San Diego County Stormwater Copermittees
Coastal Storm Drain Monitoring Program
Adaptive Monitoring Proposal
February 2003

1.0 CURRENT PROGRAM

The Copermittees initiated the Coastal Storm Drain Monitoring Program in November 2001. The current program design is a prescriptive approach that is based on elements of the AB 411 Recreational Water Monitoring Program and involves the collection of paired samples at flowing storm drain outlets and in the corresponding coastal or lagoon receiving water. Coastal receiving water samples are collected 25 yards downcurrent of the mixing zone, while lagoon samples are collected immediately in front of the storm drain outlet. Samples are collected monthly during the non-AB 411 period (November 1 – March 31), and every other week during the AB 411 period (April 1 – October 31), and are analyzed for total and fecal coliform, and enterococcus indicators (San Diego County Municipal Copermittees, 2001). Lagoons were incorporated into the program beginning November 2002.

The Revised Sampling Plan (San Diego County Municipal Copermittees, 2001b) states that, after one year of data collection the Copermittees will:

> '…. review the complete database to determine the appropriateness and applicability of an Adaptive Shoreline Monitoring matrix or any other available tools. Recommendations may include modifications to monitoring frequencies and locations in subsequent years.'

The Coastal Storm Drain Monitoring Workgroup began development of an adaptive strategy for the Coastal Storm Drain Monitoring Program in August 2002. The Workgroup decided not to follow the adaptive models developed by the State Water Resources Control Board or the USEPA. These guidance documents are designed to address recreational waters alone and do not necessarily accommodate paired sampling designs. The Workgroup discussed various adaptive approaches, conducted a comprehensive analysis of the paired sampling data collected from November 2001 to October 2002, and developed procedures to guide the implementation of an adaptive strategy.

2.0 COASTAL STORM DRAIN MONITORING RESULTS (NOV 2001 – OCT 2002)

The complete results of the data analysis are included in the San Diego Municipal Copermittees 2001 – 2002 Urban Runoff Monitoring Final Report, Attachment A, submitted to the San Diego RWQCB on January 31, 2003. The analysis included the development of a Coastal Storm Drain Monitoring database, plotting the data distributions for the 332 paired samples, identifying the samples that exceeded the receiving water AB 411 standards, calculating statistical values for the receiving water and storm drain data sets, and regression analyses.

The total and fecal coliform, and enterococcus bacterial indicators exceeded AB 411 standards 3, 5, and 15 times, respectively (23 total exceedances in 15 samples) (**Table 1**). This corresponds to overall exceedance rates of 0.9%, 1.5%, and 4.6% for the respective indicators. The higher rate of enterococci exceedance may be related to its ability to survive for comparatively longer periods in marine environments.

Table 1: Summary of Samples Exceeding AB 411 Receiving Water Standards (Nov 01 – Oct 02)

Site ID	Location Name	# of Paired Samples Collected			% of Sampling Attempts With Flowing Storm Drain	Storm Drain Flows To Ocean During Sampling?	AB 411 Exceedances		
		Wet	Dry	Total			TC	FC	Ent
Oceanside									
	Hayes	1	0	1	5	no	0	0	0
	Oceanside Blvd	1	1	2	10	no	0	0	0
EH-490	Wisconsin	0	1	1	5	no	0	0	0
OC-090	Surfrider	0	1	1	5	no	0	0	0
Carlsbad									
EH-470	Pine Ave	0	8	8	40	no	0	0	0
#2	Ocean St.	1	0	1	5	no	0	0	0
#3	Cypress Street	2	0	2	10	no	0	0	0
#5	Christiansen PBA	2	0	2	10	no	0	0	0
EH-475	Carlsbad Village Dr	1	2	3	15	no	0	0	0
Encinitas									
EH-403	North San Elijo SB	5	15	20	100	usually	0	0	0
EH-405	Swami's mid beach	5	15	20	100	yes	0	0	0
EH-410	Swami's Beach	5	15	20	100	yes	0	0	0
EH-420	Cottonwood Creek	5	15	20	100	yes	0	0	0
Solana Beach									
EH-390	Seascape Beach Park	5	12	17	85	no	0	0	0
SE-010	Fletcher Cove	5	10	15	75	sometimes	0	0	0
Del Mar									
EH-355	12th Street	4	15	19	95	yes	0	0	0
EH-360	15th Street	5	15	20	100	rarely	0	0	0
EH-370	17th Street	5	15	20	100	no	0	0	0
San Diego									
EH-250	Grand Ave	5	15	20	100	usually	0	0	0
FM-030	Tourmaline	4	4	8	40	sometimes	0	0	0
EH-255	PB Point	5	15	20	100	yes	**1**	**1**	**4**
EH-280	Playa Del Norte	5	15	20	100	yes	0	0	0
FM-050	Bonair	1	2	3	15	usually	0	0	0
EH-300	Ravina/ Horseshoes	2	9	11	55	yes	0	0	0
FM-060	Coast Blvd.	1	9	10	50	usually	0	0	0
EH-340	El Paseo Grande	3	8	11	55	sometimes	0	0	0
FM-080	Avenida De La Playa	0	1	1	5	yes	0	0	0
San Diego Unified Port District									
EH-070	Tidelands (bayside)	1	2	3	15	no	0	0	**1**
EH-120	Bayside Park (J St.)	4	6	10	50	at low tide	**1**	**2**	**3**
EH-160	Spanish Landing	1	3	4	20	sometimes	0	0	**1**
EH-200	Shelter Island	5	5	10	50	yes	**1**	**2**	**4**
EH-205	Bessemer Street	0	2	2	10	no	0	0	**1**
EH-210	Kellogg Street	5	2	7	35	usually	0	0	**1**
TOTALS:	**33 Sites**	**94**	**238**	**332**	**50.3%**		**3**	**5**	**15**

Approximately 37% of the storm drain samples had total coliform levels above of the 10,000 MPN/ 100 mls receiving water standard. Similarly, approximately 35% and 62% of the storm drain samples exceeded the fecal coliform and enterococcus AB 411 standards, respectively. Dilution, filtration, and natural UV disinfection between the storm drain outlet and the receiving water sampling location contributed to the low number of AB 411 violations during the period of record.

One of the key findings of the data analysis was that storm drains that did not discharge directly to the receiving water (soaked into beach or ponded) typically had much higher bacteria levels than conveyances that flowed across the beach and directly into the ocean. Not surprisingly, storm drains that did not reach the receiving water had comparatively lower discharge rates than storm drains that conveyed runoff directly to the receiving water. The apparent difference in storm drain bacteria levels may be related to one or more characteristics of these two categories of storm drains. Low-flow storm drains may be characterized by a lack of flushing and dilution of bacterial contaminants, stagnation of runoff in the drain pipes due to ponding behind debris blockages, and the relative predominance of urban runoff over ground water discharge. Conversely, storm drain discharges that reach the receiving water typically originate from drains that are less stagnant than low-flow conveyances.

The 2001 – 2002 data also demonstrated that although storm drain flows that did not reach the ocean had comparatively higher bacteria levels, they were rarely associated with elevated concentrations in the receiving water. Elevated receiving water results that were paired with a low-flow storm drain sample were at least partially attributable to sources within the receiving water itself (birds). Several factors may contribute to the apparent absence of negative impacts of the low-flow storm drains.

1. Effective bacteria filtration of the storm drain discharge by beach sand and other substrate before it reaches the receiving water.
2. Bacteria mortality caused by exposure to UV radiation after the flow emerges from the drain outlet.
3. Comparatively low bacterial loadings from high concentration, low flow storm drains.
4. Dilution of storm drain discharges between the mixing zone and the site of receiving water sample collection (usually 25 downcurrent of the storm drain).

A regression analysis was performed on the log-transformed data to assess the relationship between the storm drain (independent variable) and receiving water (dependent variable) concentrations. The relationship between the two variables was statistically significant for all three indicators when the storm drain flow reached the receiving water and was essentially non-existent when the storm drain did not discharge directly to the receiving water. This supported the conclusion that storm drain flows that do not reach the receiving water do not negatively impact the receiving water, regardless of their bacteria concentrations.

In summary, there is very little evidence linking high bacteria levels in storm drains that do not discharge directly to the receiving water and elevated bacteria in the corresponding receiving water sample. *The adaptive program incorporates into its design the observation that storm drains that do not discharge directly to the receiving water pose a minimal threat to receiving water quality.* Conversely, storm drains that discharge directly to the receiving water have a greater potential to cause or contribute to elevated bacteria levels in the receiving water although this effect is moderated by the generally lower bacteria levels in these discharges.

3.0 ADAPTIVE MONITORING PROGRAM

The proposed adaptive program will pursue the following objectives:

1. Evaluate the impacts of ocean and lagoon storm drains on the recreational beneficial uses in coastal receiving waters
2. Identify and eliminate sources of highly elevated bacteria from coastal storm drains

In addition, the trend assessment and database development program objectives identified in the original Coastal Storm Drain Monitoring Program will continue to be pursued.

3.1 Program Design

The adaptive strategy is designed to address the storm drains that pose the greatest threat to recreational receiving waters most aggressively, while allocating a lower monitoring intensity to locations that exhibit consistently low bacterial levels. *Thus, the adaptive strategy is intended to make efficient use of Copermittee resources by identifying and addressing high priority storm drains first and reducing sampling intensity at low priority paired sampling locations.*

The Copermittees will perform follow up procedures and management actions depending on the results of the paired samples. Existing water quality criteria and other action levels developed by the Coastal Storm Drain Monitoring Workgroup will be used to trigger these sets of follow up procedures and actions. Contaminated storm drain discharges with sufficient flow to reach the receiving water will be assigned the highest priority for additional investigation and source elimination.

Established water quality objectives that can be employed as exceedance criteria are available for the ocean and lagoon receiving waters of coastal San Diego County. Established water quality criteria applicable to storm drain discharges are not available and have been developed as outlined below. Action levels that trigger storm drain investigations in the absence of a receiving water exceedance and criteria, which when achieved, allow reductions in sampling frequency were also developed. The development of these criteria are described in **Section 3.1.2** and **Section 3.1.3**, respectively.

3.1.1 Receiving Water Exceedance Criteria

The ocean receiving water exceedance criteria are the AB 411 standards established for the protection of public health. The lagoon criteria are established in the San Diego Basin Plan (1994).

	Coastal	**Lagoon**
Total Coliform (MPN/ 100 mls)	10,000	10,000
Fecal Coliform (MPN/ 100 mls)	400	400 for REC-1areas (4,000 for REC-2 areas)
Enterococcus (MPN/ 100 mls)	104	none

Enterococci standards are not available for the lagoon receiving waters. The Coastal Storm Drain Monitoring Workgroup believes that an adaptive monitoring approach can be implemented for the lagoons using the Basin Plan total and fecal coliform standards alone. San Diego County lagoons function as important habitat for native and migratory waterfowl and other aquatic birds that are likely to be significant natural contributors of enterococci bacteria. The use of the comparatively stringent enterococcus ocean standard (104 MPN/ 100 mls) in lagoons may not be appropriate.

3.1.2 Storm Drain Exceedance Criteria

Two separate sets of storm drain criteria or action levels were developed. These criteria are applied in the following circumstances:

1. When receiving water bacteria concentration exceeds AB 411 or Basin Plan criteria given in **Section 3.1.1**, the storm drain criteria is identical to the receiving water criteria. This represents a conservative approach because it ignores the potential dilution of storm drain discharges as they mix with the receiving water however; this approach will guarantee that storm drains that may have caused or contributed to a receiving water exceedance will be investigated.

2. When the receiving water *does not* exceed AB 411 or Basin Plan guidelines a different set of storm drain criteria are applied. The vast majority of the receiving water samples did not exceed the ocean AB 411 standards during 2001 – 2002. This included numerous receiving water samples that were paired with highly elevated storm drain samples. Despite the generally low threat to the receiving water posed by many high-bacteria storm drains, the Coastal Storm Drain Monitoring Workgroup agreed that a certain percentage of the high-bacteria drains should be investigated. Accordingly, the Workgroup established action levels for further storm drain investigation when highly elevated storm drain results are paired with compliant receiving water samples.

   There are several reasons for pursuing these highly contaminated drains, including the likelihood that they are sources of bacterial pollution during storms when the contents of the storm drain do reach the receiving water, and the possibility that ongoing sources of pollution can be eliminated from the sub-watersheds by investigating these conveyances.

   The exceedance criteria for storm drains that are not paired with a receiving water sample that exceeded the AB 411 or Basin Plan criteria are based on the 95^{th} -percentile observations of the 2001 – 2002 total and fecal coliform, and enterococcus data. Storm drains that are not paired with a receiving water exceedance but exceed any of the following three 95^{th}-percentile action levels are subject to additional investigation.

Indicator	95^{th}-Percentile Storm Drain Criteria
Total Coliform	161,000 MPN/ 100 mls
Fecal Coliform	24,000 MPN/ 100 mls
Enterococcus	20,000 MPN/ 100 mls

   Over time, addressing these highly contaminated storm drains will allow the Copermittees to identify and eliminate significant bacterial sources. As sources are eliminated, the 95^{th}-percentile concentrations will decrease and the Copermittees will be tasked with investigating less and less contaminated storm drains. (The 95^{th}-percentile concentration will be re-calculated on an annual basis).

3.1.3 Criteria for Reducing Sampling Frequency

Paired sampling at all identified locations will be initiated at the ***base frequency***. The base frequency is identical to the sampling frequency implemented in the current Coastal Storm Drain Monitoring Program.

Time Period	**Base Frequency**
Nov 1 – March 31	once per month
April 1 – Oct 31	once every two weeks

Sampling frequency at a paired sampling location may change upward or downward from the base frequency depending on the analytical results. Storm drains whose samples are below the criteria outlined below can be collected at ½ the base frequency (once/month in the summer, once every two months in the winter) as long as they remain below the criteria. *A minimum of three consecutive storm drain samples with bacteria levels below the Sampling Frequency Reduction Criteria are required to reduce sampling to one-half base frequency.* The three consecutive samples must be paired with receiving water samples that do not exceed AB 411 or Basin Plan standards.

Method for Calculating the Sampling Frequency Reduction Criteria

As storm drain flows enter receiving waters, the discharge is quickly diluted by diffusion and wave action between the mixing zone and the sampling point 25 yards downcurrent. The method used to determine the Sampling Frequency Reduction Criteria involved calculating the storm drain-to-receiving water dilution factor using the slope of the regression line for each indicator's 2001-2002 data set. The slope of the paired sampling data regression line is an approximation of the dilution that occurs on a regional basis. A safety factor of 10:1 was applied to the calculated dilution factors to account for the possibility of lesser dilution rates between the storm drain and receiving water sampling points than is indicated by the slope of the regression line.

According to the results of the regression analysis, the numerical criteria for reducing the base sampling frequency is the following:

Table 2: Sampling Frequency Reduction Criteria

Indicator	Receiving Water Standard (MPN/ 100 mls)	Slope of Regression Line	Reduction Standard Without Safety Factor (MPN/ 100 mls)	Slope/Safety Factor	**Sampling Frequency Reduction Criteria (MPN/ 100 mls)**
TC	10,000	42	420,000	10:1	**42,000**
FC	400	18	7,200	10:1	**720**
Entero	104	165	17,160	10:1	**1,716**

Several coastal storm drains in San Diego County appear to be dominated by groundwater discharges and had consistently low bacteria levels during the first year of the program. These storm drains are likely to easily meet the requirements outlined for reduced sampling frequency. A small number of other storm drains may meet the criteria for reducing sampling frequency however; the first year data results indicate that the vast majority of storm drains will not meet the sampling frequency reduction criteria and will continue to be sampled at base frequency.

The sampling frequency for storm drains that are confirmed to discharge extremely low bacteria levels may be further reduced below ½ base frequency pending additional supporting information collected by the municipality. This information may include existing or future storm drain source flow studies and detailed comparisons between storm drain and local groundwater bacteria levels. The San Diego RWQCB will evaluate the appropriateness of additional sampling frequency reductions for storm drains that can meet the more stringent standards that would characterize a consistently low-bacteria storm drain on a case-by-case basis.

3.1.4 Adaptive Monitoring Diagrams

A series of scatter plots, referred to as adaptive monitoring diagrams**,** were prepared to illustrate the relationships between receiving water and storm drain bacteria levels, AB 411 and Basin Plan regulatory drivers, the storm drain criteria developed by the Coastal Storm Drain Monitoring Workgroup, and potential contamination sources. The adaptive monitoring diagrams stratify the paired sampling data into categories, or Regions, for management purposes and are essential tools in the implementation of the proposed Adaptive Monitoring Program. The diagrams are also extremely useful visual tools for summarizing the results of the 2001 – 2002 paired sampling program.

The adaptive monitoring diagrams for total coliform, fecal coliform, and enterococcus are presented in **Figures 1, 2, and 3**, respectively, with the paired sampling results for November 2001 through October 2002 indicated on the diagrams. Each adaptive monitoring diagram is divided into five regions and one subregion that are formed by superimposing a line of slope = 1, two perpendicular lines that delineate the receiving water regulatory standards summarized in **Section 3.1.1**, and the 95th percentile storm drain criteria outlined in **Section 3.1.2**. **Table 3** describes the regions of the scatter plots as they relate to the applicable bacterial standards and criteria and the required follow up actions.

Table 3: Adaptive Monitoring Diagram Regions

Region	Receiving Water Concentration	Storm Drain Concentration	Description:
I	< AB 411 or Basin Plan	< AB 411 or Basin Plan	Both the storm drain and receiving water are below the receiving water standard. No follow up action necessary.
I-A	< AB 411 or Basin Plan	> AB 411 or Basin Plan and < 95th percentile	Storm drain is above the receiving water regulatory standard but the receiving water is below. Storm drain is also below the 95th percentile criteria. No action necessary.
II	> AB 411 or Basin Plan	< AB 411 or Basin Plan	Receiving water is above standard but storm drain is below. Unlikely that storm drain contamination caused the receiving water exceedance. Non-storm drain sources are likely present. Resample to confirm scenario and address potential non-storm drain sources, if and where appropriate.
III	> AB 411 or Basin Plan	> AB 411 or Basin Plan	Both the storm drain and receiving water are above the receiving water standard but RW level is greater than storm drain level. This indicates that storm drain contamination may contribute to exceedance but that non-storm drain sources may predominate. Resample to confirm scenario and address both storm drain and non-storm drain sources, if and where appropriate.
IV	> AB 411 or Basin Plan	> AB 411 or Basin Plan	Both the storm drain and receiving water are above the receiving water standard. Storm drain appears to be a dominant contributor. Resample to confirm scenario and conduct IC/ID investigation, if appropriate.
V	< AB 411 or Basin Plan	> AB 411 or Basin Plan and > 95th percentile	Receiving water is below the standard however; the storm drain is highly contaminated. Resample and conduct IC/ID investigation, if appropriate.

The regions of the adaptive monitoring diagrams are color shaded to indicate the level of risk associated with the storm drain discharge. Green shaded areas (Regions I and II) are associated with the lowest storm drain bacteria concentrations and are low priority. Paired samples falling within Region II exceed the receiving water standard but are probably dominated by non-storm drain sources. The vast majority of the paired samples within this region are characterized by receiving water results that are substantially higher than the corresponding storm drain results. Very few paired samples collected during 2001 – 2002 fall within Region II.

Region I-A is yellow shaded to indicate a moderately high storm drain concentration that is paired with a receiving water sample within regulatory limits. Follow up action is not required in response to paired samples within Region I-A however; the high between-sample variability that characterizes storm drain samples suggests that these storm drains have a reasonable probability of exceeding the 95^{th} percentile criteria at some point.

Region III is pink shaded to indicate that both the storm drain and receiving water samples are above receiving water criteria however; Region III lies above the 1:1 slope line indicating that non-storm drain sources likely predominate. Possible sources include birds, other marine wildlife, discharges from watercraft, and ocean bathers. It is important to consider these sources and their potential contribution to observed receiving water bacteria levels to avoid wasted effort, especially when the paired sampling results fall within Regions II or III. Region V is also pink shaded and delineates storm drain samples above the 95^{th} percentile criteria. Although the paired receiving water sample is within regulatory limits, the storm drain is discharging highly elevated bacteria levels and must be investigated.

Region IV is red shaded to indicate that the combination of elevated receiving water and storm drain bacteria levels is most likely a result of storm drain contributions. The extent of the storm drain's contribution depends largely on whether the storm drain flow reaches the receiving water. This scenario represents the highest priority for follow up action according to the adaptive monitoring approach. The storm drain's influence probably decreases significantly if the discharge does not reach the receiving water. Regardless of the flow conditions, an immediate follow up investigation is warranted to further assess the situation.

In summary, additional sampling and/or investigation are required when the results of paired samples fall within one of three categories:

1. The storm drain sample is below and the receiving water is above the receiving water AB 411 or Basin Plan standard for the indicator in question (**Region II**). Follow up actions other than resampling, if necessary, are likely to focus on non-storm drain sources.
2. The storm drain and receiving water samples both exceed the receiving water AB 411 or Basin Plan standard for the indicator in question (**Regions III and IV**). The **Region IV** scenario is considered the highest priority especially if the storm drain discharge reaches the receiving water. Follow up actions may include resampling, source identification and elimination, and BMP implementation.
3. The receiving water sample is below the AB 411 or Basin Plan standard and the storm drain sample is above the 95-percentile action level (**Region V**). Follow up actions may include resampling, source identification and elimination, and BMP implementation.

4.0 IMPLEMENTATION

The Copermittees will begin implementing the Adaptive Program on April 1, 2003. Samples will continue to be collected and analyzed in accordance with the procedures described in the prescriptive Coastal Storm Drain Monitoring Program (San Diego County Municipal Copermittees, 2001). Paired samples will be collected at frequencies outlined in **Section 3.1.4**. Upon receipt of the bacteriological analytical results staff will use the respective adaptive monitoring diagrams for the three bacterial indicators to determine the status of each of the paired samples. Appropriate management actions will be implemented based on the guidelines provided on the adaptive monitoring diagram and the Coastal Storm Drain Adaptive Monitoring Matrix (**Table 4**).

The Coastal Storm Drain Monitoring Workgroup has developed data collection standards that are designed to ensure that important measurements and observations are collected during all field visits. Additional required data collection includes bird and bather counts, storm drain flow measurements, and tidal information. A more comprehensive data analysis can be conducted in future years using the additional quantitative and qualitative data that will be gathered by the Copermittees.

4.0 REFERENCES

San Diego County Municipal Copermittees, 2003. San Diego County Municipal Copermittees 2001 – 2002 Urban Runoff Monitoring Report, Final Report, Attachment A, January 31, 2003.

San Diego County Municipal Copermittees, 2001. San Diego Region: Previous Monitoring and Future Recommendations, Final Report, August 20, 2001.

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