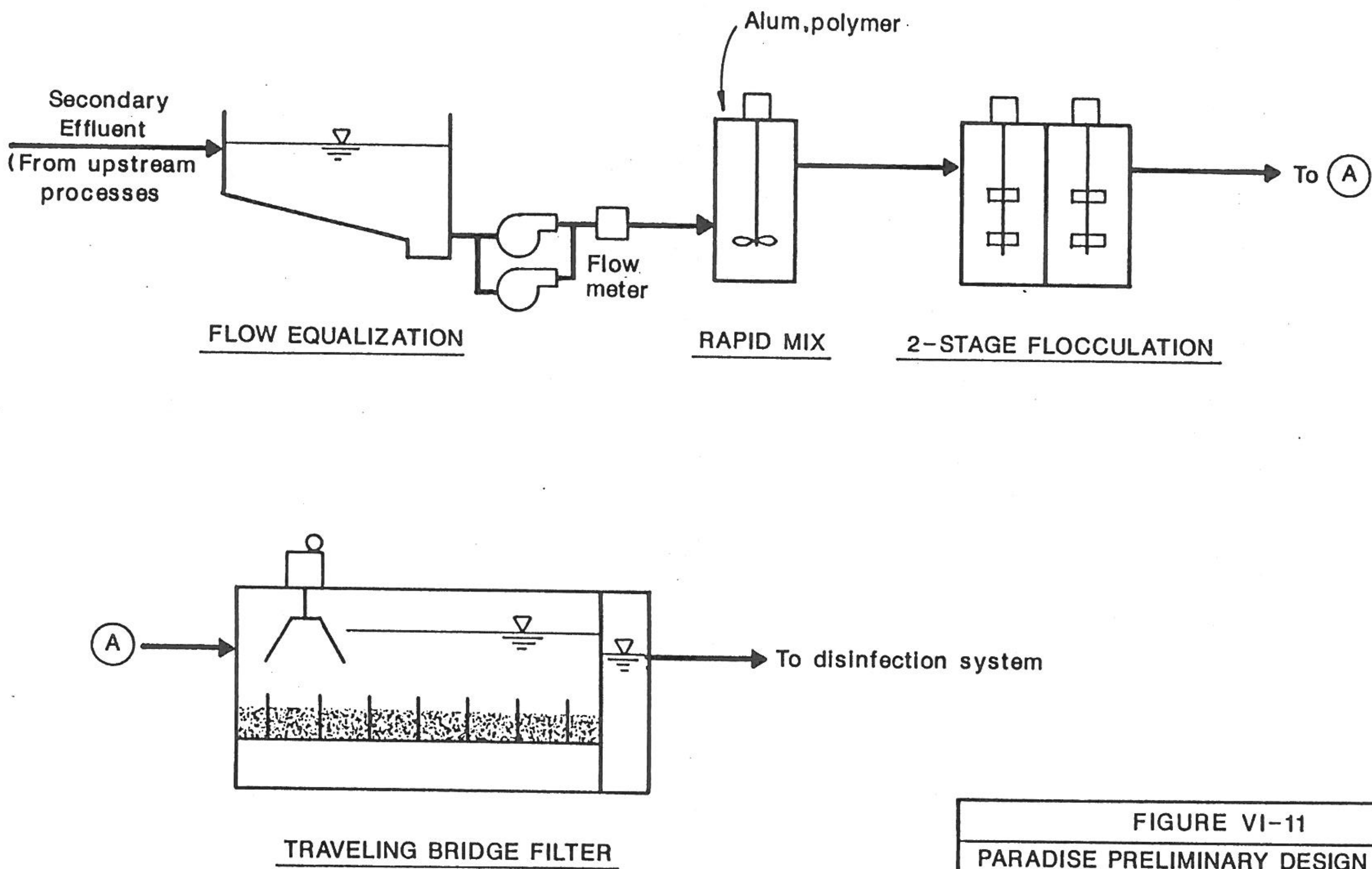


FIGURE VI-11

PARADISE PRELIMINARY DESIGN REPORT

**TRAVELING BRIDGE FILTRATION SYSTEM**

**FLOW SCHEMATIC**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

TABLE VI-35

## TRAVELING BRIDGE FILTER
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Flow Equalization, Rapid Mix, Chemical Feed: | (See Table VI-33) |
| Flocculation: | |
| Number of Trains | 1 |
| Stages per Train | 2 |
| Detention Time | 20 minutes |
| Depth | 10 ft |
| Type of Flocculation | vertical turbine |
| Velocity Gradient | |
| First Stage | 80 $sec^{-1}$ |
| Second Stage | 40 $sec^{-1}$ |
| Filtration: | |
| Type | Traveling Bridge |
| No. and Dimensions of Filters | 1-12 ft x 42 ft |
| Total Filter Area | 360 $ft^2$ |
| Cell Width | 8 in. |
| Media Characteristics | |
| Depth | 11 in. |
| Size | 0.60 mm |
| Filtration Rate at Maximum Equalized Flow | 2 $gpm/ft^2$ |
| Headloss at Maximum Flow | 1 ft |
| Backwash Pumps: | |
| Number | 2 |
| Motor Size, each | 3.5 hp |
| Backwash Rate | 15-20 $gpm/ft^2$ |
| Chemical Feed/Storage: | (See Table VI-33) |

Chemical addition facilities would be provided as described for the upflow filter option. Capital, O&M, and present worth costs for the traveling bridge filter installation, including chemical feed facilities are summarized in Table VI-36.

### 3. Recommended Filtration System Option

A summary of capital, O&M, and present worth costs for the filtration system options are presented in Table VI-37. The present worth of the two alternatives is fairly close in magnitude. Costs for the upflow continuous backwash filter are approximately 3% higher than the costs for the traveling bridge filter. Given the level of accuracy of these preliminary estimates, the alternative selection should consider other factors. The upflow continuous backwash filter is simple to operate, functions well under heavy solids loading, can tolerate varying influent loads, and has an excellent track record for wastewater effluent filtration. However, for this application high solids loadings are not anticipated because phosphorous removal and heavy algae removal are not required. In addition, there is only one manufacturer of this type of filter which will tend to discourage competition and result in a higher cost.

The traveling bridge filter with flocculator will provide excellent suspended solids removal for the Town of Paradise application. A disadvantage of a traveling bridge filter system is that there is only one unit. This disadvantage can be mitigated by maintaining an inventory of spare parts to reduce the length of those infrequent periods when the filter is out of service. The traveling bridge will have low headloss and low total backwash water usage. There are several manufacturers of these filters which will ensure good competition during bidding. These filters provide good performance at reasonable cost, therefore, the traveling bridge filter is the recommended option.

TABLE VI-36

**TRAVELING BRIDGE FILTER
PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 1,521,000 | | | 1,521,000 |
| Power | | 9,500 | 10.594 | 101,000 |
| Chemicals | | 6,000 | 10.594 | 64,000 |
| Equipment Maintenance | | 11,000 | 10.594 | 117,000 |
| Labor | | 17,000 | 10.594 | 180,000 |
| TOTAL PRESENT WORTH | | | | 1,983,000 |

TABLE VI-37

**SUMMARY OF FILTRATION OPTIONS**

| Option | Capital Cost ($) | Annual Cost ($/yr) | Present Worth ($) |
|---|---|---|---|
| Upflow Continuous Backwash Filter | 1,655,000 | 37,000 | 2,048,000 |
| Traveling Bridge Filter | 1,521,000 | 43,500 | 1,983,000 |

## DISINFECTION

Disinfection of treated wastewater is critical to reduce the risk from outbreaks of waterborne diseases such as cholera and typhoid. The appropriate level of disinfection depends on the method of disposal which will be used. Pathogens are effectively removed by soil filtration in rapid infiltration disposal systems, and therefore a separate disinfection process is usually not required. Other types of disposal such as most types of agricultural reuse or discharge to surface waters require a disinfection process.

The California DHS develops disinfection requirements based on the method of disposal and the likelihood of public exposure. The requirements are based on the total coliform (bacterial) concentrations in the plant effluent. A 7-day median total coliform level of 23 MPN/100 mL is typically required for disposal systems where the chance of public contact is relatively low. A 7-day median total coliform level of 2.2 MPN/100 mL is typically required where the chance of public contact is considered to be high.

The methods of disinfection evaluated for suitability in Paradise include chlorination, hypochlorination, and ultraviolet light disinfection. Each of the processes is discussed below, followed by descriptions of the dechlorination process and the recommended disinfection systems.

### 1. Chlorination (chlorine gas)

The term chlorination refers to the use of chlorine gas for disinfection purposes. The use of sodium hypochlorite (similar to domestic liquid bleach) for disinfection purposes is referred to as hypochlorination in this report and is discussed separately below.

a. Process Description

Disinfection using chlorine gas is the most common type of system in use at wastewater and water treatment plants throughout the country. Chlorine is a strong disinfectant but requires a contact time of 30 to 120 minutes for optimum germicidal performance. Chlorination is a chemical disinfection process which leaves a residual which can be toxic to aquatic life. A dechlorination process is therefore often required prior to surface water discharge.

A schematic diagram of a chlorine gas disinfection system is shown in Figure VI-12. Chlorine gas is transported and stored in 2,000 lb (one ton) cylinders. The gas is withdrawn by a vacuum system and is mixed with water to form a chlorine solution. The chlorine solution is then mixed with the wastewater and allowed to flow through a chlorine contact chamber. The contact chamber is designed with serpentine channels to provide the required contact time between the chlorine and the wastewater prior to discharge. The use of a contact chamber is preferable to the use of a large diameter pipe for chlorine contact because a contact chamber can be easily cleaned by maintenance personnel. The ability to readily clean the walls of the contact chamber is especially necessary if disinfection to a level of 2.2 MPN/100 mL total coliform is required.

Chlorination is an effective and reliable method of disinfection by which all other forms of disinfection are judged. Secondary effluent from any of the treatment processes described in this report can be disinfected to 23 MPN/100 mL total coliform levels with a high degree of process reliability. Reliable disinfection to 2.2 MPN/100 mL levels usually requires advanced treatment (filtration) prior to chlorination.

Paradise is planning to adopt the 1991 version of the Uniform Fire Code in July 1992, which will place restrictions on the storage of chlorine gas. The 1991 version of the Uniform Fire Code requires that extensive ventilation provisions and air scrubbers be installed at chlorine storage facilities. The scrubbers automatically actuate to neutralize the toxic gas in case of a chlorine leak. The required installation of chlorine scrubbers frequently makes the use of chlorine gas less cost effective than other disinfection methods.

The chlorination facilities would be located adjacent to the secondary and advanced wastewater treatment facilities. The chlorine contact basin would be designed to easily accommodate a future plant expansion by allowing the construction of a "mirror image" contact basin adjacent to the initial structure.

b. Design Criteria

Preliminary design criteria for a chlorination system are presented in Table VI-38. The chlorination facilities would be designed for the use of 2,000 lb chlorine cylinders. A monorail hoist system would be used to move the cylinders from the delivery truck to the storage room. The cylinders would rest on scales which are used to determine the amount of chlorine remaining in the containers. The system would be designed with automatic switch over capabilities so that chlorine gas would be automatically withdrawn from a full cylinder once another cylinder

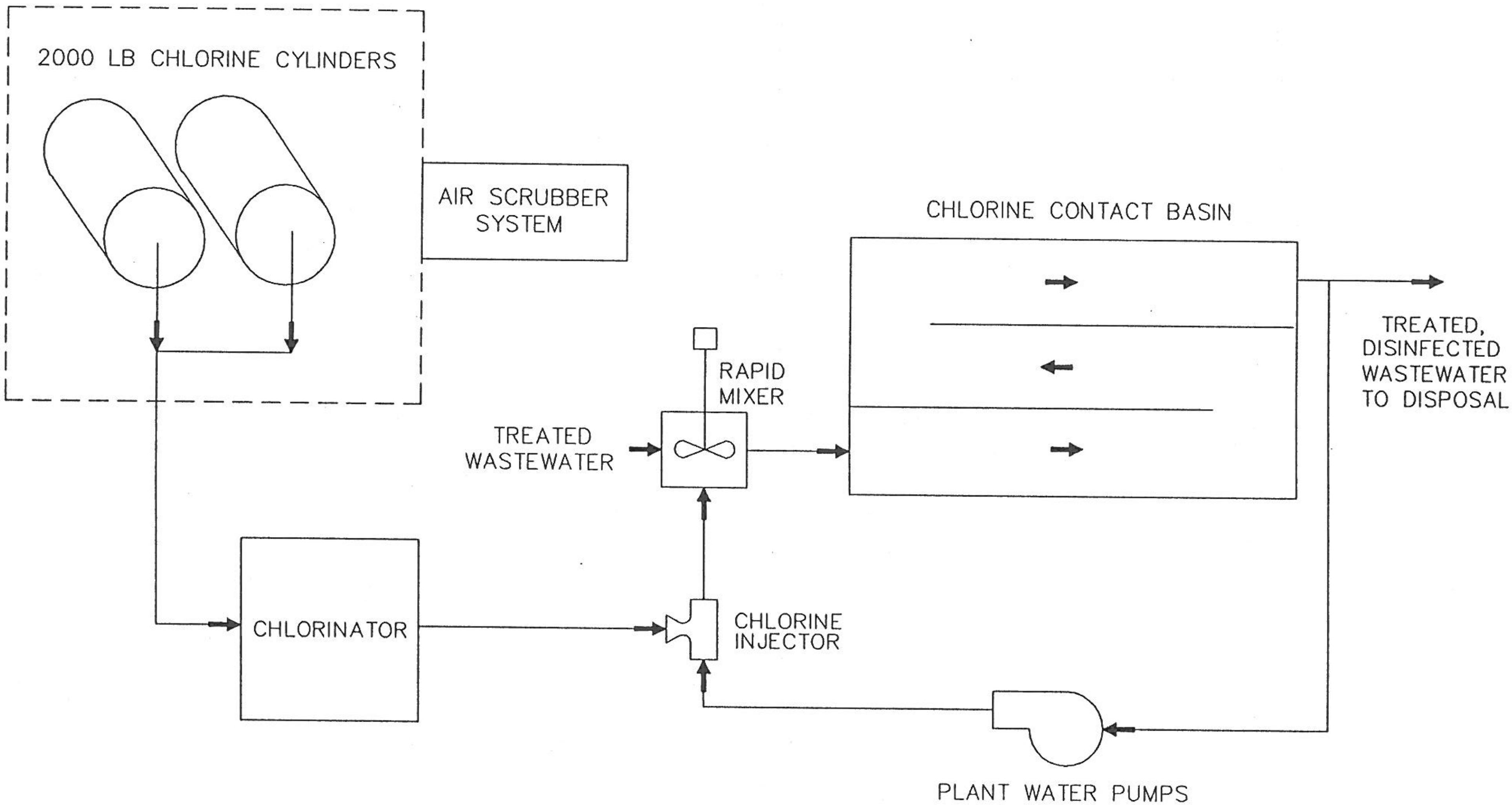


FIGURE VI–12

PARADISE PRELIMINARY DESIGN REPORT

CHLORINATION SYSTEM SCHEMATIC

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

TABLE VI-38

**CHLORINATION**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Chemical Handling: | |
| Design Dose | 12 mg/L |
| Number of Ton Cylinders on Line | 1 |
| Number of Chlorinators | 2 |
| Chlorinator Control | compound loop |
| Number of Residual Analyzers | 2 |
| Chlorine Mixing: | |
| Maximum Velocity Gradient | 500 $sec^{-1}$ |
| Chlorine Contact Basin: | |
| Approximate Detention Time at ADWF | 60 min. |
| Minimum Detention Time at PWWF | 30 min. |

is emptied. The duplex chlorinators would operate on a vacuum withdrawal basis, which is considered to be the safest type of system. The chlorine dose would be determined automatically by a compound loop control system, which uses chlorine residual analyzer data and flow meter data to properly pace the rate of chlorine withdrawal from the storage cylinders.

The chlorine gas would be mixed with plant water (chlorinated effluent) to form a chlorine solution. The solution would be mixed with the treated wastewater in a rapid mix chamber prior to flowing through the contact chamber. The contact chamber would be designed to provide at least 30 minutes of detention time at peak flow rates prior to discharge. The results of a present worth analysis of a chlorination system are presented in Table VI-39.

## 2. Hypochlorination

The term hypochlorination is used to describe the process of disinfection using sodium hypochlorite. The actual chemical process is identical to chlorination with chlorine gas. Sodium hypochlorite, however, is transported and stored in a liquid form and therefore different chemical handling facilities are required.

TABLE VI-39

**CHLORINATION**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 761,000 | | 1.00 | 761,000 |
| Labor | | 9,100 | 10.594 | 96,000 |
| Power | | 1,300 | 10.594 | 14,000 |
| Chemicals | | 5,800 | 10.594 | 61,000 |
| Equipment Maintenance | | 3,400 | 10.594 | 36,000 |
| TOTAL PRESENT WORTH | | | | 968,000 |

a. <u>Process Description</u>

The use of sodium hypochlorite for wastewater disinfection purposes is becoming increasingly popular. Commercial grade sodium hypochlorite is similar to domestic liquid chlorine bleach but at a much stronger concentration. Hypochlorite is a strong disinfectant but requires a contact time of 30 to 120 minutes for optimum germicidal performance. Hypochlorination is a chemical disinfection process which leaves a residual which can be toxic to aquatic life. A dechlorination process is therefore often required prior to surface water discharge.

A schematic diagram of a hypochlorination system is shown in Figure VI-13. Hypochlorite is transported and stored in a liquid form. Hypochlorite is delivered by tanker truck and stored in a tank at the treatment plant. Chemical metering pumps are used to deliver the proper amount of hypochlorite to the wastewater. The chlorine contact basin design is similar to the basin used with a chlorine gas system.

Hypochlorination is as effective and reliable as chlorination for disinfection. The major disadvantage of hypochlorination is the high chemical cost when compared to chlorine gas. Scrubbers are not required for hypochlorination facilities to be in compliance with the 1991 Uniform Fire Code, which tends to offset the high chemical cost when considering life cycle cost comparisons with chlorine gas systems.

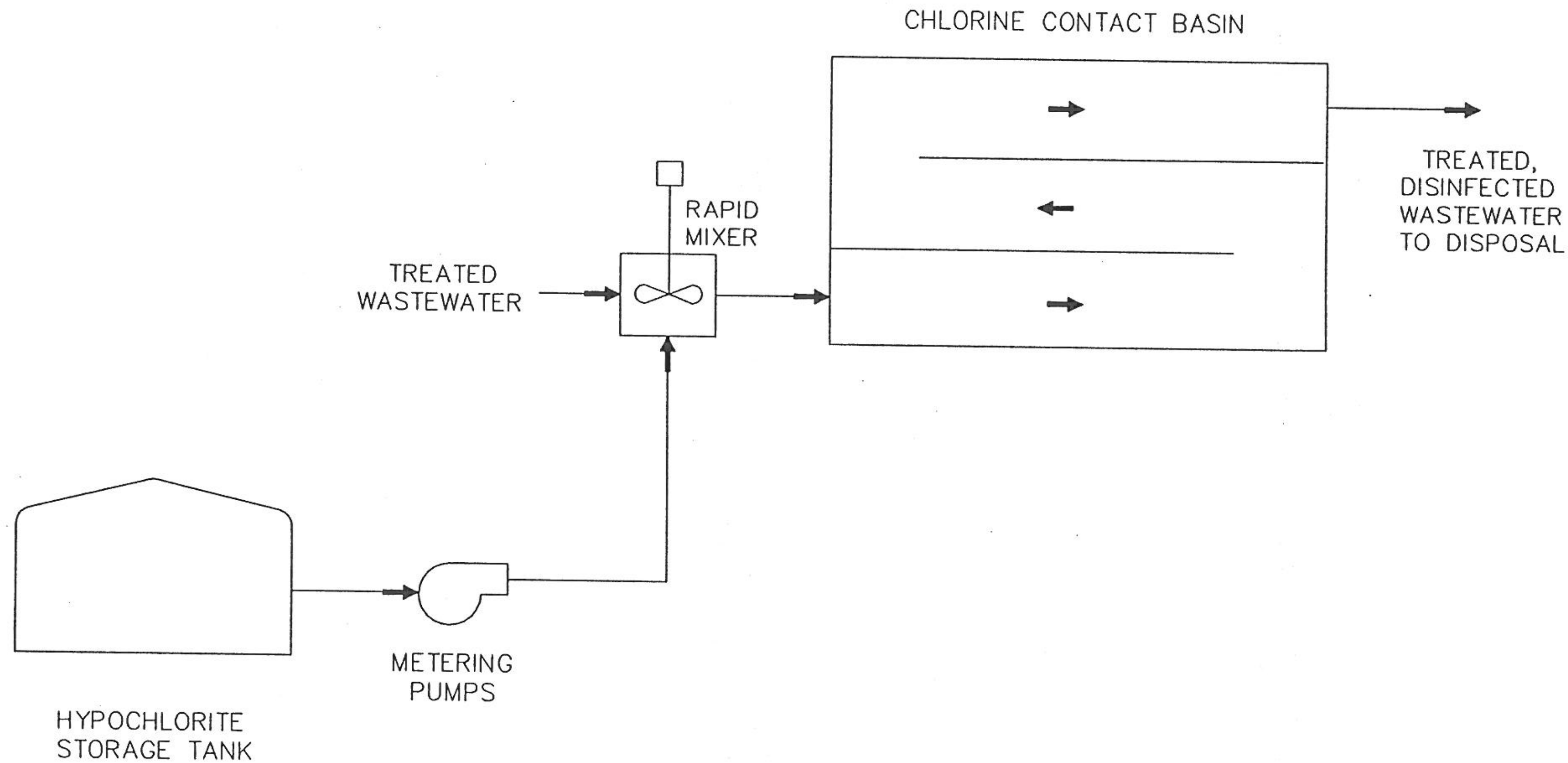


FIGURE VI-13

PARADISE PRELIMINARY DESIGN REPORT

HYPOCHLORINATION SCHEMATIC

NOLTE and ASSOCIATES
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b. Design Criteria

Preliminary design criteria for a hypochlorination system are presented in Table VI-40. Sodium hypochlorite would be stored in a 3,000 gal double containment storage tank. Duplex metering pumps would be provided to deliver the proper amount of chemical to the wastewater. Control signals from a flow meter and chlorine residual analyzers would permit accurate delivery of chemical from the metering pumps to the wastewater. The results of a present worth analysis for a hypochlorination system are presented in Table VI-41.

### 3. Ultraviolet Light (UV)

a. Process Description

UV disinfection is a physical disinfection process, unlike chlorination and hypochlorination which are chemical disinfection processes. UV light is used to damage the DNA and RNA of bacterial cells in the wastewater, making them unable to replicate. The process leaves no residual which is toxic to aquatic life. The use of UV for wastewater disinfection purposes has already found widespread applications in other parts of the country and is finding acceptance in California.

A diagram of a typical UV disinfection system is shown in Figure VI-14. Wastewater flows through a channel in which low intensity mercury vapor lamps are suspended. The lamps are spaced to provide the UV light intensity required to achieve the disinfection goals. An automatic level controller is provided to maintain the proper water depth in the channel at all times.

The dose of UV light required to achieve a disinfection goal is related to the particle size distribution of the effluent. In general, a high quality secondary effluent ($BOD_5$ and TSS less than 15 mg/L) and a high UV dose are required to achieve disinfection levels of 23 MPN/100 mL reliably. A prior filtration process is required to achieve disinfection levels of 2.2 MPN/100 mL reliably. The suitability of UV for Paradise is therefore much more dependent on the method of treatment selected than either chlorination or hypochlorination. The major advantages of UV over alternative disinfection options is that the process leaves no toxic residual and does not require the purchase and storage of chemicals. A significant disadvantage of a UV system is that large amounts of power are required to illuminate all of the UV lamps. A UV system would be easily expandable by constructing a new system parallel to the original channel.

The operations and maintenance requirements for a UV system consist of effluent monitoring, daily system performance checks, cleaning the lamps approximately every month, and replacing the lamps as needed (typically every 12 to 18 months).

TABLE VI-40

## HYPOCHLORINATION
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Chemical Handling: | |
| Design Dose | 12 mg/L |
| Hypochlorite Concentration | 15% |
| Storage Tank Volume | 3,000 gal |
| Number of Metering Pumps | 2 |
| Metering Pump Control | compound loop |
| Number of Residual Analyzers | 2 |
| Chlorine Mixing: | |
| Maximum Velocity Gradient | 500 $sec^{-1}$ |
| Chlorine Contact Basin: | |
| Approximate Detention Time at ADWF | 60 min. |
| Minimum Detention Time at PWWF | 30 min. |

TABLE VI-41

## HYPOCHLORINATION
## PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 391,000 | | 1.00 | 391,000 |
| Labor | | 9,100 | 10.594 | 96,000 |
| Power | | 1,300 | 10.594 | 14,000 |
| Chemicals | | 27,400 | 10.594 | 290,000 |
| Equipment Maintenance | | 700 | 10.594 | 7,000 |
| TOTAL PRESENT WORTH | | | | 798,000 |

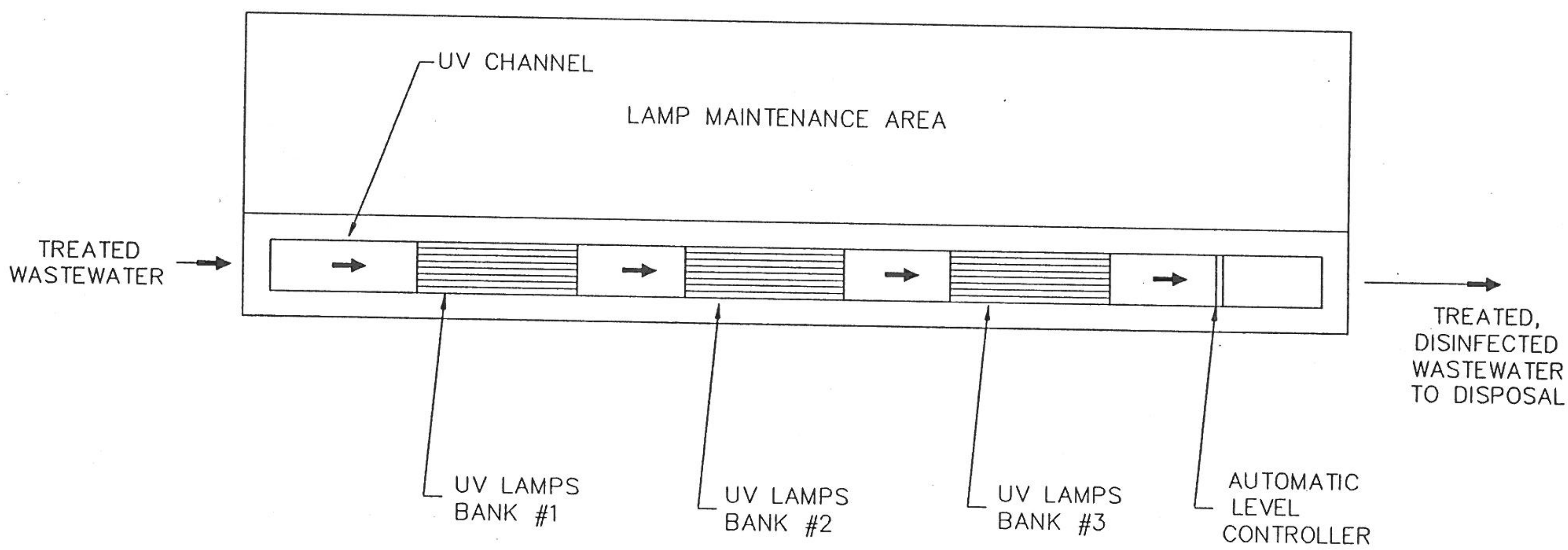


FIGURE VI–14

PARADISE PRELIMINARY DESIGN REPORT

UV DISINFECTION SYSTEM

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

b. Design Criteria

Preliminary design criteria for a UV disinfection system are presented in Table VI-42. The UV system would consist of three banks of UV lamps which operate in series. The system would be sized to deliver the required dose of UV light to the wastewater in the first 2 banks of lamps. The third bank of lamps would be provided for equipment redundancy and to provide additional disinfection reliability. The hydraulic detention time in the UV system would be less than 30 seconds, as compared to the required 30 to 120 minute detention time in a chlorination or hypochlorination system.

TABLE VI-42

**UV DISINFECTION**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Equipment Type | Horizontal Open Channel |
| Number of Banks | 3 |
| Bulb Length | 64 in. |
| Average UV Dose at PWWF | 120 mW-sec/$cm^2$ |
| Level Control Mechanism | Counter weighted flap gate |
| UV Transmittance | 70% |
| Average Lamp Life | 12,000 hrs |

The results of a present worth analysis of a UV system are summarized in Table VI-43.

TABLE VI-43

**UV DISINFECTION**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 553,000 | | 1.00 | 553,000 |
| Labor | | 9,100 | 10.594 | 96,000 |
| Power | | 14,500 | 10.594 | 154,000 |
| Lamps | | 6,100 | 10.594 | 65,000 |
| Equipment Maintenance | | 4,000 | 10.594 | 42,000 |
| TOTAL PRESENT WORTH | | | | 910,000 |

## 4. Dechlorination

Both chlorination and hypochlorination leave a toxic residual in the effluent which typically must be removed prior to discharge to surface waters to prevent adverse effects on aquatic life. A UV disinfection system leaves no such residual.

### a. Process Description

The use of sulphur dioxide for dechlorination purposes is widely accepted. The sulphur dioxide is added to the wastewater stream downstream of the chlorine contact basin where it effectively removes any chlorine residual.

Sulphur dioxide is transported and stored in 2,000 lb cylinders. The chemical handling equipment used is nearly identical to the equipment used with chlorine gas. Air scrubbing equipment is not required for sulphur dioxide facilities under the 1991 Uniform Fire Code. The chemical reaction is nearly instantaneous and therefore no contact basin is required.

Dechlorination will be required prior to discharge to surface waters if chlorination or hypochlorination are used for disinfection. Dechlorination will not be required if the plant effluent is stored and used for agricultural reuse.

b. Design Criteria

Preliminary design criteria developed for a dechlorination system are presented in Table VI-44. Sulphur dioxide gas would be mixed with plant effluent to form a sulphur dioxide solution. The solution would then be mixed with the chlorinated effluent to remove the chlorine residual. A feedback control system using residual analyzers and a flow meter signal would be used to properly regulate the flow of chemical.

The results of a present worth analysis for a dechlorination system are presented in Table VI-45. The incremental building space required for dechlorination was previously included in the chlorination and hypochlorination cost estimates.

### 5. Recommended Disinfection System Option

Results of present worth analyses of the various disinfection alternatives are shown in Table VI-46. The best apparent alternatives depend on the final disposal alternatives selected.

If all of the treated wastewater is to be stored and reused for agricultural irrigation then either of the first two disinfection alternatives (chlorination, hypochlorination) could be implemented. A UV system could not be used with an aerated pond secondary treatment system because of the low quality effluent that would be produced. Hypochlorination is the recommended method of disinfection if storage and total agricultural reuse disposal is selected. As shown in Table VI-46, hypochlorination is the most cost effective alternative. A chlorine residual would be allowed if storage and reuse is the chosen method of disposal, so dechlorination would not be necessary. Hypochlorination can also be successfully implemented with any of the secondary treatment processes described in this chapter. A filtration process would not be required to reliably achieve a 23 MPN/100 mL coliform disinfection requirement.

No chlorine residual would be allowed if treated wastewater is to be discharged to Nugen Canyon or Hamlin Slough. The last three disinfection alternatives (UV, chlorination/dechlorination, or hypochlorination/dechlorination) could therefore be implemented for this type of discharge. UV disinfection is recommended if surface discharge to Nugen Canyon is selected for disposal. As shown in Table VI-46, a UV system is more cost effective than the chlorination/dechlorination or hypochlorination/-dechlorination alternatives. Filtration will be required for any of the alternatives to reliably achieve the total coliform limitation of 2.2 MPN/100 mL.

TABLE VI-44

**DECHLORINATION**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Number of Ton Cylinders Online | 1 |
| Number of Sulphonators | 2 |
| Sulphonator Control | Continuous |
| Number of Residual Analyzers | 1 |

TABLE VI-45

**DECHLORINATION**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 138,000 | | 1.00 | 138,000 |
| Labor | | 4,600 | 10.594 | 49,000 |
| Power | | 700 | 10.594 | 7,000 |
| Chemicals | | 6,800 | 10.594 | 72,000 |
| Equipment Maintenance | | 1,000 | 10.594 | 11,000 |
| TOTAL PRESENT WORTH | | | | 277,000 |

TABLE VI-46

## SUMMARY OF DISINFECTION OPTIONS

| Option | Capital Costs ($) | Annual Costs ($/yr) | Present Worth ($) |
|---|---|---|---|
| Chlorination | 761,000 | 19,600 | 968,000 |
| | | | |
| Hypochlorination | 391,000 | 38,500 | 798,000 |
| | | | |
| Ultraviolet Light | 553,000 | 33,700 | 910,000 |
| | | | |
| Chlorination Plus | 761,000 | 19,600 | 968,000 |
| Dechlorination | 138,000 | 13,100 | 277,000 |
| | 899,000 | 32,700 | 1,245,000 |
| | | | |
| Hypochlorination Plus | 391,000 | 38,500 | 798,000 |
| Dechlorination | 138,000 | 13,100 | 277,000 |
| | 529,000 | 51,600 | 1,075,000 |

## BIOSOLIDS HANDLING

Biosolids (sludge) are the residual materials which are produced as a result of the primary, secondary, and advanced wastewater treatment processes described in this chapter. Proper handling of biosolids is important to prevent nuisance odor conditions at a wastewater treatment plant. The handling and disposal of biosolids in an environmentally-safe manner is often a major cost of constructing and operating a wastewater treatment plant.

### 1. Description of Biosolids Handling Alternatives

The wastewater treatment processes described in this chapter each produce different types and amount of sludge. The different characteristics of each type of sludge result in specific treatment requirements and different disposal opportunities. Biosolids handling alternatives applicable to the Town of Paradise sludge are described below.

a. Conventional Activated Sludge Treatment

Waste activated sludge from the conventional treatment alternatives would be handled in one of the following four methods:

(1) Aerobic Digestion/Dewatering/Composting: Waste activated sludge would be wasted to an aerobic digester. Stabilized sludge from the aerobic digester would be dewatered utilizing a belt filter press to achieve 15% to 20% solids. Dewatered sludge would be utilized for co-composting with chipped yard wastes obtained from the Neal Road Landfill.

(2) Aerobic Digestion/Dewatering/Land Application: Waste activated sludge would be wasted to an aerobic digester. Stabilized sludge from the aerobic digester would be dewatered utilizing a belt filter press to achieve 15% to 20% solids. Dewatered sludge would be transported to Lower Horning Ranch and land applied as a soil amendment.

(3) Sludge Storage Basin/Drying Beds/Landfill: Waste activated sludge would be pumped to a sludge storage basin (SSB) designed to store sludge for up to 2 years. Utilizing a floating dredge, sludge at a concentration of 4% to 6% solids would be removed from the SSB during the dry weather season. Sludge removed from the SSB would be dried on paved drying beds to achieve 50% solids and taken to the Neal Road Landfill.

(4) Sludge Storage Basin/Land Application: Waste activated sludge would be pumped to a sludge storage basin designed to store sludge for up to 2 years. Utilizing a floating dredge, sludge at a concentration of 4% to 6% solids would be removed from the SSB during the dry weather season. Sludge removed from the SSB would be land applied as a soil amendment.

b. Natural Systems and Pond Systems

For natural systems and the pond systems, sludge will accumulate in an aerated settling pond or partial mix aerated ponds and be removed approximately once every 3 to 5 years. Sludge removal and processing would be accomplished on a contract basis with final disposal by land application.

c. Primary Clarifier Sludge

For the alternative involving primary treatment in a clarifier at Elliot Spring, sludge would be handled using one of the four alternatives described in (a) above.

## 2. Sludge Quantities and Characteristics

A summary of parameters used to calculate the estimated sludge production for the initial and ultimate wastewater flows are summarized in Table VI-47.

## 3. Analysis of Sludge Handling Alternatives

a. Conventional Activated Sludge Treatment

(1) Alternative 1 - Aerobic Digestion/Dewatering/Composting: For this alternative, an aerobic digester consisting of a concrete basin, mechanical aeration, and sludge removal and basin decant facilities would be constructed to provide sludge stabilization. A 25% to 35% reduction in volatile solids would be achieved in the aerobic digester (larger reductions would be achieved at higher summer temperatures). Sludge from the digester would be pumped to a belt filter press dewatering system which would be housed in a building. In the belt press sludge is conditioned with polymer and squeezed under pressure between polyester belts to achieve a sludge solids concentration in the range of 15 to 20%. An emergency sludge holding basin would be provided to store sludge in the event the belt press is out of service.

Dewatered sludge would be temporarily stockpiled onsite and co-composted with garden wastes from the Town at the treatment plant. Composting is the aerobic, thermophilic decomposition of organic constituents to produce a relatively stable humus-like material. The most efficient operation occurs when the temperature of the sludge-amendment material is between 130°F and 150°F. The organic matter in compost is beneficial as a soil conditioner. Because sludge is stabilized, the remaining organic matter in compost will decompose slowly preventing odors and providing long lasting effectiveness in the soil. A bulking agent such as chipped wood or chipped yard wastes is required to provide a starting mixture with the proper moisture content and porosity. The sludge provides nutrients which are necessary in the compost mix.

TABLE VI-47

## SLUDGE PRODUCTION CALCULATION

| Parameter | Value |
|---|---|
| A. Conventional Activated Sludge Treatment | |
| $BOD_5$ Concentration | 264 mg/L |
| TSS Concentration | 322 mg/L |
| MCRT | 25 days |
| Sludge Yield | 1.0 lb TSS/lb BOD |
| VSS Content | 75% |
| WAS Solids Concentration | 0.8% |
| Total Sludge Production | 1,900 lb/d |
| VSS Loading | 1,400 lb/d |
| Inert Solids Loading | 500 lb/d |
| Total Sludge Volume | 28,000 gpd |
| B. Natural Systems and Pond Systems | |
| Primary Settling Ponds: | |
| Sludge Accumulation | 220,000 lb/yr |
| Volume @ 10% Solids (in 3 yrs.) | 100,000 $ft^3$ |
| Partial Mix Aerated Ponds: | |
| Sludge Accumulation (dry solids) | 350,000 lb/yr |
| Volume @ 10% Solids (in 3 yrs.) | 160,000 $ft^3$ |
| C. Primary Clarifier | |
| TSS Removal | 60% |
| Total Sludge Production | 1,400 lb/d |
| VSS Content | 70% |
| VSS Quantity | 1,000 lb/d |
| Inert Solids | 400 lb/d |
| Sludge Solids Concentration | 4% |
| Total Sludge Volume | 4,100 gpd |

In windrow composting, the sludge/garden waste mix would be placed in rows up to 300 ft long, 15 ft wide and 3 to 7 ft high. Mechanical turning of the windrow provides ventilation to maintain aerobic conditions. The windrow compost method is appropriate for Paradise because of its simplicity and reasonable cost. Care must be taken to locate the compost operation away from residential areas, due to the possibility of odor release when the windrows are turned. The final product would be sold to landscapers for use as soil conditioner.

Equipment required for the compost operation would include a tractor equipped with a front end loader and harrow, a rotary screen, and a medium sized dump truck for hauling of bulk materials. Preliminary design criteria for this alternative are presented in Tables VI-48, VI-49 and VI-50. Capital and operating costs for this alternative are presented in Tables VI-51, VI-52, and VI-53.

TABLE VI-48

**AEROBIC DIGESTION**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Sludge Loading Rate to Digester | 1,900 lb/d |
| No. of Digesters | 1 |
| Volume (total) | 0.23 Mgal |
| Sludge Detention time @ 2% Solids | 20 days |
| HP total | 30 hp |
| No. Aerators | 2 @ 15 hp |
| Basin Dimensions | 36 ft x 72 ft |
| Basin Depth | 12 ft |
| Construction Type | concrete |
| Digested Sludge Quantity | 1,400 lb/d |

TABLE VI-49

## BELT FILTER PRESS
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Sludge Loading Rate: | |
| Dry Solids | 1,400 lb/d |
| Volume @ 1.5% Solids Concentration | 11,000 gpd |
| Flow Rate (5 d/week; 8 hrs/day) | 32 gpm |
| No. of Belt Presses | 1 |
| Nominal Belt Width | 1.0 meter |
| Solids Loading | 240 lb/hr |
| Polymer Consumption | 10 to 20 lb/dry ton |
| Dewatered Solids Concentration | 15 to 20% |
| Emergency Storage Basin: | |
| Volume | 0.15 Mgal |
| Holding Time | 2 weeks |

TABLE VI-50

## SLUDGE COMPOSTING
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Sludge Loading: | |
| Dry Weight | 0.7 ton/d |
| Solids Concentration | 15-20% |
| Compost Operation: | |
| Initial Solids Concentration Required | 40 to 65% |
| Approx. Ratio Garden Waste to Sludge | 20 cy/dry ton sludge |
| C:N Ratio (Max) | 35:1 |
| C:P Ratio (Max) | 150:1 |
| Detention Time | 4 to 6 weeks |
| Temperature Achieved | 140-160° F |
| VSS Destruction | 20 to 30% |
| Compost Facility: | |
| Windrow Height | 4 to 8 ft |
| Windrow Width | 12 to 25 ft |
| Land Required (min.) | |
| Compost Operation | 0.33 ac/dry ton per day sludge |
| Truck Unloading | 300 $ft^2$/ (ton/d sludge) |
| Compost Storage | 900 $ft^2$/ (ton/d sludge) |
| Total Land Required | 0.5 acre |

TABLE VI-51

**AEROBIC DIGESTION**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 284,000 | | 1.00 | 284,000 |
| Labor | | 33,000 | 10.594 | 350,000 |
| Power | | 22,000 | 10.594 | 233,000 |
| Equipment Maintenance | | 1,300 | 10.594 | 14,000 |
| TOTAL PRESENT WORTH | | | | 881,000 |

TABLE VI-52

**BELT FILTER PRESS**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 736,000 | | 1.00 | 736,000 |
| Labor | | 23,000 | 10.594 | 244,000 |
| Power | | 2,000 | 10.594 | 21,000 |
| Chemicals | | 5,000 | 10.594 | 53,000 |
| Equipment Maintenance | | 4,000 | 10.594 | 42,000 |
| TOTAL PRESENT WORTH | | | | 1,096,000 |

TABLE VI-53

## COMPOSTING
## PRESENT WORTH ANALYSIS

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 201,000 | | 1.00 | 201,000 |
| Labor | | 50,000 | 10.594 | 530,000 |
| Power/fuel | | 19,000 | 10.594 | 201,000 |
| Equipment Maintenance | | 13,800 | 10.594 | 146,000 |
| TOTAL PRESENT WORTH | | | | 1,078,000 |

(2) Alternative 2 - Aerobic Digestion/Dewatering/Land Application: For this alternative an aerobic digester, and belt filter press would be constructed as described in Alternative 1. Dewatered sludge would be land applied at Lower Horning Ranch.

Agricultural land application of sludge is governed by federal regulations issued by EPA. The Regional Board enforces these regulations in waste discharge requirements. DHS has issued an advisory manual entitled *Manual of Good Practices for Landspreading of Sewage Sludge* (6-7) which is used by the Regional Board for establishing requirements. Basic requirements for a land application system include: limiting public access, limiting nutrient loadings to within crop uptake rates, proper management techniques to prevent nuisance conditions and contamination of runoff, and limiting cumulative metal loadings based on the cation exchange capacity of the soil.

Soils at Lower Horning Ranch are generally thin (12 to 30 in.) with many cobbles. These soils are not suitable for cultivated crops, but are appropriate for annual pasture grass. Sludge application would improve the water holding capacity of the soil, and provide nutrients for plant growth. Metals loading to the site should be relatively low given the limited industrial activity in the town. The cation exchange rate capacity of the soils is in the range of 14 to 31 milliequivalents (meq)/100 grams (g) which is sufficient to sequester metals in the soil up to reasonably high cumulative loadings.

An annual pasture grass such as fescue would be grown on the application site to provide for nutrient uptake. The site would not be irrigated and could be used for animal grazing. The sludge application rate would be limited to 3 tons/acre-year, a low loading rate reflecting the lower nutrient uptake rate of unirrigated pasture. The sludge would be applied with a slinger type sludge spreading truck. The sludge would be disced into the soil at periodic intervals. The site would be fenced to limit public access. Three monitoring wells would be installed for groundwater sampling. Preliminary design criteria and capital and operating costs for aerobic digestion and sludge dewatering are described under Alternative 1. Preliminary design criteria for the land application system are presented in Table VI-54. Capital and operating costs for the land application system alternative are presented in Table VI-55. A process flow schematic for Alternatives 1 and 2 is shown in Figure VI-15.

(3) Alternative 3 - Sludge Storage Basin/Drying Beds/Landfill: Waste sludge from the treatment process would be pumped to a sludge storage basin designed to hold the sludge for up to two years. The basin would be lined with a synthetic liner such as hypalon to prevent leakage. Asphalt concrete (AC) pavement would be placed over the liner at the bottom to protect the liner during sludge removal operations. By maintaining VSS loading to the basin below 20 $lb/ft^2 \cdot day$, oxidation of sludge decomposition products with facultative processes within the basin is possible. Surface aerators would be provided for additional aeration as a precaution against odor generation. Utilizing a floating dredge, sludge at a concentration of 4 to 6% solids would be removed from the SSB during the dry weather season.

The sludge removed from the SSB would be pumped to paved drying beds to achieve a 50% solids concentration. Each bed would be equipped with decant facilities for removal of free water prior to drying. Paved drying beds would allow equipment to enter the beds while the sludge is still wet to turn the sludge and speed the drying process. The air dried sludge would be hauled to Neal Road landfill, a Class III landfill, for disposal. Dewatered municipal sludge is normally not hazardous and under current regulations may be placed in a Class III landfill. Neal Road landfill is not currently permitted to receive wastewater sludge, however, regulations would allow the permit to be modified to accept sludge. Preliminary design criteria for the sludge storage basin and drying beds are presented in Tables VI-56 and VI-57. Capital and operating costs for this alternative are presented in Tables VI-58 and VI-59.

TABLE VI-54

**LAND APPLICATION**
**PRELIMINARY DESIGN CRITERIA**

| Parameter | Value |
|---|---|
| Land Use | Annual pasture with grazing |
| Nitrogen Uptake Rate | 150 lb/acre-yr |
| Average Sludge Application Rate (dry wt.) | 3 ton/acre-yr |
| Land Area Required: | |
| A. Conventional Treatment | |
| Aerobic Digestion | 90 acres |
| SSB | 67 acres |
| B. Natural Systems and Pond Systems | |
| Settling Pond | 40 acres |
| Partial Mix Pond | 67 acres |
| C. Primary Treatment | |
| Aerobic Digestion | 67 acres |
| SSB | 50 acres |

TABLE VI-55

**LAND APPLICATION OF DEWATERED SLUDGE**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 486,000 | | 1.00 | 486,000 |
| Labor | | 7,100 | 10.594 | 75,000 |
| Power/fuel | | 1,200 | 10.594 | 13,000 |
| Equipment Maintenance | | 2,000 | 10.594 | 21,000 |
| TOTAL PRESENT WORTH | | | | 595,000 |

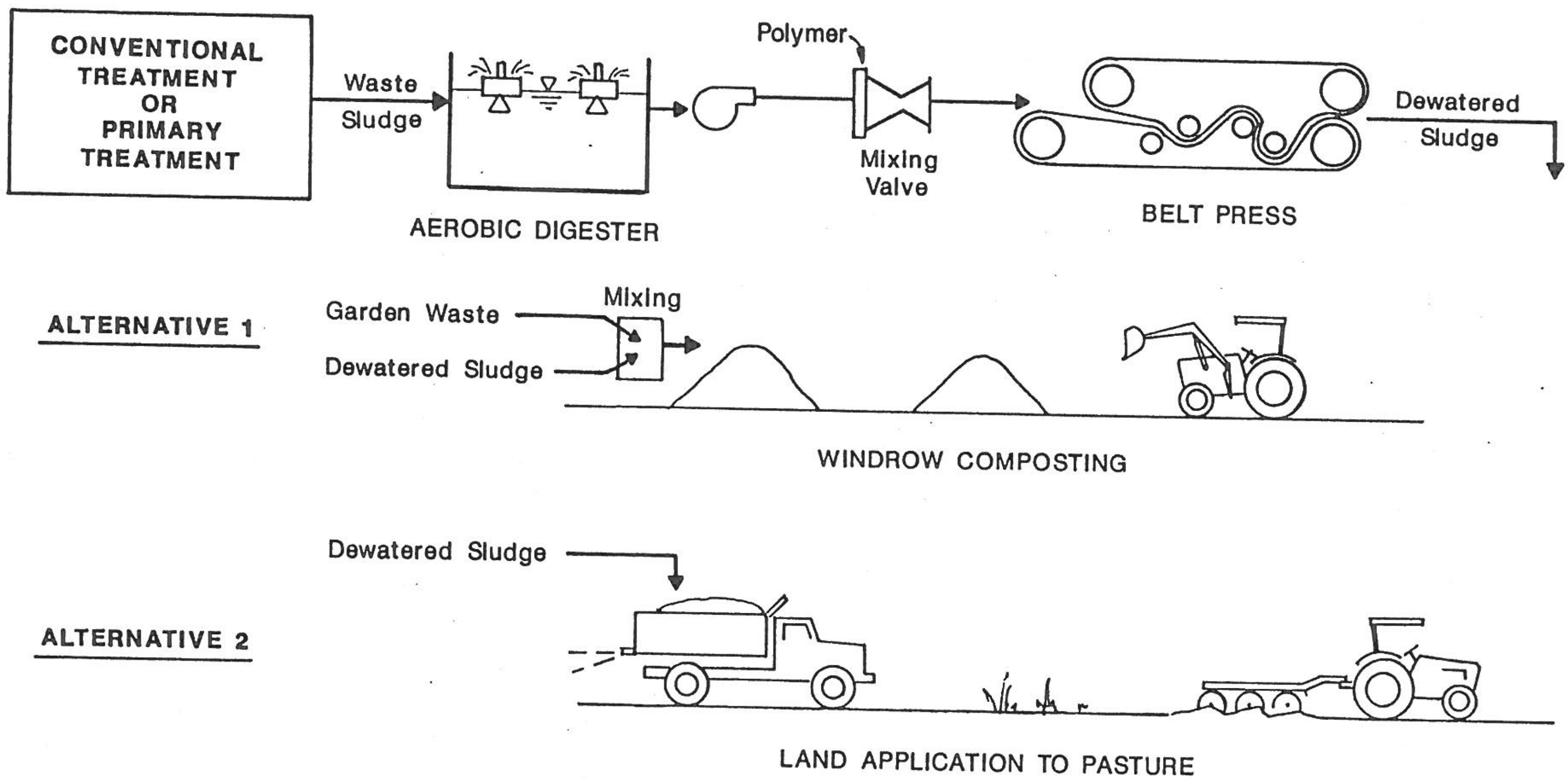


FIGURE VI-15

PARADISE PRELIMINARY DESIGN REPORT

**AEROBIC DIGESTION/DEWATERING ALTERNATIVES 1 AND 2**

**FLOW SCHEMATIC**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

TABLE VI-56

## SLUDGE STORAGE BASIN
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Sludge Loading (dry solids): | |
| Total Solids | 1,900 lb/d |
| Volatile Solids | 1,400 lb/d |
| Inert Solids | 500 lb/d |
| No. of Basins | 1 |
| Volume | 5.7 Mgal |
| Dimensions | 200 ft x 400 ft x 12 ft |
| VSS Loading | 18 lb VSS/1,000 $ft^2$-d |
| Aeration (No. and power) | 8 - 5 hp aerators |
| Liner | Hypalon w/asphalt concrete for protection |

TABLE VI-57

## SLUDGE DRYING BEDS
## PRELIMINARY DESIGN CRITERIA

| Parameter | Value |
|---|---|
| Sludge Loading (dry solids) | 1,000 lb/d |
| Type | Paved |
| Typ. Dimensions | 100 ft x 200 ft |
| Area (total) | 1.1 acre |
| Solids Loading | 8 lb/$ft^2$-yr |
| Dried Sludge Solids Concentration | 50% |

TABLE VI-58

**SLUDGE STORAGE BASIN**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 951,000 | | 1.00 | 951,000 |
| Labor | | 9,400 | 10.594 | 100,000 |
| Power | | 9,000 | 10.594 | 95,000 |
| Equipment Maintenance | | 2,700 | 10.594 | 29,000 |
| TOTAL PRESENT WORTH | | | | 1,175,000 |

TABLE VI-59

**SLUDGE DRYING BEDS**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 488,000 | | 1.00 | 488,000 |
| Labor | | 10,000 | 10.594 | 106,000 |
| Power/fuel | | 1,100 | 10.594 | 12,000 |
| Tipping Fee | | 2,000 | 10.594 | 21,000 |
| Equipment Maintenance | | 900 | 10.594 | 10,000 |
| TOTAL PRESENT WORTH | | | | 637,000 |

(4) Alternative 4 - Sludge Storage Basin/Land Application: Waste sludge from the treatment process would be pumped to a sludge storage basin designed to hold the sludge for up to two years as described for Alternative 3. Utilizing a floating dredge, thickened sludge at a concentration of 4% to 6% solids would be removed from the SSB during the dry weather season. The sludge slurry removed from the SSB would be pumped into a tank truck and land applied as a soil amendment at Lower Horning Ranch. Land application loading criteria for this operation will be as described for Alternative 2. After each application of slurry, the site would be disced to incorporate the sludge into the soil. Preliminary design criteria for the sludge land application system and the sludge storage basin are presented in Tables VI-54 and VI-56. Capital and operating costs for the sludge storage basin are presented in Table VI-58. Capital and operating costs for the land application system for thickened sludge from the sludge storage basin are presented in Table VI-60. A process flow schematic for Alternatives 3 and 4 is shown in Figure VI-16.

TABLE VI-60

**LAND APPLICATION OF THICKENED SLUDGE**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 468,000 | | | 468,000 |
| Labor | | 10,700 | 10.594 | 113,000 |
| Power | | 1,400 | 10.594 | 15,000 |
| Equipment Maintenance | | 2,500 | 10.594 | 26,000 |
| TOTAL PRESENT WORTH | | | | 622,000 |

b. Natural Systems and Pond Systems

For the natural systems, sludge will accumulate in the settling pond or partial mix ponds and be removed approximately once every 3 to 5 years. Sludge removal and processing would be accomplished on a contract basis. The contractor would pump the sludge at a concentration of 5 to 6% into tank trucks and land apply the sludge as a soil amendment on an approved site at Lower Horning Ranch. The land application design criteria would be similar to the method described for Alternative 4 above. The once every 3 year solids loading rate would be 9 tons/ac for an average annual loading of 3 tons/ac/year. Costs for removing and land applying sludge are estimated to be $0.06 per gallon.

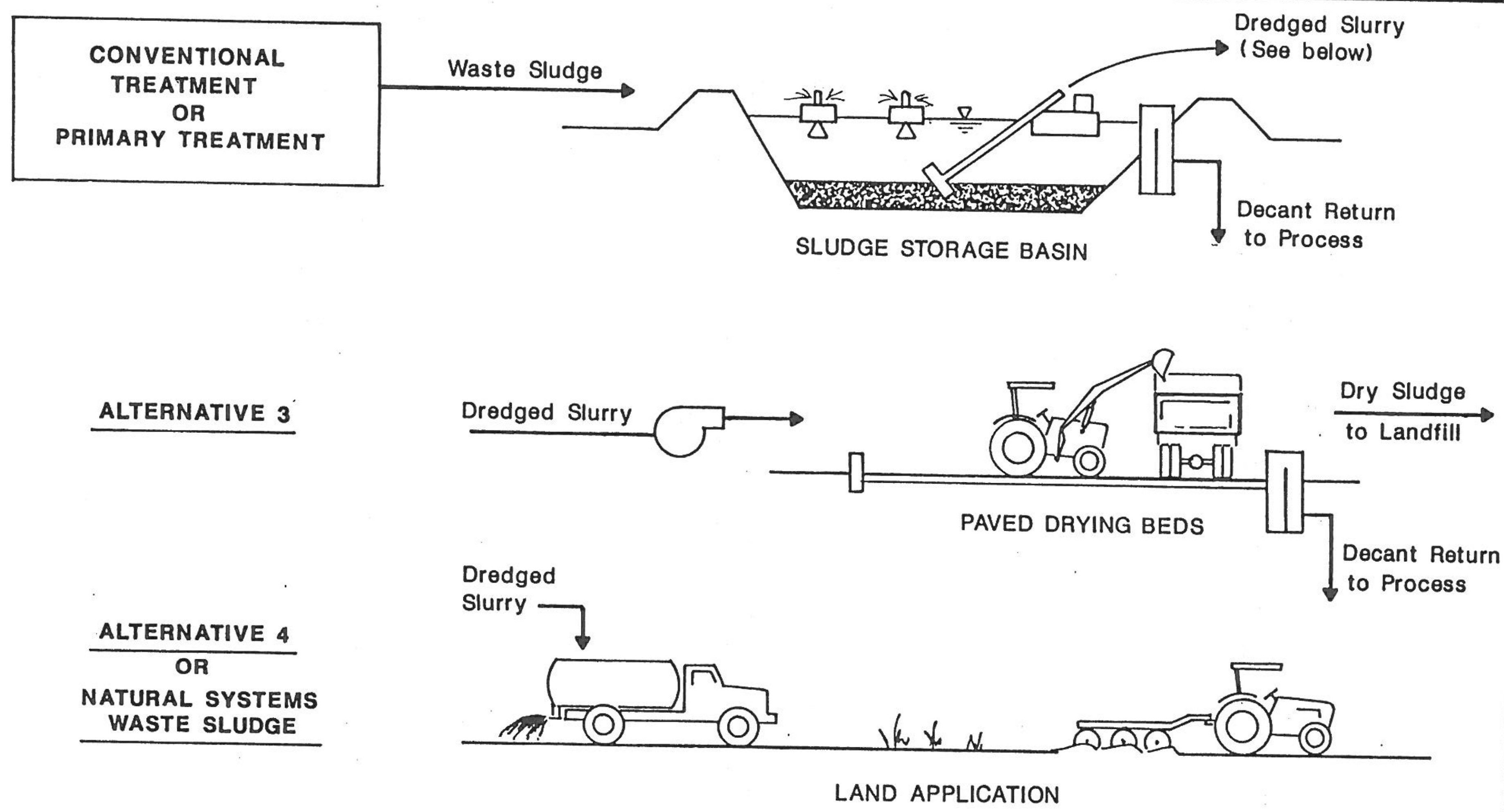


FIGURE VI-16

PARADISE PRELIMINARY DESIGN REPORT

**SLUDGE STORAGE BASIN ALTERNATIVES 3 AND 4 NATURAL SYSTEMS**

**FLOW SCHEMATIC**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

This work would be undertaken by a contractor specializing in sludge removal from ponds. A land application area (40 acres for primary ponds and 67 acres for partial mix ponds) would be set aside to accept the sludge. As described above, a pasture grass would be grown on the site to uptake nutrients. Capital and operating costs for this alternative are presented in Table VI-61.

TABLE VI-61

**NATURAL SYSTEMS AND POND SYSTEMS SLUDGE DISPOSAL PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| A. Settling Ponds | | | | |
| Construction | 187,000 | | 1.00 | 187,000 |
| Labor | | incl | 10.594 | ------ |
| Power/fuel | | incl | 10.594 | ------ |
| Contract Operations | | 26,000 | 10.594 | 275,000 |
| Equipment Maintenance | | incl | 10.594 | ------ |
| TOTAL PRESENT WORTH | | | | 462,000 |
| B. Partial Mix Ponds | | | | |
| Construction | 258,000 | | 1.00 | 258,000 |
| Labor | | incl | 10.594 | ------ |
| Power/fuel | | incl | 10.594 | ------ |
| Contract Operations | | 40,000 | 10.594 | 424,000 |
| Equipment Maintenance | | incl | 10.594 | ------ |
| TOTAL PRESENT WORTH | | | | 682,000 |

c. <u>Primary Treatment in a Clarifier</u>

For the alternative involving primary treatment in a clarifier at Elliot Spring, sludge would be handled using one of the four alternatives described in paragraph (a) above. The quantity of primary sludge generated would be approximately 75% (on a dry solids basis) of the quantity produced by the full conventional treatment system. Capital costs and operating costs would be proportionately less than those shown in the previous tables.

### 4. Recommended Sludge Handling Options

The preferred sludge handling alternative for activated sludge and primary clarifier treatment is Alternative 4 - Sludge Storage Basin/Land Application. Capital costs, annual O&M costs, and total present worth costs for each of the alternatives are summarized in Table VI-62. This system will be simple to operate and have the lowest total present worth cost. For natural systems and pond systems, land application is the preferred alternative.

TABLE VI-62

**SUMMARY OF SLUDGE HANDLING AND DISPOSAL ALTERNATIVES FOR ACTIVATED SLUDGE AND PRIMARY CLARIFIER TREATMENT[a]**

| Alternative | Capital Costs ($) | Annual O&M Costs ($/yr) | Present Worth ($) |
|---|---|---|---|
| Aerobic Digestion | 284,000 | 56,300 | 881,000 |
| Belt Filter Press | 736,000 | 34,000 | 1,096,000 |
| Composting | 201,000 | 82,800 | 1,078,000 |
| | 1,221,000 | 173,100 | 3,055,000 |
| | | | |
| Aerobic Digestion | 284,000 | 56,300 | 881,000 |
| Belt Filter Press | 736,000 | 34,000 | 1,096,000 |
| Land Application (dewatered sludge) | 486,000 | 10,300 | 595,000 |
| | 1,506,000 | 100,600 | 2,572,000 |
| | | | |
| Sludge Storage Basin | 951,000 | 21,100 | 1,175,000 |
| Drying Beds/ Landfill Disposal | 488,000 | 14,000 | 637,000 |
| | 1,439,000 | 35,100 | 1,812,000 |
| | | | |
| Sludge Storage Basin | 951,000 | 21,100 | 1,175,000 |
| Land Application (thickened sludge) | 468,000 | 14,600 | 622,000 |
| | 1,419,000 | 35,700 | 1,797,000 |

[a] Estimated sludge quantities from primary treatment would be approximately 75% (on a dry solids basis) of that produced by the activated sludge alternatives. Costs for disposal of primary sludge would be proportionately less.

## D. DISPOSAL/REUSE OPTIONS

Wastewater disposal/reuse is an important element in wastewater management planning. The disposal/reuse application usually governs the type of wastewater treatment needed and the degree of reliability required for the treatment processes and operations.

Streamflow augmentation, habitat wetlands establishment, agricultural irrigation, and rapid infiltration were determined to be the most appropriate disposal/reuse options for the Town of Paradise. Selection of the options was based on site availability, Town of Paradise objectives, and RWQCB requirements. The disposal/reuse options would be implemented in the following manners: total agricultural reuse at the Sanders Parcel, discharge to Hamlin Slough through Nugen Creek and a habitat wetland, partial agricultural reuse at Lower Horning Ranch, total agricultural reuse at Lower Horning Ranch, and rapid infiltration near Butte Creek. A synopsis of each of these disposal/reuse scenarios, including design criteria and a cost estimate, is presented in the following paragraphs. Additional information regarding the establishment of an agricultural enterprise to be managed by the Town of Paradise was detailed in Technical Memorandum 8.4-3 [6-8].

### DISCHARGE TO HAMLIN SLOUGH THROUGH NUGEN CREEK AND A HABITAT WETLAND

Discharge of treated wastewater to Hamlin Slough through a habitat wetland is an attractive disposal option. In addition to eliminating the need for pipelines below Elliot Spring and a storage reservoir, valuable wildlife habitat is created. The option was suggested by the RWQCB based on "Category A" of the California Inland Surface Waters Plan, the creation of a perennial stream with highly treated reclaimed water.

### 1. Description

Surface water discharge from a treatment plant located at Elliot Spring or Upper Horning Ranch must first progress through the existing streamcourse in Nugen Canyon. Nugen Creek is an ephemeral stream and the addition of a constant inflow of treated wastewater will transform the creek into a perennial stream, resulting in the use of the "Category A" designation. To obtain approval from the RWQCB and the California Department of Fish and Game for the discharge, a habitat wetlands would have to be created at Lower Horning Ranch.

To utilize the stream discharge option from a treatment plant at Lower Horning Ranch, screened raw wastewater would first have to be piped to the treatment plant site. After treatment and disinfection, the reclaimed water would be discharged to Hamlin Slough through one of the other ephemeral streambeds on Lower Horning Ranch and a habitat wetlands. The length of the perennial stream created by the discharge from Lower Horning Ranch would be much shorter than from the Elliot Spring site. The length of the streamcourse may be of concern to the RWQCB. Possible locations of the habitat wetlands for both treatment plant sites and the pipeline are included in Figure VI-17.

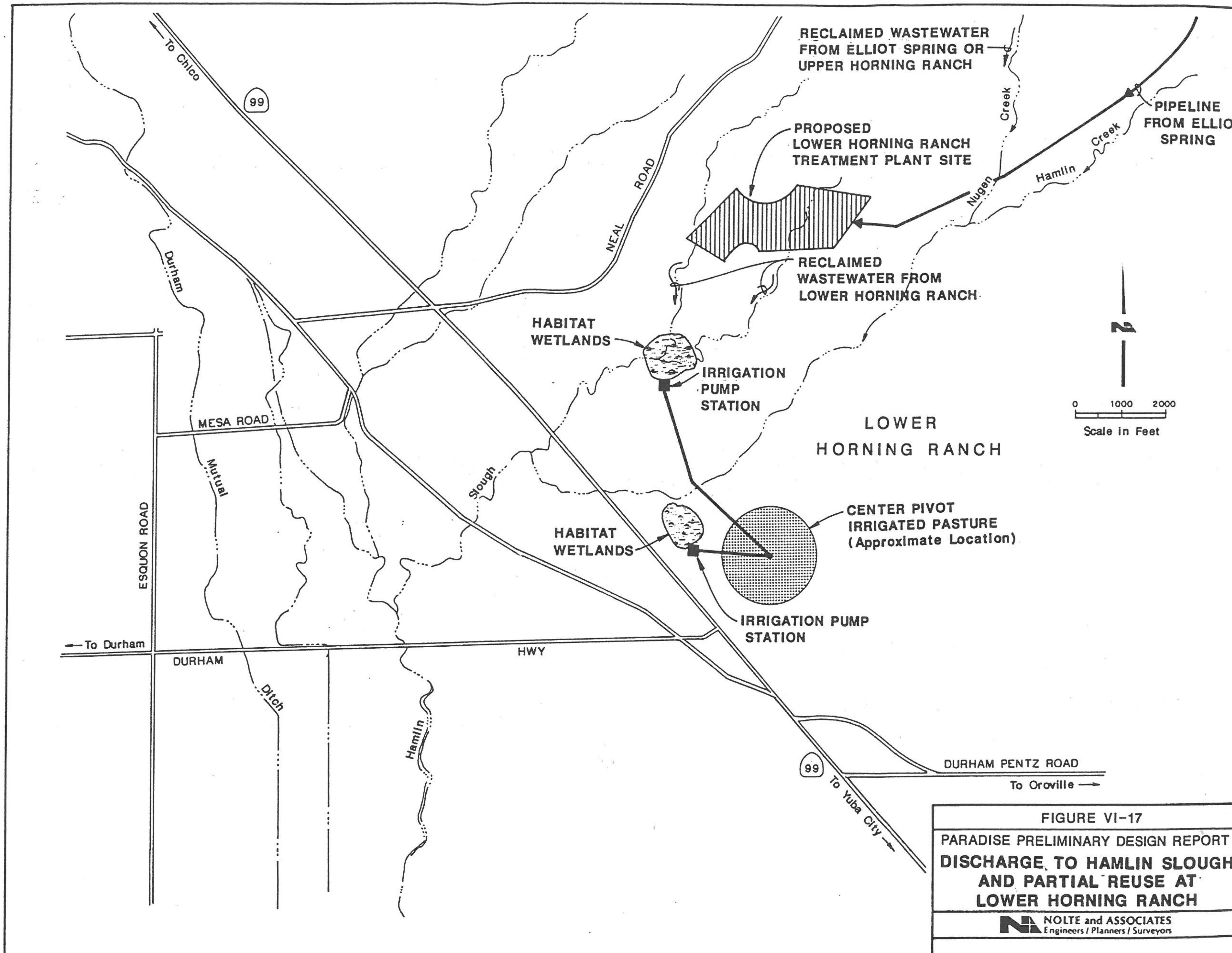


FIGURE VI-17

PARADISE PRELIMINARY DESIGN REPORT

**DISCHARGE TO HAMLIN SLOUGH AND PARTIAL REUSE AT LOWER HORNING RANCH**

NOLTE and ASSOCIATES
Engineers / Planners / Surveyors

## 2. Design Criteria

It is anticipated that minimal streambed improvements will be needed prior to use of Nugen Creek for reclaimed water discharge. The channel sides are composed mainly of ancient volcanic rock which will resist significant erosion and avoid the need for costly reinforcement efforts. Minimum flooding of the creek should occur due to the defined furrow that the channel forms in most segments of the streambed.

The habitat wetlands would comprise approximately 20 acres adjacent to Hamlin Creek on Lower Horning Ranch. Areas of shallow water and emergent vegetation would be interspersed with deep water pools and small islands. The habitat is expected to support waterfowl passing along the Pacific Flyway and add diversity to the wildlife resources of the region. The wetland may also serve as a feeding ground for endangered Bald Eagles that occasionally roost in the area during the winter months or as refuge for numerous other species of concern. The total present worth of creating the habitat wetlands is presented in Table VI-63.

TABLE VI-63

**HABITAT WETLANDS**
**PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Construction | 846,000 | | 1 | 846,000 |
| Labor | | 4,600 | 10.594 | 49,000 |
| TOTAL PRESENT WORTH | | | | 895,000 |

## PARTIAL AGRICULTURAL REUSE AT LOWER HORNING RANCH

In a partial agricultural reuse scenario at Lower Horning Ranch, a portion of the flow from Nugen Creek would be withdrawn to support an agricultural enterprise operated by the Town of Paradise. Treated effluent would be discharged to the creek year round, but an amount approved by the RWQCB could be withdrawn during the irrigation season.

### 1. Description

Establishment of an agricultural enterprise at Lower Horning Ranch was evaluated in Technical Memorandum 8.4-3 [6-8]. It was concluded in the memorandum that intensively grazed irrigated pasture would be the most appropriate agricultural enterprise to pursue. Irrigation and intensive grazing practices would increase beef production on the land and could result in a profitable enterprise.

If the treatment plant is located at Elliot Spring, surface discharge of treated effluent would occur at the top of Nugen Canyon. Withdrawal of the reclaimed water for agricultural purposes would be at Lower Horning Ranch downstream of the habitat wetlands. If the treatment plant is located at Lower Horning Ranch, stream withdrawal may not be permitted by the RWQCB. There would be limited riparian habitat value associated with both discharge and extraction occurring at Lower Horning Ranch.

### 2. Design Criteria

The supply of reclaimed water removed from the creek would initially support approximately 75 acres of pasture. At buildout flowrates, 145 acres could be supported by the creek flow. Center pivot irrigation machines would be utilized to irrigate the enclosed pastures. Use of a center pivot would minimize ground disturbance and would not require an Army Corps of Engineers wetlands filling permit for construction. Extensive cultivation may not be possible due to the shallow rocky soils that are present at Lower Horning Ranch. A possible location for the irrigated pasture at Lower Horning Ranch is indicated in Figure VI-17. Total present worth costs for partial agricultural reuse at Lower Horning Ranch are presented in Table VI-64.

## TOTAL AGRICULTURAL REUSE ON THE SANDERS PARCEL

Total agricultural reuse on the Sanders Parcel could be a revenue producing enterprise for the Town of Paradise. To effectively implement this option, screened wastewater would be transported to the Sanders Parcel where the treatment and storage facilities would be located. Because no discharge to surface waters would be occurring, a pond system without dissolved air flotation could be implemented for wastewater treatment.

TABLE VI-64

**PARTIAL AGRICULTURAL REUSE AT LOWER HORNING RANCH PRESENT WORTH ANALYSIS**

| Description | Lump Sum Cost ($) | Annual Cost ($/yr) | Present Worth Factor | Present Worth ($) |
|---|---|---|---|---|
| Initial Expenses | 698,000 | | 1 | 698,000 |
| Cultural Expenses[a] | | 53,000 | 10.594 | 562,000 |
| Harvesting Costs | | 2,000 | 10.594 | 21,000 |
| Cattle Sales | | (72,000) | 10.594 | (763,000) |
| TOTAL PRESENT WORTH | | | | 518,000 |

[a] Cultural expenses represent the yearly costs to maintain the agricultural operation, i.e., irrigation, fertilizers, labor, planting, purchase of stock cattle.

## 1. Agricultural Operation

Soils of the Sanders Parcel are up to 3 ft deep and are less rocky than the soils found east of Highway 99 on the Lower Horning Ranch. The higher quality soils should support more profitable crops, such as eucalyptus cultivation for paper pulp.

### a. Description

As detailed in Technical Memorandum 8.4-3 [6-8], a eucalyptus enterprise on the Sanders Parcel could be profitable, should require minimal maintenance, and would be suited to the climate and soils of the area. Eucalyptus, particularly *E. camaldulensis*, is a crop that is well suited for cultivation with reclaimed water. The trees grow very quickly, utilize large quantities of nitrogen and water, and can tolerate saturated soils. Flood irrigation has been found to be successful on a eucalyptus plantation near Oroville.

The location of Sanders Parcel and approximate locations of the pipeline and treatment /storage facilities are depicted in Figure VI-18. Little information is available on soil quality of the site. Prior to implementation of a full scale operation, a soils investigation should be conducted and an experimental plot of trees should be cultivated to verify site suitability.

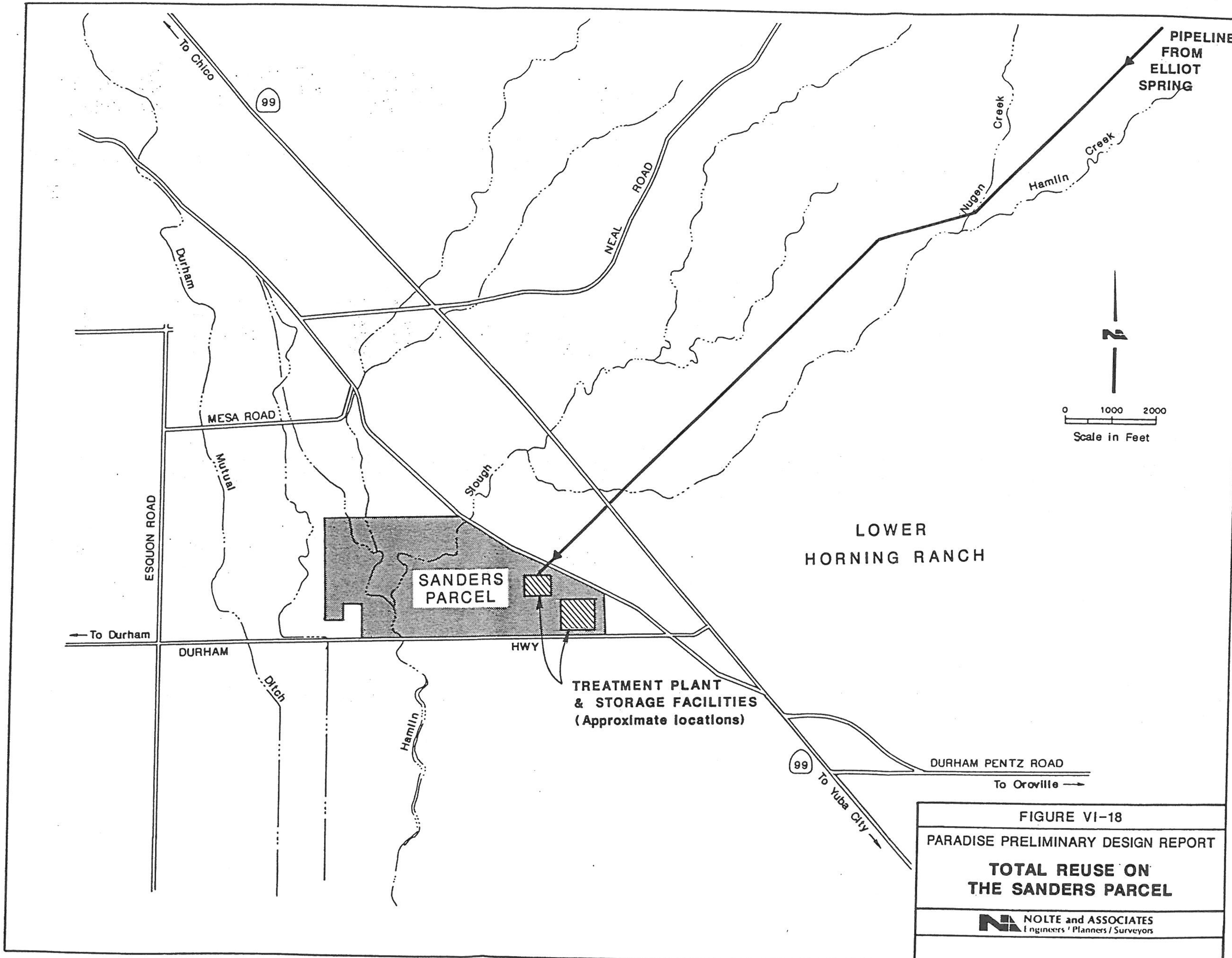


FIGURE VI-18

PARADISE PRELIMINARY DESIGN REPORT

**TOTAL REUSE ON THE SANDERS PARCEL**

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