FEASIBILITY STUDY

Short-term Treatment Alternatives
Summer Low Flows in Arroyo Burro Creek

Project Clean Water

May 1999

Prepared for:

Santa Barbara County Water Agency
City of Santa Barbara, Public Works Department

Prepared by:

URS Greiner Woodward-Clyde

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

In 1998, high levels of coliform bacteria were detected in stormwater and low flows at the mouths of creeks along the South Coast of Santa Barbara County, resulting the closure of beaches for extended periods of time during the summer. The beach closures prompted concern by the public and local government agency about public health effects on beach users and on the conditions of the coastal watersheds. The County of Santa Barbara, in cooperation with the cities of Santa Barbara and Carpinteria, initiated several programs in 1998 to assess the level of pollution in selected creeks, investigate sources of bacteria pollution, educate the public, and implement short and long term actions to reduce bacteria levels in the creek. The primary program is called Project Clean Water. The key component of this program was the investigation of the sources and levels of bacteria pollution in local watersheds through an extensive field investigation. Based on the results of this investigation, the County and cities have taken actions to remove obvious pollutant sources from the watersheds. In addition, Project Clean Water involves the development of long-term solutions, including (among others) best management practices for managing stormwater quality through source reduction and near-source treatment.

Another element of Project Clean Water is an investigation on the feasibility of short-term, temporary treatment of low flows at the bottom of the watershed to reduce coliform bacteria levels. The objective of this approach is to reduce bacteria input to the beach during the summer months when beach use is the highest. Summer flows in the local creeks are very low, and as a result, treatment would be feasible and economic. Treatment at other times of the year would be more difficult due to the high peak flows that occur after rainfall. Short-term, temporary treatment is considered one of many possible solutions that are being explored in Project Clean Water.

It should be noted that there is a concern among certain members of South Coast community that implementation of an “end-of-the-pipe” treatment approach would divert money and action from source reduction and watershed management. It is generally recognized that the latter approach would provide the most reliable and effective long-term solution because it would not rely on a facility and would be effective all year. As such, the County and the City of Santa Barbara have indicated that an “end-of-the-pipe” treatment approach would only be applied as a seasonal and temporary (i.e., several years only) solution until the long-term source reduction measures are effective. It is assumed that a treatment approach would not be necessary if bacteria levels are reduced through the actions in the watershed under Project Clean Water and the future NPDES municipal stormwater permit for the County and City of Santa Barbara that must be acquired by 2002.

1.2 STUDY OBJECTIVES AND SCOPE

The objective of this study is to evaluate the general feasibility of different state-of-the-art treatment options for reducing levels of coliform bacteria in summer low flows. Arroyo Burro Creek was used in the study because it is an example of a creek and nearby beach where short-term temporary treatment would be most suitable. Various treatment devices and processes were examined in the study to determine which ones would effectively meet project needs and could be feasibly implemented at Arroyo Burro Creek. The study included the following elements:

- Define design criteria
- Examine site conditions along lower Arroyo Burro Creek
- Identify treatment options and collect data from vendors
- Evaluate and compare feasibility

The feasibility of the treatment options was evaluated at a conceptual level. That is, we determined if an option would meet the design criteria based on available information on the technology and process, and if the facility or operation could be feasibly operated based on professional opinion. Capital and operational costs were developed for each option at a planning level. The results of our study are intended to provide a basis for the County to determine if "end-of-the-pipe" treatment should be pursued further under Project Clean Water or in the upcoming NPDES municipal stormwater permit, and to identify options that appear to be the most promising. The results of the study can be extrapolated to other creeks in the County where there are summer low flows and bacteria levels similar to those experienced at Arroyo Burro Creek.

1.3 ROLE OF CONSTRUCTED WETLANDS

Constructed wetlands are used throughout the world to treat domestic effluent, urban runoff, agricultural runoff, and industrial effluent. They are particularly effective at reducing levels of biological oxygen demand (BOD), suspended solids, metals, and nutrients. Constructed wetlands in the United States are primarily used as a secondary or tertiary treatment process at wastewater plants. Nutrients are removed in a wetland through several processes, including biological uptake by wetland plants, atmospheric release during nitrification and denitrification processes, and adsorption to sediments. Suspended solids are removed through sedimentation and adsorption to plants. Metals are primarily removed by plant uptake and adsorption.

Wetlands can reduce coliform bacteria through several mechanisms, including natural die-off of the bacteria due to extreme temperature and salinity conditions, sedimentation, adsorption to plant material, and aggregate formation. Sunlight on open water will reduce free-floating bacteria due to the lethal effects of ultraviolet radiation on bacteria. Predators, bacteriophage, and competition for limiting nutrients or trace metals may also reduce bacteria levels. Finally, there are toxins released by wetland microorganisms that may cause bacteriocidal effects. Conditions of high vegetation density, large zooplankton populations and water clarity to promote penetration of ultraviolet light will enhance removal of coliform and related bacteria.

There have been various studies on the effectiveness of aquatic plants and emergent wetlands on the removal of coliform bacteria. Removal rates ranged up to 90 percent in many pilot studies, and in operating systems such as the Arcata Marsh at the City of Arcata's wastewater treatment plant. Wastewater treatment by constructed wetlands typically reduce total coliform levels to at or near 1,000 MPN per 100 ml. The coliform bacteria removal efficiently depends on a number of factors including initial coliform load, hydraulic residence time, and emergent vegetation coverage.

The use of constructed wetlands as a temporary, short-term solution to reduce bacteria levels in Arroyo Burro Creek was not considered in this study because wetlands represent a long-term solution rather than a short-term solution. Constructed wetlands require time to develop and more land than contemplated for the alternatives addressed in this study. In addition, wetlands to treat stormwater can be applied at various levels in the watershed, including near pollutant sources. Hence, it should not be considered only an "end of the pipe" treatment option. Project Clean Water includes a Wetland and Riparian Restoration Focus Group which has prepared a separate report on the use of constructed wetlands for reducing coliform bacteria in the watersheds of the South Coast. The reader is encouraged to review that report for information on the use of wetlands for managing the quality of stormwater.

2.0 DESIGN AND EVALUATION CRITERIA

2.1 DESIGN CRITERIA

A treatment option for lower Arroyo Burro Creek must meet the design criteria listed below in order to be consider feasible. Alternatives that met these criteria are described and evaluated in Section 4.0. Options that did not meet one or more of these criteria are described in Section 5.0 for the sake of completeness.

1. Temporary Facility. The treatment system or unit must be portable and capable of being installed and dismantled with relative ease. It must not require a permanent foundation or building. The facility must be capable of being mothballed during most of the year without adverse effects to the system or significant costs.

2. Immediate Operation. The treatment system must be available from vendors within 3 to 4 months or an order, and must be capable of causing an immediate reduction in bacteria levels in the treated water upon installation.

3. Minimal Space Requirement. The system must occupy a relative small area (less than 10,000 square feet) due to space constraints at the site.

4. Minimal Maintenance. The facility must be automated and require minimal daily maintenance.

5. Variable Flows and Continuous Discharge. The system must be capable of treating flows that vary from 0 to 300 gallons per minute (gpm) [0.7 cfs or 450 million gallons per day, mgd] on a continuous basis (see Section 3.2). For treatment alternatives that include the return of treated water to the creek, the discharge of treated water must be continuous and vary with the inflows.

6. Effectiveness. The treatment process must be capable of reducing bacteria levels to below the following single sample standards established by the State Department of Health Services for recreational ocean waters (Health and Safety Code Section 7958): 1,000 total coliform bacteria per milliliters if the ratio of fecal/total coliform bacteria exceeds 0.1, or 10,000 total coliform bacteria per 100 milliliters, or 400 fecal coliform bacteria per 100 milliliters, or 104 enterococcus bacteria per 100 milliliters.

It should be noted that a determination of potential feasibility for this study *does not* include cost and permitting criteria. Hence, some of the alternatives which are considered potentially feasible may have prohibitive costs and/or may not be permitted by local, state, or federal agencies with jurisdiction. A final determination of feasibility must include an evaluation of financial feasibility amongst the funding agencies and a more rigorous evaluation of permitting obstacles based on input from the applicable permitting agencies.

2.2 EVALUATION CRITERIA

For all feasible alternatives, we provided a description of the treatment process and facility and provided an evaluation using the following criteria:

- Effectiveness in reducing bacteria levels
- Environmental and land use issues
- Permitting requirements
- Estimated capital and maintenance costs
- Key considerations, including advantages and disadvantages

2.3 CONFOUNDING FACTORS

There are three factors that could confound objectives of a treatment system at the end of Arroyo Burro Creek.

- Sediment and Bacteria. Sediments can act as a source or sink of bacteria in both freshwater and brackish water systems. Coliform bacteria in the water column or in free water within sediments have limited lifespans (e.g., usually hours), particularly in a brackish water environment with exposure to sunlight. Bacteria can also be removed by sediments if there are bacteriophages in the sediments. However, coliform bacteria can persist in sediments for days to months if it is contained in a fecal pellet. The removal of bacteria from streamflow to the Arroyo Burro Creek lagoon would not reduce bacteria contained in the sediments, which would eventually be released to the ocean. The concentration of bacteria in the sediments of the lagoon is unknown. It is also unknown if the sediments act as a source or sink for bacteria. Hence, the effect of this factor on the proposed treatment project is unknown and worthy of additional investigation.

- Other Drainages to the Lagoon. The most suitable point of diversion for the treatment system is at Cliff Drive where the creek passes under a bridge, as described in Section 3.3. No other suitable location is available downstream of the bridge. A diversion at this point will capture all but a fraction of the runoff from the watershed. However, it should be noted that there are two other inputs to the lagoon downstream of this point of diversion. The first is a 48-inch diameter stormdrain from Cliff Drive that carries runoff from the Mesa and empties into the creek immediately below the proposed point of diversion. The other sources are runoff from the parking lot at the County Park and seepage from the hillsides on the Douglas Family Preserve. The amount of bacterial input to the lagoon from these sources is expected to be small; however, there are no data to support this supposition.

- Seabird Input. The proposed diversion and treatment site is located upstream of the lagoon where seabirds and waterfowl often congregate. Fecal input from birds at the lagoon may contribute to the bacterial loading in the creek outflow to the ocean. Upstream treatment would not reduce this source.

3.0 SITE CONDITIONS

3.1 CREEK AND LAGOON CONDITIONS

The watershed of Arroyo Burro Creek extends about five miles from the Santa Ynez Mountains to its outlet at Arroyo Burro Beach County Park (Figure 1). The drainage in the watershed consists of the mainstem of Arroyo Burro Creek, Las Positas Creek, Barger Creek, San Roque Creek, and Lauro Canyon Creek. The bed and bank of Arroyo Burro Creek downstream of Highway 101 are unlined and contain varying amounts of riparian vegetation. Extensive, but degraded, riparian woodland occurs along the creek where it is parallel to Las Positas Road. The creek forms an estuarine lagoon at the beach (Figure 2).

The creek passes under a bridge at Cliff Drive (Figure 2). The bed of Arroyo Burro Creek contains grouted rock rip-rap below the Cliff Drive bridge for a distance of about 30 feet. There is a concrete sill about five to six feet high that appears to be at about 8 to 10 feet MSL. Freshwater flows cascade over the sill into a pond-like area about 30 by 80 feet (Figure 3).

The creek is intertidal from the downstream end of the grouted rip-rap to the mouth of the creek. The lagoon is dewatered when the creek mouth is open and there are low tides. Under these conditions, a narrow low flow channel about 6 to 8 feet wide extends through the lagoon and the pond below the sill is about three feet deep. High tides of 3 to 4 feet MSL can fill the lagoon and extend to the concrete sill. Under these conditions, the pond below the concrete sill is over six feet deep.

The lagoon is subject to tidal influence on most days. High tides build up a sand berm at the mouth of the lagoon that closes the lagoon, causing a build up of water in the lagoon. If the tides are of sufficient height, the lagoon is partially or fully filled with ocean water. As the tide recedes, the hydrostatic pressure in the lagoon causes it to open and discharge to the ocean.

The lagoon is used by various fish and wildlife. It supports a resident population of the federally endangered tidewater goby. The lagoon also provides habitat for ducks, shorebirds, and other water associated birds such as egrets and great blue herons. Emergent wetlands are mostly absent from the lagoon due to a lack of broad flat areas with intermittent flooding. When the mouth of the lagoon is closed, the water is stagnant and often covered with algae and floating debris. The substrate of the lagoon is sandy silt with an active decomposition layer on the surface with anaerobic conditions as evidenced by sulfuric odors during low tides.

3.2 STREAMFLOWS

The nearest gauging station along Arroyo Burro Creek is located near State Street. Based on this gauge, stream flows in Arroyo Burro Creek during May through September have ranged from 0.05 to 0.33 cfs (period of record 1971-1993; 0.03 to 0.2 MGD or 13 to 149 GPM). No stream gage is present near Arroyo Burro Beach, but it is generally observed that flows increase downstream of State Street due to inflows from the lower watershed. Based on observations and limited flow measurements by the County Flood Control District in August 1998, the maximum flow at the beach during the summer is 0.7 cfs (or 0.45 MGD, or about 300 GPM).

3.3 SITE CONDITIONS

– The most suitable location for temporary treatment facilities at Arroyo Burro Creek would be in one of two open space areas on either side of the creek, on the south side of Cliff Drive (Figure 3). The area east of the creek is about 125 by 75 feet, while the area on the west side of the creek (adjacent to the parking lot) is about 125 by 50 feet. Both sites are relatively flat and contain no sensitive biological resources or large native trees. Electrical power could be provided from nearby power poles on the north side of Cliff Drive through an underground conduit under the road.

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– The area east of the creek is owned by the City of Santa Barbara and is part of the newly established Douglas Family Preserve. It is also located with the City's boundaries. Use of land within the Douglas Family Preserve for treatment facilities may be problematic due to potential conflicts with the preserve management plan and allowable uses in the preserve.

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The most suitable location for diversion of the creek into a treatment unit would be directly below the Cliff Drive bridge, on the west side of the creek (Figure 3). This area located is within Arroyo Burro County Park and within the City of Santa Barbara municipal boundaries; however, it is located outside the Douglas Family Preserve. The creek below the Cliff Drive bridge contains grouted rock rip-rap for a distance of about 30 feet with a concrete sill about five to six feet high. Freshwater flows cascade over the sill into a pond-like area about 30 by 80 feet (Figure 3). The most efficient diversion method would be to install 12 to 18-inch tall removable steel gates on the concrete sill to create a small pond in the creek under the bridge. Water would be pumped from this pond using a small variable speed electrical pump with a float switch that would be located either adjacent to the pond under the bridge, or on the banks near the treatment unit. The pump would run continuously during the period May through September, provided sufficient water is present in the pond. Direct diversion of the creek into a treatment unit would be infeasible because the temporary treatment facility would be located 3 to 5 feet above the creek on the adjacent open area.

– Treated water would be discharged to the creek from the treatment unit to the creek about 50 feet downstream of the bridge.

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3.4 CURRENT BACTERIA LEVELS IN THE CREEK

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– The County periodically sampled water along Arroyo Burro Creek during 1998 to determine the concentrations of total coliform, fecal coliform, and enterococcus. The median and average maximum values in the lagoon (Station AB 006+00) and the lower creek sampling stations (AB 018+50, AB 021+00, AB 055+00, AB 081+00) during the period April 1998 through February 1999 are as follows:

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– TABLE 1

– BACTERIA LEVELS IN THE LOWER CREEK AND LAGOON*

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Bacteria Type	Concentrations (No. per 100 milliliter)	
	Lagoon	**Lower Creek**
Total Coliform		
Maximum	350,000	30,000
Median	11,500	11,000
Fecal Coliform		
Maximum	1,100	9,000
Median	800	400
Enterococcus		
Maximum	900	9,000
Median	10	900

– Values are approximate. Source: Project Clean Water staff report to the Board of Supervisors, 2/2/99.

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4.0 POTENTIALLY FEASIBLE ALTERNATIVES

The following treatment alternatives were determined to be potentially feasible using the criteria described in Section 2.1. Each alternative is described in the following subsections. As noted in Section 2.1, a final determination of feasibility must include an evaluation of financial feasibility amongst the agencies sharing the costs, and a more rigorous evaluation of permit feasibility.

1. Diversion to sewer system
2. Chlorination
3. Ultraviolet light
4. Ozonation
5. UV/ozonation combination
6. Electrocoagulation
7. Reverse osmosis

4.1 DIVERSION TO SEWER SYSTEM

Under this alternative, summer low flows would be diverted to the sanitary sewer system of the City of Santa Barbara (City) for commingling with other wastewater, then treated at the City's El Estero Wastewater Treatment Plant at 525 E. Yanonali Street. The plant provides secondary treatment with an average daily production of 8.3 million gallons per day (mgd). The plant has a permitted capacity of 11 mgd. A portion of the treated effluent from the plant is filtered and disinfected and used for landscaping in the City. Treated effluent is discharged to the ocean from a 1.5-mile-long outfall.

4.1.1 Description of the System

The City operates the Braemer Lift Station at the northeast corner of Alan Road and Cliff Drive. The lift station is a fully enclosed structure with 15,259-gallon wet well and two 20 horsepower pumps. The lift station pumps wastewater from the Alan Road/Vista del Mar community and the residences west of Arroyo Burro Beach, along Cliff Drive, Yankee Farm Road, and Braemer Road. The average daily pumping at the station is 0.25 mgd (about 175 gpm) with a peak average inflow of 0.54 mgd (376 gpm). Wastewater is pumped to a 10-inch diameter pipe that extends under Cliff Drive, across Arroyo Burro Creek on the bridge, and then along Cliff Drive to Mesa Lane.

As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. Water from the pump would be discharged into an existing gravity sewer line adjacent to Cliff Drive that flows into the Braemar Lift Station. A one-way valve would be installed to prevent backflow from the sewer main into the creek pump. Electrical power is available at this location. The pump would run continuously during the period May through September, provided sufficient water is present in the pond. A water level sensor would be used to turn the pump on and off. The pump would be placed in a housing to protect it from weather and vandals. Creek water will flow through the wet well and bypass the diversion during the winter months and during outages in the summer.

4.1.2 Effectiveness

This alternative would be highly effective in reducing the inflow of bacteria to Arroyo Burro Beach because all creek flows in the summer would be diverted to the sewer system and conveyed out of the watershed. The effectiveness of the system would only be reduced if there was a pump failure, or the diversion in the creek was leaking or breached. Despite the diversion of water from the creek, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.1.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of reduced freshwater flows to the lagoon, as described below. No significant land use impact is anticipated because this alternative would not involve a physical facility for treatment.

The reduction in freshwater flows to the lagoon in the summer is likely to affect the salinity levels and temperature in the lagoon, and possibly the water levels in the lagoon during low tides. These physical impacts could, in turn, adversely affect the lagoon infauna, fish and other aquatic species, and wildlife. For example, a reduction in water levels could reduce the population of the endangered tidewater goby that resides in the lagoon. An increase in salinity may or may not adversely affect the goby which is tolerant of a wide range of salinities, but which is not typically found in ocean water. The magnitude of impacts to the goby are unknown at this time.

In the fall of 1998, the County Water Agency contacted the California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (USFWS) to discuss a temporary diversion project and its impacts on the goby. The CDFG issued a Streambed Alteration Agreement (Fish and Game Code 1601) for a temporary diversion. The USFWS issued a letter dated September 10, 1998 stating that a temporary diversion would not result in "take" (i.e., harm or mortality) of the goby. The CDFG Agreement and USFWS determination required that the County monitor lagoon salinities and water levels and the goby population during the diversion, and that the diversion be halted if adverse impacts were identified.

In addition to the potential impacts to the goby, there are similar concerns about impacts to other species that reside in the lagoon. Changes in salinity, temperature, and water level in the summer could affect the number and type of free-swimming and benthic invertebrates which are part of the lagoon ecosystem, providing food for birds and fish, and contributing to the decomposition processes in the lagoon. The effect on the lagoon ecosystem cannot be predicted with the available information. While it is acknowledged that there may be other freshwater inflows to the lagoon from the Cliff Drive stormwater drain and seepage from the Douglas Family Preserve, the importance of these inputs to the lagoon compared to the inflows from Arroyo Burro Creek is unknown.

4.1.4 Permitting and Environmental Review Requirements

The construction of the wet well in the creek and the pump system will require the following permits:

- 404 permit from the Corps of Engineers (Corps) for the discharge of fill material (i.e., construction of the diversion)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- Coastal Development Permit from the City of Santa Barbara (City), with appeal jurisdiction by the California Coastal Commission (CCC)

- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the diversion on the endangered tidewater goby that resides in the Arroyo Burro Creek lagoon. Through this consultation, the impacts of reduced freshwater flows on the goby will be addressed. In addition, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. Issuance of a CDP for this treatment option may not be possible if other alternative provide the same effectiveness without adverse impacts to the lagoon. It should be noted that the CCC staff issued a letter to the County on September 17, 1998 expressing concerns about this treatment option. The Environmental Defense Center also expressed similar concerns to the County in a letter dated September 14, 1998

The temporary diversion from the creek to the sewer system may also require a water rights permit from the State Water Resource Control Board because the water will be diverted offsite. In order to acquire an appropriation permit, the water must be applied to beneficial uses. It is not clear that treatment of the creek water at the City's El Estero Wastewater Treatment Plant would represent a beneficial use. The need for a water rights permit and the likelihood of acquiring such a permit represents a significant unknown factor.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility could be an Environmental Impact Report (EIR) rather than a Negative Declaration due to the possibly significant impacts to the lagoon. The City would be the CEQA lead agency. It does not appear that this alternative would involve land in the County Park nor on the Douglas Family Preserve.

4.1.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (east side of creek) and by the County (west side of the creek).

Operational costs of the diversion and additional treatment at the El Estero were developed by the City and summarized in a memorandum dated August 28, 1998. The monthly pumping and maintenance costs for 0.45 mgd would be about $5,400 per month or $27,000 per year (assuming five months per year). The creek water contains high levels of total dissolved solids. In order to mitigate for the deterioration of water quality at El Estero, additional potable water will be required. It is estimated that an additional 87,000 gallons per day of potable water would be needed to maintain current TDS levels in El Estero treated water once the creek water is diverted to the plant. The additional costs of the potable water would be about $1,920 per month or $9,000 per year. Finally, the additional electrical and chemical costs of treating the 0.45 mgd creek inflows at El Estero were estimated to be $2,800 per month or $14,000 per year. A summary of operational costs is provided below. No equipment deterioration costs are included.

TABLE 2
ESTIMATED OPERATIONAL COSTS OF A DIVERSION TO SEWER OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping	2,700	13,500
Maintenance	2,700	13,500
El Estero chemical and electrical	2,800	14,000
El Estero potable water	1,920	9,600
Total=	$10,120	$50,600

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be a minimum of $75,000 to $150,000.

4.1.6 Key Considerations

Advantages

- Highly effective and simple system that is likely to reduce bacteria levels to a greater degree and with greater reliability compared to other alternatives
- Negligible capital costs compared to other options

Disadvantages

- Relatively high operational costs compared to other options

- The diversion could adversely affect the salinity and water levels in the lagoon, affecting the endangered tidewater goby and other species. The evaluation of this issue could require extensive hydrological and biological investigations. This issue is a potential fatal flaw.

- Acquisition of a Corps 404 permit and a CDP (with possible appeal to the CCC), as well as a possible water rights permit from the State Water Resource Control Board, may be difficult or impossible. Pursuit of a permit is likely to require to extensive coordination time and costs. This issue is a potential fatal flaw.

- Local environmental groups have expressed strong opposition to this alternative

4.2 CHLORINATION

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be disinfected by chlorine. Disinfected water would be conveyed to a second chamber for dechlorination, and then returned to the creek.

4.2.1 Description of the System

Chlorine is the chemical most often used to eliminate bacteria in both potable water supplies and wastewater. Chlorine dosage would be about 2-3 parts per million (ppm) for this type of application. The presence of particulates and reduced chemicals in the creek water may increase the required dosage of chlorine. Chlorine is available in two major forms, as described below.

- Chlorine Gas System. In this system, chlorine gas is withdrawn from pressurized containers into a vacuum-driven system and dissolved in the target water stream through an inductor or diffuser. The vacuum system reduces the risk of accidental chlorine gas discharge. Storage is required for pressurized gas containers, either 150-lb bottles or 2,000-lb containers. For this application, approximately 12 lbs of chlorine would be used each day. Three 150-lb bottles would be used each month. Required facilities would include a chlorine injection system, bottle storage, pumps, electricity and a ventilated, explosion proof space with a chlorine scrubber. For most systems, emergency ventilation is required to ventilate the space to atmosphere during an accidental leak. Proximity to residences is a major factor in determining the feasibility of chlorine gas as a disinfectant medium.

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- Liquid System. Chlorine is available in liquid form, as sodium hypochlorite which is similar to liquid bleach. Sodium hypochlorite generators are a common alternative to the storage and handling of gaseous chlorine. It is injected into the target stream where it mixes with the water and the disinfection function is performed. Storage is required for liquid hypochlorite. A ventilated space with explosion proof fixtures is required. A chlorine gas scrubber on the ventilation system would still be required to protect public safety. Because chlorine is in a liquid form, risks from accidental releases of gas are greatly reduced, but some volatilization might be expected. Handling of liquid sodium hypochlorite requires training and special procedures because of its corrosive nature.

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  - As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area.

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  - A portable treatment unit would be used, either a skid-mounted unit or a trailer-mounted unit measuring no more than 20 by 40 feet. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. The unit would be located in one of the

two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3. Water pumped from the diversion would be discharged through two high pressure chambers in the treatment unit – one with chlorine treatment and one with dechlorination treatment. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge. Chlorine would also be stored in the portable unit.

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– The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and recharging the chlorination and dechlorination containers. The diversion structure and associated pond would also require periodic inspection.

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4.2.2 Effectiveness

Chlorine is the most widely used and accepted means of providing disinfection in water systems. It is extremely effective at eliminating coliform bacteria and other human pathogens, and is expected to reduce bacteria levels to non-detectable levels. The residual effect of chlorine is purposely eliminated by the dechlorination treatment to avoid disinfection of the lagoon organisms. The level of disinfection can be modified by changing the dose of chlorine in the treatment, if so desired.

Despite the treatment of water in the creek, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.2.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. Chlorination would kill all living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. This impact could be reduced by applying a lower dosage to allow passage of a fraction of the natural organisms (as well as coliform bacteria) to the lagoon. The treatment process is not expected to adversely affect the pH, temperature, or mineral content of the water.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing. However, there will be concerns by local residents about the use and storage of chlorine at the treatment unit because chlorine is a potentially hazardous substance. There are public safety hazards associated with: (1) routine handling, storing, and use of chlorine gas or liquid; and (2) upset conditions or accidents during operations and/or transport of chlorine gas or liquid.

4.2.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility could be an Environmental Impact Report (EIR) rather than a Mitigated Negative Declaration due to the possibly significant impacts to the lagoon and public safety hazards associated with chlorine. The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.2.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000 and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (on the east side of the creek) and by the County (on the west side of the creek). The cost of a portable chlorination/dechlorination unit is estimated to be about $100,000.

A summary of operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 3
ESTIMATED OPERATIONAL COSTS OF CHLORINATION OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Chemicals	2,000	10,000
Total=	$4,700	$23,500

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $75,000 to $100,000.

4.2.6 Key Considerations

Advantages

- None identified to date.

Disadvantages

- Public safety hazards associated with: (1) routine handling, storing, and use of chlorine gas or liquid; and (2) upset conditions or accidents during operations and/or transport of chlorine gas or liquid. Potential receptors include residences across Cliff Drive, beach visitors using the adjacent parking lot, beach users (potentially affected by release of liquid chlorine into the lagoon), and pedestrians walking along Cliff Drive. In addition, the endangered tidewater goby resides in the lagoon and could be vulnerable to accidental releases to the creek.

- Likely public opposition to the use of chlorine near residences and a public park with high visitation.

4.3 ULTRAVIOLET LIGHT

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be disinfected by exposure to ultraviolet light. Disinfected water is then returned to the creek. This system has been designed by Calgon Carbon Corporation based on specifications of the project provided by URS Greiner Woodward-Clyde.

4.3.1 Description of the System

In the Sentinel™ Ultraviolet Light(UV) disinfection process, a high powered lamp emits UV radiation through a quartz sleeve into the water. The effectiveness of the system for inactivating bacteria is based on the ability of high-energy UV light to penetrate the cell membrane of the organism and photochemically sterilize the internal cell. Photons of light are absorbed by cell DNA and RNA of the bacteria causing cross-linking of the double helix strands which prevents strand splitting and replication. Cells that cannot replicate are unable to infect.

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- The UV dose required for 4 logs inactivation of enterococcus bacteria in filtered water is estimated at 30 mWs/cm^2. A design dose of 50 mWs/ cm^2 has been used for scale-up, thus providing a significant safety margin. For the scale-up from a given UV dose requirement to a full scale system design at a design flowrate, Calgon Corporation has developed a sizing model based on well recognized UV disinfection standards. The model incorporates water quality data (percent transmission of UV light at 254 nm) and the design flowrate (gpm) along with factors inherent to the UV equipment such power efficiency, lamp efficiency, lamp aging and reactor geometry. For the Arroyo Burro creek water, using a design percent transmission (254 nm) of 89% and a design flowrate of 300 gpm, the UV sizing model predicts that 1.6 kW are required for four log inactivation of bacteria. This demand can be met by 3 units each of 1 kW system.

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Calgon Corporation proposes the following equipment for 99.99% inactivation of bacteria for a peak flow of 300 gpm at the Arroyo Burro Creek locations.

- 3 kW Sentinel UV™ reactor complete with; 3*1 kW UV lamps, quartz tubes, Quicktype™ quartz sleeve cleaner, 3 UV sensors, 3 UV ports, flanged twelve inch (12”) influent and effluent connections.
- Power Supply Cabinet approximately 2 feet wide, 2 feet deep, and 7 feet high with 3 electromagnetic ballasts, cooling fans and fuses.
- Control Cabinet (NEMA 4) complete with logic control circuit, alarm indicators, stop/start switch, emergency stop button.

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- A portable treatment unit would be used, either a skid-mounted unit or a trailer-mounted unit measuring no more than 15 by 20 feet. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. The unit would be located in one of the two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3.

- As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area. Water pumped from the diversion would be conveyed to a portable unit where it would pass through a course filter prior to treatment. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge.
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- The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and replacement of UV lights. The diversion structure and associated pond would also require periodic inspection.

4.3.2 Effectiveness

UV treatment is extremely effective at disinfecting water. However, effectiveness is related to the clarity of the water to be treated. Suspended solids, particles or other materials that lower the transmissivity of the water reduce effectiveness, requiring an increase in lamp wattage. Hence, a filter would be required in the treatment unit. UV disinfection does not have a residual effect. The UV dose can be altered to provide a specific level of disinfection, if so desired to allow passage of some native bacteria and other organisms that may be important for the lagoon ecosystem. Despite the treatment of water in the creek, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.3.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. UV light would kill all living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. This impact could be reduced by applying a lower dosage to allow passage of a fraction of the natural organisms (as well as coliform bacteria) to the lagoon. The treatment process is not expected to adversely affect the pH, temperature, or mineral content of the water.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing.

4.3.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City, with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility would likely be a Mitigated Negative Declaration or an Environmental Impact Report (EIR). The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.3.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (on the east side of the creek) and by the County (on the west side of the creek). The selling price for the 3 kW Sentinel™ System as described is about $90,000.

A summary of operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 4
ESTIMATED OPERATIONAL COSTS OF UV LIGHT OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Electrical power for UV lights (at $0.06/kWh)	2,000	10,000
Replacement of UV lights and filter ($11.59/mg)	150	750
Total=	$4,850	$24,250

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $50,000 to $75,000.

4.3.6 Key Considerations

Advantages

- UV treatment is a safe system with negligible public safety hazards or ecological risks
- The dosage of UV light can be readily altered to allow passage of a fraction of natural bacteria and aquatic organisms

Disadvantages

- Moderately high capital costs

4.4 OZONATION

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be disinfected by exposure to gaseous ozone. Disinfected water would then be returned to the creek.

4.4.1 Description of the System

Ozone is a naturally occurring strong oxidant, consisting of three bonded oxygen molecules (O_3). For disinfection applications, ozone is typically generated using air or oxygen and a molecular sieve process. Ozone is toxic at high concentrations, so ventilation of spaces is required. One of the advantages of ozone is that it is naturally attenuated by conversion to oxygen and so is inherently safe after dissolution. Ozone is typically used as an alternative to chlorine where safety to humans or animals, costs, and disinfection byproducts formed by chlorinated compounds are a concern. Typical applications include potable water and aquaria. Typical dosages are 2-3 parts per million (ppm), which translates to approximately 12-15 lbs/day of ozone for this application.

- Facilities required include equipment to produce ozone, concentrate it, and dissolve it in the target water. A portable treatment unit would be used, either a skid-mounted unit or a trailer-mounted unit measuring no more than 15 by 20 feet. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. Ozone generating equipment that uses air as the oxygen source generates substantial noise (in excess of 80 dBa), and soundproofing would be necessary. The unit would be located in one of the two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3.
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- As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area. Water pumped from the diversion would be conveyed to a portable unit where it would pass through a course filter prior to treatment. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge.

- The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and replacement of UV lights. The diversion structure and associated pond would also require periodic inspection.

4.4.2 Effectiveness

Ozone is an extremely reactive oxidant. It is very effective against bacteria and other human bacterial pathogens. It is also a very effective virucide and believed to be more effective than chlorine. Ozonation does not produce dissolved solids and is not affected by the ammonium ion or pH influent to the process. There is no residual effect of ozonation. The ozonation dose can be altered to provide a specific level of disinfection, if so desired to allow passage of some native bacteria and other organisms that may be important for the lagoon ecosystem. Despite the treatment of water entering the lagoon, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.4.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. Ozonation would kill all living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. This impact could be reduced by applying a lower dosage to allow passage of a fraction of the natural organisms (as well as coliform bacteria) to the lagoon.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing.

4.4.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility would likely be a Mitigated Negative Declaration rather than an Environmental Impact Report (EIR). The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.4.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve. No vendor cost estimates were available for this study. It is estimated that the capital costs of an ozonation system would be about $100,000.

A summary of operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 5
ESTIMATED OPERATIONAL COSTS OF OZONATION OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Electrical power for ozone generation	2,000	10,000
Replacement filters	50	250
Total=	$4,750	$23,750

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $50,000 to $75,000.

4.4.6 Key Considerations

Advantages

- Relatively safe due to the inherent safety of ozone.
- Ozone can be used in water containing particulates or turbidity.
- Dissolved oxygen concentration of the effluent will be elevated to saturation levels
- The dosage of ozone can be readily altered to allow passage of a fraction of natural bacteria and aquatic organisms

Disadvantages

- Moderately high capital costs

4.5 UV/OZONATION COMBINATION

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be disinfected by exposure to a combination of ozone and ultraviolet light. Disinfected water would then be returned to the creek. This system has been designed based on specifications provided by Bioxide Corporation.

4.5.1 Description of the System

Bioxide Corporation is manufacturing and distributing a combination treatment system that uses both ozonation and UV treatment based on a patented process, called the Dilegen II™ process. According to materials published by the Bioxide Corporation, the combination of UV, moisture, and ozone produces a synergistic effect that is highly effective against bacteria. UV light, by itself, creates a resonance in the chemical bonds of organic molecules (e.g., DNA) which breaks the bonds and causes the bacteria to die. Ozone, by itself, is a highly reactive molecule that breaks chemical bonds in organic molecules and deactivates them. In the patented Diligen II™ process, UV light activates ozone and creates free radicals (single oxygen molecules and hydrogen peroxide) which kill organic pathogens more effectively that ozone or UV light alone. There is no residual ozone or other by-product.

Portable package units are sold by Bioxide Corporation for this type of application. A portable treatment unit would be used, either a skid-mounted unit or a trailer-mounted unit measuring about 10 by 10 feet. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. The treatment unit would be located in one of the two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3.

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– As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area. Water pumped from the diversion would be conveyed to a portable unit where it would pass through a course filter prior to treatment. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge.

The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and replacement of UV lights. The diversion structure and associated pond would also require periodic inspection.

The City of Malibu will be installing a 330 gpm capacity unit for treating stormwater emptying into Malibu Creek and Surfrider Beach. The City of Malibu facilities will include a Continuous Deflective Separation (CDS) unit to remove trash, debris, oil, and grease prior to treatment. This type of separator is not expected to be required for Arroyo Burro Creek because water will be diverted from the creek by a hose and pump system with a trash screen. However, a course filter will be required prior to treatment to remove large floating debris.

4.5.2 Effectiveness

The UV/ozonation treatment process by Bioxide Corporation appears to be more effective in reducing bacteria and viruses in natural water than UV or ozonation systems alone. As such, it could remove most of the bacteria from the creek water. There is no residual effect of UV/ozonation. The dose can be altered to provide a specific level of disinfection, if so desired to allow passage of some native bacteria and other organisms that may be important for the lagoon ecosystem. Despite the treatment of water entering the lagoon, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.5.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. The combination of UV/ozonation would kill all living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. This impact could be reduced by applying a lower dosage to allow passage of a fraction of the natural organisms (as well as coliform bacteria) to the lagoon. The treatment process is not expected to adversely affect the pH, temperature, or mineral content of the water.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing.

4.5.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek

- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility would likely be a Mitigated Negative Declaration rather than an Environmental Impact Report (EIR). The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.5.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (east of the creek) and by the County (west of the creek). The estimated costs of a UV/ozonation unit from Bioxide Corporation is about $250,000.

A summary of operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 6
ESTIMATED OPERATIONAL COSTS OF UV/OZONATION OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Electrical power for UV/ozonation	2,000	10,000
Replacement filters	50	250
Total=	$4,750	$23,750

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $50,000 to $75,000.

4.5.6 Key Considerations

Advantages

- Combination of UV and ozonation treatments is an effective disinfection agent with moderate operational costs
- The dosage can be readily altered to allow passage of a fraction of natural bacteria and aquatic organisms
- Treatment is a safe system with negligible public safety hazards or ecological risks

Disadvantages

- Relatively high capital costs

4.6 ELECTROCOAGULATION

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be disinfected by electrocoagulation. Disinfected water is then returned to the creek. This system has been designed based on specifications provided by Water Solutions, LLC.

4.6.1 Description of the System

Coagulation is a physiochemical process that is commonly employed in conventional water treatment. It may be achieved through chemical or electrical means. Electrocoagulation is a water treatment process that involves passing an electrical current through water. Electrocoagulation uses electricity to precipitate the dissolved and suspended solids. Bacteria is removed by precipitation of colloidal materials that contain bacteria, electrically-induced oxidation of organic compounds, and increased osmotic pressure in the water as it is flooded with electrons. Sludge or floc is produced in the process which must be removed and disposed.

Portable packaged units are sold by Water Solutions, LLC for this type of application. A portable treatment unit would be used, either on two skids measuring 8 by 20 feet, or on a 40-foot long trailer. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. The treatment unit would be located in one of the two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3.

The treatment system includes an electrocoagulation unit and a centrifugal separator. Sludge produced by the system would disposed in two possible ways: (1) collection of sludge on site in tanks that are periodically replaced; or (2) discharge of the sludge to the City's sewer system at the Braemer Lift Station.

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- As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area. Water pumped from the diversion would be conveyed to a portable unit. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge.

The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and replacement of electronic plates. The diversion structure and associated pond would also require periodic inspection.

4.6.2 Effectiveness

Based on testing data provided by Water Solutions, LLC, bacteria can be reduced by over 99 percent. However, their testing was performed on sewage wastewater with bacteria concentration several orders of magnitude greater than that observed in Arroyo Burro Creek. There is no residual effect of electrocoagulation. Despite the treatment of water entering the lagoon, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.6.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. The electrocoagulation would kill all living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. This impact could be reduced by applying a lower dosage to allow passage of a fraction of the natural organisms (as well as coliform bacteria) to the lagoon. The treatment process is not expected to adversely affect the pH of the water; however, it will reduce the mineral content and increase temperatures slightly.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing.

4.6.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive

- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility would likely be a Mitigated Negative Declaration rather than an Environmental Impact Report (EIR). The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.6.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (east of the creek) and by the County (west of the creek).

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve. The estimated costs of an electrocoagulation system from Water Solutions, LLC, is about $267,000 for the electrocoagulation unit and $200,000 for a centrifugal separator. An additional 10% would be needed for a variable flow system. An additional $4,000 would be required to connect to the City's sewer pipeline at the Braemer Lift Station to remove sludge.

Literature provided by Water Solutions, LLC indicates operational costs of about $0.24 per 1,000 gallons treated using an electrocoagulation process. This cost does not include sludge disposal. A summary of operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 7

ESTIMATED OPERATIONAL COSTS OF ELECTROCOAGULATION OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Electrical power for electrocoagulation process	3,200	10,000
Maintenance and replacement of plates	100	500
Sludge disposal (est.) at El Estero	2,000	10,000
Total=	$8,000	$34,000

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $50,000 to $75,000.

4.6.6 Key Considerations

Advantages

- Electrocoagulation removes numerous types of pollutants in addition to coliform bacteria. Therefore, this type of treatment provides the advantage of removing metals, TSS, and oil and grease from the creek.

Disadvantages

- The process generates sludge which must be diverted to the sanitary sewer, or collected disposed at offsite facilities.

- Very high capital and operational costs compared to other treatment options

4.7 REVERSE OSMOSIS

This alternative requires the diversion of low flows from the creek to a contact chamber where creek water would be filtered by reverse osmosis. Disinfected water would then returned to the creek.

4.7.1 Description of the System

Reverse osmosis is a process in which water is caused to flow in the reverse manner through a semi-permeable membrane from brackish to dilute fresh water. It is separated from dissolved salts at a pressure greater than the osmotic pressure caused by the dissolved salts in the wastewater. The semi-permeable membrane acts like a filter to retain the ions and particles in solution on the brackish-water side, while permitting water alone to pass through the membrane. The basic components of reverse osmosis are the membrane support structure, a containing vessel, and a high pressure pump. Bacteria is filtered from the water as it passes through the membrane.

A portable treatment unit would be used, either a skid-mounted unit or a trailer-mounted unit measuring up to 50 by 50 feet. Both types of units would be placed inside aluminum housing to protect from the elements and vandals. The treatment unit would be located in one of the two open areas adjacent to the creek near the Cliff Drive bridge (Figure 3), as described in Section 3.3. Brine would be diverted to the City's sewer line at Braemer Lift Station, similar to the diversion described in Section 4.1.

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– As described in Section 3.3, the most efficient diversion would be to construct a temporary diversion on the concrete sill in the creek bed on the downstream side of the Cliff Drive bridge, creating a small pond. Water would be pumped from this pond by a variable speed pump (300 gpm capacity) with a floating sensor and switch. The pump could be located next to the creek, or inside the treatment unit on the adjacent upland area. Water pumped from the diversion would be conveyed to a portable unit where it would pass through a course filter prior to treatment. Treated water would be discharged to the creek through pipe about 50 feet downstream of the bridge.

The facility would require periodic maintenance, including daily inspections, periodic maintenance of the pump, and replacement of membranes. The diversion structure and associated pond would also require periodic inspection.

4.7.2 Effectiveness

Reverse osmosis is highly effective in removing bacteria and other dissolved organic matter. However, it is difficult to vary the level of treatment compared to other treatment processes. Despite the treatment of water entering the lagoon, bacteria in the lagoon would not be completely eliminated due input from other side drains, seeps and birds.

4.7.3 Environmental and Land Use Issues

The primary environmental issue associated with this alternative is the ecological effect of disinfecting freshwater flows to the lagoon. The reverse osmosis would exclude most living organisms in the water, including other bacteria, aquatic invertebrates, protozoa, and algae that are native to coastal freshwater systems. These organisms play a role in the ecology of the lagoon, providing primary productivity, food for higher organisms, and/or decomposition capacity. The importance of these organisms from Arroyo Burro Creek to the ecological functions of the lagoon in the summer is unknown at this time. The treatment process is not expected to adversely affect the pH, temperature, or mineral content of the water.

No direct land use impact is anticipated because the treatment unit would be a temporary facility that would not be located near any residences or park facilities, and because noise from the pump and treatment system could be reduced to imperceptible levels for residences on the north side of Cliff Drive by noise attenuation materials in the housing.

4.7.4 Permitting and Environmental Review Requirements

Construction and operation of the diversion and treatment facility would require the following permits or approvals:

- 404 permit from the Corps for the discharge of fill material (i.e., construction of the diversion structure)
- 401 water quality certification from the Regional Water Quality Control Board to validate the 404 permit
- Endangered species clearance for the 404 permit from the USFWS due to potential impacts on the endangered tidewater goby in the Arroyo Burro Creek lagoon
- Section 1601 Streambed Alteration Agreement from the CDFG for work in the creek
- NPDES permit from the Regional Water Quality Control Board for discharge of treated water to the creek
- Coastal Development Permit from the City with appeal jurisdiction by the CCC
- Approval by the County for facilities located in the County Park.
- Encroachment permit from the County Department of Public Works for work on Cliff Drive
- Encroachment permit from the County Flood Control District for work in the creek

During the review of the 404 permit application, the Corps will need to conduct a Section 7 endangered species consultation with the USFWS regarding impacts of the treatment on the habitat in the lagoon for the endangered tidewater goby. Through this consultation, the impacts of disinfection of freshwater flows on the goby will be addressed. As noted earlier, the Corps can only permit the least environmentally damaging practicable alternative under the 404 regulations. To the extent other treatment alternatives avoid or lessen impacts to the lagoon and do not have other adverse impacts, a 404 permit could not be issued for this alternative.

This alternative would require a Coastal Development Permit (CDP) from the City, subject to appeal to the CCC. Issuance of this permit requires compliance with all applicable policies of the Local Coastal Plan and the Coastal Act. Many of these policies require that coastal resources such as the lagoon be protected from adverse impacts to the maximum extent feasible, and that the least environmentally damaging alternative be implemented. In addition, Coastal Act policies require set-backs from streams which would likely apply to the treatment unit.

The project would be subject to the environmental review requirements of CEQA. The environmental document for this type of facility would likely be a Mitigated Negative Declaration rather than an Environmental Impact Report (EIR). The City would likely be the CEQA Lead Agency, while the County would be a Responsible Agency.

4.7.5 Estimated Costs

The capital cost of a 300-gpm stainless steel electrical pump would be approximately $3,000, and piping would be $10/linear foot. There would be no costs for land acquisition or an easement because the land downstream of Cliff Drive bridge is owned by the City and is part of the Douglas Family Preserve (east of the creek) and by the County (west of the creek). No vendor cost estimates were available for this study. It is estimated that the capital costs of a reverse osmosis system would be about $200,000.

A summary of estimated operational costs is provided below. No ordinary maintenance costs or equipment deterioration costs are included.

TABLE 8
ESTIMATED OPERATIONAL COSTS OF REVERSE OSMOSIS OPTION

Item	Monthly Costs	Annual Costs (five months only)
Pumping (electrical)	2,700	13,500
Electrical power for process	2,000	10,000
Replacement membranes	1000	5000
Total=	$5,700	$28,500

In addition to the above capital and operational costs, there would be costs associated with permitting and environmental review. Estimated costs for agency staff time and consultants would be $50,000 to $75,000.

4.7.6 Key Considerations

Advantages

- Highly effective removal rate for bacteria and all dissolved organics, as well as dissolved minerals.

Disadvantages

- Membranes are easily fouled by colloidal matter in the feed stream. This is a significant disadvantages because it requires continual cleaning of membranes and periodic replacement. Membranes are very expensive. To reduce this effect, pre-treatment to remove organic compounds is possible, but would require a new unit at the site and additional costs.

- As noted above, pre-treatment may be necessary. For example, the removal of iron and manganese is sometimes necessary to decrease scaling potential. The pH of the feed should be adjusted to 4 to 7.5 to inhibit scale formation.

- Brine disposal through the sewer diversion would represent an additional cost and facility

- Very high capital and maintenance costs compared to other treatment alternatives

5.0 COMPARISON OF ALTERNATIVES

A summary of the key attributes of the potentially feasible alternatives described in Section 4.0 is presented below and in Table 9. The treatment alternatives that appear to be the most promising are the UV or ozonation systems. Package units with these treatment processes are effective, small in size, and highly portable. They are scalable systems that could allow passage of a certain level of natural aquatic organisms into the lagoon to address concerns about impacts to lagoon ecosystem. Capital and maintenance costs of the UV and ozonation systems are similar. The combined UV/ozonation system has similar attributes, but appears to have a higher capital costs. We recommend that all three systems be evaluated if the County decides to pursue the implementation of a temporary, short-term treatment project. The capital and operational costs of these systems presented in this report are approximate; direct coordination with vendors is likely to provide more precise and competitive cost estimates that can be used in the development of a project.

Diversion of the creek to the City's sewer system would be difficult, if not impossible, to permit due to concerns about impacts to the lagoon ecosystem and tidewater goby. Other treatment options appear to have significantly higher capital and operational costs without any clear advantage.

TABLE 9
SUMMARY OF TREATMENT ALTERNATIVES

Treatment Alternatives	Relative Capital Costs	Relative Opera-tional Costs	Primary Advantages	Primary Disadvantages	Potential Fatal Flaw
1. Diversion to sewer	Low	High	Highly effective; low capital costs; small physical plant	Reduction in freshwater flows to lagoon; impacts to endangered tidewater goby and other species; difficult permitting	Impacts to the lagoon and tidewater goby may preclude permitting
2. Chlorination	Moderately high	Moderate	Effective and proven treatment	Public safety hazard with use and storage of chlorine on-site; high capital costs	Public and environmental safety hazard due to chlorine may create public opposition
3. Ultraviolet light	Moderately high	Moderate	Effective treatment; scaleable; safe treatment	High capital costs	None
4. Ozonation	Moderately high	Moderate	Effective treatment; scalable; safe treatment	High capital costs	None
5. UV/ozonation	High	Moderate	Effective treatment; scalable; safe treatment	Very high capital costs	None
6. Electro-coagulation	Very high	Moderate to high	Removes other pollutants	Sludge production and disposal; very high capital and operational costs	None
7. Reverse osmosis	High	Moderate to high	Removes other pollutants	Very high capital costs	None

6.0 ALTERNATIVES DISMISSED FROM CONSIDERATION

The following alternatives were reviewed as part of this study to determine if they would meet the basic design criteria listed in Section 2.1. Each alternative failed to meet one or more of these criteria, as explained below.

6.1 OCEAN OUTFALL

This alternative would involve discharging low flows from Arroyo Burro Creek via a pipeline to an ocean outfall beyond the surf zone (e.g., about 1,500 feet or more from shore). The objective of this alternative is to prevent potentially contaminated low flows from reaching beach, and to discharge them in an area where human contact would be infrequent. To accomplish this disposal, a diversion and pump system would be required, similar to that described in Section 3.3. A pipeline would be buried along the margins of the lagoon and across the beach and wading zone, then placed on the ocean bottom to an outfall structure. To bury the pipeline at the beach and surf zone would require trenching through bedrock and reefs that are present at Arroyo Burro Beach. The outfall must be located beyond the zone of littoral sand transport to avoid continual burial.
The advantage of this system is, as in the case of the sanitary diversion, that the bacteria-laden flow is prevented from reaching the beach.

This alternative would reduce freshwater flows to the lagoon during the summer months. This could result in adverse impacts to the endangered tidewater goby that resides in the lagoon, as well as to riparian vegetation on the margins of the lagoon. This alternative would also cause significant short-term impacts to the beach due to pipeline installation. This alternative would require numerous permits. The most important permits would be a CDP from the CCC and a State Lands Commission encroachment permit. It is highly unlikely that these permits would be issued for this alternative because: (1) there would be significant adverse impacts to the lagoon, beach, and nearshore waters; (2) the discharge would be potentially contaminated with bacteria, as well as other contaminants that could not be controlled, including hazardous substances accidentally released to the creek; and (3) there are feasible alternatives that do not involve ocean disposal. In addition, this alternative does not reduce bacteria concentrations in the lagoon, the basic objective of the project. For these reasons, this alternative was considered infeasible.

6.2 OFF HOURS DRAINING OF THE LAGOON

This alternative would involve the opening of the lagoon mouth each evening or early morning to drain the lagoon to the extent feasible prior to the arrival of beach users. The lagoon mouth would be opened by a small loader pushing sand on the beach. If high tides are present, the mechanical opening of the lagoon would be postponed or skipped. The objective of this alternative is to reduce the volume of potentially contaminated water in the lagoon that could deposit bacteria in the ocean immediately prior to, and during, the peak beach recreational hours each day. The alternative would not reduce the amount of bacteria in the lagoon or that is conveyed to the ocean. It would only regulate the timing of the discharge, to the extent allowable under tide conditions. This alternative would also include artificially blocking the lagoon from discharging during the daytime beach use hours by building a sand berm at the opening that would withstand high tide action.

The effectiveness of this alternative is unknown. It has the potential to reduce bacteria loading during peak beach use hours. However, it may not be possible to ensure the closure of the lagoon during the day due to the actions of high tides. In addition, the lagoon will continue to discharge to the beach through subsurface flows. As such, there will always be a continuing source of bacteria. As such, this method is not considered an effective nor reliable alternative. In addition, it does not reduce bacteria concentrations in the lagoon, the basic objective of the project. Finally, this approach may not be feasible at other creeks on the South Coast, and therefore, has limited applicability.

6.3 REGULAR FLUSHING OF THE LAGOON

The lagoon at the mouth of Arroyo Burro Creek is subject to tidal influence on most days. High tides build up sand at the mouth of the lagoon that closes the lagoon, causing a build up of water in the lagoon. If the tides are of sufficient height, the lagoon is partially or fully filled with ocean water. As the tide recedes, the hydrostatic pressure in the lagoon causes it to open and discharge to the ocean.

One alternative that has been recently proposed is to maintain the opening of the lagoon to allow continual drainage to the ocean. The underlying assumptions for this alternative are that the lagoon sediments may be a source of bacteria and that continual discharge from the lagoon may prevent accumulation of bacteria in the sediments. There are no data to support these assumptions. Sediments in a lagoon setting may represent either a source or sink of bacteria, depending upon the dynamics of the lagoon wave environment, the nature of the bacterial inputs (i.e., are bacteria deposited as free swimming or in fecal pellets), and the salinity of the lagoon.

This alternative was considered infeasible for several reasons. One, maintaining an opening to the lagoon would require almost daily use of a small loader to remove the sand bar. This would represent an expensive effort and could also cause adverse impacts to recreational users of the beach. Two, the invert of the lagoon is lower than mean sea level, and as such, opening the lagoon would not fully drain the lagoon. Three, reducing the water level in the lagoon would cause adverse impacts to the endangered tidewater goby. Four, allowing continual flow of potentially contaminated creek water to the ocean could exacerbate the bacteria problems at the beach rather than reduce them. Five, this alternative is not considered effective nor reliable. Six, it does not reduce bacteria concentrations in the lagoon, the basic objective of the project. Finally, this approach may not be feasible at other creeks on the South Coast, and therefore, has limited applicability.

6.4 IN-SITU OZONATION

Under this alternative, ozone would be bubbled through the water column in the Arroyo Burro Beach lagoon from a lattice of plastic pipes on the bottom of the lagoon. Water in contact with the ozone would be disinfected. This alternative would require an ozone generating facility near the lagoon and the placement and maintenance of a pipeline network in the bottom of the lagoon.

This alternative was dismissed as infeasible for several reasons: (1) The effectiveness of disinfection would be very low because the passive bubbling of ozone would not provide sufficient contact time between ozone molecules and bacteria. Furthermore, the lagoon is very turbid which would reduce disinfection rates. (2) Installation and maintenance of a bubbling system would cause adverse impacts to the endangered tidewater goby. (3) The pipeline system would be prone to sedimentation and damage from wave action. (4) The pipeline system in the lagoon would result in adverse aesthetic impacts to beach visitors.