

California Regional Water Quality Control Board  
San Francisco Bay Region

## **Richardson Bay Bacteria Water Quality Monitoring Report**



February 2026

**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD**

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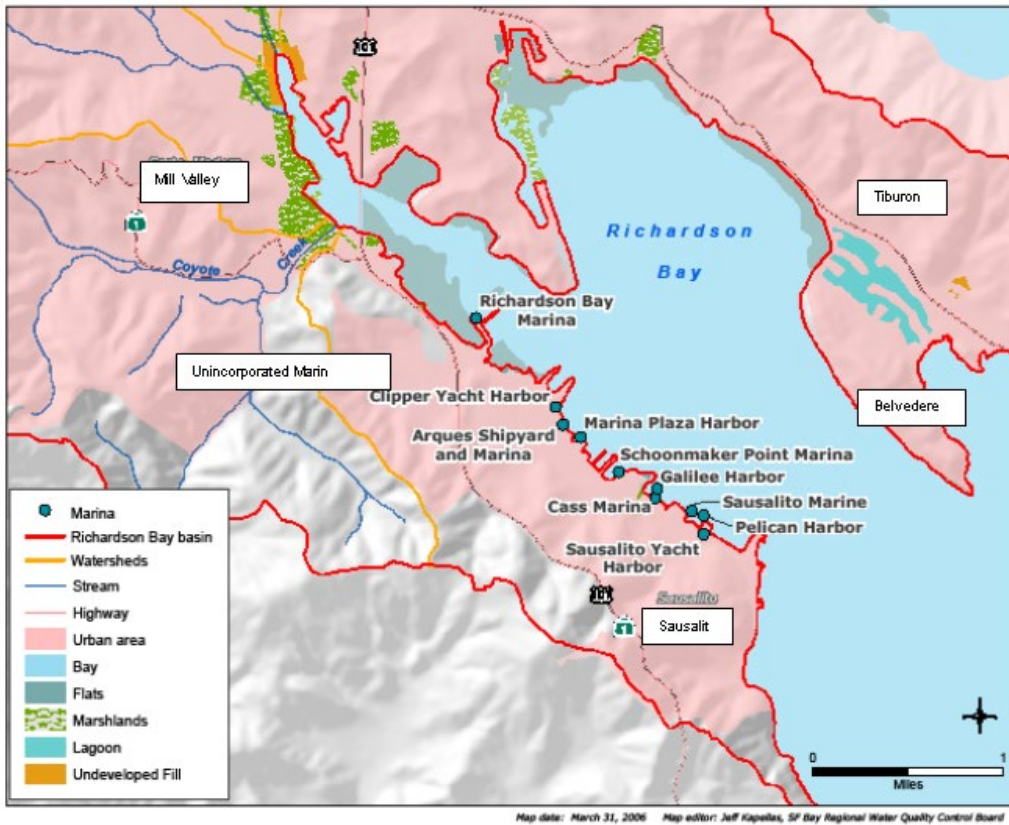
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# 1. Setting

Richardson Bay is a shallow, ecologically rich arm of San Francisco Bay located just northeast of the Golden Gate in southern Marin County. It is managed by the Richardson Bay Regional Agency (RBRA), created under a joint powers agreement by the County of Marin, Town of Tiburon, and Cities of Belvedere, Mill Valley, and Sausalito. Despite its urbanized periphery, Richardson Bay supports extensive eelgrass areas and sizable undisturbed intertidal habitats. It is a feeding and resting area for an array of estuarine and pelagic birds, while its associated marshes and shoreline zones support a variety of animal and plant life.



The Bay is widely used for recreational activities including boating, kayaking, rowing, and swimming. Because it is shallow and enclosed, with little tidal action or freshwater inflow from local creeks, the Bay has only a limited ability to disperse or dilute pollution.

Historically, Richardson Bay supported oysters, mussels, and clams. Local populations of these shellfish have declined significantly since the 1920s. In 1984, the Richardson Bay Special Area Plan, developed by Bay Conservation and Development Commission, documented two shellfish beds in Richardson Bay, containing approximately 146,000 clams. The plan noted that “Shellfish are not presently authorized to be taken from these beds for human consumption because they contain pollutants.”

Because of its sheltered location, size, and proximity to Sausalito and San Francisco, Richardson Bay is highly desirable as an anchorage and harbor for recreational and small commercial vessels. The Bay has a long history of maritime use as a watering station and harbor for careening, whaling, fishing, and shipbuilding since the first European settlement of the Bay Area. Since the Second World War, however, recreational boating has become the major maritime use of the Bay. As of 2004, the Californian Department of Boating estimated that there were approximately 2,400 recreational marina berths, mainly located in marinas that have been constructed by dredging the shallows along the Sausalito waterfront.

In all of San Francisco Bay, Richardson Bay is home to the largest number of houseboats (non-navigable structures used as residences, also known as floating homes) marina and residential vessels (navigable structures also known as live-aboards) and floating structures used for long-term residential purposes. Richardson Bay, especially the northwest Sausalito shoreline, and adjacent area under the jurisdiction of Marin County, has accommodated houseboats and residential vessels since the early 1900s. The extensive use of the water area for residential use commenced after World War II when salvaged barges and other floating structures left over from the wartime ship building activity in the Marin shipyards were converted to houseboats. In early 1980s, the Sausalito/Marin County waterfront witnessed an increase in the numbers, sizes, designs, and shapes of houseboats and live-aboard vessels locating in the area.

## **2. Water Quality Impairment**

Richardson Bay was listed as an impaired water body (by the U.S. Environmental Protection Agency, under section 303(d) of the Clean Water Act) due to high coliform bacteria levels. The listing of the Bay as impaired was based on widespread exceedance of bacterial water quality objectives (e.g., fecal coliform bacteria water quality objectives (WQOs)) for two beneficial uses designated in the Water Quality Control Plan for the San Francisco Bay Region (Basin Plan): shellfish harvesting (SHELL) and water contact recreation (REC-1).

## **3. Historical Bacterial Monitoring Studies**

The San Francisco Bay Regional Water Quality Control Board (Water Board) staff conducted bacteriological studies in Richardson Bay in 1973 and 1981. In the 1973 study, the data showed excessively high total and fecal coliform counts in the houseboats area on the northern edge of Sausalito. Sewage discharge from houseboats was identified as the source. Coliform counts at the other Richardson Bay marinas were no higher than those in the surrounding waters.

The 1981 study was more detailed and provided more information. Its purpose was to see if vessel waste discharges were causing violations of bacteriological water quality objectives for REC-1 and SHELL. Water Board staff conducted sampling during September and October 1981. Water samples were analyzed for total and fecal coliform. Sampling in the late summer avoided inclusion of waste contributions from stormwater runoff or sanitary sewer overflows.

The 1981 study sampled at 24 stations at marinas in Richardson Bay, plus 4 control stations located in the main channel, away from the shore. Results at the control stations were good; coliform levels were low enough to meet both the REC-1 and SHELL WQOs. At 13 of the non-control stations, coliform levels exceeded both objectives. Another 9 stations had coliform levels in excess of the SHELL WQO. Two stations met both objectives.

High coliform counts at some stations were attributed to unsewered houseboats. However, the report stated that unsewered houseboats did not explain all the high coliform counts. It concluded

that vessel waste discharges contributed significantly to the excessive coliform counts in 12 marinas.

Additional water quality monitoring studies were conducted in 1990, 1991, and 1992. Coliform data collected in these studies were assessed based on REC-1 WQOs. In general, in comparison with the 1981 survey, these subsequent studies showed overall improvements in water quality, with some exceedances of fecal and total coliform REC-1 WQOs at the Gates Co-op and Galilee Harbor areas. The 1992 water quality results demonstrated significant improvement from 1981, in both fecal and total coliform levels at Gates Co-op and Galilee Harbor, following installation of temporary sewage lines at Gates Co-op and temporary sewage disposal strategies at Galilee Harbor. Both the 1991 and 1992 survey results indicated the possibility of episodic sewage discharges in 40 percent of the recreational boating marinas. However, overall water quality was good, meeting WQOs for REC-1 (calculated based on the average of five sampling events).

Coliform sampling was resumed in 1994 and continued annually through 2003. Fecal coliform monitoring data from 1994-2003 showed that approximately 70 percent of the samples exceeded the WQO for SHELL. The data showed that 9 percent of the samples also exceeded the WQO for REC-1. Of the sampling stations exceeding the shellfish WQO, those located in the houseboat marinas clearly had the largest number of exceedances. Waldo Point Marina, Yellow Ferry Dock, Kappas Houseboat Marina, and the outer part of the Galilee Harbor (station 8) exceeded SHELL nearly every year from 1994 to 2003. Among the houseboat marinas, as well as overall, sampling stations at Waldo Point's Gates Coop (stations 41 and 42) by far showed the highest fecal coliform counts of all stations.

Among the sampling stations located within the boat marinas, Sausalito Yacht Harbor (station 5), Pelican Yacht Harbor (station 6), Arquez Marina (station 37), and Clipper Basin 4 (station 14) had the highest number of exceedances over the monitoring period of 1994–2003.

Among the control sites, control station B, located somewhat closer to the recreational boat marinas and a wildlife haul-out area, showed some exceedances of SHELL. Control station C, which is a good representative of open waters away from any pollution sources, exceeded the SHELL WQO only once.

In summary, results of fecal coliform monitoring between 1994 and 2003 revealed that both in terms of frequency and magnitude, houseboat marinas were consistently the most significant sources of pollution in Richardson Bay during that period. The data also suggested that a few recreational boat marinas have been consistent, yet less frequent, sources of pollution in the Bay.

#### **4. Long-term Bacteria Monitoring Program**

The long-term Richardson Bay bacteria water quality monitoring program was initiated in 2005. The Richardson Bay Regional Agency (RBRA) staff monitored *Enterococcus*, total coliform, and *E. coli* to assess REC-1 beneficial use, and the Water Board staff monitored fecal coliform to assess both REC-1 and SHELL beneficial uses. Due to State budget shortfalls, there are some gap years in the fecal coliform monitoring conducted by the Water Board staff.

The program included a 5-week sampling series in the dry seasons only. The dry season is defined as May through October but, practically, the sampling was typically conducted within the August through October period.

The Richardson Bay Pathogens Total Maximum Daily Load (TMDL), a water quality improvement plan developed by the Water Board, was approved by the United States Environmental Protection Agency (U.S.EPA) in 2009, to address impairment of SHELL and REC-1 beneficial uses. In response to the TMDL, starting in 2010, both parties extended their water quality monitoring programs to also include 5-week series in wet seasons. The wet season is defined as November through April but, practically, the sampling was typically conducted within the January through March period.

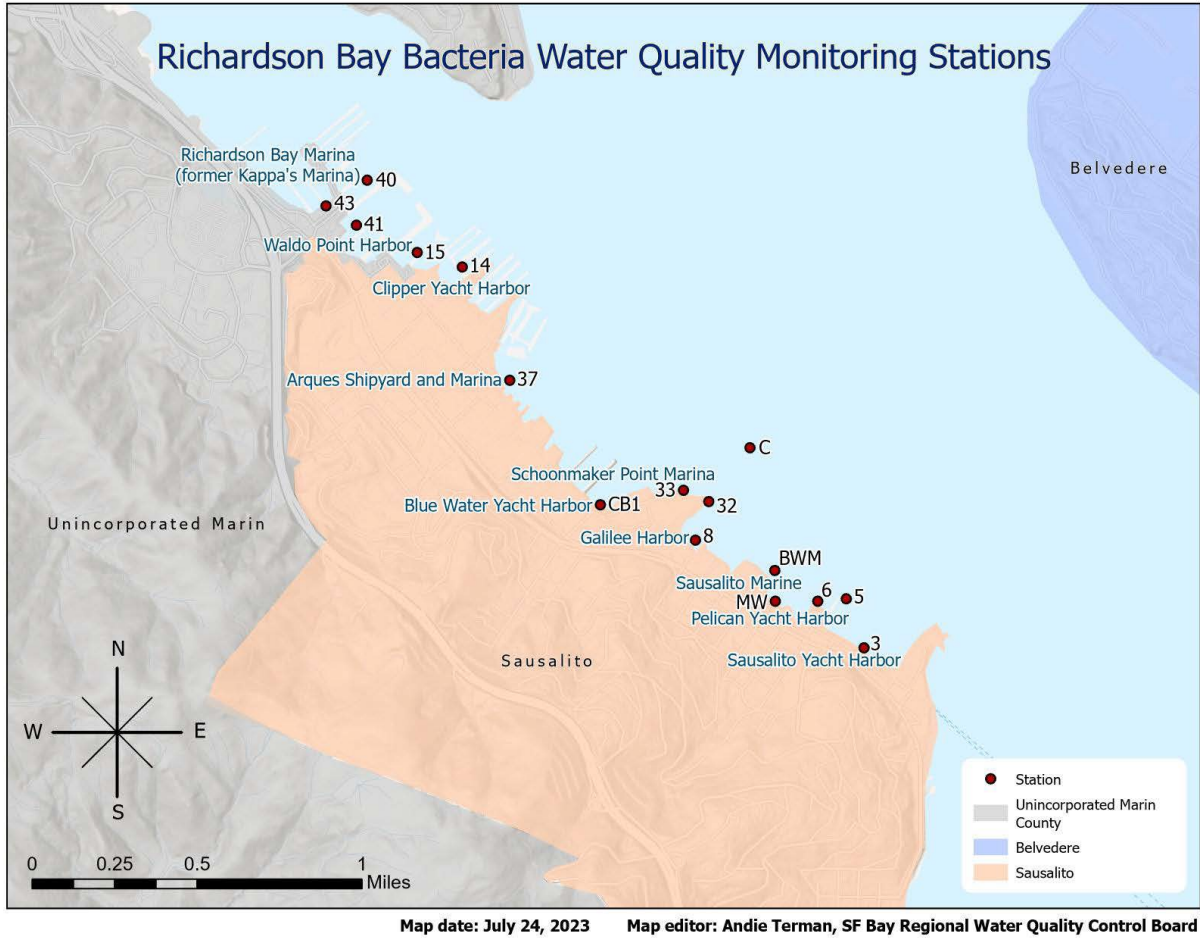
#### 4.1. Monitoring Program Design

The long-term monitoring program includes 16 stations within the floating homes and vessel marinas along the Sausalito shoreline and unincorporated Marin County land (the control site “C” is in the open waters). These stations are listed in Table 1, below.

**Table 1. Richardson Bay Long-term Monitoring Stations**

<b>Station ID</b>	<b>Station Name</b>	<b>Marina Type</b>
41	Waldo Point gates coop	Floating Home Marina
43	Kappas Houseboats	Floating Home Marina
40	Waldo Point "A" dock	Floating Home Marina
15	Waldo Point south 40	Floating Home Marina
14	Clipper Basin #4	Vessel Marina
37	Arques Marina	Mix, Floating Home, and Vessel Marina
CB1	Clipper Basin #1	Vessel Marina, Stormwater Outfall
33	Schoonmaker Beach	Vessel Marina
32	Schoonmaker	Vessel Marina
8	Galilee / Napa	Floating Home Marina
BWM	Bridgeway Marina	Vessel Marina
MW	Marine Ways	Vessel Marina, Stormwater Outfall
6	Pelican Harbor	Vessel Marina
5	Sausalito Yacht Harbor (5)	Vessel Marina
3	Sausalito Yacht Harbor (3)	Vessel Marina
C	Control "C"	Open Channel, Control Site

Figure 1 shows the location of sampling stations and corresponding floating home or vessel marinas.



**Figure 1. Long-term Richardson Bay Bacteria Monitoring Stations**

The monitoring was conducted annually and included two five-week series, one in the dry season and one in the wet season. The program monitored fecal coliform, total coliform, *E. coli*, and Enterococcus.

The fecal coliform samples were analyzed at the Water Board’s contract laboratory (currently Cel Analytical) and paid for by the Water Board. The other constituents were analyzed at the County laboratory used by Marin County (currently Napa-Solano-Yolo-Marin-Mendocino County Public Health Laboratory) and paid for by RBRA.

**4.2. Applicable Water Quality Objectives**

The applicable water quality objectives for this project, as specified in the TMDL (numeric targets), are listed in Table 2.

**Table 2. TMDL Bacteria Water Quality Objectives for Richardson Bay <sup>a</sup>**

<b>Beneficial Use</b>	<b>Numeric Target</b>
Shellfish Harvesting (SHELL)	Median fecal coliform density <sup>b</sup> < 14 (MPN/100 mL) <sup>c</sup> 90 <sup>th</sup> percentile fecal coliform density < 43 (MPN/100 mL)
Water Contact Recreation (REC-1)	Geometric mean fecal coliform density < 200 90 <sup>th</sup> percentile fecal coliform density < 400 Geometric mean Enterococci density < 35 (CFU <sup>d</sup> /100 mL) Single sample maximum Enterococci density < 104 (CFU/100 mL)
<p>a. Based on a minimum of five consecutive samples equally spaced over a 30-day period</p> <p>b. “Density” refers to the number of bacteria in a given volume of water (U.S. EPA, 1986, 2002, 2003). The term is analogous to “concentration,” which refers to the mass of chemical pollutant in a given volume of water. “Bacterial density” and “bacterial concentration” are sometimes used interchangeably.</p> <p>c. Most Probable Number (MPN) is a statistical representation of the standard coliform test results.</p> <p>d. CFU stands for colony forming unit (e.g., as in number of bacterial colonies)</p>	

Since the TMDL adoption, State and Regional Water Boards have adopted new bacteria WQOs for protection of REC-1 beneficial use. These WQOs are listed in Table 3 and are also used to assess the bacteriological data collected by this project.

**Table 3. Regional Bacteria Water Quality Objectives for Richardson Bay**

<b>Beneficial Use</b>	<b>Numeric Target</b>
Shellfish Harvesting (SHELL)	Median fecal coliform density < 14 (MPN/100 mL) <sup>a</sup> 90 <sup>th</sup> percentile fecal coliform density < 43 (MPN/100 mL)
Water Contact Recreation (REC-1)	Geometric mean Enterococcus density < 30 (CFU/100 mL) <sup>b</sup> Statistical Threshold Value (STV) Enterococcus density < (110 CFU/100 mL)
<p>a. Most Probable Number (MPN) is a statistical representation of the standard coliform test results.</p> <p>b. Numeric values are from Part 3 of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California based on Section 7958 of Title 17 of the California Code of Regulations, 69FR 67217 et seq., and 40 CFR Part 131.41 (effective date December 16, 2004). The Enterococcus objective applies to marine and estuarine waters where the salinity is greater than 1 part per thousand more than 5 percent of the time. The geometric mean for enterococcus is computed weekly for all samples in a 6-week interval. The STV is the statistical threshold value and shall not be exceeded by more than 10 percent of the samples collected in a calendar month.</p> <p>The units CFU denote colony forming units. This unit of measurement is equivalent to MPN (most probable number). The use of either MPN or CFU is based on the method used to detect bacteria, and both are valid measures of bacteria density.</p>	

## 5. TMDL Adoption and Actions

To address the bacteria water quality impairment in Richardson Bay, on December 18, 2009, the U.S.EPA approved a Basin Plan amendment incorporating a TMDL for pathogens in Richardson Bay and an implementation plan to achieve the TMDL. The amendment was formerly adopted by the San Francisco Bay Water Board on July 9, 2008, and the State Water Resources Control Board on August 4, 2009. The TMDL was approved by the State Office of Administrative Law and became effective on November 2, 2009. It is now officially incorporated into the Basin Plan, the region's water planning document for protecting water quality.

The main sources of pathogens to the Bay were identified by the TMDL Plan as houseboat (floating homes) and vessel waste discharges, sanitary sewer system failures, and municipal stormwater runoff. The TMDL Plan is implemented through Basin Plan prohibitions of discharge for houseboats and vessels, waste discharge requirements (WDRs) for Sanitary Sewer Systems, and the Statewide National Pollutant Discharge Elimination System (NPDES) stormwater permit for small municipalities. Specific implementation actions include creation and implementation of Sewage Spill Reduction and Sewage Management Plans, renovation of dilapidated houseboat marinas, increased mobile sewage pumpout services, installation of additional stationary sewage pump-outs, increased inspection and education and outreach for all marinas, and ongoing water quality monitoring.

The sanitary sewer system implementation actions occurred through the Statewide WDRs General Permit managed by the Water Board's NPDES division. Other implementation actions occurred either voluntarily (e.g., renovation of dilapidated houseboat marinas), or through informal (e.g., e-mail or verbal) requests by the Water Board staff. An implementation plan developed by RBRA, titled "*TMDL Local Implementation Plan*" and dated September 17, 2009, summarizes the most significant implementation actions to be taken by RBRA and partners. A copy of this plan is kept on file.

The implementation of significant corrective actions is believed to have started after 2012, as it usually takes a few years after the TMDL effective date for the implementing parties to plan, organize, and implement actions. For example, the renovation of the Gates Coop marina did not start until 2014. As such, for water quality comparison purposes, the post-TMDL period is defined as 2012 to present.

## 6. Water Quality Monitoring Data Analyses

This report analyzes 23 years of bacteria water quality monitoring data collected in Richardson Bay, from 2000 to 2023. The sections below summarize and discuss the results of these analyses.

In addition, an interactive online map displaying the pre- and post-TMDL Enterococcus levels and water quality objective exceedance rates is available at:

<https://gispublic.waterboards.ca.gov/portal/home/webmap/viewer.html?webmap=6df9df3d90c04b4dbe823d5439aeed87>

### 6.1 Data Included in These Analyses

Even though total coliform and *E. Coli* data were also collected by RBRA staff, since the only indicator bacteria applicable to the TMDL are fecal coliform and Enterococcus, the total coliform and *E. Coli* data are not included in these analyses.

RBRA staff likely chose these indicator bacteria because, at the time, they were used by Marin County Public Health Program for monitoring bacteria water quality at public beaches. Water Board staff has discussed this issue with the RBRA staff a few times in the past, but RBRA staff chose to continue collecting total coliform and *E. Coli* data. The rationale given by one of the RBRA's previous harbor administrators for continuing to collect these constituents was that they wanted to keep their dataset consistent.

## 6.2 Questions the Report Aims to Answer

In analyzing the long-term bacteriological data, this report aims to answer the following questions:

- What is the current impairment status of SHELL and REC1 beneficial uses?
- What are the long-term trends in water quality?
- Is the TMDL improving water quality?
- Are the TMDL water quality targets being met?

The following sections summarize and discuss the results of the analyses performed to answer these questions.

## 6.3 Beneficial Use Impairment Assessment

To assess the current impairment status of the beneficial uses in the Bay, the fecal coliform data from 2000-2023 are analyzed for SHELL beneficial use impairment assessment, and the Enterococcus data from 2005-2023 are analyzed for REC-1 beneficial use impairment assessment. For these assessments, we have relied on the current Regional WQOs listed in Table 3. Further, to evaluate the TMDL's impact on the water quality impairments, the data are also divided into the pre-TMDL (2000-2011) and Post-TMDL (2012-2023) periods.

### 6.3.1 SHELL Beneficial Use Impairment Assessment

According to the Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List ("Listing Policy"), a waterbody is considered impaired by bacteria when more than roughly 17 percent of the samples exceed the applicable WQOs for a given beneficial use, such as SHELL. The exact threshold percentage is dynamic and varies some depending on the size of the given dataset.<sup>1</sup>

We analyzed the fecal coliform data to find out if the SHELL beneficial use is currently impaired. We further compared the pre- and post-TMDL exceedance rates of fecal coliform WQOs designed to protect the SHELL beneficial use. The results are summarized in Tabel 4. They show that while

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<sup>1</sup> The procedures in the Listing Policy for assessing bacteria impairment are designed to determine if the true exceedance rate of the applicable water quality objectives in the water body is less than 10%. If the exceedance rate is more than 10%, the water body would be listed as impaired. As discussed in Section 3.3 of the Listing Policy and in Table 3-2, California's listing procedures explicitly account for statistical errors and include an explicit effect size. Consequently, the effective exceedance rate triggering impairment for conventional pollutants like bacteria is approximately 17 percent.

the SHELL beneficial use is currently impaired, there has been a significant decrease in the exceedance rates of fecal coliform WQOs for SHELL since the TMDL implementation started.

**Table 4. Exceedance Rates of Fecal Coliform Water Quality Objectives for Shellfish Harvesting**

Period	Median Fecal Coliform Exceedance Rates	90th Percentile Fecal Coliform Exceedance Rates
All Data	55.5 %	63.9 %
Pre-TMDL	62.7 %	75.3 %
Post-TMDL	51.9 %	55.1 %

### 6.3.2 REC-1 Beneficial Use Impairment Assessment

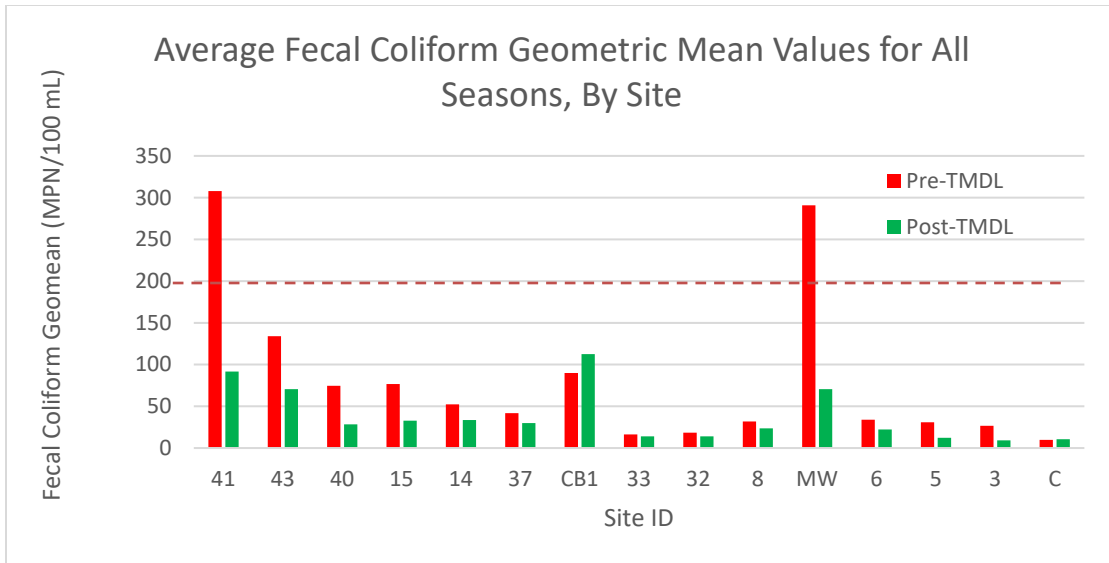
Similar to SHELL beneficial use impairment assessment, we analyzed the Enterococcus data, using the current Regional WQOs (Table 3), to determine the impairment status of the REC-1 beneficial use in the Bay. These results are summarized in Table 5. They show that the REC-1 beneficial use is currently being attained and that this beneficial use is no longer impaired in the Bay. However, the exceedance rates are still close to the impairment threshold of 16.7 percent prescribed for this particular dataset. Further, the results also show a significant improvement in water quality post-TMDL as compared to the pre-TMDL period.

**Table 5. Exceedance Rates of Enterococcus Water Quality Objectives for Water Contact Recreation**

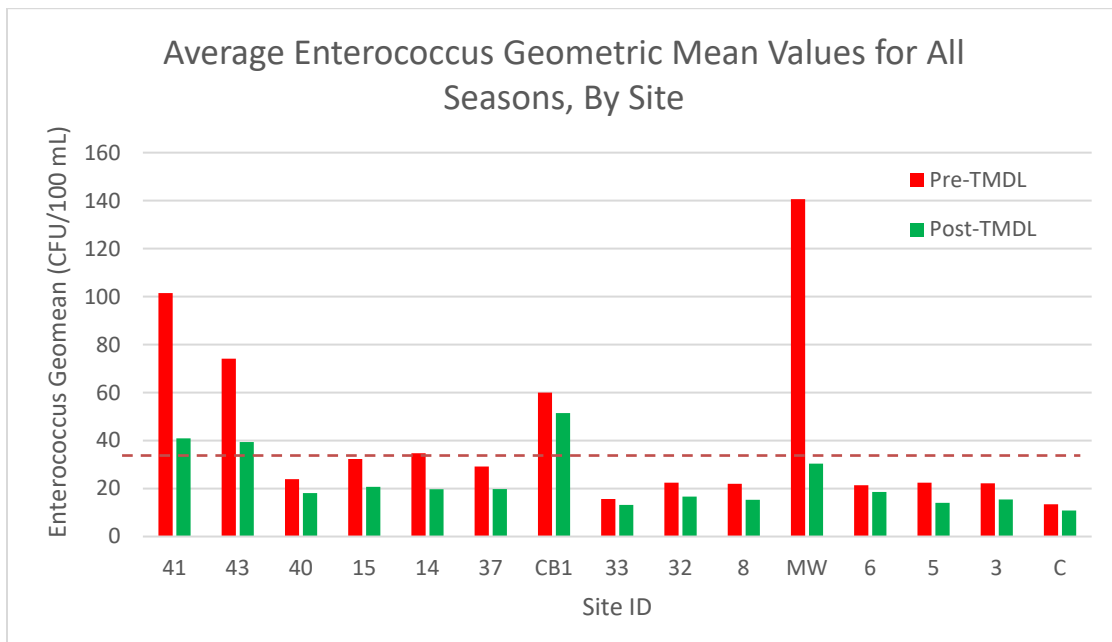
Period	Enterococcus Geometric Mean Exceedance Rates	Enterococcus STV Exceedance Rates
All Data	23.3 %	17.6 %
Pre-TMDL	35.2 %	25.3 %
Post-TMDL	15.6 %	16.1 %

### 6.4 Overall Water Quality Trends

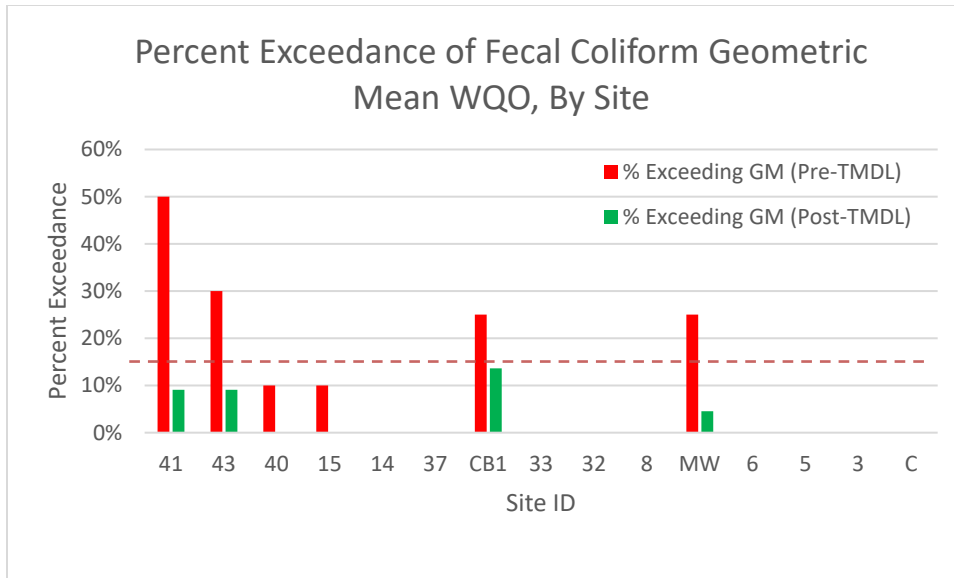
To examine the long-term trends in bacteria water quality, we evaluated the fecal coliform and Enterococcus geometric mean data using both the average magnitude and the rates at which those data exceeded the applicable WQOs listed in the TMDL (Table 2), for both the pre- and post-TMDL periods. The results of these analyses are shown in Figures 2-5. Separately, an interactive map displaying the pre- and post-TMDL Enterococcus monitoring results is available online at: <https://gispublic.waterboards.ca.gov/portal/home/webmap/viewer.html?webmap=6df9df3d90c04b4d8e823d5439aeed87>



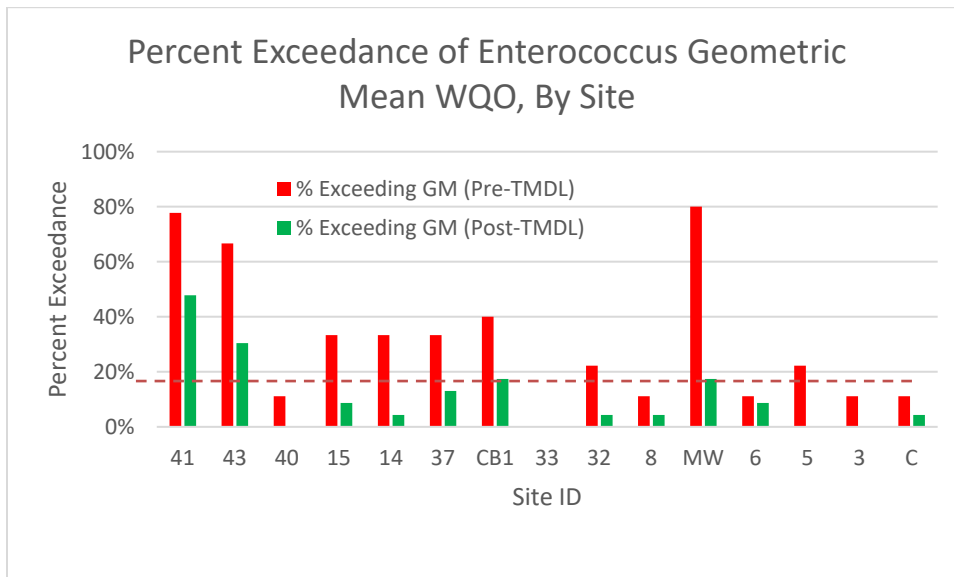
**Figure 2. Comparison of combined dry and wet seasons fecal coliform geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 200 MPN/100 mL.**



**Figure 3. Comparison of combined dry and wet seasons Enterococcus geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 35 CFU/100 mL.**



**Figure 4. Comparison of exceedance rates of fecal coliform geometric mean water quality objective for pre- and post-TMDL periods. The red dashed line represents the applicable impairment threshold of ~16%. Missing bars indicate an exceedance rate of zero.**



**Figure 5. Comparison of exceedance rates of Enterococcus geometric mean water quality objective for pre- and post-TMDL periods. The red dashed line represents the applicable impairment threshold of ~16.7%. Missing bars indicate an exceedance rate of zero.**

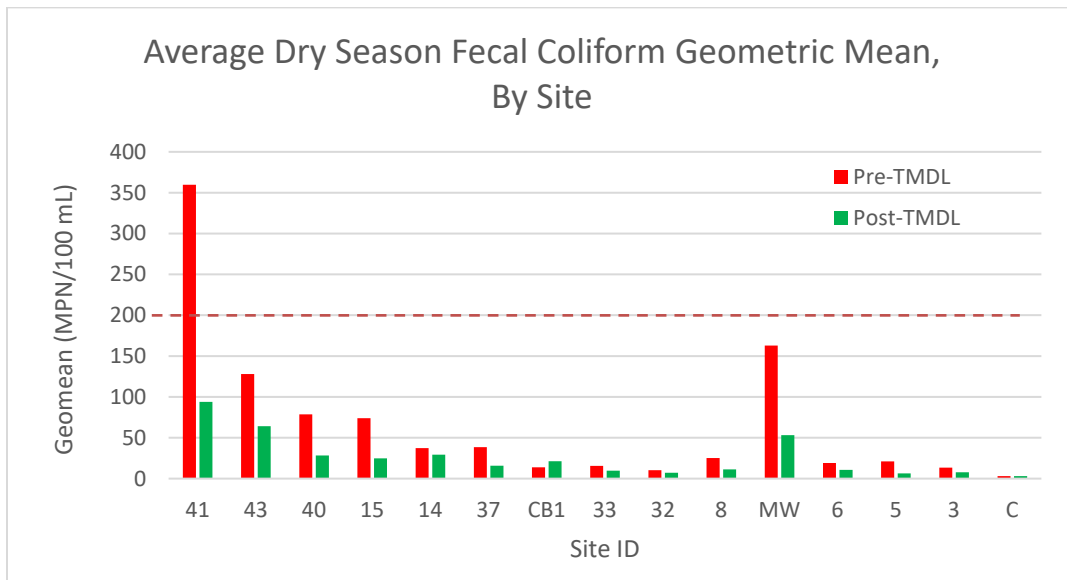
In all cases, the post-TMDL data show marked improvement in water quality, both in terms of average geometric mean magnitudes and percent exceedances of the applicable WQOs.

They also reveal that while the post-TMDL fecal coliform geometric means and exceedance rates are all below the applicable thresholds, the post-TMDL Enterococcus data exceed these thresholds at a few sites. These exceedances are specifically observed at sampling sites 41, 43, CB1, and MW. Sites 41 and 43 are located in floating home marinas, while sites CB1 and MW are located at vessel marinas but directly in front of large stormwater outfalls. These observations could suggest

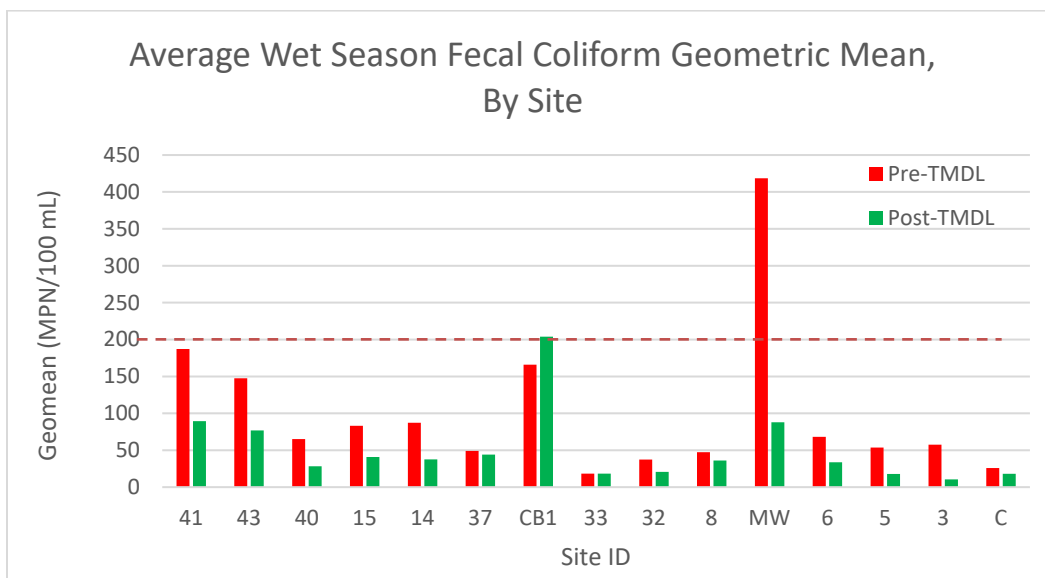
the adverse impact of stormwater runoff at sites CB1 and MW, and waste management practices at sites 41 and 43, on the water quality. Alternatively, the higher bacteria levels observed at sites 41, 43, and CB1, could be due to the lower flushing dynamics caused by structural impediments at these locations.

### 6.5 Seasonal Water Quality Trends

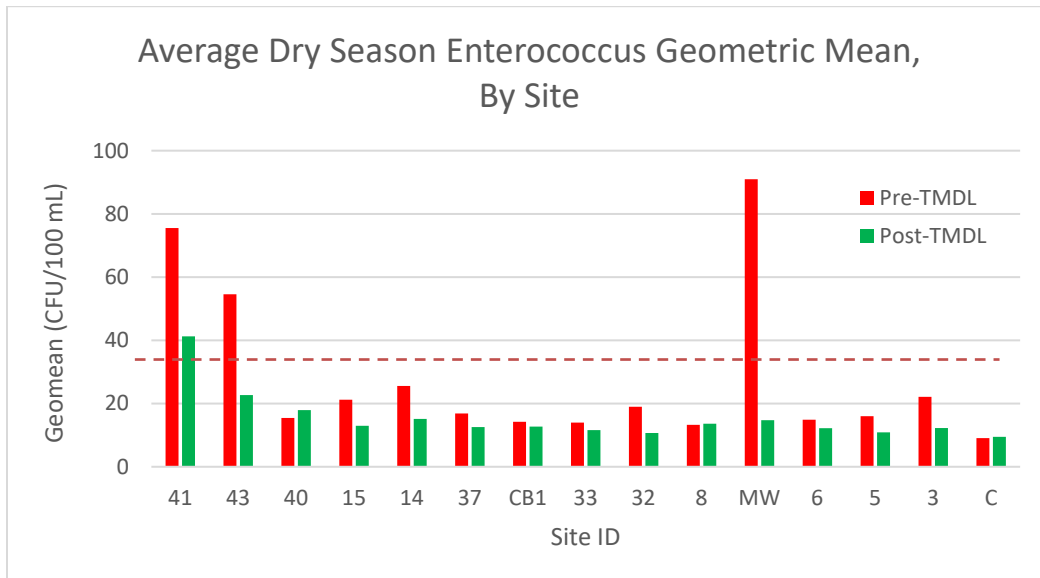
To evaluate the seasonal trends in water quality, we examined the average fecal coliform and Enterococcus geometric mean magnitudes, by season, for both the pre- and post-TMDL periods. The results of these analyses are shown in Figures 6-9. Further, we analyzed the seasonal exceedance rates of the applicable TMDL WQOs (Table 2) for both fecal coliform and Enterococcus. The results of these analyses are presented in Tables 6-7.



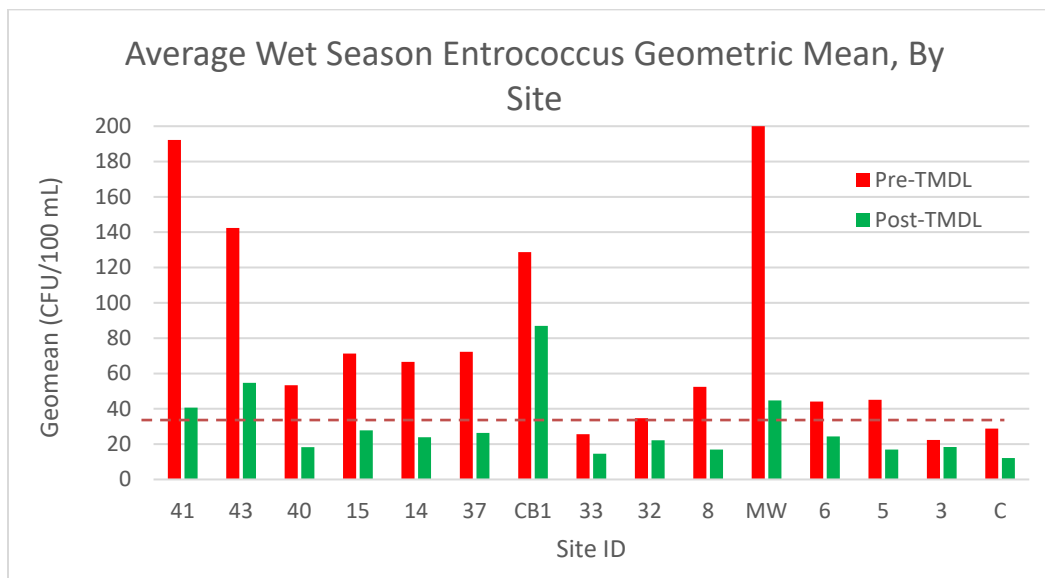
**Figure 6. Comparison of dry season fecal coliform geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 200 MPN/100 mL.**



**Figure 7. Comparison of wet season fecal coliform geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 200 MPN/100 mL.**



**Figure 8. Comparison of dry season Enterococcus geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 35 CFU/100 mL.**



**Figure 9. Comparison of wet season Enterococcus geometric mean values for pre- and post-TMDL periods. The red dashed line represents the applicable water quality objective of 35 CFU/100 mL.**

The seasonal evaluation of the average geometric mean magnitudes shows the same pattern as when the data from all seasons were combined. For either the fecal coliform or Enterococcus data, at almost all sites, the post-TMDL results are clearly lower than the pre-TMDL results, during either the dry or wet seasons. Also, in the great majority of instances they meet the applicable thresholds.

Once again, the only sites that do not meet the applicable thresholds are sites 41, 43, CB1, and MW, which were discussed above. Further, as expected, the seasonal evaluation shows that the wet season geometric mean magnitudes are higher than those measured in the dry season. This observation is likely due to enhanced mobilization of bacteria in the wet season facilitated by stormwater runoff.

**Table 6. Overall and Seasonal Exceedance Rates of Fecal Coliform Water Quality Objectives**

<b>Period</b>	<b>Geometric Mean Fecal Coliform Exceedance Rates (%)</b>	<b>90th Percentile Fecal Coliform Exceedance Rates (%)</b>
All Data Overall	4.4	15.8
Pre-TMDL Overall	8.3	24.1
Post-TMDL Overall	2.1	11.1
All Data Fall	3.7	14.0
Pre-TMDL Fall	6.4	20.7
Post-TMDL Fall	0.5	7.1
All Data Winter	3.9	14.3
Pre-TMDL Winter	9.1	26.5
Post-TMDL Winter	3.7	15.2

**Table 7. Overall and Seasonal Exceedance Rates of Enterococcus Water Quality Objectives**

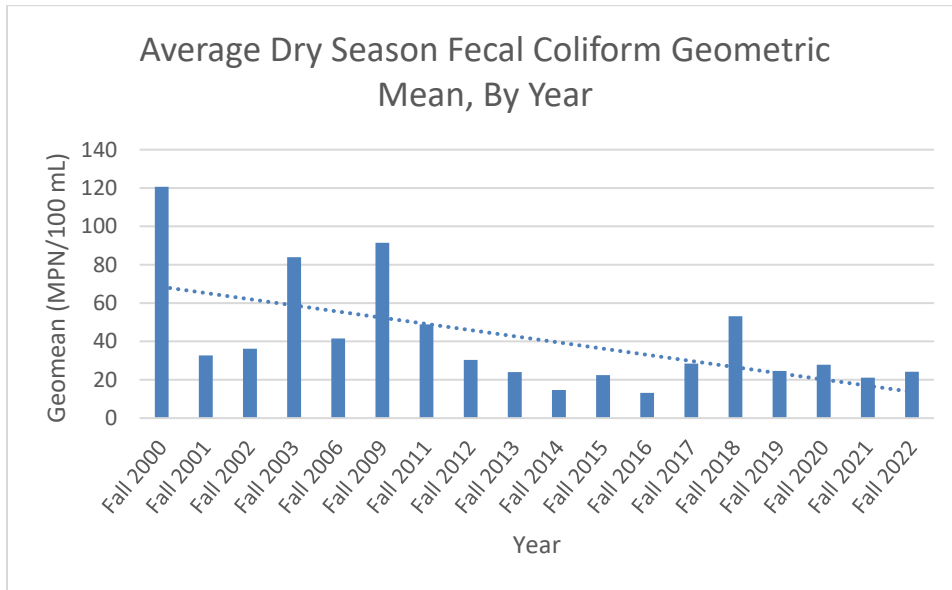
<b>Period</b>	<b>Geometric Mean Enterococcus Exceedance Rates (%)</b>	<b>Single Sample Maximum Enterococcus Exceedance Rates (%)</b>
All Data Overall	16.2	9.3
Pre-TMDL Overall	27.8	14.7
Post-TMDL Overall	9.0	7.7
All Data Fall	12.2	6.6
Pre-TMDL Fall	18.5	10.7
Post-TMDL Fall	5.3	4.0
All Data Winter	21.1	14.5
Pre-TMDL Winter	65.6	33.5
Post-TMDL Winter	12.4	11.0

The evaluation of the overall and seasonal exceedance rates of the applicable TMDL WQOs (Table 2), for both fecal coliform and Enterococcus data, show a clear and significant reduction from the pre- to post-TMDL periods (Tables 6-7). While the wet season exceedance rates are expectedly higher than the dry season rates; nonetheless, the post-TMDL wet season rates are still

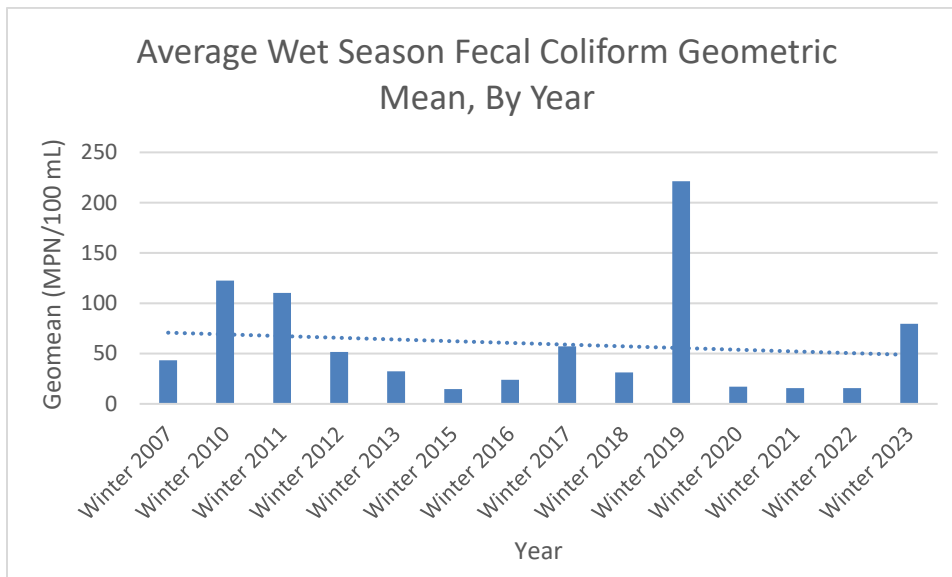
much lower than the pre-TMDL wet season rates. Further, irrespective of season, the post-TMDL exceedance rates, for either bacteria species, are all below the applicable impairment threshold of roughly 16%.

### 6.6 Annual Water Quality Trends

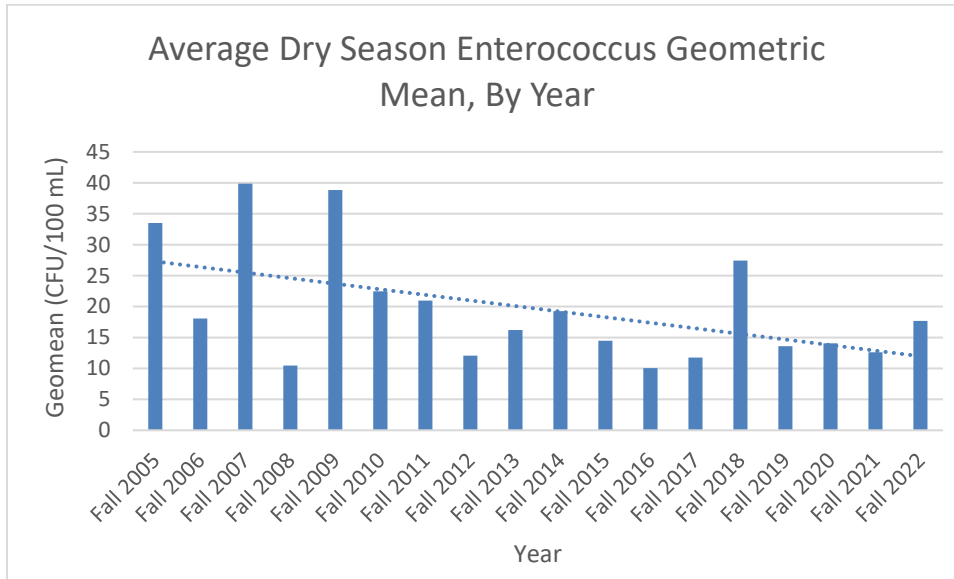
To evaluate the annual trends in water quality, we additionally examined the average fecal coliform and Enterococcus geometric mean magnitudes, by year, for both dry and wet seasons. The results of these analyses are shown in Figures 10-13.



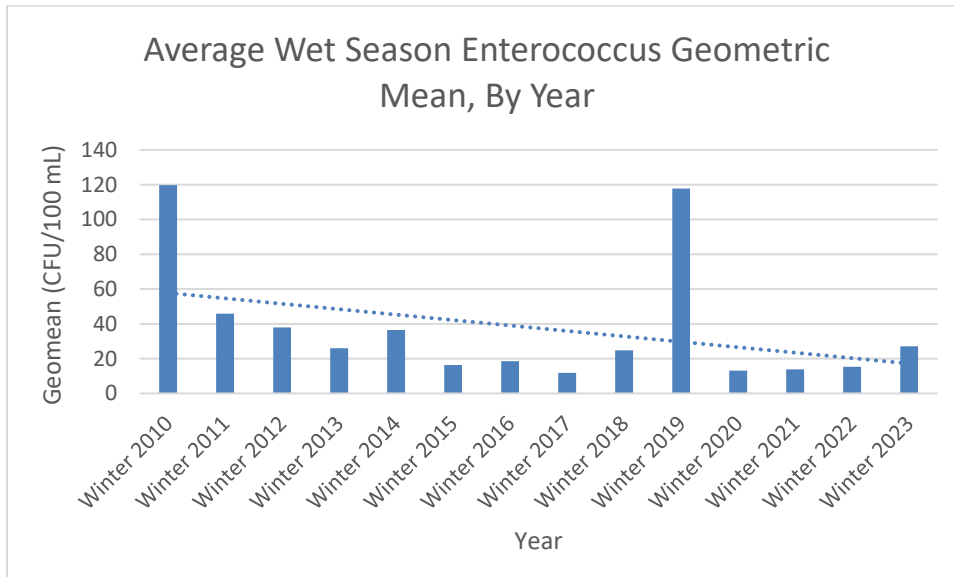
**Figure 10. Annual average dry season fecal coliform geometric mean values.**



**Figure 11. Annual average wet season fecal coliform geometric mean values.**



**Figure 12. Annual average dry season Enterococcus geometric mean values.**



**Figure 13. Annual average wet season Enterococcus geometric mean values.**

The examination of the annual average geometric mean values reveals that with one exception (winter 2019 fecal coliform data-Figure 11) the highest annual geometric mean values were measured in the pre-TMDL period. It further shows a decreasing trend from the pre-TMDL to post-TMDL and present time. This observation is held true for both bacteria species and seasons. Also, as expected, the wet season bacteria levels in the unusually wet years such as 2019 and 2023 spike considerably higher than the other years, in the post-TMDL period.

## 7. Conclusions

Evaluation of the SHELL beneficial use impairment status, based on the current Regional fecal coliform WQOs (Table 3), reveals that this beneficial use is still impaired. However, the impairment level has significantly decreased in the post-TMDL era, as shown by the noticeably lower exceedance rates observed in the post-TMDL period.

Conversely, evaluation of the REC-1 beneficial use impairment status, based on the current Enterococcus WQOs (Table 3), shows that the post-TMDL exceedance rates of the Enterococcus data have decreased to the point that, at this time, this beneficial use is no longer impaired.

Evaluation of the long-term overall, seasonal, and annual trends in the fecal coliform and Enterococcus levels reveal that, in all cases, the post-TMDL results show marked improvement in the water quality of the Bay, both in terms of the average geometric mean magnitudes and percent exceedances of the applicable WQOs. This observation confirms the TMDL is making significant improvement in water quality.

Further, the examination of the data show that the TMDL fecal coliform targets for the REC-1 beneficial use are being met at all sites, and the TMDL Enterococcus targets are being met at all but a few of the sites with extenuating circumstances. Nonetheless, when the data from all sites are combined, the post-TMDL exceedance rates of the applicable REC-1 WQOs, for either bacteria species, are all below the applicable impairment threshold of roughly 17 percent. These findings demonstrate that the TMDL's water quality targets for the protection of the REC-1 beneficial use are by and large being met.

## 8. Recommendations

Based on the results of these analyses, we recommend the following modifications to the Richardson Bay bacteria water quality monitoring plan.

- We recommend discontinuing monitoring for total coliform and *E. coli* bacteria because these constituents are not included in the TMDL, and the TMDL water quality targets are not based on these bacteria.
- We further recommend discontinuing monitoring for fecal coliform bacteria for the REC-1 beneficial use protection assessment. Even though this constituent and associated water quality targets are included in the TMDL, we now have updated and better Regional bacteria standards for assessing the REC-1 beneficial use attainment, based on Enterococcus bacteria, which we can use. Therefore, we recommend stopping the fecal coliform monitoring, but continuing the Enterococcus monitoring, for the REC-1 beneficial use assessment purposes.
- Since the fecal coliform bacteria are still used for the SHELL beneficial use assessment, we recommend conducting fecal coliform monitoring for this purpose but at a reduced frequency of one dry season five-week series every five years. This recommendation is based on the understanding that adequate reduction in the fecal coliform levels to meet the SHELL water quality objectives would not be achieved in the short-term. Therefore, annual monitoring for this constituent would not be an effective use of our resources.
- We also recommend reducing the Enterococcus monitoring frequency to no more than every other year. This recommendation stems from the facts that there has been significant

improvement in the water quality of the Bay since the TMDL implementation, the REC-1 beneficial use is currently being attained, and the bacteria levels have been trending downward. Therefore, annual monitoring would not be necessary at this point.

- Further, we recommend discontinuing the wet season monitoring series. This is due to the understanding that REC-1 beneficial uses in the Bay primarily take place in the dry season and, as discussed above, the bacteria levels and water quality objectives exceedance rates are below applicable targets, in both dry and wet seasons. As such, the wet season monitoring would not be essential and its discontinuation would allow us to allocate limited resources to higher priority projects.,
- Lastly, if the current water quality conditions continue, we recommend a note to be included in the next “Integrative Report” to state that the REC1 beneficial use is no longer impaired.