Moonlight Beach
Urban Runoff Treatment Facility
Final Report

City of Encinitas
Clean Water Program
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EXECUTIVE SUMMARY

Introduction

Moonlight State Beach is the most popular coastal feature in the City of Encinitas (City) and is one of the North San Diego County's most famous recreation areas. The City is a semi-arid coastal community located 22 miles north of downtown San Diego, California with a population of approximately 60,000. The City has estimated beach attendance at over 2 million visitors annually for the past five years and estimates that its beaches bring in $47 million annually to the local economy.

One of the unique features of Moonlight State Beach is that Cottonwood Creek flows across the beach year-round. It drains approximately three square miles of heavily developed land and has contributed to water quality degradation at Moonlight State Beach for years. In the year 2000 Moonlight State Beach was posted over 70 days due to bacteria indicator exceedances during routine monitoring.

Beginning in 1999, the City implemented best management practices (BMPs) and performed heavy enforcement of urban runoff regulations throughout the Cottonwood Creek watershed. Although these efforts resulted in a reduction in pollutant levels, a more aggressive contaminant removal system was necessary to protect public health. The City obtained funding through the Clean Beaches Initiatives grant program and selected an ultra-violet treatment process. The Moonlight Urban Runoff Treatment Facility (UV Facility) was designed in the fall of 2001 and constructed between June 2002 and August 2002.

Project Description

The UV Facility is located approximately 230 yards upstream of Moonlight State Beach. It is sited adjacent to Cottonwood Creek at the southeast corner of 3rd and B Street within the footprint of the Moonlight Beach Sewer Pump Station. The UV Facility diverts approximately 135 gallons per minute of dry weather flows from the creek into a wet well that consists of a five-foot diameter concrete cistern with two alternating 7.5-HP pumps. The water initially passes through a basket strainer and multi-media filter to reduce turbidity and maximize the effectiveness of the system. The water then is passed through two a disinfection unit designed to inactivate bacteria and viruses in the creek water. The disinfection unit consists of two UV chambers approximately 48 inches in length and 8 inches in diameter. Each chamber has four low-pressure, high intensity UV lamps. The chambers are mounted horizontally. The treated water is finally re-introduced to Cottonwood Creek and discharges to the Pacific Ocean at Moonlight Beach. The UV Facility operates only during dry weather periods, as it does not have the capacity to treat wet weather flows and the high turbidity associated with storm water renders the UV process ineffective.

Monitoring Program

The main objectives of the UV Facility are protection of public health by eliminating or reducing the risk of illness from urban runoff and thereby reducing or eliminating the need for beach postings. In order to monitor the effectiveness of the UV Facility to meet these objectives two assessment methods were used: water quality monitoring and beach posting data. The City routinely monitored the concentrations of bacteria at three locations in Cottonwood Creek and in the mixing zone (ankle to knee deep in the surf) at the creek mouth. Samples were collected above (influent) and below (effluent, at the creek mouth and in the mixing zone) the facility, and before and after project implementation. Monitoring locations include influent, effluent, the mouth of Cottonwood Creek, and the Moonlight Beach mixing zone. Approximately 160 routine sampling events occurred during the monitoring period. Beach postings were assessed using data from the San Diego County Department of Environmental Health (DEH).

Results

Bacteria removal efficiencies through the UV Facility were calculated at >99% based on 153 pairs of influent and effluent samples. Through weekly bacteria monitoring and a special study, the City determined that additional sources of bacteria and regrowth contributed to the degradation of water quality downstream of the facility. However, the overall removal efficiency from the facility influent to the creek mouth (50 feet upstream of the mixing zone) was measured at approximately 50%. Monitoring also showed an improvement of water quality in the mixing zone as measured by changes in exceedances of AB411 standards. AB411 exceedances were reduced from 9.4% prior to the project to 4.8% after the project representing nearly a 50% reduction in exceedances in the mixing zone.

Annual days of beach postings at Moonlight State Beach have declined since 2000; reduced by an average of 85%. The beach was posted an average of 42.5 days per year in the two years preceding construction and 6.5 days per year of postings after construction. This assessment is based on DEH beach posting data.

Operations and Maintenance

The facility operated for 68%, 81% and 65% of the year for 2003, 2004, and 2005, respectively. Generally, the facility was in operation for the entire dry season (May through September). The facility was taken off-line in the event of rain, as a result of a sewer spill, or for maintenance. The major maintenance issues for the UV Facility during the first 3.5 years of operation were associated with the intake structure (including the wet well), the filtration system, and UV units. Problems with the intake structure included the height of the weir, algae in the intake screens and maintenance of the pumps.

The filtration system includes basket strainer, a turbidity meter, an anthracite, multi-media filter unit. Basket strainers have required little maintenance, however, the turbidity meter required frequent adjustments and maintenance to operate properly. The multi-media filter was sensitive to suspended solids in the creeks flow which obstruct the filter and required back flushing on a regular basis. The automatic back flushing interval was adjusted to balance the need to increase flow though the system and the cost of potable water for back flushing. Back flush water was discharged to the adjacent sewer pump station.

The most frequent maintenance need for the UV unit included bulb replacement and ballast replacement. Bulbs generally needed to be replaced once per year. The ballast has only needed replacement once. In general, the UV unit maintenance has been relatively low. Weekly water quality monitoring and instrumentation within the facility were used for process control. Increased bacteria in the facility effluent were an indicator of process control problems, typically these were:

- Increased bacteria loading in the creek indicative of rainfall or illicit discharges
- Obstruction of multimedia filters
- Increased turbidity in the influent associated with rainfall or illicit discharges

- Decreased performance of UV bulbs, bulbs burnt out.
- Decreased performance of UV bulbs due to wiper problems.

Conclusion and Recommendations

The UV Facility is instrumental in reducing bacteria concentrations in Cottonwood Creek and at Moonlight State Beach. The facility removes greater than 99% of all pathogenic organisms from creek water prior to its discharge at Moonlight State Beach. With reduced beach postings, fewer bacterial exceedances in the mixing zone, and demonstrated improvements in water quality in the creek and in the mixing zone, the project has been a success; meeting the main objectives of the project.

Exceedances of water quality associated with bacterial regrowth and sources of bacteria in Cottonwood Creek downstream of the UV Facility continue to cause occasional beach postings. Based on the monitoring program and special studies, the following recommendations are provided to mitigate these bacteria sources:

- Regular maintenance and cleaning of the storm drain system to reduce the media for regrowth.
- Placement of UV Facilities as close as possible to the receiving water being protected
- Removal of the kelp wrackline at the creek or storm drain outlet that can contribute bacteria at the beach.
- Continuous monitoring of turbidity and flow data to identify trends and identify illicit discharges.
- Back flush multi-media filters with influent water if it is relatively low in turbidity to save water costs.
- A DNA study to identify sources of bacteria introduced to the creek downstream of the facility.
- An epidemiology study to identify the potential for health risks associated with the sources of bacteria downstream of the facility
- Continued monitoring of influent and effluent bacteria concentrations, influent turbidity, and flow as process controls.

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1.0 Introduction

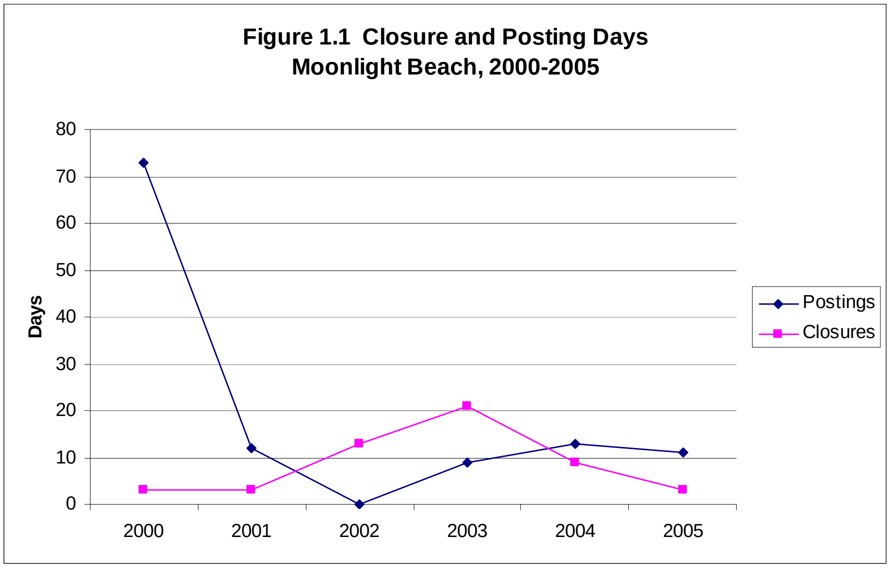
Figure 1.0 Fourth of July at Moonlight Beach

Moonlight State Beach is the most popular coastal feature in the City of Encinitas and is one of the North San Diego County's most famous recreation areas. Encinitas beaches attract visitors from all over San Diego County and internationally. The City has estimated beach attendance at over 2 million visitors annually for the past five years and estimates that its beaches bring in $47 million annually to the local economy.

One of the unique features of Moonlight Beach is that Cottonwood Creek flows across beach year-round. It drains approximately three square miles (2,000 acres) of heavily developed land and serves as a major storm drain channel for wet weather flows. Due to the altered nature of the creek from development within the watershed, Moonlight Beach has experienced numerous postings for decades. In the year 2000 Moonlight Beach was posted over 70 days due to fecal indicator bacteria (FIB) exceedances during routine monitoring. FIB includes total and fecal coliform and enterococcus bacteria indicators. The primary source of contaminants at the beach is the perennial, dry season urban runoff in Cottonwood Creek.

Beginning in 1999, the City implemented upstream BMPs and performed heavy enforcement of urban runoff regulations throughout the watershed. Although this effort resulted in a reduction in pollutant levels, it did not reduce beach postings, thus, a more aggressive contaminant removal system was necessary to protect public health. The City embarked on a study to determine the most effective solution. The ultra-violet treatment process was selected and funding through the Clean Beaches Initiatives grant program was secured. The Moonlight Urban Runoff Treatment Facility was designed in the fall of 2001 and constructed between June 2002 and August 2002.

The Moonlight Urban Runoff Treatment Facility has resulted in a reduction of beach postings. Beach postings and closures are distinctly different and are tracked separately. Beach postings to protect public health occur because of elevated concentrations of bacteria indicators detected in routine monitoring. Closures occur as a result of sanitary sewer overflows. Figure 1.1 illustrates the total number of beach postings and beach closures from 2000 to present.



1.1 Historical Water Quality at Moonlight Beach

The California Regional Water Quality Control Board listed the Pacific Ocean at the outlet of Cottonwood Creek (at Moonlight State Beach) as 303(d) impaired by coliform bacteria, in accordance with the EPA Clean Water Act (SWRCB, 2003). Heal the Bay's Summer 2000 Beach Report Card™ gave Moonlight Beach an "F" based on risk of adverse health effects to humans. As mentioned above, there were over 70 beach postings in the year 2000 as a result of high bacteria counts in the mixing zone adjacent to Cottonwood Creek. Table 1.0 details Heal the Bay grades for Moonlight Beach from FY 2000-2001 through 2004-2005. These grades have improved significantly with the implementation of the urban runoff treatment facility at Cottonwood Creek in August 2002.

Table 1.0 Heal the Bay Grades for Moonlight Beach, 2000-2005

Period	AB411 Dry Weather*	Overall Dry Weather**
2000-01	F	F
2001-02	D	D
2002-03	B	No samples
2003-04	B	A
2004-05	B	B

*The AB411 sampling period is from April through October.

**The overall dry weather grade reflects this period and dry weather samples collected throughout the year. Dry weather samples are characterized as those collected more than 72 hours after a significant rainfall.

The City of Encinitas has a very aggressive urban runoff program. For years the City has investigated pollutant sources and methods for reducing beach postings at Moonlight Beach. Structural and nonstructural BMPs have been implemented throughout the watershed. The City has issued hundreds of Notices of Violations to restaurants, gas stations, automotive and other businesses for stormwater infractions. Two years of source identification, upstream BMPs and enforcement within the watershed did improve water quality. However, due to the constant creek discharge, meeting AB411 standards became unattainable.

With the introduction of Assembly Bill 411 (AB411) in 1999, the California Department of Health Services requires counties to monitor recreational waters more frequently and adhere to new water quality standards set forth in the bill. The AB411 season corresponds to the season of highest usage at California beaches, from April 1 through October 31. The bill requires monitoring for three bacterial indicators (total coliform, fecal coliform, and enterococcus) that are thought to be indicative of pollution and potential risks to human health. Previously testing only included total and fecal coliforms; AB411 introduced enterococcus to the list. Studies at marine beaches have shown that enumeration of enterococci is the most efficient indicator of water quality (Cabelli, 1983). All three indicators must be within the standards established in the bill, see Table 1.1 below.

Table 1.1 AB411 Standards for Bacteria Monitoring, Marine Recreational Waters

Indicator	Single Sample Maximum (organisms per 100 ml)	Geometric Monthly Mean Maximum (organisms per 100 ml)
Total Coliform	10,000 1,000 if FC/TC $\geq$ 0.1	1,000
Fecal Coliform	400	200
Enterococcus	104	35

The bill requires the posting of advisory signs when bacterial standards are exceeded to protect public health.

1.2 Project Description

With financial assistance from the State Water Resources Control Board (SWRCB), the City of Encinitas designed, constructed, and operates an urban runoff treatment facility on Cottonwood Creek. The urban runoff treatment facility will be referred to in this report as the “UV Facility”. The facility is in operation only during dry weather periods, as it does not have the capacity to treat wet weather flows.

The facility diverts 85% of the dry weather flows in Cottonwood Creek into an ultra-violet treatment system designed to inactivate bacteria and viruses in the creek water (berson UV-techniek, 2002). A 15% by-pass was required by the Regional Water Quality Control Board (RWQCB) to allow for biological connectivity. Water is withdrawn from Cottonwood Creek inside an existing concrete double-box culvert. It is diverted to a wet well and pumped via two, alternating 7.5HP, float-controlled submersible pumps to the UV treatment facility. After pre-screening at the wet well intake, a second stage of screening is provided by two basket strainers. Water is then filtered through two dual media (sand and anthracite) pressure filters. Filters are backwashed periodically to remove trapped material. The screens and filters are operated in parallel and are necessary to increase the effectiveness of the UV lamps. The disinfection unit consists of two UV disinfection chambers approximately 48 inches in length and 8 inches in diameter. Each chamber has four low-pressure, high intensity UV lamps. The chambers are mounted horizontally. The treated, bacteria-free water is then re-introduced to Cottonwood Creek and discharges to the Pacific Ocean at Moonlight Beach.

The system is operated from a programmable logic controller (PLC). Treated flow is returned to Cottonwood Creek inside a second portal of the concrete box culvert. The entire treatment facility is housed in a 24 feet long, 10 X 10 foot prefabricated steel enclosure. Weekly water quality monitoring assists in process control within the facility and provides feedback on the effectiveness of the facility at protecting public health and reducing beach postings. Figure 1.2 shows the blue multimedia filters and the horizontal UV disinfection chambers.

Figure 1.2 Ultra-violet Treatment Facility

1.3 Project Goals

The main objectives of the project are:

- Protection of public health by eliminating or reducing the risk of illness from urban runoff.
- Reduction or elimination of the need for beach postings.

The goals of the monitoring program are:

- Establishment of baseline bacteria data prior to construction.
- Illustration of the effectiveness of the treatment facility in protecting public health and reducing beach postings.
- Illustrate trends of bacteria levels upstream of the treatment facility, immediately after the treatment facility, creek outlet to the ocean, and in the mixing zone at Moonlight Beach.
- Improvement of the operation and maintenance of the treatment facility through process control.
- Monitoring for illicit discharges upstream of the facility.

1.4 Site Description

The City of Encinitas is a semi-arid coastal community located in the North County area of San Diego County, approximately 22 miles north of downtown San Diego. The city has six miles of coastline and encompasses an overall area of nearly 20 square miles. The population of Encinitas is approximately 60,000.

Moonlight Beach is a California State Park located at the heart of the City of Encinitas. Figure 1.3 shows the location and configuration of the beach. The beach is approximately 800 feet in length and is geographically constrained by high coastal bluffs on either end. Because of it high use, the beach contains two full-time lifeguard stations throughout the dry season. The beach is used primarily for swimming, surfing, scuba diving, boogie-boarding and fishing. Moonlight Beach has restrooms, shower facilities, sand volleyball courts and a picnic/BBQ area.

Figure 1.3 Vicinity Map

Moonlight Beach State Park

One of the predominant features of the beach is Cottonwood Creek which discharges onto the beach at its northern end. Cottonwood Creek is a perennial stream that drains approximately 20 percent of the City of Encinitas. It drains approximately three square miles (2,000 acres) and serves as a major storm drain channel for wet weather flows.

The average dry-weather flow is approximately 100 to 150 gallons per minute (GPM). Ninety-five percent of this watershed is heavily urbanized as shown in Table 1.2. The City is economically dependent on the area beaches and is negatively affected by beach postings. A recent study concluded that the economic value of the City of Encinitas beaches is $47 million per year, see presentation on economic study provided in Appendix A. An example of the public perception problems that Moonlight Beach has is shown in the cartoon in Figure 1.4.

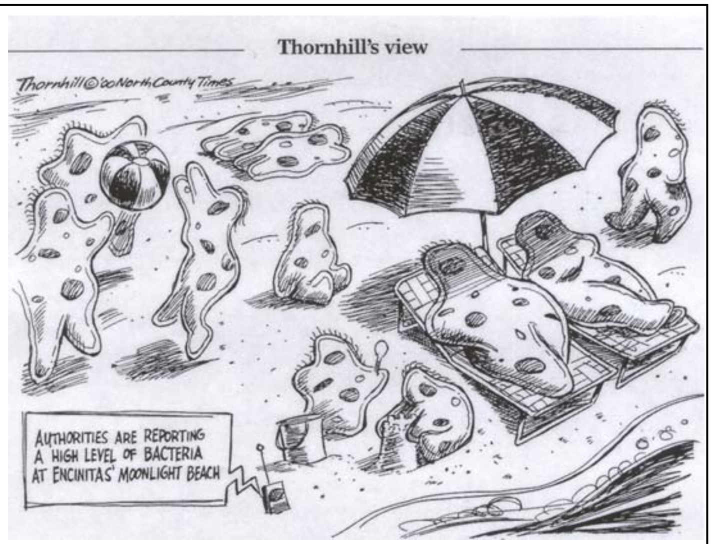


Figure 1.4 Cartoon from newspaper.

Table 1.2: Summary of Cottonwood Creek Watershed Land Use	
Land Use Category	**Percent of Watershed**
Residential (low, medium and high density)	55
Right-of-way and Transportation Corridor	18
Public/semi-Public	14
Ecological Resource, Open Space, Park	2
General Commercial/Light Industrial	7
Agricultural	4
Total	**100**

The layout of the watershed is shown below in Figures 1.5.

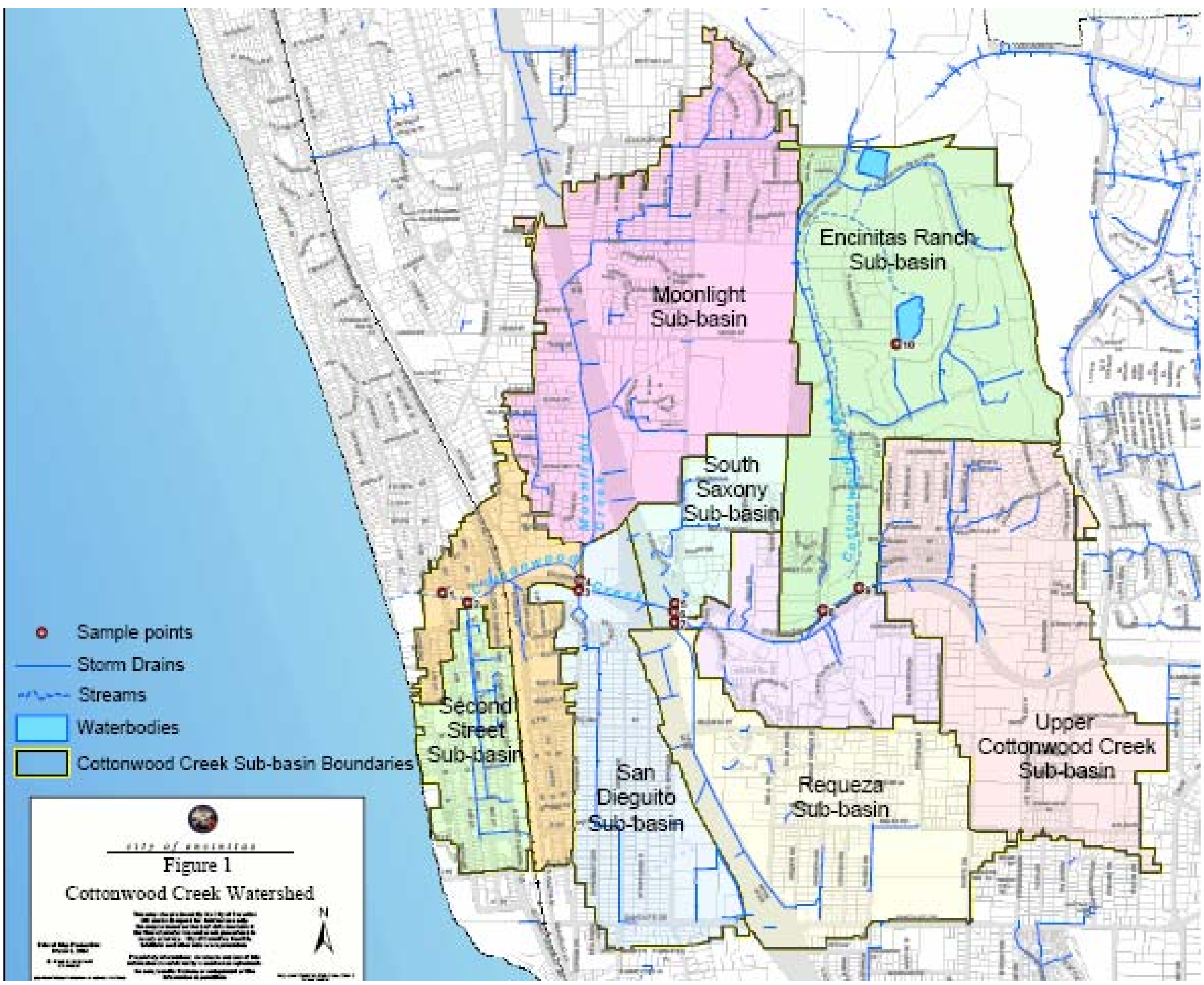


Figure 1.5: Cottonwood Creek Watershed

2.0 Project Schedule

The following table shows the projected and actual schedule for the project. The project construction was fast-tracked and completed on schedule.

Table 2.0 Project Schedule of Tasks		
Activity	**Date**	**Date Submitted**
Project Management and Administration	December 31, 2005	Ongoing
Permits	March 30, 2002	March 30, 2002
Quality Assurance Project Plan	March 30, 2002	May 27, 2002
Pre-Design Report	March 30, 2002	December 2001
Construction Documents	February 28, 2002	March 2002
Construction	August 31, 2002	August 31, 2002
Sample and Monitoring Plan	July 31, 2002	Ongoing
Quarterly Reports	Quarterly	Ongoing
Final Report	December 31, 2005	February 28, 2006

3.0 Methods

This section discusses the monitoring program. Routine monitoring was conducted to assess the effectiveness of the UV Facility.

3.1 Monitoring Design

The overarching goal of the project is to protect public health by eliminating or reducing the risk of illness from urban runoff. In order to assess the effectiveness of the UV Facility at reducing the risk of illness to swimmers at Moonlight Beach, the City monitored the concentrations of bacteria at several locations in Cottonwood Creek and in the mixing zone at the creek outfall. Bacteria samples were collected at four locations on a weekly basis when the facility is online, during dry weather periods only. Due to the semi-arid environment, the facility is in operation for the majority of the year, often extending into the wet season until January or February. Typically the facility is turned off for short periods of time only for storm events. The four routine monitoring locations are:

1. UV Influent – Upstream of the treatment facility, collected at the influent port prior to filtration.
2. UV Effluent – Downstream of the treatment facility, collected at the effluent port, after filtration and UV treatment.
3. Cottonwood Creek Mouth (EH-420 (-20)) – At the creek mouth prior to discharge to the surf zone.
4. Moonlight Beach Mixing zone (EH-420 (0M)) – In the mixing zone where Cottonwood Creek enters the Pacific Ocean.

A map of the routine monitoring locations is included as Figure 3.0.

Figure 3.0 Routine Monitoring Locations

In order to assess baseline bacteria conditions in Cottonwood Creek, bacteria samples were collected at the future location of the facility prior to construction. This data was used to supplement existing bacteria data to establish an accurate baseline for bacteria. Monitoring locations for the baseline data correspond to the Influent, Cottonwood Creek Mouth, and at Moonlight Beach in the mixing zone.

Weekly samples collected at the four monitoring locations allowed assessment of trends of bacteria concentrations upstream of the treatment facility, immediately after the treatment facility, creek outlet to the ocean, and in the mixing zone at Moonlight Beach. Samples collected at the influent and effluent ports to the facility assisted in process controls and operation and maintenance of the facility.

Overall, the monitoring at the four locations allowed the City to assess the effectiveness of the UV Facility in protecting public health by improving water quality and preventing or reducing the number of beach postings due to elevated bacteria levels at Moonlight Beach.

Turbidity data collected within the facility assisted the City in monitoring for illicit discharges or activities upstream of the facility. Flow data is also collected within the facility. Each of these parameters is monitored with instruments within the facility itself.

A special investigation study was also completed to assess bacteria regrowth and additional sources downstream of the UV Facility. This study consisted of 15 sampling locations downstream of the facility, each sampled during five separate events. This study is discussed in Section 6.0.

3.2 Sampling Methods

Bacteria samples are collected in accordance with methods established in Standard Methods for the Examination of Water and Wastewater, 20th Edition, Sections 9060 A and B. Samples collected in the mixing zone adhere to these methods and also follow guidelines established by the San Diego County Department of Environmental Health (DEH). Details of the sample collection and analysis methods are included in the Quality Assurance Project Plan.

All bacteria samples are grab samples collected in sterile bottles using sterile sampling techniques to reduce the risk of contamination. Influent and effluent samples are collected at sample ports within the treatment facility. The sample ports are visually inspected prior to sampling and tubing at the sampling ports is replaced regularly to ensure that the samples are representative. Samples collected at the creek mouth are taken at the headwall prior to discharge of the water to the sand beach. A sampling pole is used to assist in collection from the headwall. The mixing zone samples are collected according to DEH protocols, calling for collection in ankle to knee depth on an incoming wave. The samples are collected using a sampling pole to minimize contamination from the sampler. The mixing zone samples are generally collected in the morning to minimize the effects of natural UV light on bacteria counts.

Figures 3.1 and 3.2 Hach 1720D Nephelometer used to analyze turbidity in influent water.

Water from Cottonwood Creek is analyzed for turbidity near the influent sampling port within the facility. The nephelometer selected for the facility is plumbed inline with the intake structures and analyzes the creek water prior to filtration by the multimedia filters. The water entering the facility is continually analyzed for turbidity. See figures 3.1 and 3.2 above.

3.3 Analytical Methods

Bacteria samples are collected and analyzed for total and fecal coliform and enterococcus. Bacteria samples at all locations are analyzed using membrane filter techniques described in Standard Methods for the Examination of Water and Wastewater (S.M.), 20th Edition. The analyses are performed according to S.M. 9222B, 9222D, and 9230C for total coliform, fecal coliform, and enterococcus respectively. Results are reported in colony forming units per 100 milliliters of sample (cfu/100 ml).

Turbidity is analyzed according to Standard Methods for the Examination of Water and Wastewater, 20th Edition, Section 2130B, the nephelometric method. Results are reported in nephelometric turbidity units (NTU). The inline instrument for measuring turbidity is a Hach 1720D unit, commonly used in wastewater applications.

3.4 Data Collection, Management, and Analysis

The data is transmitted electronically from the laboratory to minimize transcription errors. This data is entered into a spreadsheet in Microsoft Excel 2003. The data templates utilized are designed to be compatible with others throughout the region to facilitate the storage and transfer of data within and between organizations.

The templates for the spreadsheet were developed by the San Diego Region Stormwater Copermittees, Coastal Monitoring Workgroup. The template was developed in accordance with guidance provided by the Southern California Stormwater Monitoring Coalition (SMC). This group is comprised of representatives from several Regional Water Quality Control Boards (Los Angeles, Santa Ana, and San Diego), municipal permittees, Heal the Bay, and the Southern California Coastal Water Research Project (SCCWRP).

All analyses were performed using the Statistical Package in Microsoft Excel 2003.

4.0 Results

4.1 Routine Monitoring

Routine monitoring for the UV Facility includes sample collection for baseline data and for system monitoring after construction. Monitoring consists of analyses for total and fecal coliform and enterococcus in routine samples. Data is also collected for turbidity in the creek and for flow through the UV Facility. The location of the routine monitoring stations is listed below in Table 4.0.

Table 4.0 Monitoring Locations

Baseline Data Collection	Post-startup Data Collection
1. Cottonwood Creek at Third and B Street	1. UV Influent
2. N/A	2. UV Effluent
3. Cottonwood Creek Mouth – EH-420 (-20)	3. Cottonwood Creek Mouth – EH-420 (-20)
4. Moonlight Beach Mixing Zone – EH-420 (0M)	4. Moonlight Beach Mixing Zone – EH-420 (0M)

Turbidity data is collected at sample location 1 and flow data is recorded at sample location 2.

Monitoring location 1 is in Cottonwood Creek at Third and B Street. After startup, this sample was collected at the influent sampling port within the facility. This sample is representative of untreated creek water.

Monitoring location 2 is representative of the treated creek water (UV effluent). This sample is collected inside the facility at the effluent sampling port. There is no correlating sample location for #2 in the baseline data.

Monitoring location 3 is at the creek mouth prior to entering the Pacific Ocean at Moonlight Beach. This location is representative of the creek after treated water is re-introduced and flows downstream to the beach. This water co-mingles with untreated creek water due to the required 15% bypass. Other small flows drain to the creek below location 3, primarily consisting of groundwater.

Monitoring location 4 is in the mixing zone at Moonlight Beach, in the Pacific Ocean, directly adjacent to the creek ("point zero"). This location is representative of the conditions in the surf zone after mixing of Cottonwood Creek with the Pacific Ocean.

A map of the monitoring locations is provided in Figure 3.0.

4.1.1 Baseline/Pre-construction Data

Baseline data for bacteria was collected prior to construction of the UV Facility in order to establish baseline, or ambient conditions in the creek and in the mixing zone in support of monitoring goal #1.

Goal 1: Establish baseline bacteria data prior to construction.

Samples were collected weekly beginning in May 2002 and continued until the start-up of the facility in September 2002. Three monitoring locations were selected to correspond with three of the four monitoring locations to be sampled after construction. Baseline data was collected at monitoring locations 1, 3, and 4 over 13 sampling events. All data baseline data collected as part of the project is included in Appendices C, D, and E.

The baseline data collected as part of the project represents only a snapshot of conditions in the creek and ocean during the summer of 2002. This set of data is relatively small in comparison to the set of data collected after the startup of the facility. In order to supplement the set of baseline data collected as part of the project, bacteria data collected prior to the onset of the project was included in parts of the analysis.

Table 4.1 contains geometric means of all of the data collected before the UV Facility was constructed. In addition to the baseline data collected as part of the project, data from 1999, 2000 and 2001 was added for a more complete baseline assessment.

Table 4.1 Baseline Bacteria Concentrations, 1999-2002
Geometric Mean Data (cfu/100 ml)

Monitoring Location Number	Location	Total Coliform	Fecal Coliform	Enterococcus
1	Influent (Third and B)	21,072	1,428	1,586
3	Cottonwood Creek Outlet (EH-420 (-20))	13,797	964	609
4	Mixing Zone (EH-420 0M)	67	23	14

Where this supplemental data was included, sample locations, collection methods, and analysis techniques were consistent with those utilized in this project. Additional data was included for monitoring locations 1, 3, and 4. This data allows for a more thorough comparison of water quality before and after implementation of the UV Facility. A discussion of the baseline data follows in Section 5.

4.1.2 Post Construction Data

Comprehensive Water Quality Data

Staff performed a one time comprehensive water quality monitoring of the influent and effluent for a comprehensive evaluation of the water quality before and after the treatment facility at the beginning of the project. Data collected for this evaluation is included in Appendix B. As expected with filtration of the water, turbidity was reduced by 74% and the total suspended solids were reduced by 64%. The increases the transmittance of the UV light through the creek water, allowing for a reduction of bacteria by >99.9%. There were no bacteria detected in the treated water. The only constituent that increased significantly from influent to effluent was ammonia-nitrogen. The concentration increased from 0.37 mg/l to 0.52 mg/l. Because this data is well below the action level (1.0 mg/l) for dry weather flows and there is no associated increase in bacteria, the rise in ammonia is considered negligible and was not investigated further. All other constituents remained consistent from influent to effluent demonstrating that there is no negative effect on the creek water by the selected treatment process.

Bacteria Data

Data for fecal indicator bacteria was collected after construction of the UV Facility in order to support monitoring goals 2, 3, 4, and 5.

Goal 2: Illustrate the effectiveness of the treatment facility in protecting public health and reducing beach postings.
Goal 3: Illustrate the trends of bacteria levels upstream of the facility, immediately after the treatment facility, creek outlet to the ocean, and in the mixing zone at Moonlight Beach.
Goal 4: Improvement of the operation and maintenance of the treatment facility through process control.
Goal 5: Monitor for illicit discharges upstream of the facility.

Upon start-up of the UV Facility, samples were collected three times per day for the first week and then daily for the first two months of the project, September and October 2002. Beginning November 2002, samples at all four locations were collected weekly. There were periods when the UV Facility was offline due to rain events and data was not collected.

Table 4.2 summarizes the number of samples collected at each monitoring location after start-up of the treatment facility. There were a few monitoring events in which only influent and effluent samples were collected for process control purposes.

Table 4.2 Number of Samples Collected Post Construction	
Location	**n=**
Influent (Third and B Street)	163
Effluent	163
Cottonwood Creek Outlet (-20)	156
Mixing zone (0M)	159

Table 4.3 summarizes the bacteria data collected at each monitoring location after start-up of the UV Facility. Geometric means were calculated for each month of data collection in which there were one or more samples collected. Typically the monthly geometric mean data was based on four samples. An overall site specific geometric mean was then calculated using all of the monthly data for that location. These results are presented below.

Table 4.3 Post UV Facility Construction Bacteria Geometric Mean Data (cfu/100 ml)				
Monitoring Location Number	**Location**	**Total Coliform**	**Fecal Coliform**	**Enterococcus**
1	Influent (Third and B Street)	16,155	1,432	773
2	Effluent	5	3	3
3	Cottonwood Creek Outlet (EH-420 (-20))	6,482	679	327
4	Mixing Zone (EH-420(0M))	52	16	10

This bacteria monitoring data collected after construction will be discussed in Section 5. Appendix F contains all routine monitoring data collected as part of the UV Facility project.

4.2 Beach Postings

The overall goal of the project is to protect public health for those recreating at Moonlight Beach by removing bacteria and viruses from the water in Cottonwood Creek, decreasing the concentrations of pathogenic organisms in the mixing zone, and thereby reducing beach postings. Postings at Moonlight Beach occur when bacteria concentrations exceed AB411 standards (Table 1.1). In order to assess the effectiveness of the project at reducing beach postings, annual beach posting data beginning in 2000 and continuing through 2005 was compared. This data is collected from the San Diego Department of Environmental Health Annual Beach Closure and Advisory Reports.

Beach postings have shown a decreasing trend since the inception of the project. With the startup of the facility in 2002, beach postings dropped to zero in that year. Since then, postings during dry weather have averaged just over six days per year, a 91% reduction since the high of 73 days in 2000. Days in which Moonlight Beach was posted within 72 hours of a rain event were not included in the totals below. On these instances, the rain triggered shut-down of the facility as it is designed to treat only dry weather flows, therefore these postings were not preventable with the project. The table below contains annual beach posting data at Moonlight Beach from 2000-2005.

Table 4.4 Beach Postings at Moonlight Beach during Dry Weather (2000-2005)	
Year	Days Posted
2000	73
2001	12
2002	0
2003	8
2004	12
2005	6

A second method used to complement beach posting data to assess the effectiveness of the UV Facility in protecting public health is to study the number of samples in the mixing zone which exceed State AB411 standards. This monitoring location, #4, is permanently posted with metal signs warning of the risks associated with swimming near the creek mouth. The exceedance ratios at this location were compared from year to year to demonstrate an improvement in overall water quality at Moonlight Beach following the implementation of the UV Facility.

Water quality at monitoring locations 1, 3, and 4 will also be compared before and after the UV Facility was constructed. Examing the before and after data and the annual data allows for illustration of changes in water quality at the three locations and how each may have affected the other locations downstream.

4.3 Seasonal Trends

The monthly geometric mean data for each location was also used to identify seasonal bacteria trends at each monitoring location. The monthly geometric mean data was divided further into distinct seasonal data with each season represented by the months indicated below in Table 4.5.

Table 4.5 Seasonal Bacteria Trends Based on Monthly Data	
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November
Winter	December, January, February

Calculations for the seasonal geometric mean data were based on the monthly geometric mean data. Data from each season was then combined over the four year study period to calculate an overall seasonal geometric mean for spring, summer, fall, and winter. Mean calculations for spring, summer, and fall were all based on four seasons of data collection. Winter mean calculations were based on three years of data collected at the influent monitoring location, and four seasons of data collection at the creek mouth and mixing zone locations. The UV Facility was offline during the entire winter season for 2002-2003 resulting in no sample collection during this period. The fourth winter season will be collected this year. Table 4.6 includes the seasonal geometric mean data calculated over four years of monitoring.

Table 4.6 Seasonal Geometric Mean Data (cfu/100 ml)

	Season	number of seasons (data points)	Total Coliform	Fecal Coliform	Enterococcus
Influent	Spring	4 (27)	20,629	1,222	471
	Summer	4 (53)	14,299	1,840	825
	Fall	4 (81)	21,669	2,062	1,328
	Winter	3 (15)	9,374	339	258
Creek Mouth	Spring	4 (26)	7,621	555	207
	Summer	4 (53)	8,963	1,049	475
	Fall	4 (75)	5,652	828	465
	Winter	4 (15)	6,373	270	127
Mixing Zone	Spring	4 (26)	46	11	8
	Summer	4 (53)	42	5	7
	Fall	4 (78)	57	22	12
	Winter	4 (15)	114	30	28

At locations monitored in the creek (influent and creek mouth), mean bacteria concentrations increase from spring to summer to fall, and then a reduction is observed in the winter. At the beach, in the mixing zone, the bacteria levels are low in the spring and summer, increasing into the fall, and peaking during the winter months. The data is represented graphically and discussed further in Section 5.

4.4 Biological Monitoring

A biological study was performed on Cottonwood Creek and the surrounding habitat in order to determine if the facility had an effect on the biological health of the creek. The study was conducted in three phases: field habitat reconnaissance was performed in October 2001, pre-project stream bioassessments on Cottonwood Creek was performed in May 2002, and post-project stream bioassessments were performed in October 2003.

The focus of the habitat reconnaissance was to map vegetation and habitats and to prepare a list of wildlife observed. The bioassessments consisted of two evaluations: a physical habitat assessment and benthic invertebrate measurements. The study assessed habitat quality parameters to provide an indication of the overall physical condition of the reach. Parameters such as substrate complexity, channel alteration, frequency of riffles, width of riparian zones, and vegetative cover were quantified to allow for a more comprehensive assessment of the reaches of the creek upstream and downstream of the project. In combination with other measures such as physical habitat and water quality assessments, the assessment of the invertebrate community of Cottonwood Creek allows for a cumulative measure of the stream habitat health. (Weston, 2005)

Biologists followed the sampling and analysis protocols of the California Stream Bioassessment Procedure (CSBP) (Harrington, 1999). CSBP is a standardized procedure developed for California that was adapted for the USEPA Rapid Bioassessment Protocols (Barbour et al., 1999).

Pre-Project Surveys

The first pre-project survey was performed on October 2001. This study was a biological reconnaissance and concluded that the survey area was predominated by degraded wetland and upland habitats that are characterized by invasion of non-native species. No sensitive or otherwise listed species were observed or detected during the cursory field reconnaissance of the site. The creek banks were overgrown with fig-marigold and morning glory with one small cluster of arroyo willow. The creek bed was characterized by freshwater marsh vegetation. (MEC, 2001)

The second pre-project survey was a more complete Biological Study and was performed in May of 2002. Bioassessments were performed up and downstream of the facility with three replicates collected at each location. Upstream and downstream sites were found to be quite similar during this assessment, in both physical habitat scores and in benthic invertebrate metrics.

The total Physical Habitat Scores were found to be 93 and 95 in the upstream and downstream reaches, respectively. The scores are very similar, although the primary difference is related to lower bank stability in the two locations with the upstream banks being less stabile. Several benthic invertebrate metric were assessed including Species Diversity and Dominance, EPT Taxa, Tolerance Measures, Functional Feeding Groups, and Estimated Total Abundance. Species Diversity is assessed using measures of Cumulative Taxa (total number of unique species for the three replicate samples) and Taxa Richness (the average number of individual taxa collected across the replicates), among others. The taxa richness was nearly equal for the upstream and downstream sites and was found to be 12.67 and 12.33, respectively. The cumulative taxa value was 18 for both sites. For the majority of stream macroinvertebrates, a tolerance value has been established through prior research, ranging from 0 for those species highly sensitive to impairment to 10 for those which are highly tolerant to impairments. However, the presence of impairment tolerant animals does not always imply impairment (SDRWQCB, 2001). Both sites were characterized by taxa with moderate to high tolerance ranges. The overall tolerances for the two sites were also similar with the upstream overall tolerance level being 5.86 and downstream at 6.17. Overall, the reaches of Cottonwood Creek assessed upstream and downstream of the project site are very similar in physical characteristics and benthic macroinvertebrate composition. (MEC, 2002) All results for the pre-project survey are included in Appendix G.

Post-Project Survey

The post-project survey was performed in October 2003 which included a physical habitat assessment and a benthic macroinvertebrate assessment. As with the assessment in May 2002, the 2003 assessment found that the upstream and downstream sites have similar physical habitat characteristics and similar benthic invertebrate metrics. The total Physical Habitat Scores were found to be 114 in the upstream and 109 in the downstream reaches. The mean Taxa Richness and Cumulative Taxa Values for the upstream and downstream sites were found to be 9 and 10, respectively. The overall tolerances for the two sites were also similar with the upstream overall tolerance level being 6.9 and downstream at 7.4.
In addition, an Index of Biotic Integrity (IBI) was calculated for the 2003 assessment. The IBI was developed by the California Department of Fish and Game and is applicable to the region extending from Monterrey County to the Mexican Boarder. In order to have a more site specific IBI, an index for Southern California was published in 2003 and was used to calculate IBI scores for the survey in October 2003. The IBI is a multi-metric index based on the cumulative value of

seven biological metrics used to assess the overall health of the benthic community in the stream. The IBI score was substantially higher downstream of the project sight, as calculated in 2003. The upstream IBI = 3 while the IBI downstream = 11. The downstream site had a lower percentage of non-insect taxa and a lower percentage of tolerant taxa indicating a relatively healthier benthic community downstream of the project. (MEC, 2003) All results for the post project survey are included in Appendix H.

4.5 Monitoring for Process Control (Operations and Maintenance)

Several parameters are monitored regularly to assist in process controls at the UV Facility. The purpose of this monitoring is to assess the efficiency of the system and assure that it is functioning properly and to capacity. Process control monitoring helps maintenance personnel identify and correct problems, enhancing the effectiveness of the treatment facility. Monitoring for process control includes bacteria monitoring of influent and effluent, turbidity monitoring, and flow monitoring.

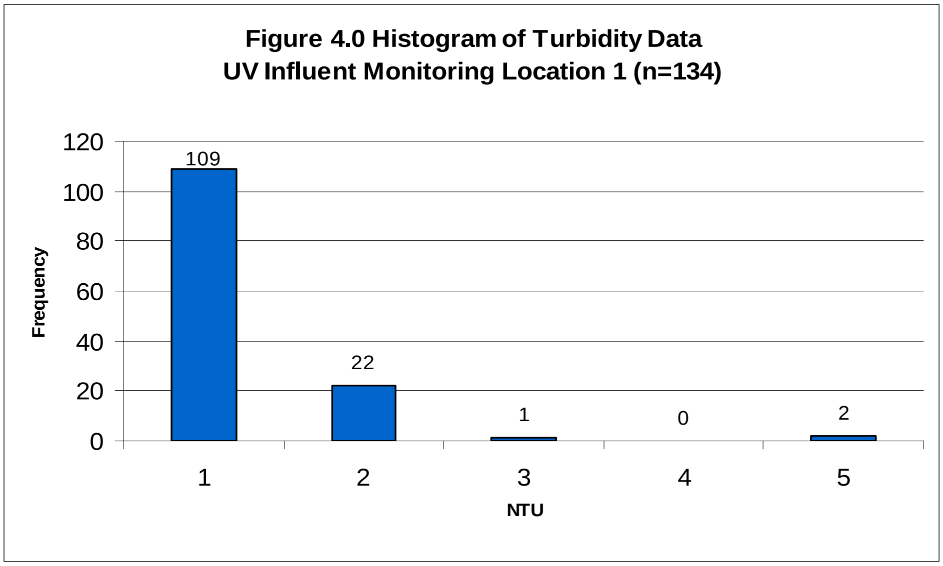
Bacteria monitoring includes sampling for total and fecal coliform, and enterococcus at the influent and effluent monitoring stations. This data allows for calculations of bacteria concentrations entering the facility and bacteria concentrations discharged from the facility in the treated water. From this data, removal efficiencies are calculated for each indicator. Under normal conditions, where relatively clean, clear water is filtered and treated within the UV Facility, removal efficiencies of >99% were obtained consistently. Typically all bacteria was removed from the treated water; lab data was generally <4 cfu/100 ml in the effluent samples. Removal efficiencies of bacteria in the water treated at the UV Facility are shown in Table 4.7 below.

Table 4.7 Bacteria Removal Efficiencies from Influent to Effluent (n=159)

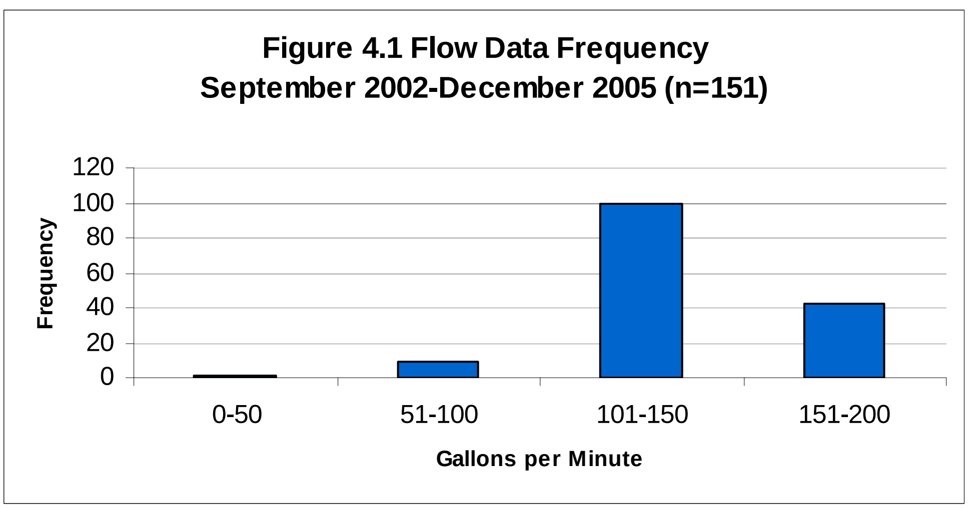
Total Coliform	Fecal Coliform	Enterococcus
99.97%	99.79%	99.64%

Turbidity data was also collected to assist in process control. An inline Hach 1720D nephelometer was utilized to continually monitor turbidity in the influent. Water in Cottonwood Creek is clear, with turbidity <5 NTU. An increase in the turbidity over 5 NTU was considered abnormal and was most often attributable to rain or to an illicit discharge upstream. Turbidity data was collected continually and is available for the past 30 days on the Hach instrument. This was used primarily for process controls. During each monitoring event, the turbidity was noted on the field data sheet. This data is provided in Appendix I. The mean turbidity for the influent in Cottonwood Creek is 3.60 NTU over the since the startup of the facility. This is based on a sample size of 126 and includes data from rain events and illicit discharges when the facility was online. Maintenance issues with the nephelometer occasionally prevented data collection, hence a smaller data set than used in the bacteria monitoring.

Figure 4.0 presents turbidity data collected at the UV Influent monitoring location. Rain events were not often captured as the facility is usually off during these periods; therefore most readings are of ambient conditions in Cottonwood Creek.



Increases in turbidity often resulted in changes in the amount of flow through the facility. There is a direct relationship between the flow in the creek and the turbidity. However, the relationship between flow through the facility and turbidity is inverse. As the flow in the creek rises, the turbidity rises, and the ability of the facility to filter the water decreases, thereby decreasing flows through the facility. Flow is measured on the downstream side of the multimedia filters and is continually logged onto the Program Logic Control (PLC) in the facility. This flow data was monitored daily for process control. Flow measurements were recorded weekly during routine monitoring. Flow measurements were recorded during routing monitoring 151 times. The average flow of treated water was 134 gallons per minute (gpm). The facility is designed to operate at 150 gallons per minute. The lower flows were often a result of increased turbidity and obstructed filters. The greatest volume of flow through the facility was 175 gallons per minute. Figure 4.1 illustrates the frequency of flow volumes through the facility during routine monitoring.



Of 151 flow measurements recorded, 141 (93%) were greater than 100 gallons per minute. Most often, 66% of the time, flows ranged from 101-150 gallons per minute. Average flows in Cottonwood Creek are on the order of 150 gpm, with the facility designed to treat 85% of these flows, or 128 gpm. With an average flow of treated water at 134 gpm over the monitoring period, it is apparent that the facility was functioning as designed for the majority of time, reducing the bacteria in treated water by >99% for 85% of the flows in Cottonwood Creek. The most common cause of decreases in flows through the UV Facility was algal blooms in the creek. Often in the summer months mats of brown algae are present on the creek bed and tend to obstruct the intakes to the facility. During these times, increased maintenance of intake screens and increased back flushing of the multimedia filters are necessary to maintain the desired volume of flow through the facility. All flow data is included in Appendix J.

Routine monitoring of bacteria concentrations and turbidity allow City staff to detect and track illicit discharges. Elevated bacteria concentrations usually do not result in immediate detection of the illegal discharge, as turn around times for bacteria data are generally 24 hours. However, on several occasions, spikes in turbidity readings at the facility triggered immediate upstream source investigations. These investigations often led staff to find and eliminate sources of pollution such as illegal sediment discharges from construction sites. Dewatering operations were often the cause of turbidity spikes.

5.0 Discussion

5.1 Baseline Bacteria Data (1999-2002)

Baseline data was collected weekly as part of the project, with sampling initiated in May 2002. Thirteen baseline samples were collected and analyzed for total and fecal coliform and enterococcus.

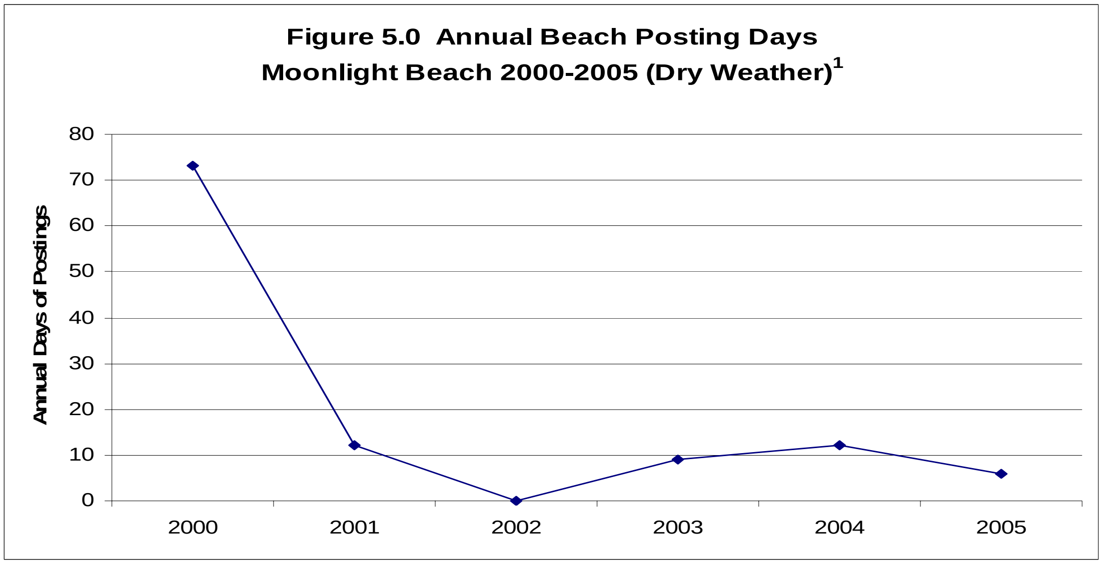
Although this baseline data presents a picture of bacteria concentrations in Cottonwood Creek and at the mixing zone, the set of data is relatively small when compared to the data collected post construction. In order to supplement this data, bacteria data collected prior to the project is included in the set of baseline data. Data is available for sample locations 1, 3, and 4 and is helpful in evaluating baseline conditions before the construction of the UV Facility. This additional data was included to provide a better picture of conditions in the creek and mixing zone prior to BMP implementation. Exceedance rates for the pre-construction monitoring data in the mixing zone were 11.4% in 2000 and 7.4% in 2001, averaging 9.4% over the two years preceding construction of the facility.

5.2 Protection of Public Health

The main objective of the project is to protect public health by improving water quality at Moonlight Beach thereby reducing beach postings. The protection of public health can be shown by a reduction in beach postings and by an improvement in water quality. Both methods show an overall improvement from 2000-2005.

Beach Postings

As shown in Figure 5.0, the number of days Moonlight Beach was posted annually due to exceedances in routine monitoring has been on a downward trend since peaking in 2000. Included in the original DEH data are instances where samples were collected following isolated rain events in the North County. Due to the localized nature of these storms, a general advisory was not issued across the County. Instead routine monitoring continued and as expected, the samples collected following rain exceeded AB411 standards. The beach was posted within 72 hours of a significant rain. These events were excluded from the graph below.



[1] Data was collected from the San Diego County Department of Environmental Health's Annual Beach Closure and Advisory Reports. Postings within 72 hours of a rain event were excluded.

As indicated above, annual days of beach postings at Moonlight Beach have been declining since 2000 averaging 42.5 days in the two years preceding construction and 6.5 days of postings annually after construction. This illustrates that one of the major objectives of the project, reducing beach postings, has been achieved since its inception.

There are many factors which may have contributed to this reduction in beach postings. The contributing factors fall into two clear categories: changes (improvements) in water quality and changes in regulatory requirements.

The improvements in water quality are attributable to several structural and non-structural BMPs implemented in the watershed during this time period. The two most significant BMPs implemented include the UV Facility and the construction of Cottonwood Creek Park. The park is located upstream of the UV Facility and includes a detention basin and daylighting of a length of the creek previously underground in storm drain pipes. The new park was constructed in 2003 and has reduced the amount of bacteria entering the UV Facility downstream. The remaining bacteria in the creek water are then eliminated by the filters and ultra-violet light in the UV Facility.

In addition, the reduction in beach postings since 2000 is attributable to a change in regulatory requirements. In 2000, with the introduction of AB411, more stringent requirements to post beaches when bacteria concentrations exceed standards were implemented. Enterococcus was also added with the bill, as it has been shown to be a good indicator of water quality in marine waters (Cabelli, 1983). The year 2000 was the first full year that the San Diego County Department of Environmental Health implemented the new regulations in their monitoring program. (San Diego County Department of Environmental Health, San Diego County Beach Closure and Advisory Report, 2000.) During this monitoring period, samples were collected in the mixing zone where the creek enters the ocean. The location corresponds to monitoring location 4 for this project.

In 2001, the Department of Environmental Health changed its sampling protocol for shoreline sampling at storm drain outlets. In an effort to be consistent with other monitoring programs in the region, and based on the recommendation of the State Water Resources Control Board Beach Water Quality Workgroup, the sampling location was changed. Originally located at the mixing zone, the sampling location was changed to 25 yards down current from the mixing zone where the storm drain or creek flows enter the ocean. With this change, permanent metal health risk warning signs were posted at the mouth of Cottonwood Creek. (San Diego County Department of Environmental Health, 2001) As originally designed, prior to 2001, samples were collected at the creek mouth (location 1) where water quality is presumably worst. New sampling design, accompanied by permanent advisory signs at the creek mouth, requires that samples are collected 25 yards down current. Because of the dilution of the creek water and bacteria die-off due to sunlight and saline conditions, the water quality 25 yards down current likely has lower concentrations of bacteria than at point zero (creek mouth). The decrease in posting days from 2000 to 2001 is at least in part due to the change in sample location. For this reason, it is difficult to assess improvement in water quality though beach posting data alone, actual changes in bacteria concentrations are a better assessment of the change in water quality in the creek and mixing zones.

Water Quality Improvements

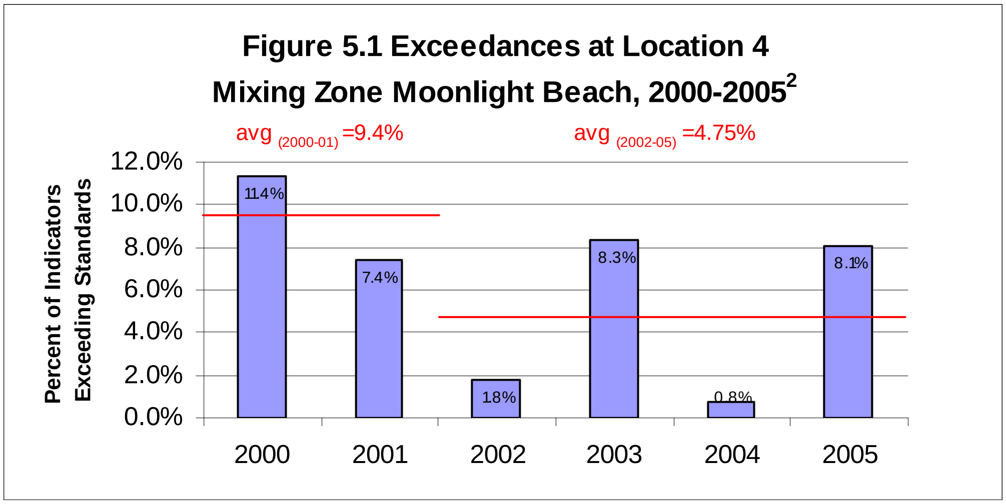
The differences in water quality pre and post BMP implementation were evaluated to further assess the efficacy of the UV Facility. The bacteria at Location 2 (UV Effluent) is reduced by >99% from the influent. This data is essential for process control and is considered further in the special study but is not used in measuring the overall change in creek and ocean water quality.

Changes in water quality were examined in two ways. First, annual AB411 exceedance ratios were calculated. These ratios, or rates of exceedances, are equal to the percentage of analytes of the total exceeding water quality standards. A second method of observing changes in water quality is in studying the numeric water quality data collected before the implementation of the UV Facility and after implementation. This is most effective when comparing the before and after sets of data at monitoring stations 1, 3, and 4.

Exceedance Ratios

Because of regulatory changes in monitoring location, it is useful to compare water quality changes at the mixing zone over the study period to supplement the finding of a reduction in beach postings. Data was collected by the stormwater program at the City during 2000 and 2001 as a part of a study to determine the relationship of the creek fecal indicator bacteria (FIB) concentrations to the mixing zone FIB concentrations. This data was collected at the mixing zone (monitoring location 3) where the creek enters the ocean and is used to compare before and after water quality exceedance ratios at this location.

Figure 5.1 illustrates the annual percentage of analyses collected in the mixing zone that were above Rec-1 water quality standards (AB411).



[2]The exceedances after the year 2000 were in the mixing zone, after the permanent metal signs were posted at the creek mouth. Because the mouth of the creek was posted with permanent metal signs, these exceedances did not result in beach postings. Therefore, this exceedance data is not necessarily reflective of the San Diego Department of Environmental Health posting data in Figure 5.0. The exceedance data was obtained from the City of Encinitas sampling data before and after the project.

The data presented in the figure above indicates an improving trend in water quality in the mixing zone at Moonlight Beach, as the numbers of exceedances have declined since the inception of the project. In 2000, more than 1 in 10 indicators analyzed in the mixing zone (monitoring location 4) were above standards. In this year, these exceedances resulted in postings at Moonlight. In the two years preceding the project (2000, 2001), exceedance ratios averaged 9.4%. In the years following, the percentage of exceedances in the mixing zone declined. Although this correlates with the data in the beach posting Figure 5.2.1, exceedance ratios are more indicative of an improvement in water quality in the mixing zone, because the sample location remains constant throughout the data set. The average annual exceedance ratio since the inception of the project (2002-2005) is 4.75%. This reduction in exceedances is indicative of decreasing bacteria concentrations in the mixing zone, i.e. improving water quality. Understanding that these exceedances in the mixing zone are attributable to a variety of sources, eliminating bacteria from urban runoff has decreased water quality exceedances in the mixing zone by approximately 50% (9.4% to 4.75%). The exceedances that continue to occur are likely attributable to sources other than urban runoff and are further discussed in Section 6.

Water Quality Data

Comparisons of annual data and data collected before (2000 through August 2002) and after (September 2002 to present) BMP implementation are useful in determining the effectiveness of the UV Facility in improving water quality. This data has been collected across all six years at three of the monitoring locations: influent (location 1), creek mouth (location 3), and mixing zone (location 4). In the following section, data collected before implementation of the UV Facility and data collected after implementation of the UV Facility is discussed for each station monitored.

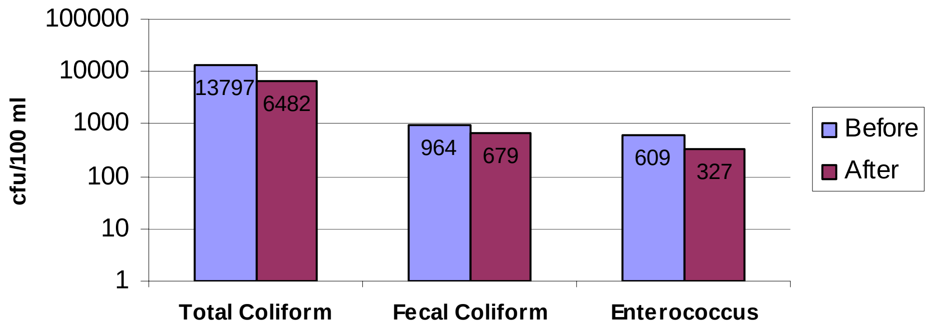
Data collected before and after the project is presented in Table 5.0.

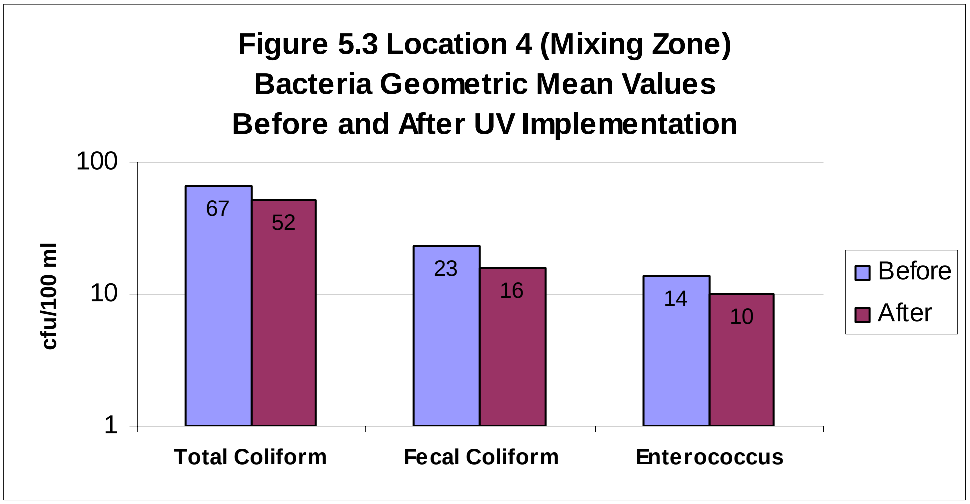
Table 5.0 Observed Geometric Mean Values: Monitoring Locations 1,3, and 4 (Before and After Inception of the UV Facility) cfu/100 ml			
	Total Coliform	**Fecal Coliform**	**Enterococcus**
		Location 1 (Influent)	
Before	21,072	1,428	1,586
After	16,155	1,432	773
		Location 3 (Creek Mouth)	
Before	13,797	964	609
After	6482	679	327
		Location 4 (Mixing Zone)	
Before	67	23	14
After	52	16	10

This data shows that there have been reductions at all three sampling locations from 2000 to 2006. Samples collected from location 1 are upstream of the UV Facility. Reductions in FIB concentrations at this location are reflective of BMP implementation upstream of the UV Facility and effectively change the bacteria concentrations at the control of the study. Although this causes a reduction of bacteria into the facility, the efficiency of bacteria removal from the influent to effluent at the facility is >99% before and after construction of Cottonwood Creek Park. With the effective pathogen removals at the facility in 85% of the flows, the park further assists in reducing the bacteria in the 15% of the flows that bypass the facility.

There are significant reductions in FIB at monitoring locations 3 and 4 as well, as shown in Figures 5.2 and 5.3. Each location is affected by reductions in bacteria upstream of the UV Facility and reductions at the UV Facility. The elimination of the bacteria in treated water at the treatment facility is effective in reducing bacteria concentrations at the creek mouth and in the mixing zone.

Figure 5.2 Location 3 (Cottonwood Creek Mouth) Bacteria Geometric Mean Values Before and After UV Implementation





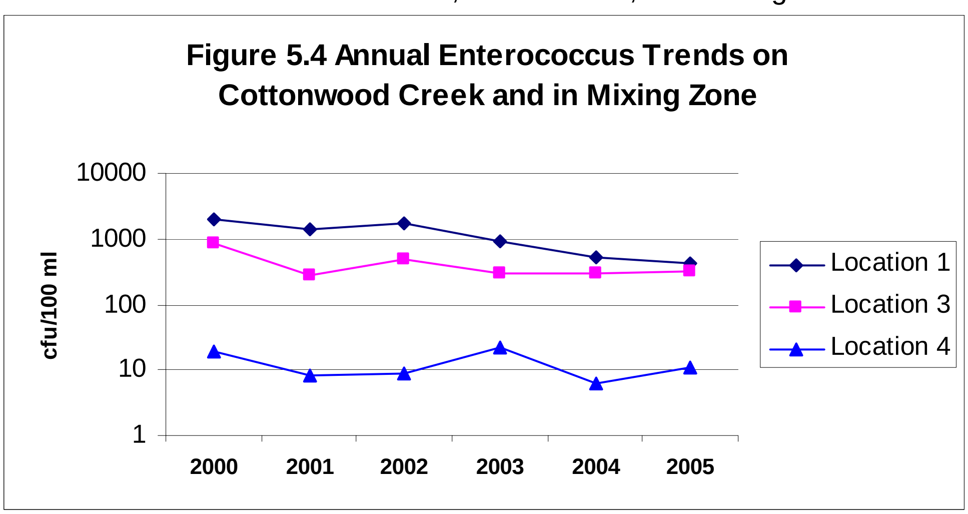
Percent FIB reductions at these three sampling locations are presented in the Table 5.1.

Table 5.1 Percent Reduction in Fecal Indicator Bacteria Before to After UV Implementation

Location	Total Coliform	Fecal Coliform	Enterococcus
1 (Influent)	23%	0%	51%
3 (Creek Mouth)	53%	30%	46%
4 (Mixing Zone)	22%	30%	29%

The percent reductions are supportive of the goals of the project, in that FIB concentrations were reduced for all three indicators in the creek and in the mixing zone. This reduction is indicative of an overall improvement in water quality, as supported by fewer beach postings in the recent years and a reduction in FIB exceedances at the mixing zone in recent years.

In order to further understand the effects of the structural BMPs implemented during the study time period, annual FIB concentrations for each indicator at each sampling location were calculated and graphed. Because the majority of water quality exceedances are caused by enterococcus, these figures are presented first. Figure 5.4 illustrates the reduction in concentrations of enterococcus at the influent, creek mouth, and mixing zone.



These reductions in enterococcus at the influent and at the creek mouth led to a reduction in FIB concentrations in the mixing zone, also illustrated in the figure. Of note is the spike in enterococcus concentrations in the mixing zone in 2003 that is not present in the sampling locations on the creek. This suggests that factors other than the creek may be responsible for the increases in FIB concentrations in the mixing zone.

Figures 5.5 and 5.6 correspond to Figure 5.4 above. These are similar graphs using total and fecal coliform data trends in Cottonwood Creek and in the mixing zone and show similar results.

Figure 5.5 Annual Total Coliform Trends on Cottonwood Creek and in Mixing Zone

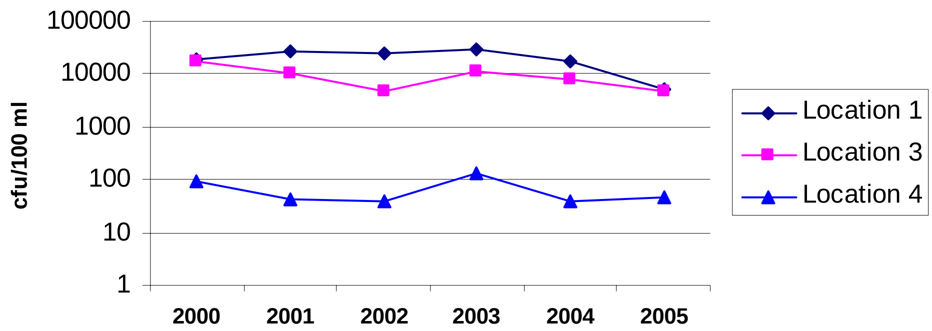


Figure 5.6 Annual Fecal Coliform Trends on Cottonwood Creek and in Mixing Zone

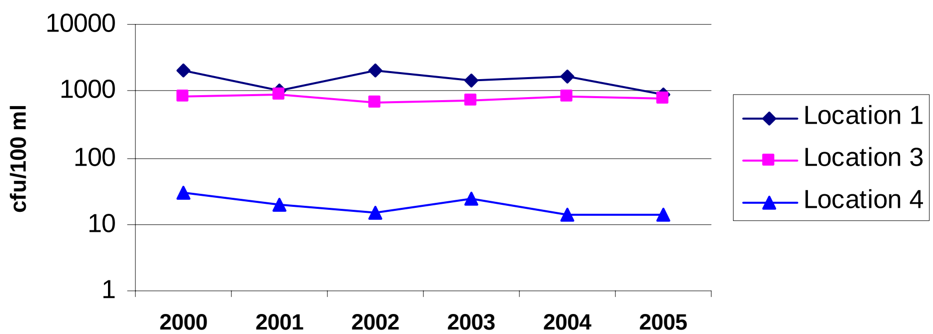


Figure 5.4 shows annual reductions in enterococcus concentrations at monitoring location 1. The construction of Cottonwood Creek Park began in 2003 and was complete in 2004. In the park, urban runoff is collected in a detention basin prior to flowing into an open natural channel. Prior to the construction of the park, the creek flowed directly into a 96” underground storm drain through this section. Improvements in water quality are observed by the decrease in bacteria concentrations over the study period upstream of the facility, likely attributable to the new park.

Photographs of Cottonwood Creek Park are included below as Figures 5.7 and 5.8.


Figure 5.7 Detention Pond at Park.

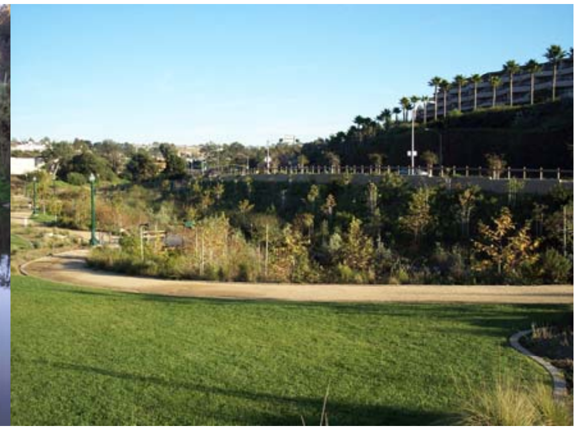


Figure 5.8 Daylighted open channel at Park.

The data presented above illustrate two key points supporting the success of the UV Facility. With the goal of protecting public health by improving water quality and reducing beach postings at Moonlight Beach, the data collected shows that the goal was achieved. It is apparent from the beach posting data that postings at Moonlight Beach, although they continue to occur, have declined 85% since the inception of the project. Although this reduction is evident, it may be attributable to several factors including:

1. bacteria removal at the UV Facility
2. the construction of Cottonwood Creek Park
3. the stormwater program
4. the change in regulatory requirements (AB411) sampling locations.

These factors, particularly the change in regulatory requirements, make it difficult to assess the efficacy of the project with beach posting data alone.

In order to compensate for the regulatory change in monitoring location and its effect on assessing changes in water quality at Moonlight Beach, past data at all three monitoring locations were included in the water quality assessment. Examining water quality data in the mixing zone, all collected at the same location, allows for a more accurate assessment of the changes occurring over the study period. Water quality data collected from 2000 through 2005 shows that reductions are evident for all three indicators at all three sampling locations, two in Cottonwood Creek and one in the mixing zone at Moonlight Beach. The improvement in water quality due to the reduction in FIB at the influent, creek mouth, and mixing zone locations are likely due to the combination of BMPs implemented upstream in the watershed.

Data from 2003 suggests that a lack of rainfall in the preceding year may have contributed to a buildup of debris in the storm drain system leading to elevated bacteria levels at the stormdrain outfall and in the mixing zone. A lack of rainfall, coupled with reduced treated flows at the UV Facility, and natural sources of bacteria on the beach (i.e. wrackline, birds, and sediment) at the creek mouth may have all contributed to the increase in FIB exceedance ratios and bacteria concentrations in 2003. Appendix K includes all rainfall data as collected in Encinitas for 2000-2005.

Exceedances in the mixing zone in 2003 triggered a special bacteria study of the final segment of Cottonwood Creek, downstream of the UV Facility, prior to entering the mixing zone. Results and conclusions of the study are discussed below in Section 6.0.

5.3 Bacteria Data and Seasonal Trends

One of the goals of the monitoring program is to assess seasonal bacteria trends in the creek and in the mixing zone. With approximately 150 samples collected at four locations, seasonal trends are evident. For the analysis a seasonal geometric mean was calculated across all four years of data collection. Table 4.8 summarizes the geometric mean data calculated for each sample location: influent, -20, and 0M.

Figures 5.9 and 5.10 illustrate the bacteria trends in Cottonwood Creek for total and fecal coliform and for enterococcus concentrations. In each figure, the concentrations of fecal coliform and enterococcus remain proportional in the creek from season to season. At both locations on the creek (influent and -20), bacteria concentrations rise throughout the year, from spring to summer and summer to fall. The concentrations in the creek peak in the fall months, with consistent elevated bacteria counts in samples collected in September from year to year. In the winter months at each location, bacteria levels decrease below spring concentrations.

Figure 5.9 Seasonal Bacteria Trends
Monitoring Location 1 (Influent) on Cottonwood Creek
(2000-2005)

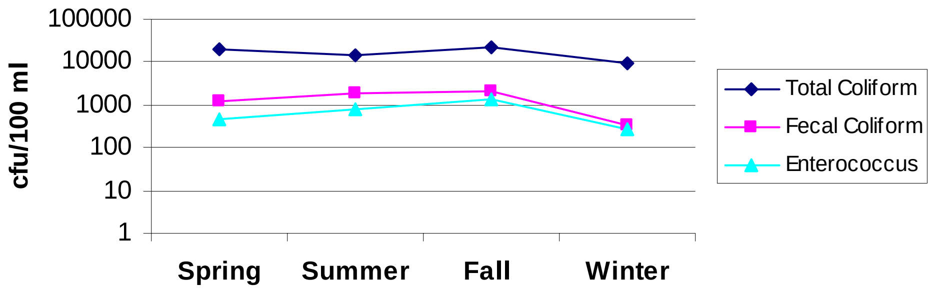


Figure 5.10 Seasonal Bacteria Trends
Monitoring Location 3
Cottonwood Creek Mouth at Moonlight Beach
(2000-2005)

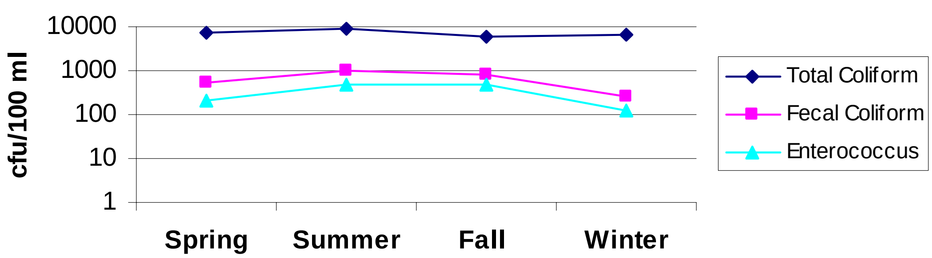
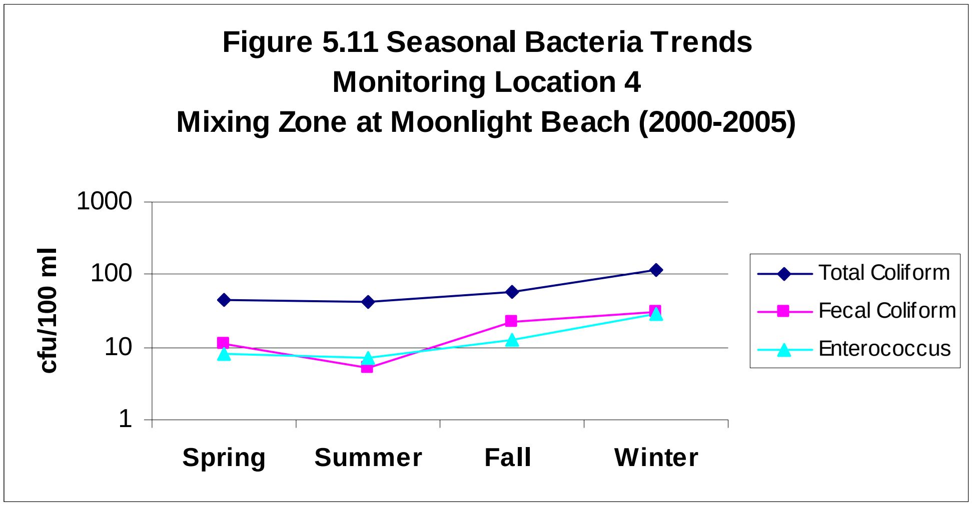


Figure 5.11 illustrates the bacteria trends in the mixing zone. These concentrations mimic the bacteria trends in the creek, rising from spring to summer and into the fall. However, where

concentrations in the creek decline in the winter, a steady increase is apparent in the mixing zone through the winter season, returning to lower levels in the spring.



These trends correlate to the theory of bacteria regrowth in Cottonwood Creek. The bacteria concentrations are lowest in the spring and rise through summer and fall. There are three full seasons where regrowth of bacteria in the creek is evident. As winter rains begin, bacteria concentrations are reduced as debris and bacteria are washed into the mixing zone. This directly supports the observed seasonal trends in the mixing zone, in that bacteria concentrations increase through the year, from spring to fall, correlating with the increase in bacteria concentrations in the creek. As the bacteria concentrations are reduced in the creek due to the winter rains and wash off, the concentrations in the mixing zone peak. The bacteria build-up in the creek is washed directly to the mixing zone where the highest seasonal concentrations are observed. As winter rains continue, the creek and storm drains are cleaned of bacteria and debris, resulting in lower bacteria concentrations in the creek during the winter going into spring. The mixing zone also recovers during this time, as bacteria concentrations in the mixing zone decrease with the end of the rainy season.

5.4 Monitoring for Process Control (Operations and Maintenance)

Samples were collected for process control purposes at the influent and effluent monitoring locations. Table 4.5 contains the removal efficiencies calculated from influent to effluent based on 153 pairs of samples. Expected bacteria concentrations in the effluent were generally <4 cfu/100, indicating that all of the bacteria in the treated water was removed. When effluent bacteria concentrations were elevated, there were often problems with the operation of the facility.

Possible problems associated with increased bacteria in the effluent include:

- Increased bacteria loading in the creek indicative of rainfall or illicit discharges
- Obstruction of multimedia filters
- Increased turbidity in the influent associated with rainfall or illicit discharges
- Decreased performance of UV bulbs, bulbs burnt out.
- Decreased performance of UV bulbs due to wiper problems.

A rise in effluent bacteria concentrations is indicative of the inability of the UV light to fully treat the water flowing through the system. This reduced effectiveness in treatment was usually caused by an increase in turbidity of the water in Cottonwood Creek. Increased turbidity causes light to be scattered and absorbed rather than transmitted through the sample (S.M. 2130, 2-8) Effective treatment with ultra-violet light largely depends on relatively high levels of transmittance in the water. Reasons for increased turbidity in the creek are either rain or illicit discharges upstream. Rises in turbidity were noted when the facility was on during periods of rain. Occasionally, increases in turbidity were noted during dry weather periods. This typically indicated an illicit discharge upstream. If the facility was online during a rain event, the turbidity was usually greater than 20 NTU indicating that dirty water was running through the facility.

Increased turbidity in the influent was detected at the nephelometer and often resulted in increased bacteria in the effluent and reduced flow volumes through the facility. The increased turbidity often resulted in obstructed multimedia filters triggering increased back flushing.

When flows were continually reduced and bacteria concentrations were consistently increased in the effluent, the multimedia filters were usually obstructed. When back flushing of the filters was not enough to remedy to problems, the filters were generally shock treated with chlorine. The shock treatments were part of the routine maintenance.

Maintenance issues with bulbs and wipers were evident due to increased bacteria and were also indicated on control panels within the facility. Bulbs and wiper motors were replaced as necessary.

6.0 Special Bacteria Study Downstream of UV Facility

With completion of the ultra-violet facility in late August 2002, 85% of the dry weather flows in Cottonwood Creek are rendered free of bacteria and re-introduced to the creek downstream of Third Street. However, through weekly bacteria monitoring, as prescribed for the UV Treatment Facility, the City has determined that additional sources of bacteria are contributing to the degradation of water quality to the west (downstream) of the Facility.

Although beach postings were reduced with the UV Facility, there continues to be periodic exceedances of State water quality standards in the mixing zone. After approximately one year of data collection, the City has observed occasional elevated bacteria concentrations at the mouth of the creek and in the mixing zone, while obtaining nearly 100% bacteria kills in the water entering the treatment facility. Over the first year of data collection, there were seven AB411 exceedances in the mixing zone while the UV Facility was in operation. One of the seven was for fecal coliform while six of the exceedances were for enterococci concentrations. The percent reduction in bacteria in the treated creek water is greater than 99% for all three indicator bacteria. However, overall reduction in bacteria from the UV Influent (monitoring location 1) to the mouth of Cottonwood Creek (monitoring location 3) is not as large. Table 6.0 summarizes the percent reduction in bacteria concentrations from the influent (location 1) to the mouth of Cottonwood Creek (location 3), prior to entering the Pacific Ocean.

Table 6.0 Bacteria Removal Efficiencies
Influent (n=159) to Creek Mouth (n=152)

Total Coliform	Fecal Coliform	Enterococcus
59.87%	52.59%	57.75%

Because of these spikes in bacteria concentrations in the mixing zone, the City of Encinitas initiated this study to further understand the bacteria influences in the western portion of Cottonwood Creek. This special bacteria study consisted of five intensive monitoring events from October 2003 to December 2004 in an effort to characterize possible bacterial sources impacting water quality in Cottonwood Creek downstream of the UV Facility, prior to discharge to the Pacific Ocean. Figure 6.0 illustrates the study area downstream of the UV Facility.

Figure 6.0 Special Bacteria Study Area

The distance from the UV Facility to the beach is approximately 230 yards. In an attempt to identify and characterize the observed increase in bacteria, a series of intensive monitoring events supplemented the routine monitoring at the facility. The goal of this special study was to identify any possible sources of bacteria downstream of the UV Facility. Samples were collected at approximately 15 locations downstream of the facility along the creek. This last stretch of the creek was divided into three reaches.

The first reach begins at the box culvert under Third Street, just downstream of the UV Facility, to the entrance of the three 72" pipes leading to Moonlight Beach. This reach of the creek is an open natural channel and has two pipes entering from the north bank that flow during dry weather. There are also two pipes entering the channel from the south that flow only during storm events. The two flowing pipes are the only other sources of water downstream of the UV Facility. Samples were collected at various intervals in the channel according to changes in channel topography. Both flowing pipes entering the channel were isolated and sampled, and samples were collected up and downstream of each pipe. Figure 6.1 and 6.2 show Reach 1 (R1) characterized in the special study.

Figure 6.1

Figure 6.2

The second reach (R2) monitored in the special study is in the three 72" pipes leading to the beach. There are no inputs into these pipes. Samples were collected upstream and downstream to characterize changes in bacteria concentrations occurring in the pipes. Figure 6.3 is of the three 72" pipes in R2 as they flow to the beach.


Figure 6.3

The third reach (R3) of the special study was from the outlet of the 72" pipes, off of the headwall, and across the beach to the ocean. Samples were collected periodically across the stretch of beach in an attempt to isolate bacteria contributors along the shoreline. Figure 6.4 illustrates the Third Reach monitored in the special study.


Figure 6.4

Table 6.1 contains descriptions of the locations monitored as part of the special study.

Table 6.1 Sample Locations for Special Bacteria Study

Reach	Station Number	Location
1	1	UV Treated (South box culvert)
1	1A	UV Return
1	1B	32 Feet west in South Box
1	1C	64 Feet west in South Box
1	1D	80 Feet west in South Box (Ponded)
0	2	UV Diverted (North box culvert)
1	3	Creek Constriction @ 34'
1	4	Upstream of 6" PVC Pipe @ 108'
Pipe	5	6" PVC Pipe
1	6	Downstream of 6" PVC Pipe @ 132'
1	7	Upstream of 12" CMP Pipe @ 244'
Pipe	8	Fourth Street Storm Drain (12" CMP)
1	9	Downstream of 12" CMP @ 297'
2	10	Upstream of 3x72" Pipes at 345'
2	11	Headwall West of 3x72" Pipes
3	12	3' West of Headwall
3	13	25' West of Headwall
Pipe	14	2 North Pipes at MLB
3	15	MLB -20, after convergence with North Pipes

Reach 1 (R1) consists of open natural creek channel running from the discharge of treated creek water to the 72" pipes. There are two pipes which enter the creek in this area, one discharging groundwater and one is a storm drain with minimal flow. R1 is the eastern-most

reach isolated in the study as shown in Figure 6.0. Samples were collected at 1A-1D on one sampling occasion to ensure that bacteria regrowth was not occurring in the discharge culvert.

Reach 2 consists of three 72" storm drain pipes connecting Cottonwood Creek to the beach. This reach is isolated by samples collected directly upstream and downstream of the pipes. There are no additional pipes entering these storm drains in R2.

Reach 3 is the westernmost reach in the study and consists of samples collected west of the 72" storm drain pipes on the sand at Moonlight Beach. Samples were collected at various locations in R3 to isolate potential sources on the beach. There are two pipes entering R3 that convey groundwater and creek water. All reaches are illustrated in Figure 6.0.

Staff collected samples for the special study during five separate sampling events: October 9, 2003; July 28, August 25, September 30, and December 20, 2004. All data collected during the special study is presented in Appendix L. Table 6.2 contains a summary of the data collected at each site during the study. Values are the geometric mean for each location across the five sampling events.

Table 6.2 Special Bacteria Study Downstream of UV Facility
Geometric Mean Data (n=5) (cfu/100 ml)

Station Number	Location	Reach	Total Coliform	Fecal Coliform	Enterococcus
1	UV Treated (South box culvert)	1	93	20	11
2	UV Diverted (North box culvert)	0	12,344	1,304	343
3	Creek Constriction @ 34'	1	6,687	1,082	145
4	Upstream of 6" PVC Pipe @ 108'	1	5,019	632	165
5	6" PVC Pipe	1	192	28	35
6	Downstream of 6" PVC Pipe @ 132'	1	7,776	1,566	224
7	Upstream of 12" CMP Pipe @ 244'	1	6,374	1,110	253
8	Fourth Street Storm Drain (12" CMP)	1	5,492	1,209	178
9	Downstream of 12" CMP @ 297'	1	9,331	2,124	257
10	Upstream of 3x72" Pipes at 345'	2	9,401	1,252	334
11	Headwall West of 3x72" Pipes	2	12,213	2,196	396
12	3' West of Headwall	3	9,781	1,387	567
13	25' West of Headwall	3	11,457	1,872	488
14	2 North Pipes at MLB	3	6,616	1,085	310
15	MLB -20, after convergence with North Pipes	3	10,717	1,235	675

Data collected is used to further characterize bacteria sources and the possibility of bacteria re-growth occurring in the final stretch of Cottonwood Creek and on the beach. Results and implications of the special studies are discussed below.

In order to further understand the possible contributors of bacteria in the western reaches of Cottonwood Creek, individual sources were isolated. Possible sources of the bacteria fall into two main categories in the western reaches of Cottonwood Creek. The first group of potential bacterial sources is from the City's stormwater conveyance transporting bacteria laden urban runoff to the beach. The second possibility is that the bacteria are from natural sources such as animals, decaying plant material, or sediments in the creek or on the beach.

Table 6.3 below summarizes the geometric means of data collected in each reach of the study. Influent data is equal to the geometric mean of all influent data collected as part of the study, including routine monitoring.

Table 6.3 Geometric Mean Data by Reach (n=5 at each location), cfu/100 ml					
Reach	**Station Number**	**n**	**Total Coliform**	**Fecal Coliform**	**Enterococcus**
0	Influent	227	17,493	1,431	943
1	1,3,4,6,7,9	5	3,361	606	125
2	10,11	5	10,715	1,658	364
3	12,13,15	5	10,629	1,474	572

Expected bacteria concentrations downstream of the UV Facility are equal to the bacteria in the treated effluent, at 85% of the flows in the creek, plus bacteria in 15% of the creek flow designed to bypass the facility. Using the influent and effluent data collected over the entire project, calculations and expected bacteria concentrations downstream of the UV Facility are presented in Table 6.4 below.

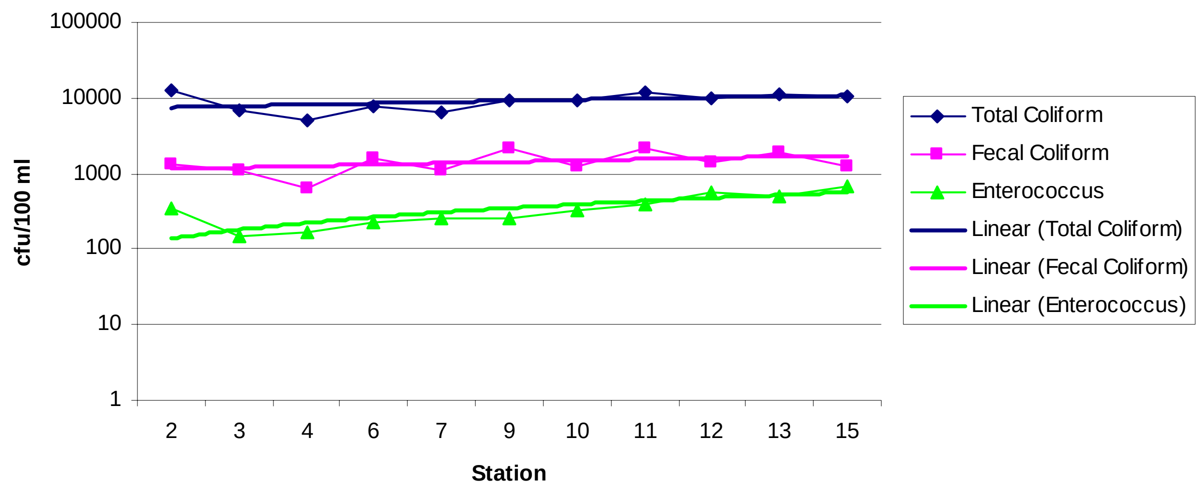
Table 6.4 Expected Fecal Indicator Bacteria Concentrations Downstream of UV Facility			
Indicator	Bacteria Concentrations (cfu/100 ml)		
	Actual Geometric Mean Data		Expected Downstream
	Treated Flows at 85%	Untreated Flows at 15%	
Total Coliform	5	17,493	2,628
Fecal Coliform	3	1,431	217
Enterococcus	3	943	144

The expected FIB concentrations downstream of the facility were calculated using the formula below.

$$[FIB]_{Expected} = 0.85*[FIB]_{treated\ flows} + 0.15*[FIB]_{untreated\ flows}$$

This formula does not take into account any additional sources of bacteria which may be present downstream. The expected FIB concentrations downstream of the treatment facility are slightly lower than the average of samples collected in Reach 1 of this study. Bacteria concentrations continue to rise as the water is conveyed to the beach, from R1 to R3. Figure 6.5 illustrates the rising bacteria concentrations at the creek flows from east to west, with Stations 2-9 in R1 (natural creek), Stations 10-11 in R2 (72” storm drain pipes), and Stations 12-15 in R3 (on sand at Moonlight Beach). These reaches are illustrated in Figure 6.0.

Figure 6.5 Fecal Indicator Bacteria Trends Downstream of UV Facility (east to west)



Tables 6.5, 6.6, and 6.7 contain percent changes in bacteria concentrations from expected FIB concentrations to Reach 1, Reach 2, and Reach 3.

Table 6.5 Percent Change in FIB Concentrations Reach 1

Indicator	Expected (cfu/100 ml)	Actual (cfu/100 ml)	Percent Change
Total Coliform	2,628	3,361	28%
Fecal Coliform	217	606	179%
Enterococcus	144	125	-13%

Table 6.6 Percent Change in FIB Concentrations Reach 1 to Reach 2

Indicator	Reach 1	Reach 2	Percent Change
Total Coliform (cfu/100 ml)	3,361	10,715	219%
Fecal Coliform (cfu/100 ml)	606	1,658	174%
Enterococcus (cfu/100 ml)	125	364	191%

Table 6.7 Percent Change in FIB Concentrations Reach 2 to Reach 3

Indicator	Reach 2	Reach 3	Percent Change
Total Coliform (cfu/100 ml)	10,715	10,629	-1%
Fecal Coliform (cfu/100 ml)	1,658	1,474	-11%
Enterococcus (cfu/100 ml)	364	572	57%

A significant increase of fecal coliform (nearly 200%) was observed at the monitoring locations in Reach 1 (R1) above the expected concentrations. This is not accompanied by large increases in total coliform or enterococcus. This immediate increase in fecal coliform is suspected to be from animal sources in R1. Many squirrels, rodents, and birds have been observed in this reach of the creek.

There are four storm drains entering this stretch of creek. The two entering from the south do not flow during dry weather. The next pipe west is a 6” PVC pipe conveying groundwater. The flows are on the order of 5 gallons per minute. Bacteria concentrations at this location are low and have not shown an effect on water quality in R1. There is also a 12" corrugated metal pipe (CMP) further downstream in R1. This pipe serves as a culvert under B Street and only has one inlet on the corner of 4^{th} and B Street, across the street from the creek. The bacteria concentrations are higher at this location however, the flow is typically a trickle and this water was shown not have an effect on water quality in R1 during dry weather. See Table 6.2 above for bacteria data collected up and downstream of storm drain pipes entering R1 and data from the pipe flows. The increases shown from up to downstream of the pipes are thought to be a result of regrowth and/or natural sources in the creek.

Reach 2 in the study consists of two samples up and downstream of three 72" pipes that convey the creek from the open channel in R1 to the beach in R3. Samples collected up and downstream show a large increase in bacteria concentrations for all three indicators, each up by about 200%. This is the most significant rise in FIB concentrations from the UV Facility to the Pacific Ocean. The pipes are old corrugated metal and tend to trap organic debris and sediment within. There is a curve in the pipes which likely causes debris to accumulate. Adding to the problem, high tides often push sand and heavy kelp into the ends of the pipes. All factors combined in a dark, damp storm drain provide an ideal environment for bacterial regrowth. (MEC, 2004) Taking into account the possibility of animals living in these storm drains and the ideal conditions present for bacterial survival and growth, the increase in bacteria in the storm drain pipes is explained.

Reach 3 of the study consists of three samples collected at intervals on the beach/sand and one sample from two pipes entering the beach/creek area from the north. The pipes convey creek water that does not enter the 72" pipes. The flow here is low, relative to the creek, less than 5 gallons per minute. Data collected downstream of these pipes is similar to the data collected upstream, indicating no significant contributions of bacteria from these two pipes. Comparing mean data from R2 to R3, an increase in enterococcus bacteria is evident. Concentrations of total and fecal coliform are both slightly reduced from R2. Likely sources of the increase in enterococcus concentrations in R3 are the wrackline and birds on the beach.

Understanding that all bacteria and associated pathogenic organisms are removed from the UV treated water; two main conclusions can be drawn from the special study. Any bacterial increases downstream of the facility must be from sources other than urban runoff, as the storm drains in the downstream reaches do not affect concentrations of bacteria in the creek. This leads to the conclusion that the rising bacteria concentrations are due to the wildlife, sediments, and organics in and around Cottonwood Creek. These sources may be compounded by the high nutrient levels endemic to the groundwater in Cottonwood Creek. Each of these sources was isolated in R1, R2, and R3. It is suspected that sources in R1 include primarily wildlife and sediment, sources in R2 include primarily sediment and organic debris, and sources in R3 include the wrackline and birds on the beach. Additional bacterial source identification techniques such as DNA analyses would be helpful in definitively isolating the sources of bacteria in these reaches and are recommended as a follow-up to this study.

7.0 Operations and Maintenance

Operations

The UV facility has been operating since August of 2002. The original operational design was for the facility to treat only dry weather flows because increased turbidity and flow render the facility ineffective. It was estimated that the facility would not be in operation from approximately November through April and would be shut down for long periods of time through the wet season. However, in order to maximize the facilities effectiveness, it was operated off and on through the winter. The facility operated for 68%, 81% and 65% of the year for 2003, 2004, and 2005, respectively. Generally, the facility was in operation for the dry season (May through September). Figure 7.0 illustrates the percentage of time that the facility was operational.

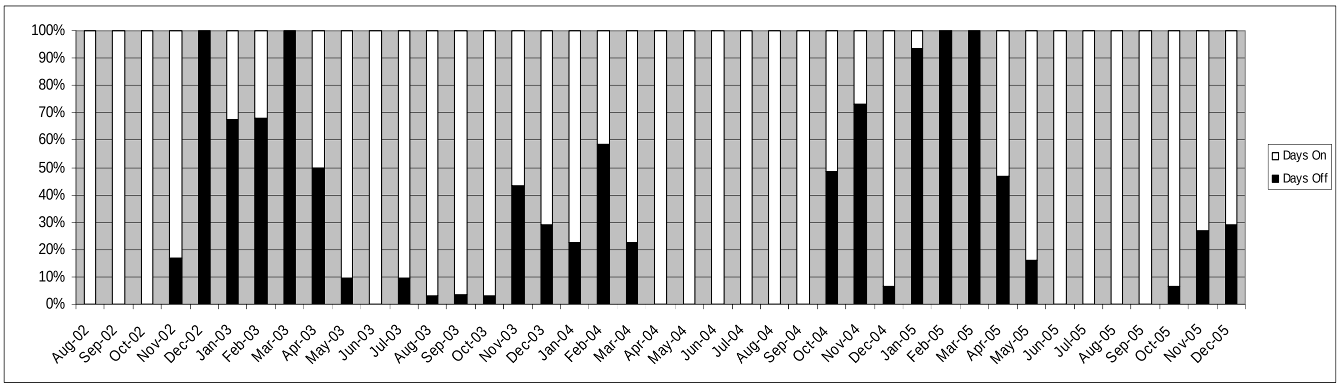


Figure 7.0 UV Facility Operational Days

Shutting down the facility involved physically removing the 12-inch high weir in the box culvert so that there was no flow constriction and powering down the facility. The primary reason for shutting down the facility was for wet weather. The general practice was to shut down the facility when the weather report predicted greater than a 40% chance of measurable rain. In addition, the facility was shut down periodically for maintenance or spills in the watershed that resulted in high turbidity in Cottonwood Creek that might foul the multimedia filters. These incidents generally resulted in shutting down the facility for less than a few days.

Maintenance

Maintenance of the facility was performed in a collaborative manner by the City of Encinitas Clean Water Program staff and San Elijo Joint Powers Authority (JPA) staff. City staff visited the facility weekly on a routine basis and more frequently when events occurred, such as shut-down, start-up and maintenance. JPA staff was on site more routinely as part of their maintenance of the adjacent Moonlight Beach Sewer Pump Station. In addition any alarms, high water, low water or high turbidity were telemetrically communicated to the City's emergency dispatch center and then communicated to both the City and the JPA.

This section outlines the most common maintenance issues at the facility. These issues were resolved by either repairing a component of the facility or adjusting an operational detail. This section is broken into the three major components of the facility; the intake structure (including the wet well), the filtration system and UV units.

Intake Structure – The major maintenance issues for the intake structure included the weir, algae in the intake screens and the pumps. Initially the weir required a great deal of adjustment to set the water level appropriately so that the creek flow was adequately diverted into the wet well. Initially, a 6-inch weir was constructed; however, the final weir configuration was a 12-inch weir. At 12 inches the weir structure can potentially reduce the overall capacity of the box culvert, therefore, must be removed prior to any storm resulting in measurable rainfall.

The intake screens mounted on the side of the box culvert often clog with algae, particularly in late summer, when the water temperature is higher. Cottonwood Creek has relatively high nitrate concentration and algae growth is abundant. Removal of the algae requires physically scraping the algae or removing the screens and cleaning them. In the late summer the screens require cleaning on a weekly basis. Algae-clogged intake screens result in low flows through the system and frequent clogging of the multi-media filters.

The wet well consists of a five-foot diameter concrete cistern with two alternating 7.5-HP pumps. Typical pump maintenance has been required, including repair of seals and valves, adjusting the seating of the pumps and occasional pump repair. In addition, one pump has required full replacement, and the other pump has required a full overhaul repair. The pumps generally operate at 150 gpm. Fluctuating system readouts indicating a marked increase or decrease in pumping are investigated as possible maintenance problems. Occasionally decreases in flows were detected at the PLC. Several times the cause of the decrease was associated with back flushing valves designed to discharge back flush water to the sanitary sewer. Due to problems with the valves, they would fail to close 100% at the end of the back flush cycle. This would cause treated creek water to flow to sewer and not register as treated flow at the facility. This problem was remedied with new valves better suited for the application resulting in the back flush waste discharging to sewer and treated creek water discharging to the creek, as designed.

Filtration System – The filtration system includes basket strainer, a turbidity meter, and anthracite, multi-media filter unit. Basket strainers trap large particles that have made their way through the pumps from sticks to algae and are cleaned manually on a regular basis. These strainers are similar to a swimming pool strainer and have required little maintenance.

The turbidity meter has been the source of frequent maintenance. The turbidity of the intake water is monitored on a continual basis and is an indicator of activities in the creek. High turbidity, greater than 20 ntu, triggers manual shut down the facility since high turbidity renders the UV units ineffective and fouls the multi-media filter. High turbidity can result from erosion caused by wet weather, algae, or an illicit discharge from a wash-down activity or construction site. Required maintenance of the turbidity unit includes adjustments to the intake device. Initially the turbidity shut-down feature was to be automatic; however, this feature was problematic and was removed.

The main component of the filtration system is the multi-media filter. This filter is sensitive to suspended solids in the creeks flow which clog the filter. The filters are backwashed on a regular basis. The automatic backwashing interval is adjusted to balance the need to increase flow though the system and potable water use. If the interval is too long, system flow decreases and water flows over the weir, if the interval is too short, water usage rates (and costs) increase.

UV Units – The most frequent maintenance need for the UV unit include bulb replacement and ballast replacement. Bulbs generally need to be replaced once per year. The ballast has only needed replacement once. The facility can operate effectively with up to three of the eight bulbs out of operation. The UV unit maintenance has been relatively low.

8.0 Conclusions

- The UV Facility is instrumental in reducing bacteria concentrations in Cottonwood Creek and at Moonlight Beach. The facility removes greater than 99% of all pathogenic organisms from treated creek water prior to its discharge at Moonlight Beach. With reduced beach postings, fewer bacterial exceedances in the surf zone, and demonstrated improvements in water quality in the creek and in the surf zone, the project has been a success. Ultimately, the main objectives of the project have been met: the public health is better protected because of the UV Facility on Cottonwood Creek and the need for beach postings has been reduced.
- The theory of bacteria regrowth in the creek and storm drains is supported by seasonal bacteria trends. In the creek, bacteria concentrations are lowest in the winter after rains, and increase through the spring and summer, peaking in the fall. The bacteria concentrations in the mixing zone correlate to the buildup of bacteria in the creek and storm drains through the year which is washed into the ocean with winter rains.
- Bacteria regrowth in the creek was substantiated in the special study conducted downstream of the UV Facility. Storm drain sources were isolated and eliminated, however, bacteria concentrations continue to increase from the UV Facility to the mouth of the creek. Factors contributing to the regrowth are believed to be: the environment in the 72" storm drain pipes leading to Moonlight Beach and natural factors on the beach such as the wrackline, sediment (sand) and birds.
- Bacterial regrowth coupled with sources of bacteria present in the last reaches of Cottonwood Creek continue to cause occasional exceedances of water quality in the mixing zone, leading to beach postings. The City is seeking funding to support further studies in bacterial source identification and epidemiology at Moonlight Beach. With bacteria sources identified and the correlation between the bacteria and public health defined, the City will be able to assess the need for further bacteria reduction/elimination. Until these studies are funded, recommendations have been made to better maintain and control sources of bacteria. Specifically, the City should remove kelp and debris from the mouth of Cottonwood Creek at Moonlight Beach regularly and the storm drain system west of the Park should be cleaned more frequently.
- Process controls benefited greatly from monitoring of influent and effluent bacteria concentrations, influent turbidity, and flow.

9.0 Recommendations

- Regular maintenance and cleaning of the storm drain system to reduce the media for bacterial regrowth.
- Due to bacteria regrowth, UV Facilities should be placed as close as possible to the receiving water to be protected.
- Additional BMPs such as removal of the wrackline at the creek or storm drain outlet may further reduce beach postings.
- The storm drain system west of Cottonwood Creek Park should be cleaned more frequently.
- A DNA study to identify sources of bacteria introduced to the creek downstream of the facility is recommended and sources of funding are needed.
- An epidemiology study to identify the potential for health risks associated with the sources of bacteria downstream of the UV Facility is also recommended. Viruses such as adenovirus have been identified in the waters of Cottonwood Creek prior to implementation of the UV Facility. Treatment with ultraviolet light continually removes pathogens from the creek waters. A health effects study would validate the effectiveness of the best management practices implemented to date. Moonlight Beach is heavily visited during the summer months and would be an ideal location to study health effects and water quality. Funding for an epidemiology study at Moonlight Beach is needed.
- Continuous logging of turbidity and flow data may be beneficial in recognizing trends and may be helpful in identifying illicit discharges.
- If influent water is relatively low in turbidity, this water should be considered for use in back flushing the multimedia filters to save water costs.

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