COASTAL WATER QUALITY REPORT 2019

Technical Report

PREPARED FOR:

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Making progress possible. Together.

REPORT REF.: LT 857 TR V 1.0

June 2019

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Report Version and Quality Control:

Date	Report No. and Revision No.	Created	Reviewed	Authorised for Release
12/06/2019	LT 857 TR V 0.1	L. Weston, A. McGrath, M Malange	R Carter, L Holton	

EXECUTIVE SUMMARY

To be completed after client review.

Contents

Figures

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1 INTRODUCTION & REPORT STRUCTURE

Commented [LH1]: CCT – final formatting and appearance edits will be conducted in the final version

This is a technical report compiled by Lwandle Technologies (Lwandle) for the City of Cape Town (CCT), which precedes the official Coastal Water Quality Report to be compiled by CCT for release to the public. It is assumed that CCT has provided all available historic and current faecal indicator bacteria (FIB) data which has been collected since project inception in 1967 at coastal monitoring points, recreational nodes and marine outfalls sites along the section of coastline that falls within the CCT jurisdiction. The aim of this report is to provide a consolidated description of coastal water quality, as reflected by the FIB data over the monitoring period, and in relation to national water quality guidelines. Possible causative factors and explanatory variables for trends and apparent anomalies are identified from available data/information where possible.

CCT routinely monitors FIB at various sites along the coastline from Silwerstroomstrand on the West Coast to Kogel Bay on the eastern corner of False Bay. The earliest measurements were conducted in the 1960's at some sites. Historically, only total faecal coliform counts were measured, however *E. Coli* and enterococci were added to the monitoring campaign in 2002 and 2005, respectively.

The report is structured as follows:

- The CCT's coastal water quality monitoring regime, its importance, as well as the effects of poor water quality are discussed in section 2. Data parameters and analysis approach are detailed in section 3.
- In section 4, for each area, the data set is split into a historical data subsection and a current data subsection. The primary aim of the former, is to present the full time series and attempt todetect change and trends in FIBs over the entire monitoring period. The latter provides a more in-depth description of the FIB data over the last five years. Water quality at each site is classified by percentile thresholds for enterococci as per the Water Quality Guidelines for Recreational Use (DEA, 2012). In sections 5 and 6 respectively, data collected at the city's three marine coastal outfalls are examined, and natural events such as algal blooms (HABs and Anaulus) are discussed.
- In section 7, the CCT coastal water quality monitoring efforts are discussed in a global context, both first world and third world; and
- Lastly, conclusions and recommendations to the City of Cape Town, based on the FIB data presented, performance in relation to guidelines, and possible explanatory variables is provided in section 8.

2 COASTAL WATER QUALITY MONITORING IN THE CITY OF CAPE TOWN

Cape Town is one of the largest coastal cities in Africa, with its coastline extending approximately 307 km from Silwerstroom Strand on the west coast around the Cape Peninsula, along the False Bay coast to Kogel Bay (City of Cape Town 2018). This stretch of coastline is one of the most ecologically diverse and productive in South Africa and comprises a range of ecosystems, including estuaries, rocky shores, sandy beaches, kelp forests and islands. These provide a variety of ecosystem services to the surrounding communities in the City of Cape Town (hereafter referred to as the CCT) including the provision of fish and shellfish stocks which support both small- and large-scale fisheries, the protection from natural hazards such as storm surges and the provision of areas for recreational activity. The coastline and abutting sea area are a significant ecological, social and economic asset.

2.1 EFFECTS OF POLLUTION

The CCT hosts a large population (approximately 4 million people) and numerous anthropogenic pressures can compromise its coastal ecosystems through degraded coastal water quality. Marine pollution from point and diffuse source discharges of domestic sewage effluent is one such pressure which is becoming a critical issue as the population increases. These bring pathogenic microorganisms, such as viruses and bacteria, into the marine environment, which can have detrimental effects on human health, *inter alia* through diseases such as typhoid, dysentery and cholera (Clark 2002; UNEP/Nairobi Convention Secretariat 2009). The sources of these organisms include formal wastewater treatment works (WWTW) discharges, sewage overflows and storm water runoff (City of Cape Town 2018).

There are 26 WWTWs in Cape Town, from which treated effluent is either released into rivers and then into coastal waters via estuaries or is discharged directly into the ocean through marine outfall pipes (City of Cape Town 2018). The latter discharges receive primary treatment only whilst the others are treated to the tertiary level, including biocidal disinfection that reduces microbial loads). Even where tertiary treatment is applied overflows of untreated sewerage can occur, and if not addressed, can flow into the stormwater systems and from there into rivers and ultimately into the coastal environment. Stormwater systems in inadequately serviced informal settlements can contain large amounts of untreated sewage and domestic wastewater (City of Cape Town, 2018). Thus, episodic rainfall event increased stormwater flows can exacerbate degradation of coastal water quality by increased loads of pathogenic microorganisms being discharged into CCT's coastal water body.

2.2 COASTAL WATER QUALITY MONITORING

To prevent the degradation of coastal water bodies and to protect public health, effective management of microbial contamination is required. Globally, coastal water quality management strategies focus on maintaining or achieving the state of the receiving water body such that it is fit for designated uses. Designated uses of coastal waters include aquaculture, recreational use, industrial use as well as the protection of biodiversity and ecosystem functioning. Recreational use of the coastal waters and beaches within the City of Cape Town is widespread; Cape Town's beaches are world renowned and attract a large number of local and foreign visitors annually.

To effectively manage coastal water quality, appropriate indicators need to be consistently monitored and compared against established thresholds or guidelines. In South Africa, in 1992, the Department of Water and Sanitation (DWS) developed four volumes of Water Quality Guidelines (WQG) aimed at managing coastal and marine water quality for specific designated uses. These were updated in 1995, and again between 2012 and 2018 where they were relaunched by the Department of Environmental Affairs.

The City of Cape Town has commenced monitoring coastal water quality in accordance with the new DEA guidelines, and for the purposes of this report, the Guidelines for Recreational Use (DEA 2012) will be used. These guidelines stipulate the use of two faecal microbiological indicators (FIBs) for this; intestinal enterococci and *Escherichia coli*. A range of target values are specified, based on 90th and 95th percentiles, corresponding to different levels of risk. These are shown in Table 2.1 below. Note that the previous guidelines for recreational use (DWAF 1995) also used faecal coliforms as an indicator, however these have been excluded in the updated guidelines.

Table 2.1: Risk-based ranges for intestinal enterococci and Escherichia coli for recreational waters in the coastal marine environment (DEA 2012).

Category	Estimated Risk per Exposure	Enterococci (count per 100 ml)	*E. coli* (count per 100 ml)
Excellent	2.9% gastrointestinal (GI) illness risk	≤ 100 (95th percentile)	≤ 250 (95th percentile)
Good	5% GI illness risk	≤ 200 (95th percentile)	≤ 500 (95th percentile)
Sufficient or Fair (minimum requirement)	8.5% GI illness risk	≤ 185 (90th percentile)	≤ 500 (90th percentile)
Poor (unacceptable)	> 8.5% GI illness risk	> 185 (90th percentile)	> 500 (90th percentile)

The percentile exceedance approach underlying the DEA (2012) recreational use guidelines require aggregation of sample data in space or time. The DEA recommends that recreational water body classification according to the Table 2.1 criteria be applied over rolling 5-year monitoring periods, allowing the state of the recreational waters to be updated annually. This provides a robust

classification despite the known wide fluctuations in FIB counts. However, the approach is not useful in defining short term risks posed by, e.g. high FIB loads in stormwater discharges accompanying episodic rain events, that may require management intervention.

2.3 CCT COASTAL WATER QUALITY MONITORING

For this report the CCT monitoring is partitioned into an 'historical' period when water quality was managed according to the DWAF (1995) guidelines, and a 'current' with management under the DEA (2012) regime. The historical period extends from the late 1960's to 2014 and the current period from 2014 to the present.

2.3.1 Historic period (1960's to 2014)

Monitoring was conducted at 96 coastal sites around the CCT coastline extending from Silverstroom Resort on the Atlantic coast in the north to Kogel Bay in False Bay in the south. Sampling intervals was variable to an extent but was generally fortnightly. The faecal indicator bacteria (FIB) variable analysed for was total faecal coliform bacteria with *E. coli* and Enterococci being added towards the end of the period.

2.3.2 Current period (2014 to present)

The CCT currently conducts fortnightly FIB monitoring of nearshore enterococci and *E. coli* counts at approximately 91 sites (Figure 2.1). Sites are classified as being either a recreational node, located in or adjacent to popular recreational use areas, or a coastal monitoring point, located further from these and/or in close proximity to, e.g., stormwater discharges. For the purposes of this report, monitoring sites were split up into 11 geographical areas as shown in Figure 2.1. Dependent on the area, it may contain a combination of recreational nodes and coastal monitoring points or one or the other as displayed in section 4.

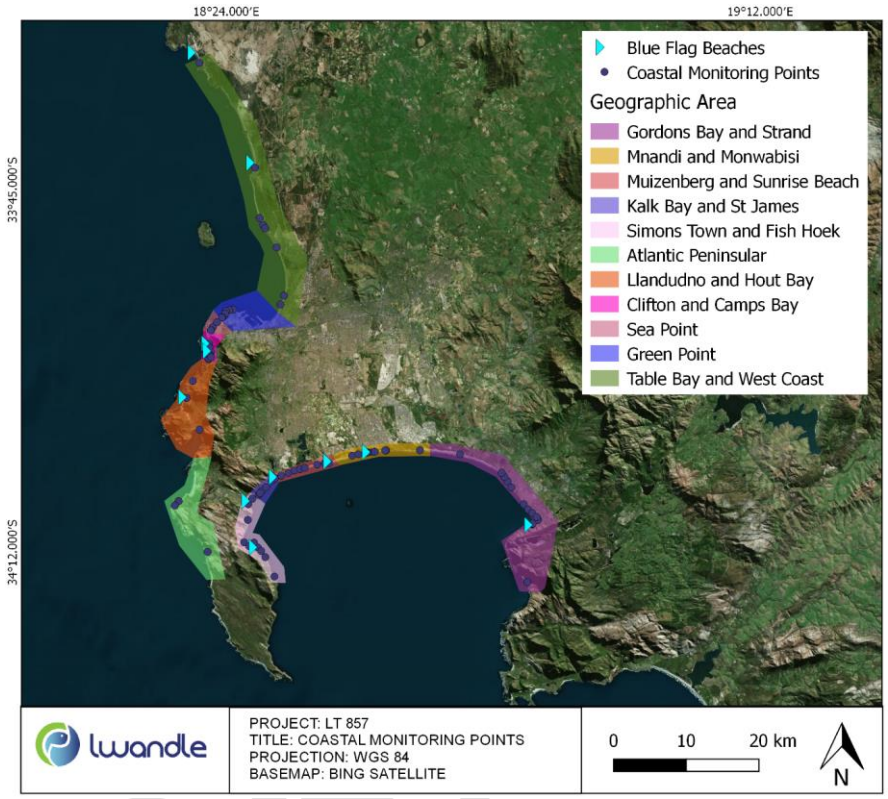

Figure 2.1: Current CCT coastal water quality monitoring sites. Geographic areas relevant to this report are colour coded and blue flag beaches are indicated by blue triangles.

In conjunction with these monitoring efforts the CCT analyses FIB and physical-chemical parameters, at the various Blue Flag beaches located in the metropole every fortnight. The Blue Flag Programme is an international ecolabelling initiative that is accredited to beaches on an annual basis. The award is based on the maintenance of safety, amenity, cleanliness and environmental standards. Currently, ten of the City's beaches have been awarded Blue Flag status (Table 2.2), and most have upheld their status over several consecutive years.

Commented [LH2]: CCT – please provide a list of parameters measured and locations where these are measured. We need to explain why some beaches are blue flag but have poor classification later in the report. I am assuming it will be due to location of measurement, so knowing the site will allow us to further discuss the spatial effect of measurements in the recommendations

This will be discussed in the conclusions

Table 2.2: Blue Flag beaches in the City of Cape Town (CCT, 2018).

Beach	Duration of status (years)
Silwerstroomstrand	6
Melkbosstrand	1
Clifton 4th	13
Camps Bay	9
Llandudno	6

Seaforth	2nd year of Pilot Status
Fish Hoek	1
Muizenberg	8 (Did not achieve status in 2015/16)
Strandfontein	5
Mnandi	6
Bikini	13

3 DATA PARAMETERS AND APPROACH

3.1 DATA

The FIB data evaluated in this report are those provided to Lwandle by the CCT; the data being derived from their fortnightly (with some exceptions) coastal water quality monitoring programme. This sampling interval is consistent with comparative international practices (e.g. Figueras et al. 2000) and monitoring recommendations in DEA (2012). In addition to this monthly water quality survey data from CCT's ocean outfalls monitoring programme for the period 2016 to 2018 was also provided for analyses.

The CCT supplied quality checked data in their raw format to Lwandle. This comprised faecal coliform, enterococci and *E. coli* counts from water samples obtained at varying frequencies from 98 monitoring sites within the Cape Town metropole. Lwandle partitioned the data into those collected prior to 2014 (historical) and those collected subsequently from 2014 to the present (current). Seventeen of the monitoring sites had fewer than 10 measurements over the entire time period and were excluded from the analyses, owing to a lack of replication. Data that were recorded in text form as <nn (less than) or >nn (greater than) were converted to numeric values by dividing and multiplying by three (3) respectively.

A log of the data analysed in this report partitioned by geographic area is shown in Table 3.1. Note that no information on beach grading was provided or is reported on.

Table 3.1: Summary of coastal water quality data provided by the CCT to Lwandle for this report.

Geographic Area	# Monitoring Sites	Indicators Measured	Historical		Current	
			Start	End	Start	End
Table Bay West Coast	10	Faecal coliforms	1979	2014		
		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Greenpoint	8	Faecal coliforms	1968	2014		
		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Seapoint	8	Faecal coliforms	1968	2014		
		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Clifton and Camps Bay	13	Faecal coliforms	1968	2014		
		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Llandudno and Hout Bay	3	Faecal coliforms	1991	2014		
		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Atlantic Peninsula	3	Faecal coliforms	1991	2014		

		Enterococci	2005	2014	2014	2019
		E. coli	2002	2014	2014	2019
Simon's Town and Fish Hoek	10	Faecal coliforms	1991	2014		
		Enterococci	2002	2014	2014	2019
		E. coli	2002	2014	2014	2019
Kalk Bay and St James	10	Faecal coliforms	1967	2014		
		Enterococci	2002	2014	2014	2019
		E. coli	2002	2014	2014	2019
Muizenberg and Sunrise Beach	9	Faecal coliforms	1967	2014		
		Enterococci	2002	2014	2014	2019
		E. coli	2002	2014	2014	2019
Mnandi and Monwabisi	10	Faecal coliforms	1978	2014		
		Enterococci	2002	2014	2014	2019
		E. coli	2002	2014	2014	2019
Gordon's Bay and Strand	14	Faecal coliforms	1991	2014		
		Enterococci	2002	2014	2014	2019
		E. coli	2002	2014	2014	2019
Green Point Outfall	14	Enterococci			2016	2018
		E. coli			2016	2018
Camps Bay Outfall	13	Enterococci			2016	2018
		E. coli			2016	2018
Hout Bay Outfall	12	Enterococci			2016	2018
		E. coli			2016	2018

3.2 APPROACH

Commented [LH3]: Will edit approach section when plots and approach finalised.

3.2.1 Historical Trends

Within each defined geographic area, historical data and trends for all monitoring sites, prior to 2014, were analysed and are presented. Prior to the early 2000s monitoring campaigns at most sites only involved the analysis of faecal coliforms. After 2003 the analysis of *E. coli* was implemented, and after 2005, enterococci counts were included. Time series for each indicator are presented with measurements extending up to 2014.

Commented [LH4]: This is a repeat of an earlier statement - check

The historical data time series are used to identify whether there are any temporal trends in FIB counts over the monitored period. For this the data were smoothed by establishing geometric means over six incrementing sampling intervals (~3 months) through the overall measurement period.

3.2.2 Current trends and status

Within each geographic area, sites were separated into recreational nodes and coastal monitoring points as per the CCT monitoring programme and FIB data collected from 2014 to 2019 analysed.

Time series of raw data at each site are presented to show the high frequency variability and to identify whether adjacent sites co-vary or are influenced by different forcings and anthropogenic sources. The 185 cfu/100ml upper threshold for enterococci measurements as used for the classification of coastal water quality (Table 2.1) is overlaid as a visual indicator of times when enterococci counts exceed 'acceptable' levels.

In accordance with the DEA (2012) guidelines percentile values (90^{th} and 95^{th}) were calculated using the Hazen method for each site over the five-year measurement period. This is a non-parametric estimator considered appropriate for data which are seldom normally distributed (e.g. MfE 2003). These percentile values were compared to the stipulated guidelines (Table 2.1) and the enterococci values used to categorise water quality over the five years as excellent, good, sufficient or poor (Table 2.1). Note that *E. coli* counts are not considered to be entirely suitable for this due to rapid die-off rates in the marine environment (e.g. DEA 2012).

3.3 CHARACTERISATION OF WATER QUALITY AT MARINE OUTFALLS

E. coli and enterococci counts from water samples obtained monthly from 2016 to 2018 from monitoring points surrounding the Green Point, Camps Bay and Hout Bay outfalls were analysed to determine locations on the monitoring grids where water quality was compromised. For this the proportion of samples obtained from each of the three locations over the three-year monitoring period where *E. coli* counts exceeding 500 cfu/100 ml and enterococci counts exceeding 200 cfu/100 ml were determined. Ultimately presenting the percentage of measurements that exceeded the 'good' classification as defined in Table 2.1.

4 HISTORICAL AND CURRENT COASTAL WATER QUALITY

This section presents the coastal water quality data collected both historically and currently by the CCT using the approach outline in section 3.

4.1 TABLE BAY AND WEST COAST

4.1.1 Monitoring Sites

The CCT currently monitors FIB at nine sites within the defined Table Bay and West Coast area region (Figure 4.1). Historically, monitoring was also undertaken at Milnerton Beach. All 10 sites are classified as recreational nodes (Table 4.1).

Table 4.1: Table Bay and West Coast area monitoring sites. The time frame of data available for each site in terms of historical (prior to 2014) and current (2014 to 2019) is shown.

Site	Type of Monitoring Point	Data Presented
Silwerstroomstrand Resort	Recreational Node	Historical and Current
Silverstroom	Recreational Node	Current
Van Riebeeck Strand	Recreational Node	Historical and Current
Melkbos	Recreational Node	Historical and Current
Big Bay	Recreational Node	Historical and Current
Small Bay	Recreational Node	Historical and Current
Tableview	Recreational Node	Historical and Current
Milnerton Beach	Recreational Node	Historical
Milnerton Lighthouse	Recreational Node	Historical and Current
Lagoon Beach	Recreational Node	Historical and Current

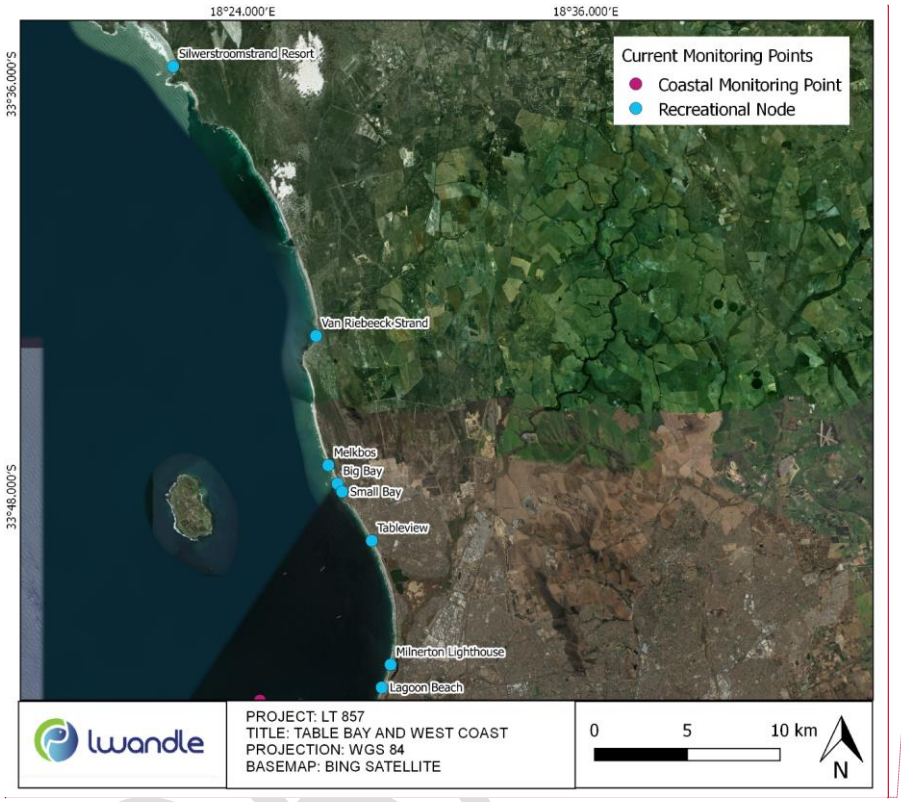

Figure 4.1: FIB monitoring sites within the Table Bay and West Coast area.

4.1.2 Sample Coverage

Figure 4.2 shows a comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage, based on an optimum amount of 26 samples per year (fortnightly), within the area. Coverage has been above 70% throughout the period and has improved post 2014 with most sites reaching between 90 and 100%. This demonstrates that the current required sampling frequency is being attained. As stated, sampling at Milnerton Beach stopped prior to 2014, while an additional monitoring point at Silverstroom was added to the programme post-2014.

Commented [LH5]: CCT – the stormwater location files provided do not line up with known stormwater discharges, so we have not included them here. If you can confirm the correct file to use and also provide information on what the point provided is (classification of discharge) we can add to these area maps to be able to discuss proximity effects. Any reports on stormwater quality for the various outlets would be helpful otherwise we will just assume that they are discharge very low-quality water. River/vlei outlets and pollution information would help.

Please advise if we should go into this kind of detail or whether the city will input this information into the final version?

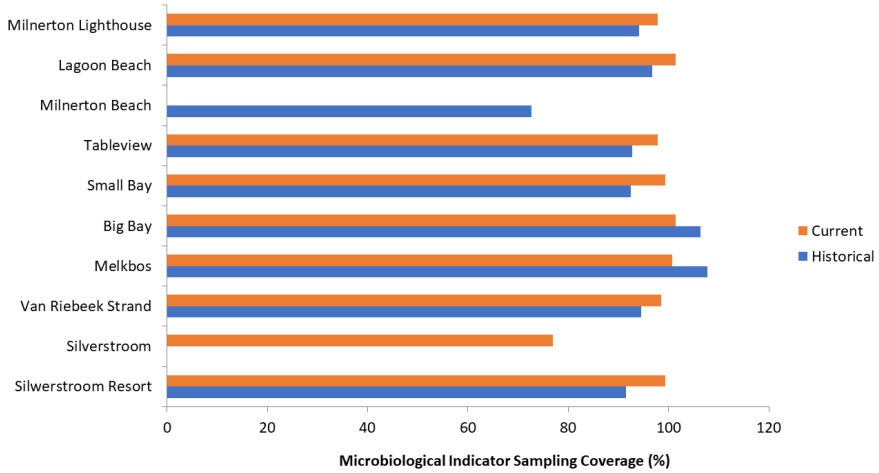

Figure 4.2: Historical and current FIB sampling coverage (% of optimal total) at all sites located within the Table Bay and West Coast area.

4.1.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at the Table Bay and West Coast sites for which there are historical data are shown in Figure 4.3. No clear temporal trend can be seen in any of the FIB indicators at any of the sampled sites. At most sites, FIB counts remain low throughout the measured time period (1995 to 2010). There appears to be an increase in the frequency of faecal coliform spikes with time, however, this may be due to the addition of the Big Bay and Melkbos sites post 2000. Spatially, Lagoon Beach had consistently higher microbiological indicator counts throughout the measured time period compared to the other sites in the area.

Commented [LH6]: Maria please ignore historical section text for all areas as needs to be amended as I was not sure of the graphs being used.

I have replaced the plots for now with the entire historical time series so that you can see the full dataset. Although this is interesting to see the historic faecal coliforms are not particularly helpful as we cannot compare them to the current data. I was thinking instead we could put the whole time series of all data historic and current in the appendix for reference and to show that there is no obvious trend. Then in these historic section it would fit better with the narrative if only ecoli and enterococci were displayed which cuts the time series to between 2006-2019 and then we can do a thorough comparison and look at changes in exceedances and whether there are any dominant patterns relating to rainfall etc.

Do you agree with this approach?

Either way it may flow better to change the structure to first discuss current water quality for each area and then discuss this in the context of the historic data from beginning of measurements to now. As it is easier to discuss changes in this order. Do you agree with that approach?

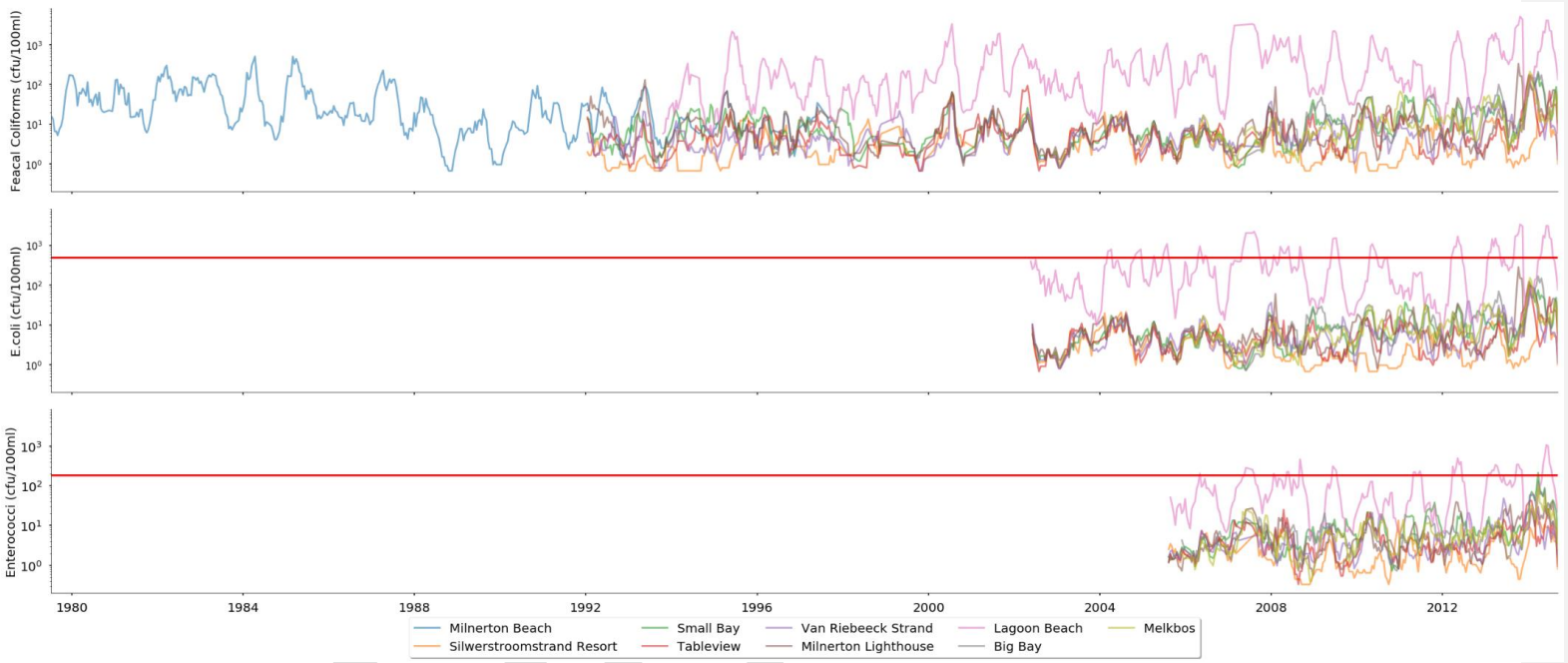

Figure 4.3: Rolling geometric mean for faecal coliform, E. coli and enterococci counts at sites within the Table Bay and West Coast area. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.1.4 Current State of Coastal Water Quality

All of the sites monitored in the Table Bay and West Coast area are classified as recreational nodes.

4.1.4.1 Defined Recreational Nodes

Figure 4.4 - Figure 4.6 show the time series of FIB counts for the recreational nodes in the Table Bay and West Coast area. At most recreational nodes, the counts rarely exceed the 185 cfu/100 ml indicative threshold. Lagoon Beach is an exception to this; counts greater than 1,000 cfu/100 ml were frequently recorded. This site is located in close proximity to the mouth of the Diep River (Figure 4.1) and it is likely that stormwater flows into the lower reaches of the river (Milnerton Lagoon) contribute to the observed high FIB counts. Enterococci counts at this site exceed the 185 cfu/100ml threshold on multiple occasions over the time period, but less so during 2017 and 2018. Given that the pollution at this site is most likely primarily driven by contaminated stormwater runoff, which is related to rainfall, the drought that the Western Cape has been facing since 2016 would have a substantial influence on this.

Commented [LH7]: CCT – once we have rainfall data we can substantiate these statements and add more detail (if results show correlation).

The five-year period water quality classification based on the percentile guidelines is summarised in Table 4.2 showing that the majority of the monitored sites had at least sufficient water quality. Lagoon Beach is an exception where high microbial counts, particularly *E. coli* were found, resulting in a Poor water quality classification. This indicates that the water quality at this site posed an unacceptable risk over this time.

Table 4.2: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within the Table Bay and West coast area. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Lagoon Beach	5425	15000	1120	3590	Poor
Big Bay	139	400	65	100	Excellent
Melkbos	53	135	45	385	Sufficient
Milnerton Lighthouse	150	325	58	200	Good
Silwerstroomstrand Resort	10	27	25	47	Excellent
Small Bay	91	333	145	585	Sufficient
Tableview	76	156	42	280	Sufficient
Van Riebeeck Strand	75	390	43	150	Good
Silverstroom	10	19	38	225	Sufficient

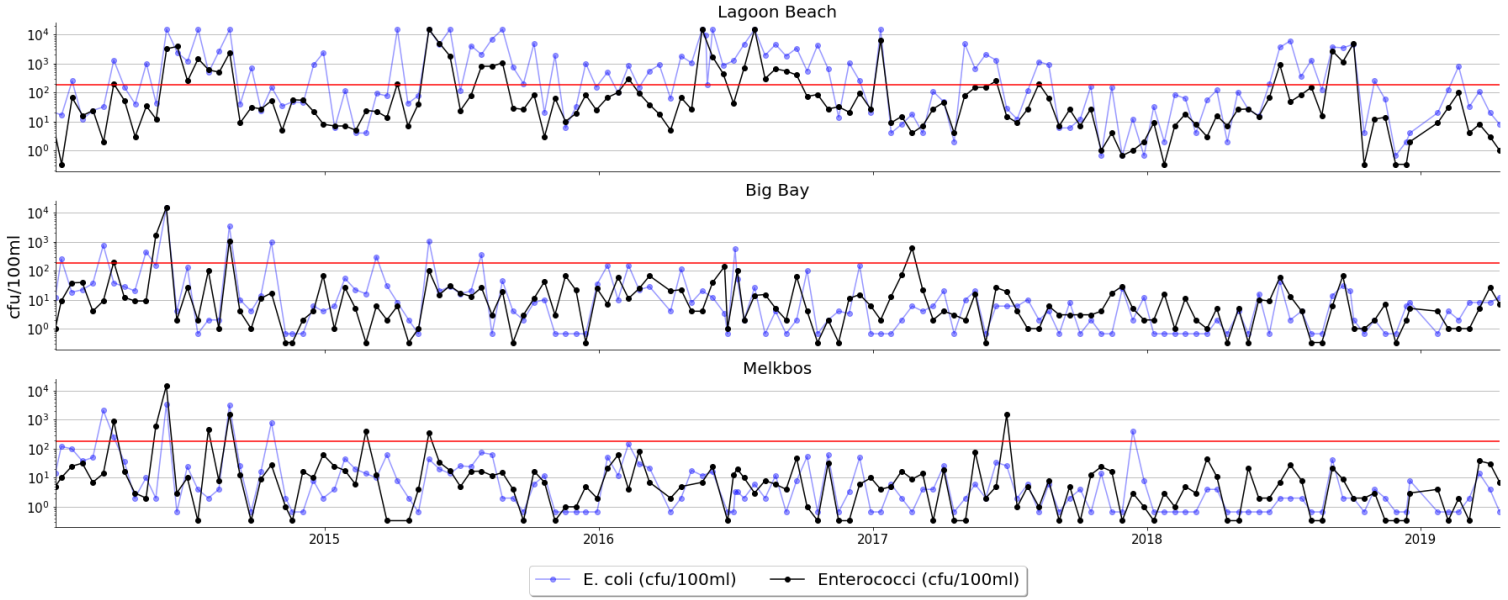

Figure 4.4: Time series of E. Coli and enterococci counts at recreational nodes within the Table Bay and West Coast area from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). The y axis is on a logarithmic scale.

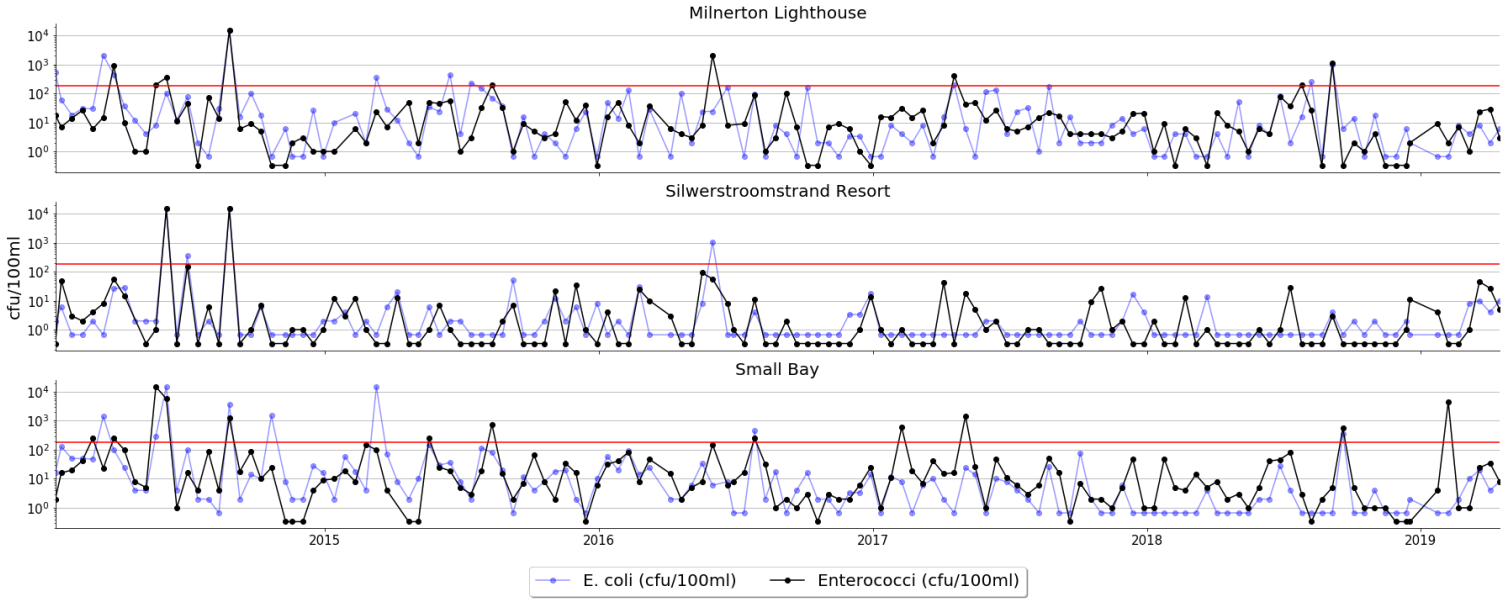

Figure 4.5: Time series of E. Coli and enterococci counts at recreational nodes within the Table Bay and West Coast area from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). The y axis is on a logarithmic scale.

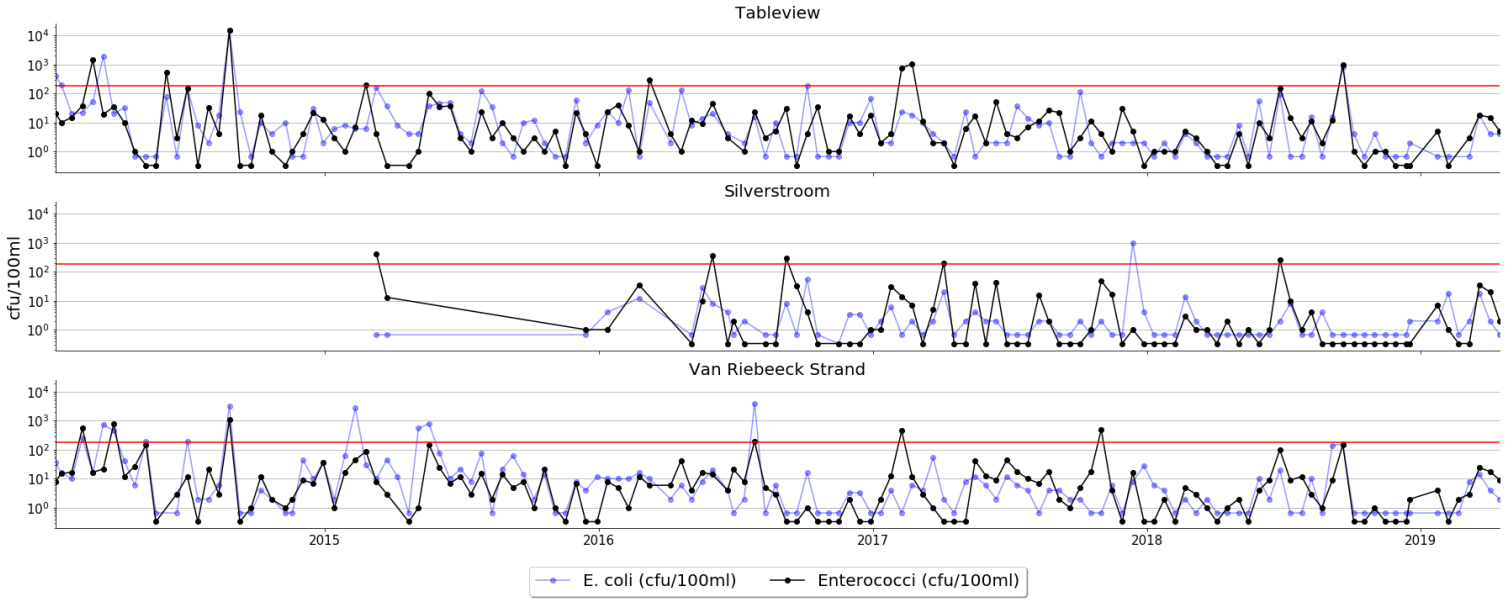

Figure 4.6: Time series of E. Coli and enterococci counts at recreational nodes within the Table Bay and West Coast area from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). The y axis is on a logarithmic scale.

4.2 GREEN POINT

4.2.1 Monitoring Sites

The CCT currently monitors FIB at seven sites within the Green Point area (Figure 4.7). Historically monitoring was also undertaken within the Table Bay Docks. Of these eight points, one (Three Anchor Bay) is considered to be a recreational node, while the other seven are considered to be coastal monitoring points, outside of popular recreational use areas (Table 4.3).

Table 4.3: Sites in the Green Point area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Table Bay Docks	Coastal Monitoring Point	Historical
Granger Bay	Coastal Monitoring Point	Historical and Current
Mouille Point	Coastal Monitoring Point	Historical and Current
Green Point Outfall	Coastal Monitoring Point	Historical and Current
Park Road Green Point	Coastal Monitoring Point	Historical and Current
Three Anchor Bay	Recreational Node	Historical and Current
Rocklands	Coastal Monitoring Point	Historical and Current
Rocklands Beach	Coastal Monitoring Point	Historical and Current

Figure 4.7: Recreational nodes and coastal monitoring points within the Green Point area.

4.2.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), within Green Point, is shown in Figure 4.8 below. Microbiological indicator sampling coverage improved at all sites after 2014, with most sites reaching between 90 and 100% coverage. Exceptions to this were Park Road Green Point, where only ten samples were obtained in 2015, Green Point Outfall where only three samples were obtained in 2016 and Rocklands where 16 and 17 samples were obtained in 2017 and 2018 respectively.

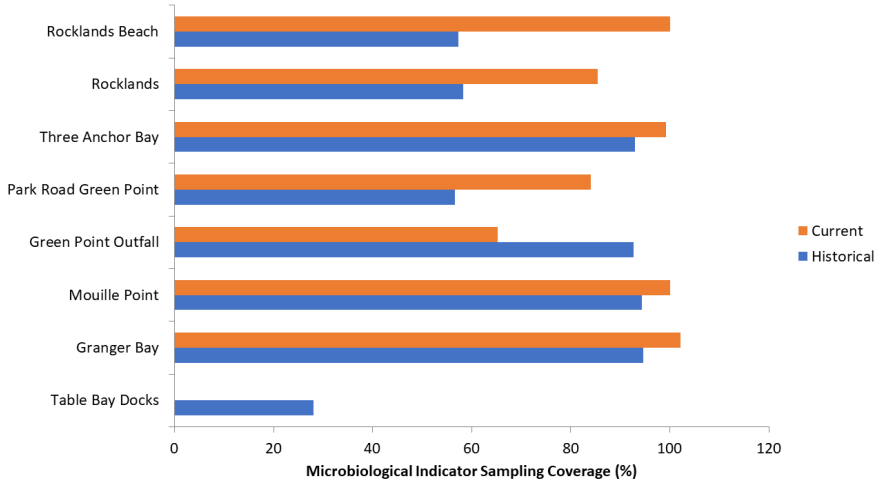

Figure 4.8: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within the Green Point area.

4.2.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Green Point sites are shown in Figure 4.9. Temporally there appears to be a decrease in faecal coliform counts over the measurement period during 1994 and 1995 over all the sampled sites followed by a slight increase. Although there is no overall increase or decrease in faecal coliforms in the area, Granger Bay, Mouille Point and Green Point Outfall sites appear to be generally lower from 1994 onwards. No clear temporal increase or decrease in *E.* coli or enterococci can be seen at any of the sites. Spatially, Three Anchor Bay had the most frequent peaks in *E.coli* and enterococci and Green Point Outfall had the highest peaks in enterococci.

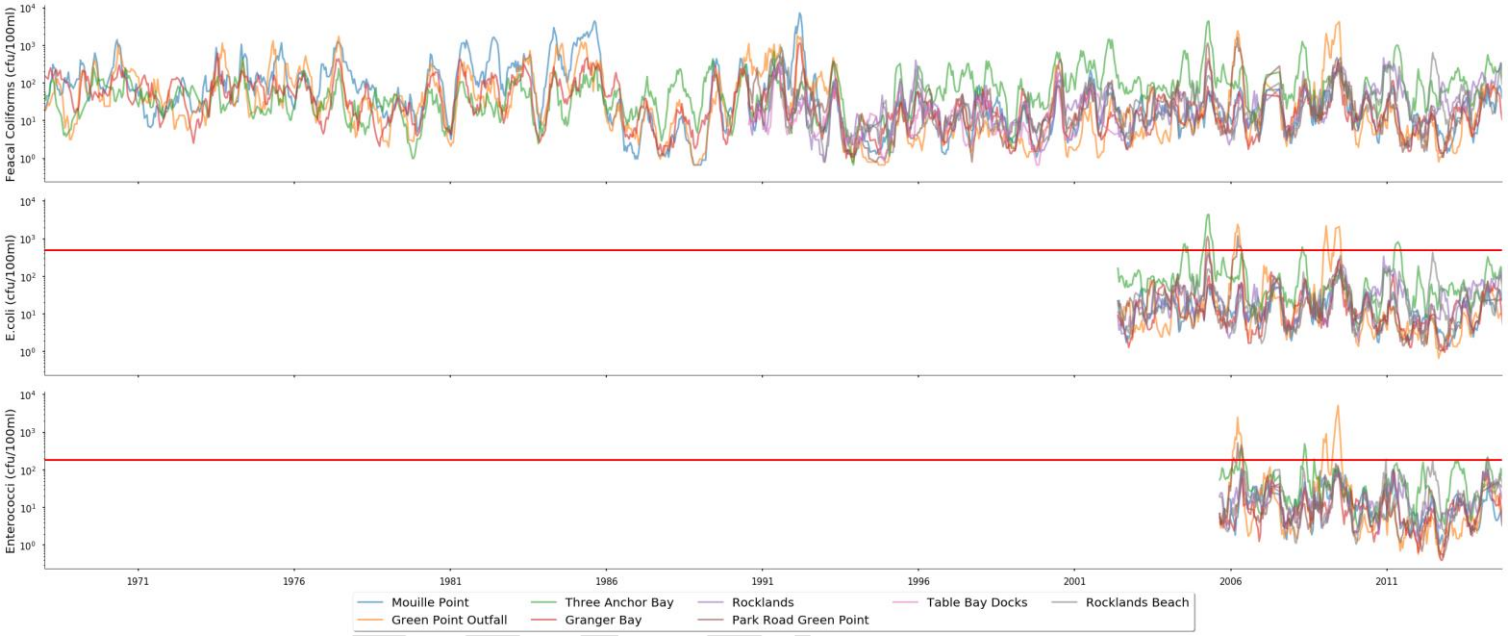

Figure 4.9: Rolling geometric mean for faecal coliform, E. coli and enterococci counts at monitoring sites within Green Point. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.2.4 Current State of Coastal Water Quality

4.2.4.1 Defined Recreational Node

The time series of FIB counts at Three Anchor Bay from January 2014 to May 2019 is shown in Figure 4.10. Enterococci counts exceeded the 185 cfu/100 ml threshold on multiple occasions over the time period. This site is situated in close proximity to a stormwater flow, which flows year-round, therefore this likely contributes to the high FIB counts measured. This site is also adjacent to the Green Point Marine Outfall. The frequency of exceedances is less from mid-2015 to mid-2016. The base trough levels from 2016 onwards seem to be less than those prior. This could be attributed to the drought that the Western Cape has been facing since 2016.

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The five-year period water quality classification based on the DEA (2012) percentile guidelines for Three Anchor Bay is shown in Table 4.4. The water quality classification at this site is Poor, indicating that the enterococci count exceeded the 185 cfu/100 ml threshold more than 10% of the time (i.e the 90th percentile was greater than 185 cfu/100 ml). The measurements exceed this threshold 21.9% of the time at Three Anchor Bay, indicating that the water quality at Three Anchor Bay posed an unacceptable risk during these periods (DEA, 2012).

Table 4.4: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within Green Point. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Three Anchor Bay	1000	2080	1400	2795	Poor

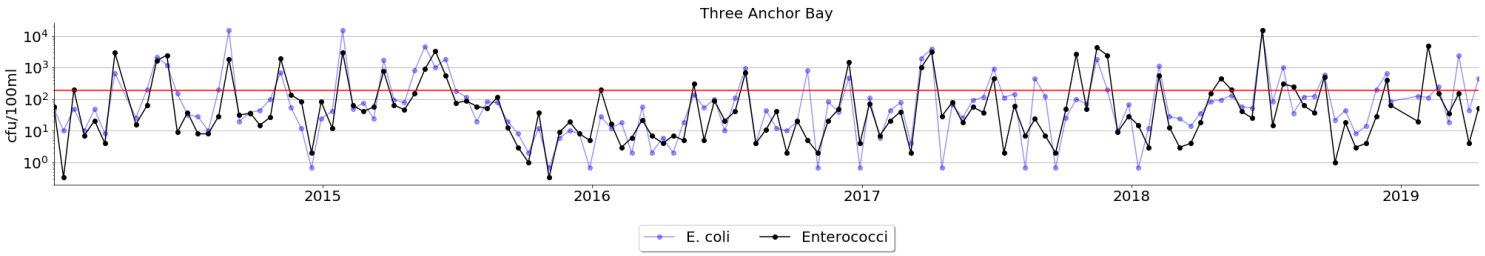

Figure 4.10: Time series of E. Coli and enterococci counts at Three Anchor Bay, a recreational node within the Green Point area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.2.4.2 Coastal Monitoring Points

Time series of FIB at coastal monitoring points within the Green Point area is shown in Figure 4.11 and Figure 4.12. The majority of counts are below the 185 cfu/100 ml threshold used for percentile classification. The highest enterococci count, which is far greater than 1,000 cfu/100 ml, is observed at Mouille Point in 2015, however this is an isolated anomaly and values very rarely exceed the percentile threshold for the remainder of the time series. The most exceedances over the threshold are observed at Park Road Green Point and Rocklands. Most of the exceedances at the Park Road site were measured in the second half of the time series, and there is an increase in variation from mid-2016 onwards. The opposite is true for the Rocklands site, where the majority of exceedances were measured in the first half of the time series. These sites lie to the south of the Green Point Marine Outfall.

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The water quality at most of the coastal monitoring points (Granger Bay, Mouille Point, Green Point Outfall and Rocklands Beach) was classified as either Sufficient or Good over the five-year period, according to the DEA (2012) percentile guidelines (Table 4.5). However, the water quality at Park Road Green Point and Rocklands were classified as poor. Park Road and Rockland measurements exceeded the threshold 10.3 and 11% of the time respectively, indicating that the water quality at these sites during these peaks posed an unacceptable risk.

Table 4.5: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points within Green Point. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Granger Bay	138	303	64	235	Sufficient
Mouille Point	66	149	58	183	Good
Green Point Outfall	239	700	118	156	Good
Park Road Green Point	200	1275	215	435	Poor
Rocklands	335	830	200	810	Poor
Rocklands Beach	172	230	100	400	Sufficient

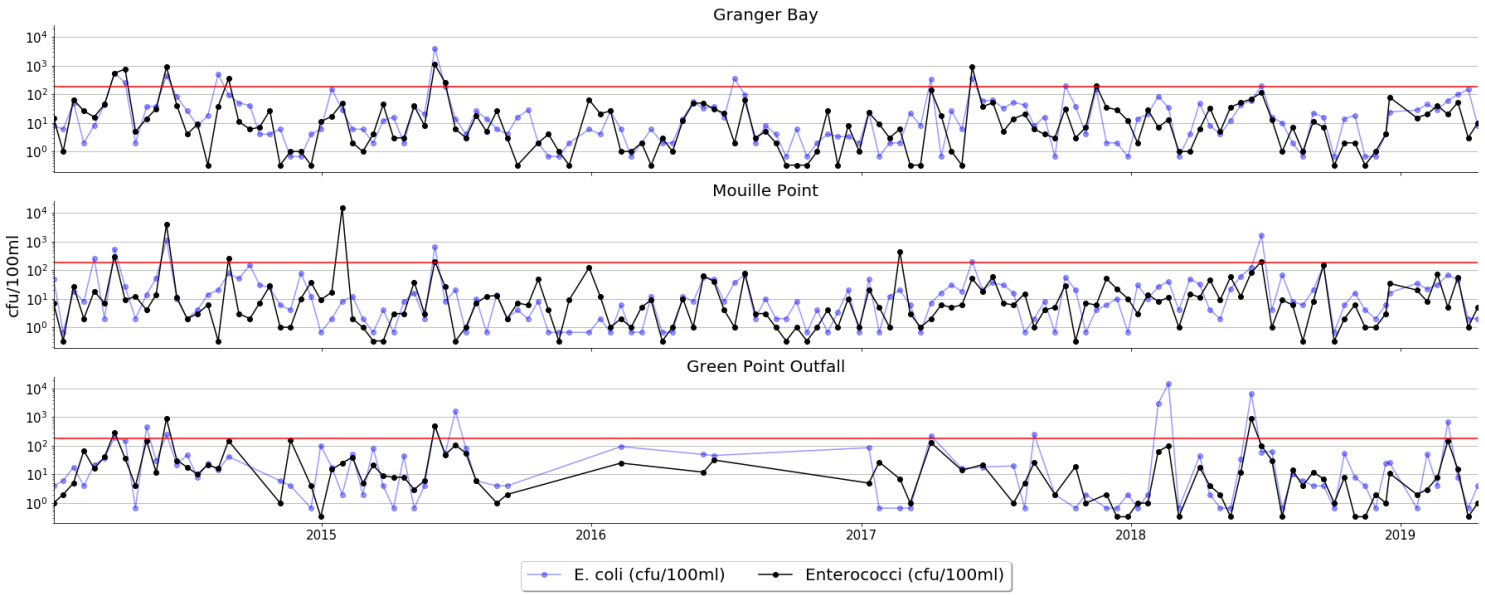

Figure 4.11: Time series of E. Coli and enterococci counts at coastal monitoring points within the Green Point area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

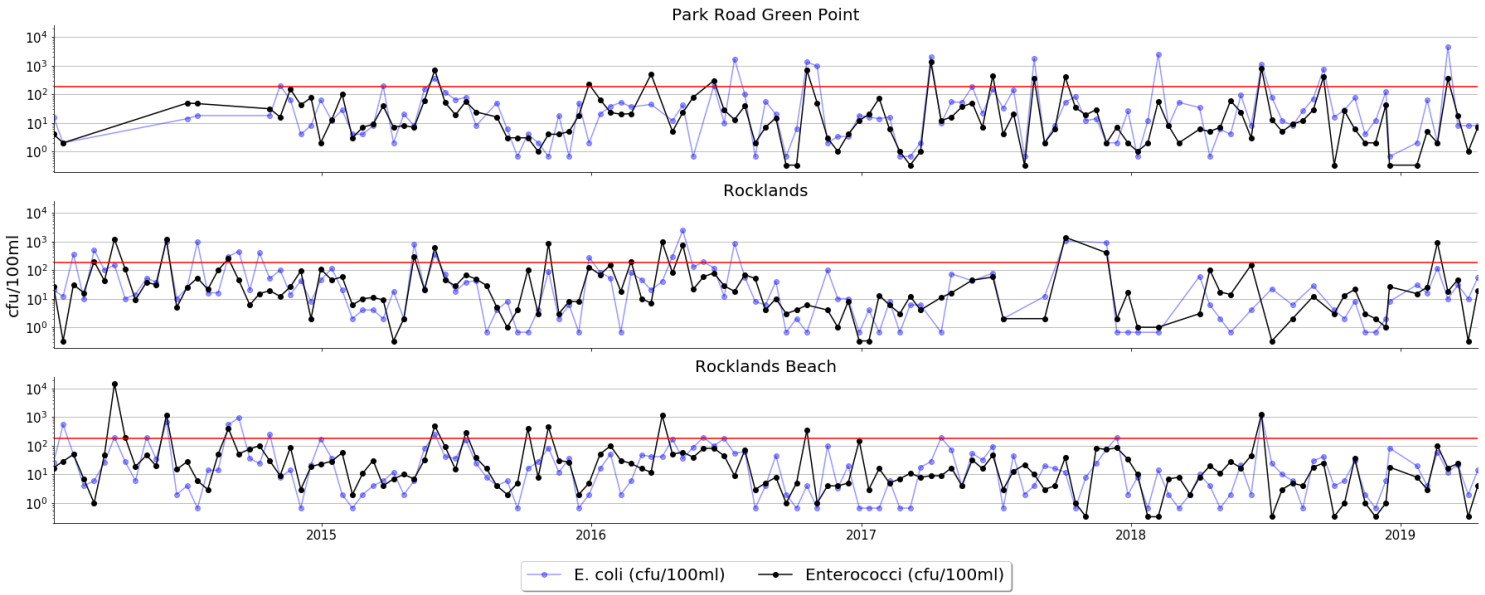

Figure 4.12: Time series of E. Coli and enterococci counts at coastal monitoring points within the Green Point area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.3 SEA POINT

4.3.1 Monitoring Sites

The CCT currently monitors FIB at six sites within the Sea Point area (Figure 4.13). Historically points at Graafs Pool and inside Sunset Beach tidal pool were monitored for faecal coliform and *E. coli* counts. Of these eight points, three are considered to be recreational nodes, and five are considered to be coastal monitoring points, outside of popular recreational use areas. There are three tidal pools within Sea Point which are monitored including Milton tidal pool (TP), Sunset Beach TP and Saunders Rocks TP (Table 4.6).

Table 4.6: Sites in the Sea Point area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Graafs Pool	Coastal Monitoring Point	Historical
Milton Beach TPI	Recreational Node	Historical and Current
Milton Beach TPO	Coastal Monitoring Point	Historical and Current
Sunset Beach TPI	Recreational Node	Historical
Sunset Beach TPO	Coastal Monitoring Point	Historical and Current
Saunders Rocks	Coastal Monitoring Point	Historical and Current
Saunders Rocks TPI	Recreational Node	Historical and Current
Saunders Rocks TPO	Coastal Monitoring Point	Historical and Current

Figure 4.13: Recreational nodes and coastal monitoring points within the Sea Point area.

4.3.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites in the Sea Point area is shown in Figure 4.14 below. Microbiological indicator sampling coverage improved at all sites after 2014, with most sites reaching between 90 and 100% coverage. Exceptions were seen at both sites located at Milton Beach TP where only five samples were obtained in 2015. Monitoring was stopped inside Sunset Beach TP and at Graafs Pool prior to 2014.

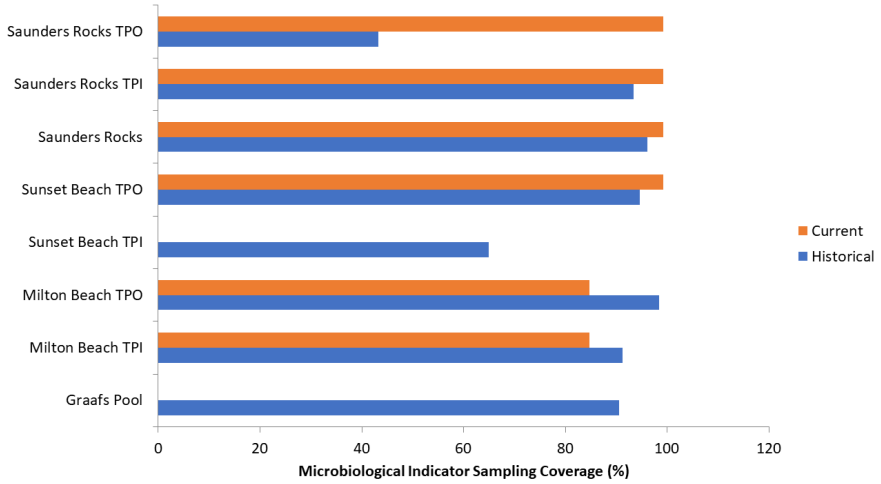

Figure 4.14: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within the Sea Point area.

4.3.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Sea Point sites, for which there are historical data, are shown in Figure 4.15 below. Similar to Green Point, a temporal decrease in faecal coliform count is observed during 1994 and increases again in 1995 at all sampled sites. However, there was no clear temporal trend can be seen in any of the indicator counts at any of the sampled sites. There appears to be an increase in the frequency of faecal coliform spikes from the early 2000s onwards, however this is most likely as a result of increased site coverage during this time. Spatially, Saunders Rock had consistently higher microbiological indicator counts throughout most of the measured time period compared to the other sites in the area.

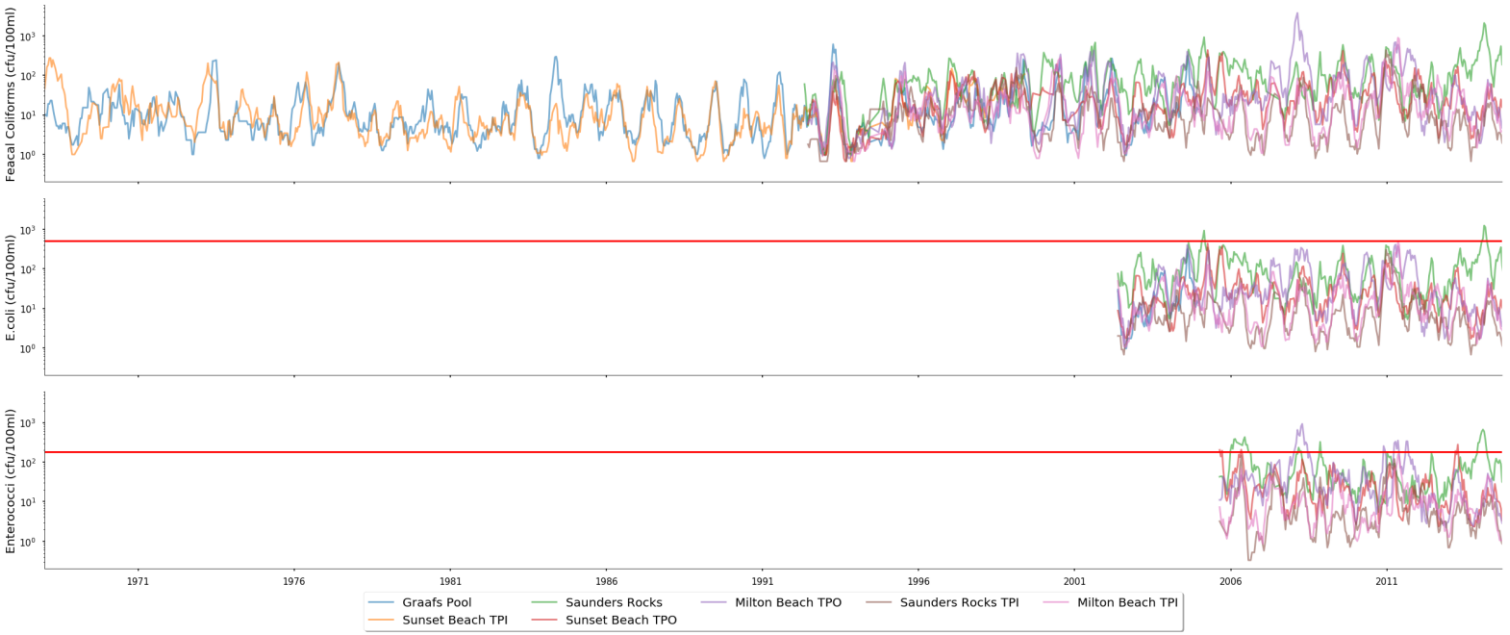

Figure 4.15: Rolling geometric mean for faecal coliform, E. coli and enterococci counts at all monitoring sites within Sea Point. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.3.4 Current State of Coastal Water Quality

4.3.4.1 Defined Recreational Nodes

The time series of FIB counts inside Milton Beach Tidal Pool (Milton Beach TPI) and Saunders Rocks Tidal Pool (Saunders Rocks TPI), shown in Figure 4.16, display that counts rarely exceed the percentile threshold of 185 cfu/100 ml. However, peaks of approximately 1,000 cfu/100 ml were measured at the same time in mid-2016. Therefore, it is likely that there is a common causative factor.

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The water quality inside the Milton Beach and Saunders Rocks tidal pools, was classified as Excellent according to the DEA (2012) percentile guidelines (Table 4.7). This indicates that the enterococci measurements were less than 100 cfu/100 ml for 95% of the five-year monitoring period.

Table 4.7: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within Sea Point. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Milton Beach TPI	46	91	48	78	Excellent
Saunders Rocks TPI	66	138	52	100	Excellent

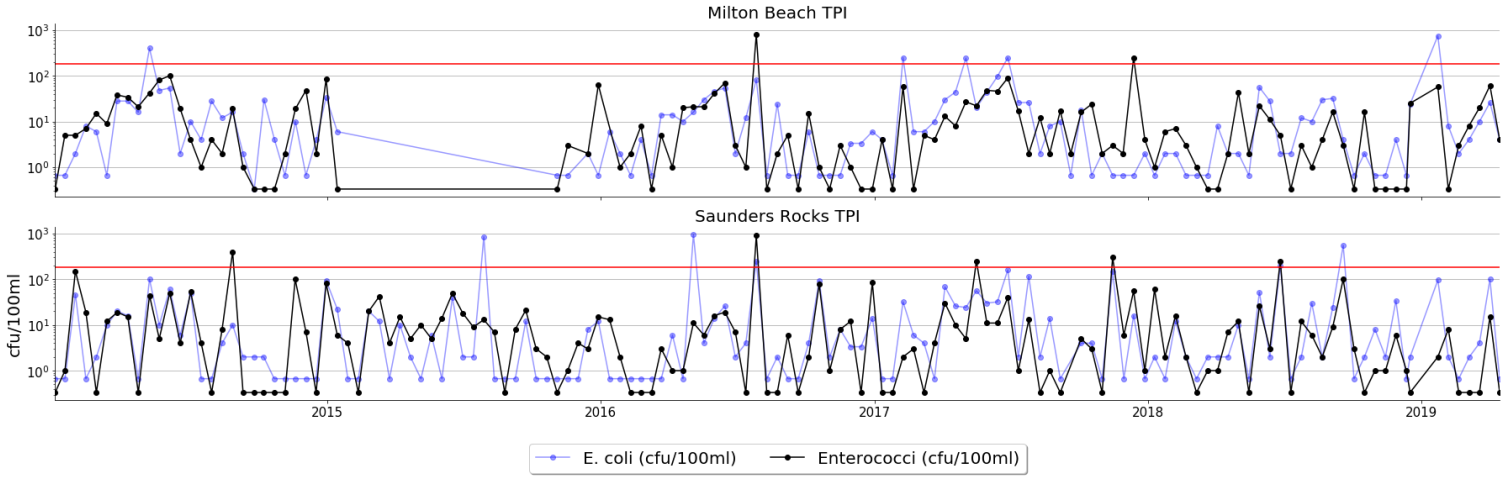

Figure 4.16: Time series of E. Coli and enterococci counts at recreational nodes within the Sea Point area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.3.4.2 Coastal Monitoring Points

The time series of FIB counts for the coastal monitoring points within the Sea Point area is shown in Figure 4.17. Exceedances of enterococci counts over the percentile threshold for the water quality outside Milton Beach (Milton Beach TPO) and Sunset Beach tidal pools (Sunset Beach TPO) are rare. This is not the case for Saunders Rocks and outside the Saunders Rocks tidal pool (Saunders Rocks TPO), where peaks exceed 10,000 cfu/100 ml. There is co-variance apparent between these sites, which is expected as these sites are in close proximity to each other.

The water quality at Saunders Rocks and outside the Saunders Rocks tidal pool (Saunders Rocks TPO) was classified as Poor according to the DEA (2012) percentile guidelines (Table 4.8), with exceedances measured 18.2 and 27.7% of the time indicating that the water quality at these sites posed an unacceptable risk during these times. While the water quality outside the Milton Beach (Milton Beach TPO) and Sunset Beach tidal pools (Sunset Beach TPO) were classified as Good and Sufficient respectively over the five-year period.

Table 4.8: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points within the Sea Point area. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Milton Beach TPO	58	206	59	128	Good
Sunset Beach TPO	247	695	95	265	Sufficient
Saunders Rocks	1590	2598	1320	3728	Poor
Saunders Rocks TPO	1090	1783	490	1550	Poor

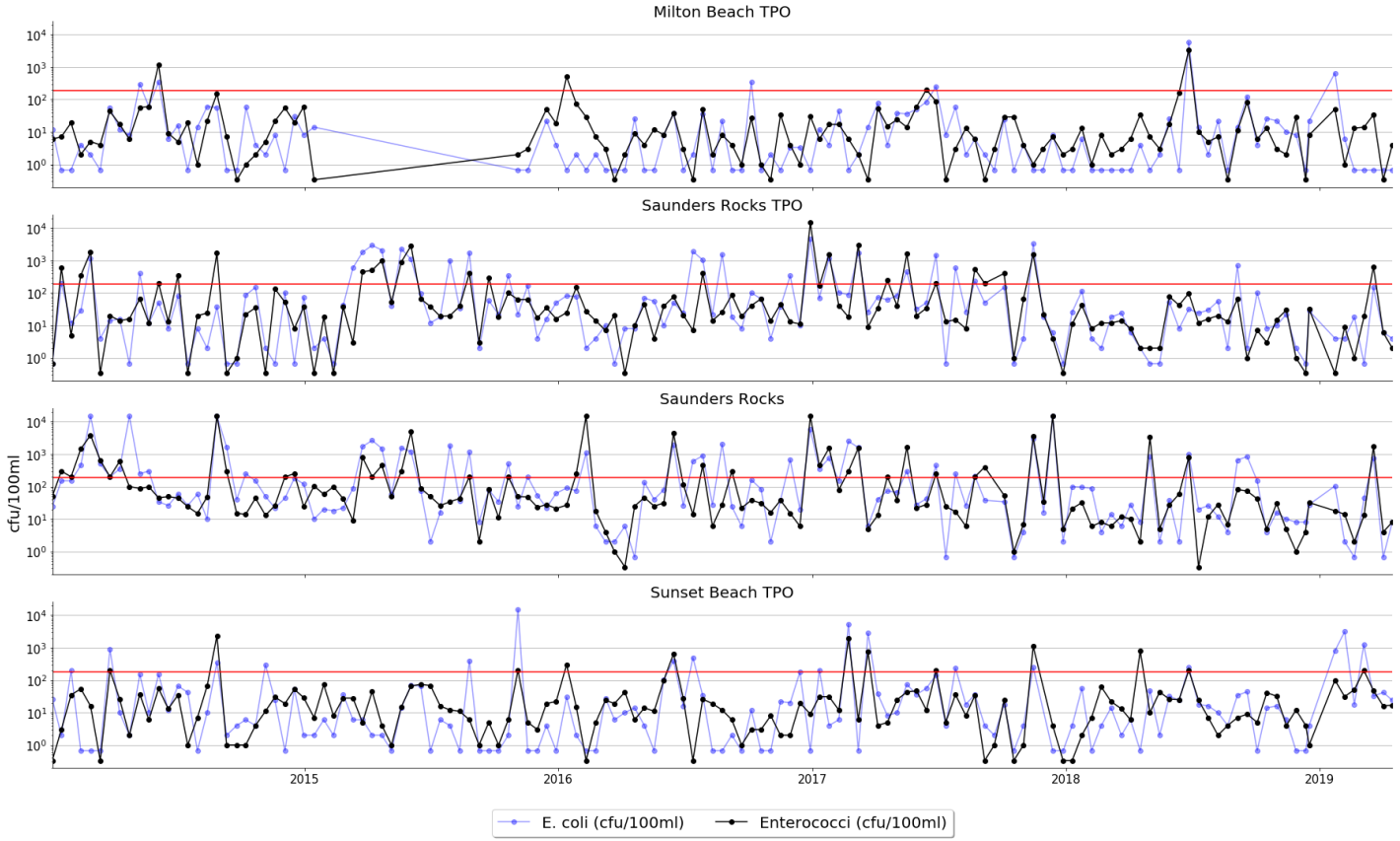

Figure 4.17: Time series of E. Coli and enterococci counts at coastal monitoring points within the Sea Point area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.4 CLIFTON AND CAMPS BAY

4.4.1 Monitoring Sites

The CCT currently monitors FIB at thirteen sites within the Clifton and Camps Bay area (Figure 4.18). Of these 13 points, eight are considered to be recreational nodes, and five are considered to be coastal monitoring points, outside of popular recreational use areas. A significant portion of the monitoring points are within or just outside tidal pools which occur in the area including the two tidal pools at Maidens Cove and Camps Bay TP (Table 4.9).

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Table 4.9: Sites in the Clifton and Camps Bay area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Clifton 1 – 4	Recreational Node	Historical and Current
Maidens Cove	Coastal Monitoring Point	Historical and Current
Maidens Cove TP1I	Recreational Node	Historical and Current
Maidens Cove TP1O	Coastal Monitoring Point	Historical and Current
Maidens Cove TP2I	Recreational Node	Historical and Current
Maidens Cove TP2O	Coastal Monitoring Point	Historical and Current
Camps Bay	Recreational Node	Historical and Current
Camps Bay TPA	Recreational Node	Historical and Current
Camps Bay TPB	Recreational Node	Historical and Current
Camps Bay TPO	Coastal Monitoring Point	Historical and Current
Horne Bay Beach	Coastal Monitoring Point	Historical and Current
Beta Beach	Recreational Node	Historical and Current
Bakoven Bungalows	Recreational Node	Historical and Current

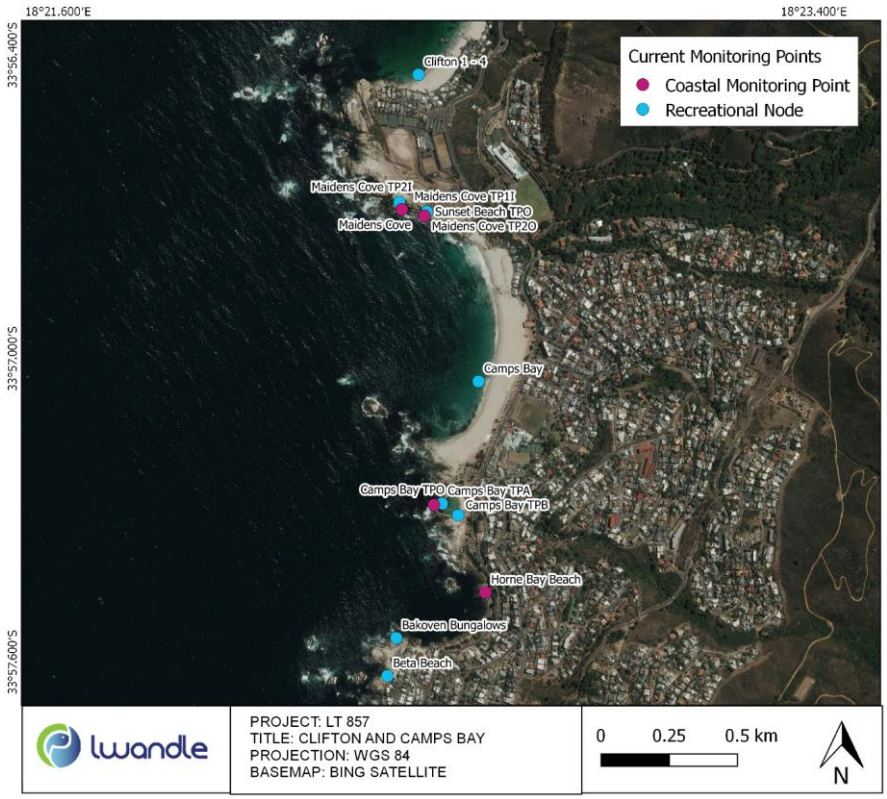

Figure 4.18: Recreational nodes and coastal monitoring points within the Clifton and Camps Bay area.

4.4.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), within the Clifton and Camps Bay area is shown in Figure 4.19 below. Microbiological indicator sampling coverage improved at all sites after 2014, with all reaching 100% coverage.

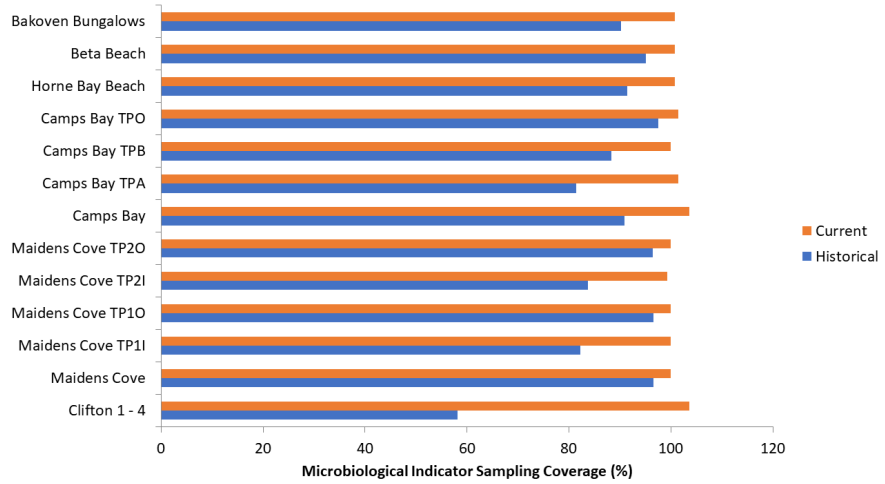

Figure 4.19: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within Clifton and Camps Bay.

4.4.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Clifton and Camps Bay sites, for which there is historical data, are shown in Figure 4.20 and **Error! Reference source not found.**. No clear temporal trend can be seen in any of the indicator counts at any of the sites. At most sites within Clifton and Maidens Cove (**Error! Reference source not found.**), FIB counts generally remained lower than the Camps Bay sites (Figure 4.19) throughout the measured time period, with spikes occurring more frequently at the Camps Bay site. Signals in all three of the indicators were correlated and covariance is seen between sites at the Clifton and Maidens Cove sites. Furthermore, peaks appear to be aligned between indicators.

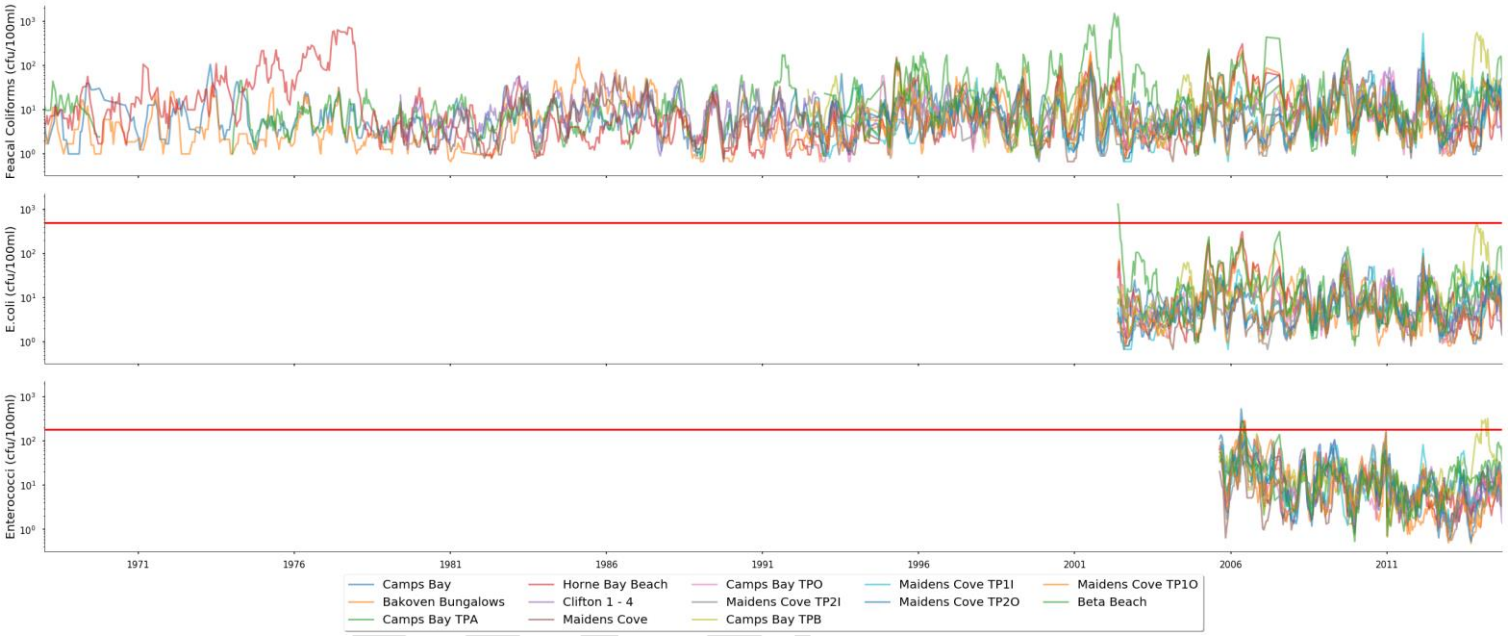

Figure 4.20: Rolling geometric mean for faecal coliform, E. coli and enterococci counts at monitoring sites within the Clifton and Camps Bay area, for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.4.4 Current State of Coastal Water Quality

4.4.4.1 Defined Recreational Nodes

Figure 4.21 and Figure 4.22 display the FIB count time series for recreational nodes within the Clifton and Camps Bay area. Most sites exceed the enterococci percentile threshold very rarely. However, Camps Bay TPB, a site within the Camps Bay tidal pool, exceeds the threshold fairly often in 2014 with enterococci counts greater than 1,000 cfu/100 ml. The frequency of exceedances as well as the peak values and variation decrease over time at this site. The enterococci count at Bakoven Bungalows displayed high peaks from mid-2015 to mid-2016.

The water quality at most recreational nodes within the Clifton and Camps Bay area wer classified as either Sufficient (the minimum requirement), Good or Excellent over the five-year period according to the DEA (2012) percentile guidelines (Table 4.10). Camps Bay TPB is the exception as the water quality has been classified as Poor. At Camps Bay TPB enterococci counts exceeded the 185 cfu/100ml threshold 13.8% of the time indicating that the water quality at this site posed an unacceptable risk during these times.

Table 4.10: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within Clifton and Camps Bay. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Clifton 1 - 4	40	94	47	125	Good
Maidens Cove TP1I	71	107	61	112	Good
Maidens Cove TP2I	45	109	46	87	Excellent
Camps Bay	72	117	160	453	Sufficient
Camps Bay TPA	81	111	79	250	Sufficient
Camps Bay TPB	184	1140	350	710	Poor
Beta Beach	188	733	150	428	Sufficient
Bakoven Bungalows	45	109	59	483	Sufficient

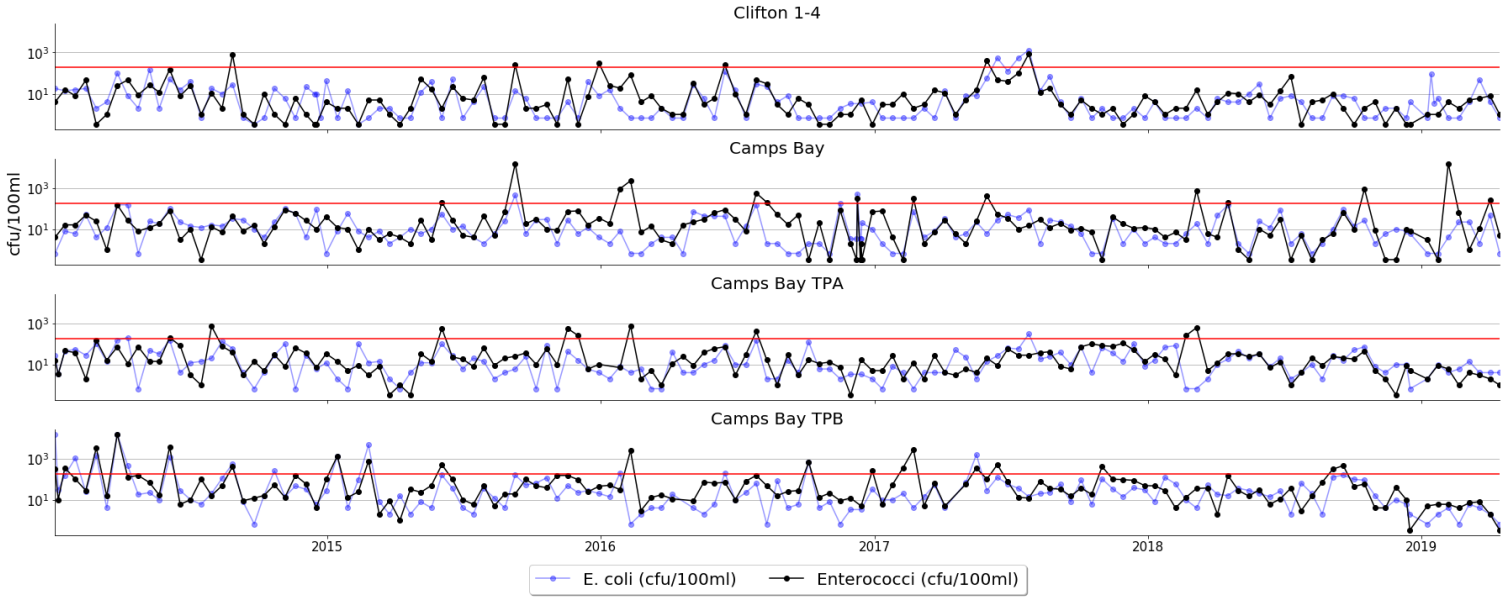

Figure 4.21: Time series of E. Coli and enterococci counts at recreational nodes within the Clifton and Camps Bay area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

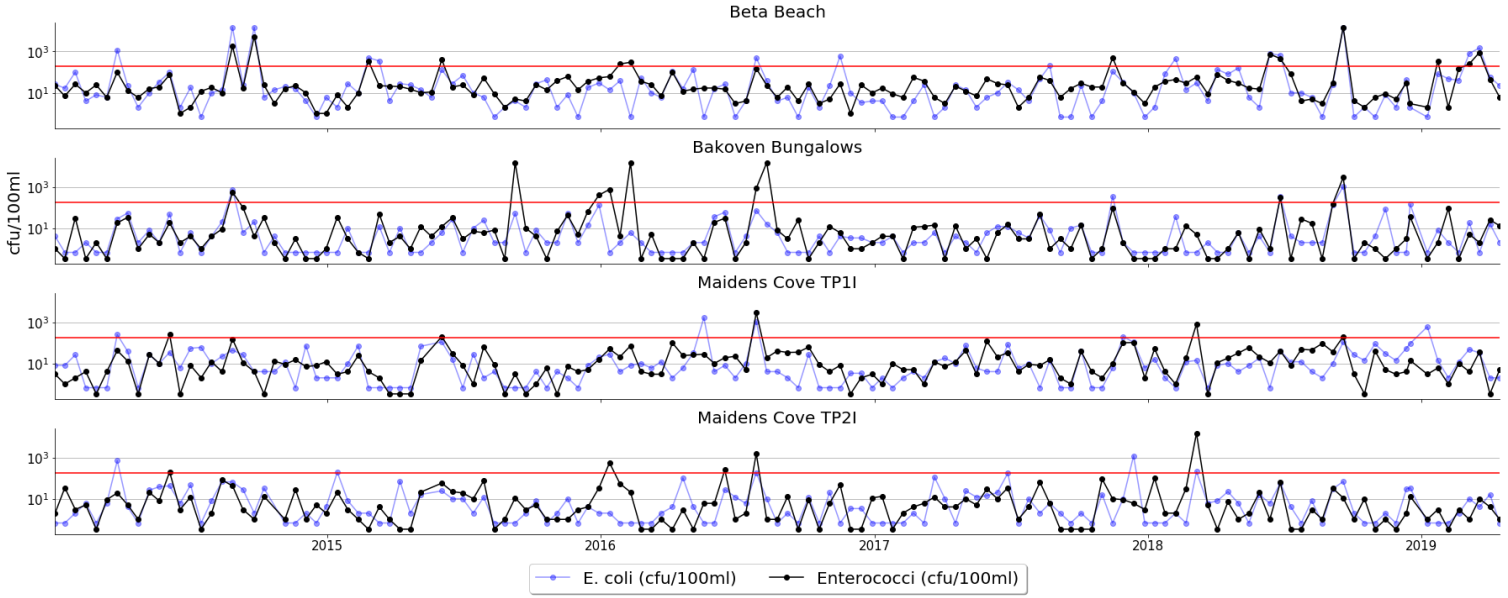

Figure 4.22: Time series of E. Coli and enterococci counts at recreational nodes within the Clifton and Camps Bay area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.4.4.2 Coastal Monitoring Points

The FIB count time series for the coastal monitoring points within Clifton and Camps Bay are shown in Figure 4.23. These display that enterococci counts at all of these sites rarely exceeded the percentile threshold over the five-year period. However, infrequent peaks to approximately 10,000 cfu/100 ml are apparent at a site outside the Maidens Cove tidal pool (Maidens Cove TP2) in 2018 and 2019, as well as at Maiden Cove in 2016.

As the frequency of these peaks is below 10% of the measurement data over the five year period the water quality at all of the coastal monitoring points within the Clifton and Camps Bay area was classified as either Sufficient (the minimum requirement), Good or Excellent according to the DEA (2012) percentile guidelines (Table 4.11).

Table 4.11: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points within Clifton and Camps Bay. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Maidens Cove	32	55	50	132	Good
Maidens Cove TP1O	35	59	52	94	Excellent
Maidens Cove TP2O	31	69	42	71	Excellent
Camps Bay TPO	95	975	103	323	Sufficient
Horne Bay Beach	39	70	49	233	Sufficient

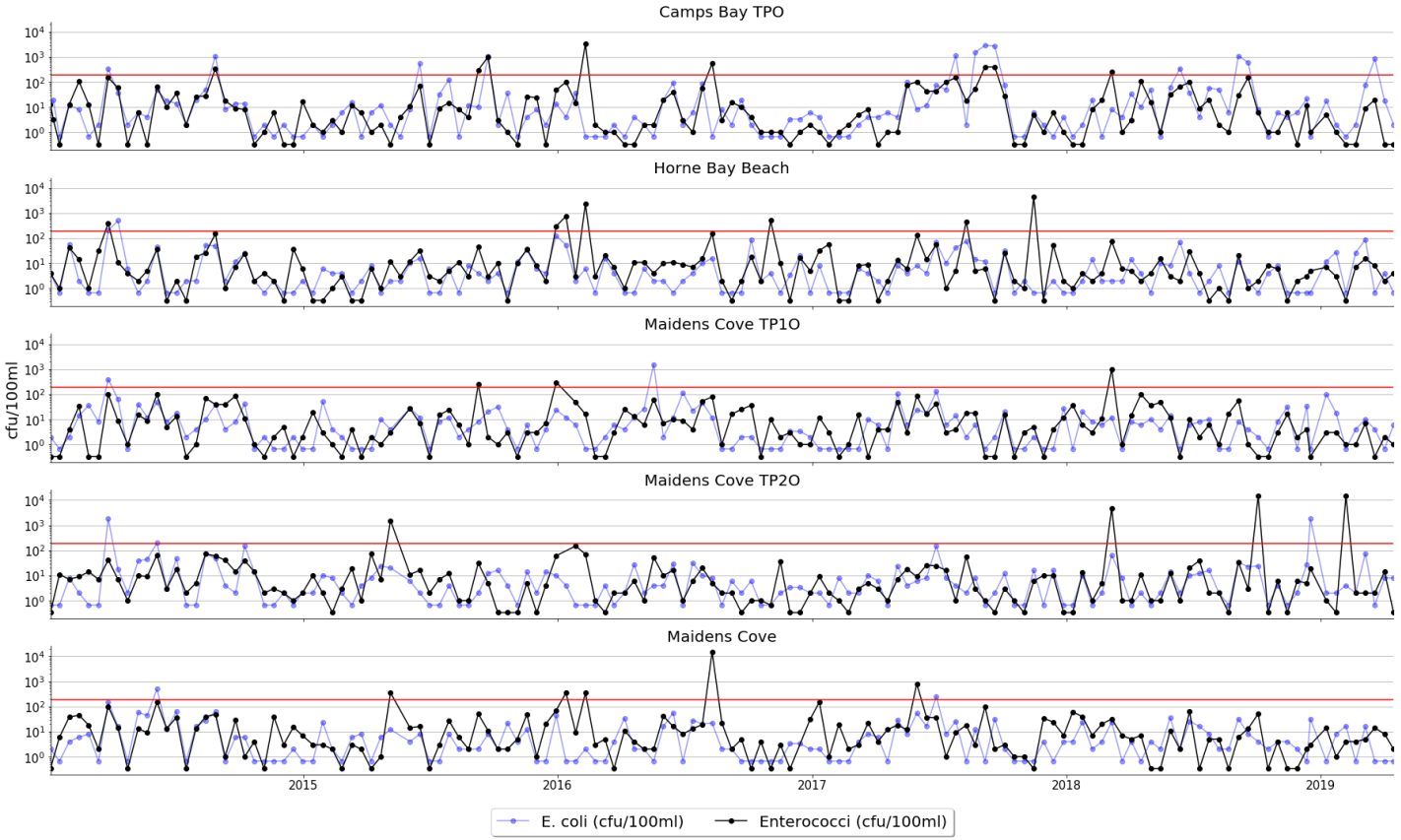

Figure 4.23: Time series of E. Coli and enterococci counts at coastal monitoring points within the Clifton and Camps Bay area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.5 LLANDUDNO AND HOUT BAY

4.5.1 Monitoring Sites

The CCT currently monitors FIB at three sites within the Llandudno and Hout Bay area (Figure 4.24) and all these are considered to be recreational nodes (Table 4.12).

Table 4.12: Sites in Llandudno and Hout Bay monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Cosy Bay	Recreational Node	Historical and Current
Llandudno Beach	Recreational Node	Historical and Current
Hout Bay Beach	Recreational Node	Historical and Current

Figure 4.24: Recreational nodes and coastal monitoring points within the Llandudno and Hout Bay area.

4.5.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites within Llandudno and Hout Bay is shown in Figure 4.25 below. Microbiological indicator sampling coverage improved at Hout Bay Beach and Llandudno after 2014, with both sites reaching 100% coverage, however the sampling of indicators at Cosy Bay has decreased since 2014.

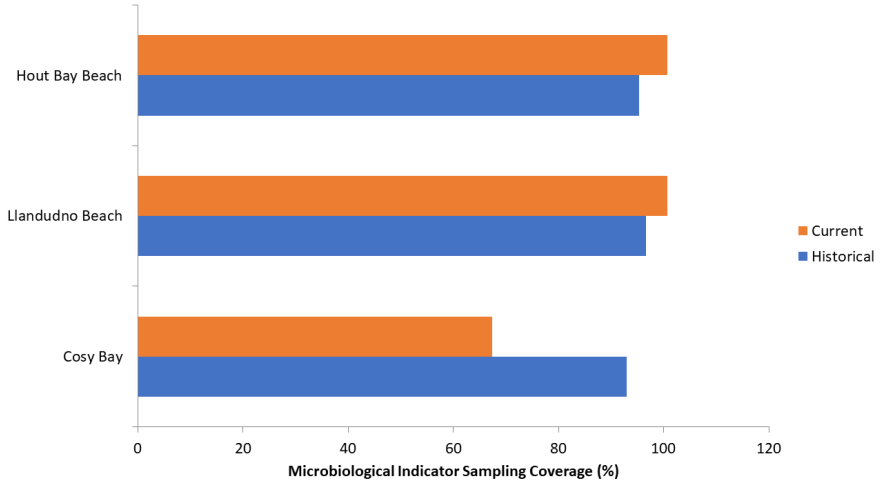

Figure 4.25: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within Llandudno and Hout Bay.

4.5.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Llandudno and Hout Bay sites, for which there are historical data, are shown in Figure 4.26 below. No clear temporal trend can be seen in any of the indicator counts at any of the sampled sites. Spatially, Hout Bay Beach had consistently higher microbiological indicator counts throughout the measured time period compared to the other sites in the area.

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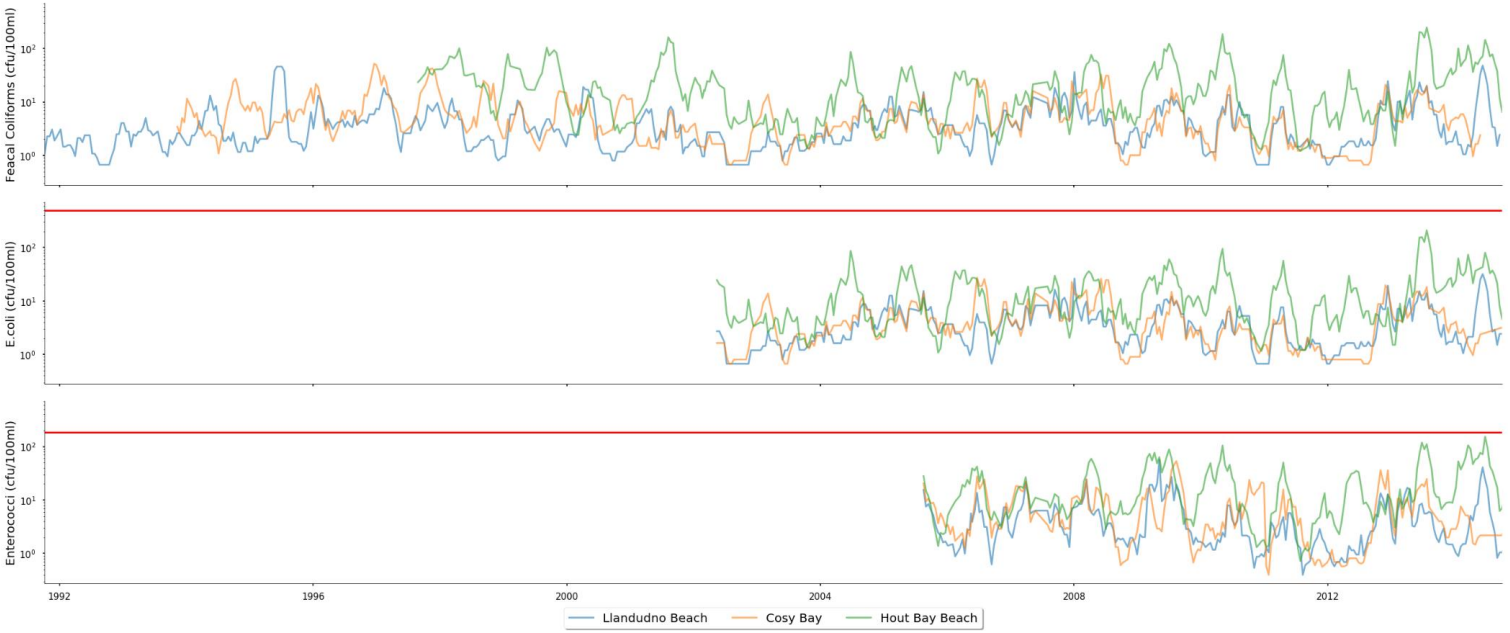

Figure 4.26: Rolling geometric means for faecal coliform, E. coli and enterococci counts at monitoring sites within the Llandudno and Hout Bay area for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.5.4 Current State of Coastal Water Quality

4.5.4.1 Defined Recreational Nodes

The time series of FIB counts at the recreational nodes within the Llandudno and Hout Bay area are displayed in Figure 4.27. These display that the enterococci counts rarely exceed the percentile threshold of 185 cfu/100 ml. Llandudno Beach displays a peak of greater than 10,000 cfu/100 ml in 2018, however this is an isolated event. An isolated peak of similar magnitude is also apparent at Hout Bay Beach in 2014. Exceedances are more common at Hout Bay beach, with exceedancences above the 185 cfu/100ml threshold 9.5% of the measurement period.

The water quality at all sites was classified as either Sufficient (the minimum requirement), Good or Excellent over the five-year period, according to the DEA (2012) percentile guidelines (Table 4.13).

Table 4.13: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within the Llandudno and Hout Bay area. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Cosy Bay	18	37	42	92	Excellent
Llandudno Beach	20	228	42	109	Good
Hout Bay Beach	144	47	150	625	Sufficient

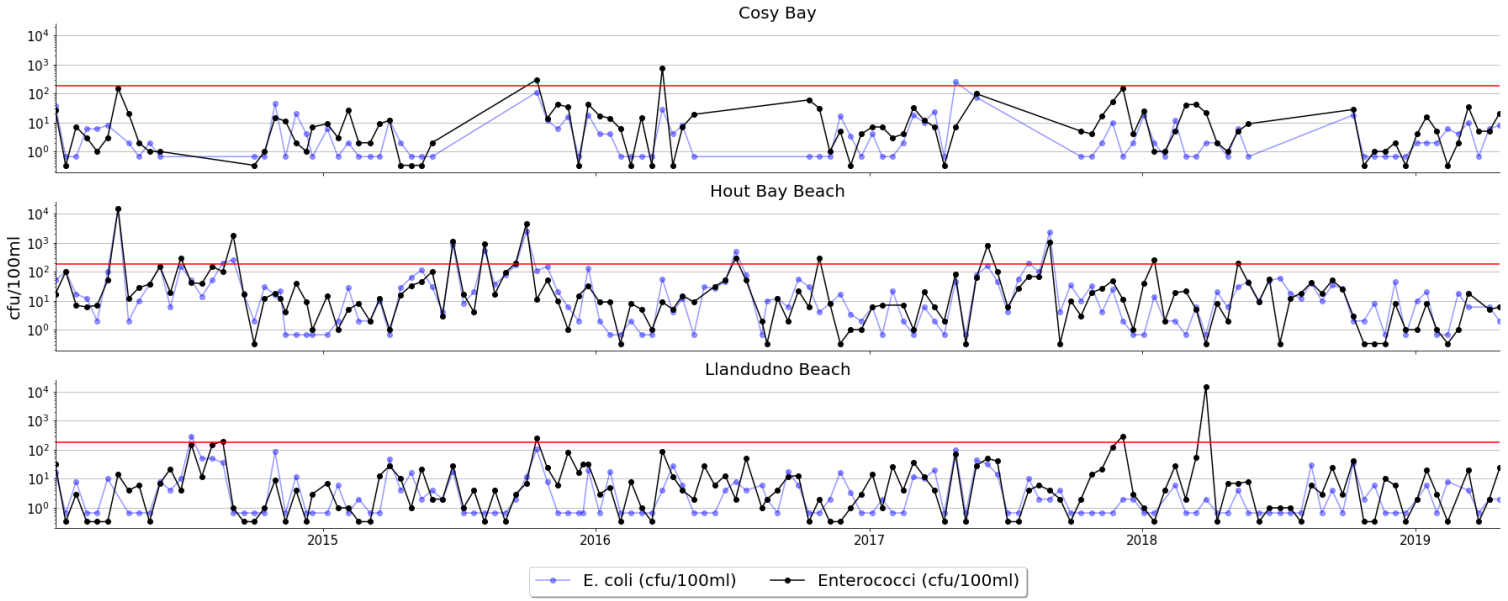

Figure 4.27: Time series of E. Coli and enterococci counts at recreational nodes within the Llandudno and Hout Bay area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.6 ATLANTIC PENINSULA

4.6.1 Monitoring Sites

The CCT currently monitors FIB at three sites on the Atlantic Peninsula (Figure 4.28). Of these three points, two are considered to be recreational nodes, and one is considered to be a coastal monitoring point, outside of popular recreational use areas (Table 4.14).

Table 4.14: Sites on the Atlantic Peninsula monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
The Kom	Coastal Monitoring Point	Historical and Current
Long Beach Kommetjie	Recreational Node	Historical and Current
Scarborough Beach	Recreational Node	Historical and Current

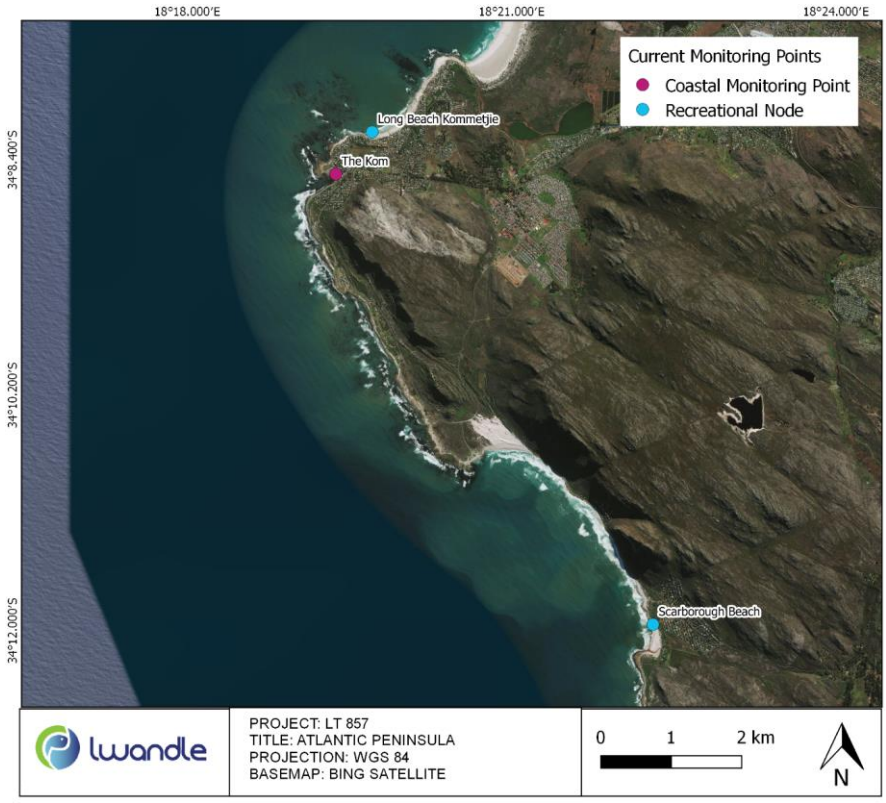

Figure 4.28: Recreational nodes and coastal monitoring points within the Atlantic Peninsula area.

4.6.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites on the Atlantic Peninsula is shown in Figure 4.29 below. Microbiological indicator sampling coverage improved at all sites after 2014, with all reaching 100% coverage.

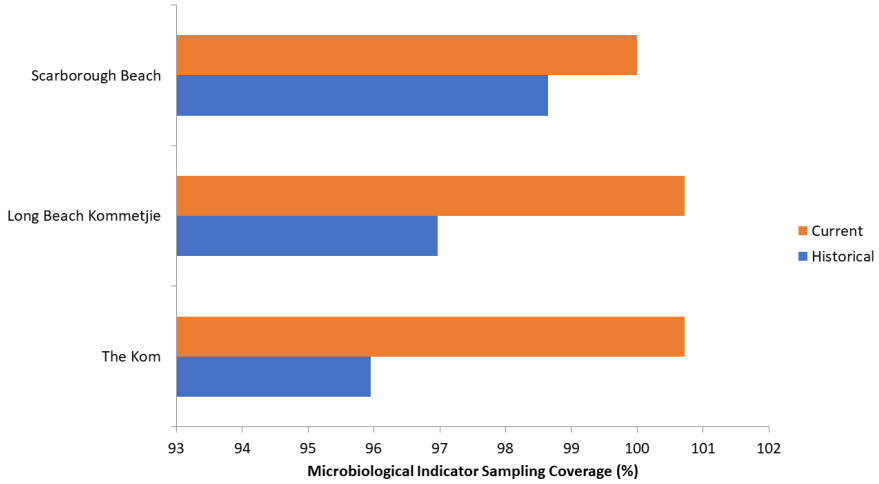

Figure 4.29: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located on the Atlantic Peninsula.

4.6.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Atlantic Peninsula sites, for which there are historical data, are shown in Figure 4.30 below. Temporally, no clear long-term trends can be seen in any of the indicator counts at any of the sites, with multiple spikes in counts occurring at varying frequencies over the time period. Spatially, The Kom appeared to have consistently higher microbial indicator counts throughout the measured time period compared to the other sites in the area.

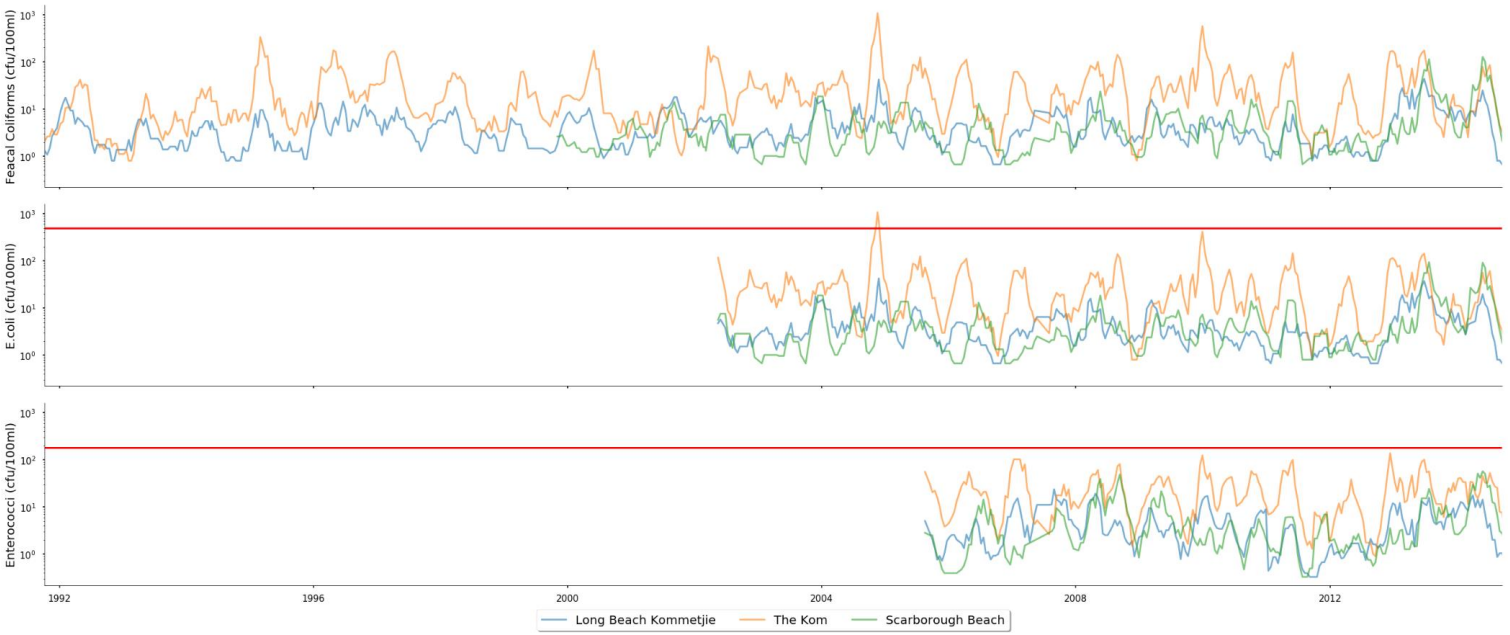

Figure 4.30: Rolling geometric means for faecal coliform, E. coli and enterococci counts at monitoring sites on the Atlantic Peninsula for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.6.4 Current State of Coastal Water Quality

4.6.4.1 Defined Recreational Nodes

The FIB count time series, shown in Figure 4.31, display low counts for both recreational nodes within the Atlantic Peninsula area. The enterococci counts exceed the percentile threshold on very few occasions over the five-year period.

The water quality at Long Beach Kommetjie and Scarborough Beach was classified as Excellent over the five-year period, according to the DEA (2012) percentile guidelines (Table 4.15).

Table 4.15: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes on the Atlantic Peninsula. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Long Beach Kommetjie	21	55	33	50	Excellent
Scarborough Beach	20	28	33	60	Excellent

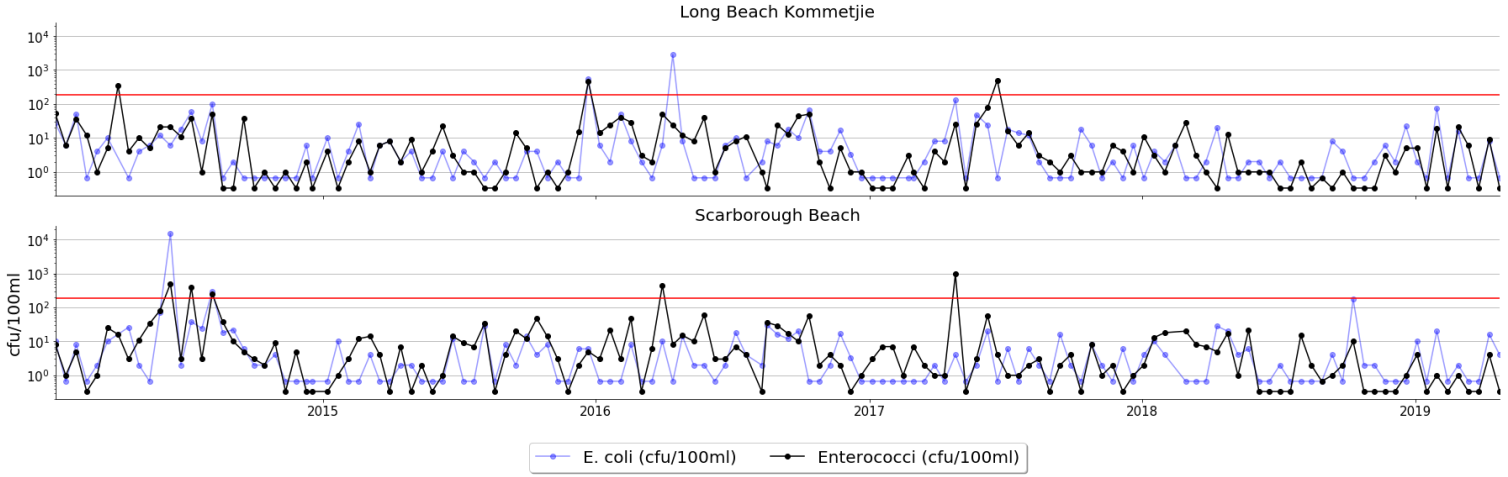

Figure 4.31: Time series of E. Coli and enterococci counts at recreational nodes within the Atlantic Peninsula area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.6.4.2 Coastal Monitoring Points

The time series of FIB counts for The Kom, the single coastal monitoring point within the Atlantic Peninsula area, shows that the enterococci counts frequently exceed the percentile threshold of 185 cfu/100 ml over the five-year period (Figure 4.32). Seasonality is apparent as generally higher enterococci counts are recorded in the winter months, when rainfall is highest. This indicates that there is likely a source of anthropogenic run-off close to the site contributing to the FIB load when rainfall is high.

Commented [LH12]: Check with rainfall data and discharge locations

Water quality at The Kom was classified as Poor over the five-year period, according to the DEA (2012) percentile guidelines (Table 4.16). This indicates that enterococci measurements were above the threshold (185 cfu/100 ml) more than 10% of the time. At The Kom exceedances were recorded 23.7% of the time, leading to unacceptable risk during these periods.

Table 4.16: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at the coastal monitoring point on the Atlantic Peninsula. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
The Kom	1310	2288	900	1478	Poor

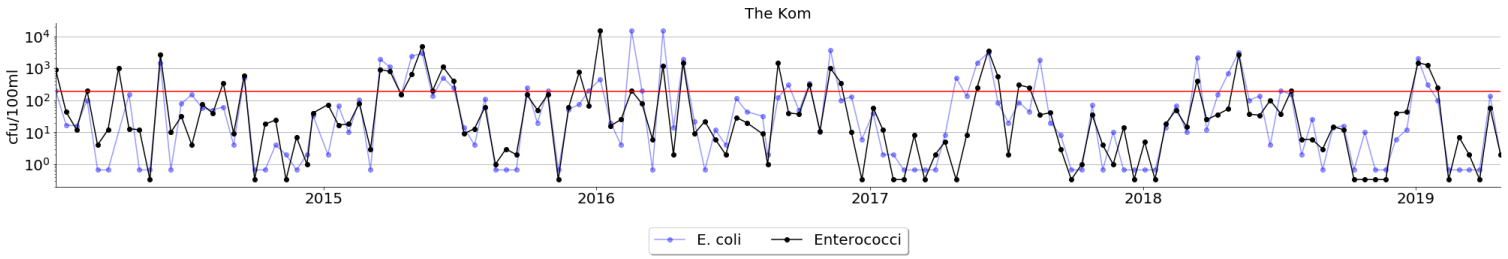

Figure 4.32: Time series of E. Coli and enterococci counts at The Kom, the coastal monitoring point within the Atlantic Peninsula area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.7 SIMON'S TOWN AND FISH HOEK

4.7.1 Monitoring Sites

The CCT currently monitors FIB at 10 sites within the Simons Town and Fish Hoek area (Figure 4.33). Of these 10 points, seven are considered to be recreational nodes, and three are considered to be coastal monitoring points, outside of popular recreational use areas (Table 4.17).

Table 4.17: Sites in the Simons Town and Fish Hoek area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Millers Point	Coastal Monitoring Point	Historical and Current
Franks Bay	Recreational Node	Historical and Current
Seaforth Beach	Recreational Node	Historical and Current
Boulders Beach	Recreational Node	Historical and Current
Simons Town Harbour	Coastal Monitoring Point	Historical and Current
Simons Town Diving School	Coastal Monitoring Point	Historical and Current
Simons Town Long Beach	Recreational Node	Historical and Current
Glencairn Beach	Recreational Node	Historical and Current
Fish Hoek Beach	Recreational Node	Historical and Current
Clovelly	Recreational Node	Historical and Current

Figure 4.33: Recreational nodes and coastal monitoring points within the Simon's Town and Fish Hoek area.

4.7.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), in the Simons Town and Fish Hoek region is shown in Figure 4.34 below. Microbiological indicator sampling coverage improved at all sites after 2014, with all reaching 100% coverage.

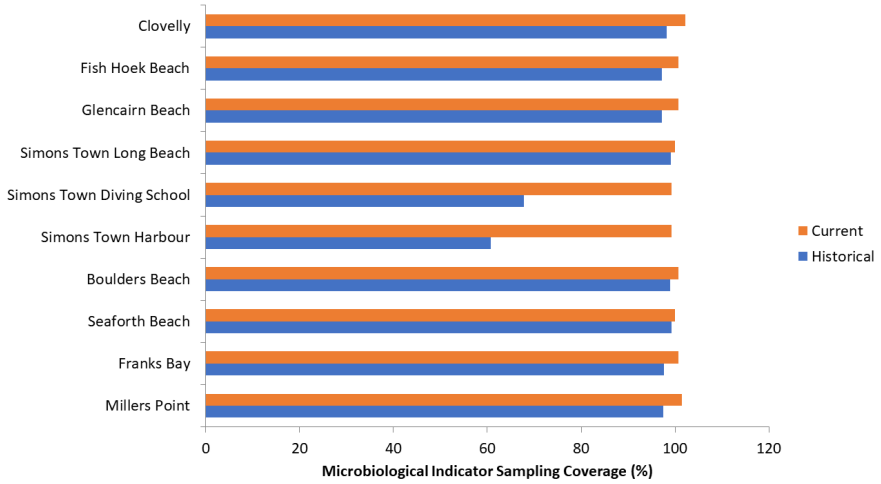

Figure 4.34: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within the Simons Town and Fish Hoek area.

4.7.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Kalk Bay and St James sites for which there are historical data are shown in Figure 4.35 below. Temporally, no clear long-term trend can be seen in any of the indicator counts. Intermittent spikes in indicator counts of varying magnitude and at varying frequencies occur throughout the measurement period at all sites. However spatially, higher microbial counts consistently occurred at the Kalk Bay Harbour and at the Muizenberg Station site which are sites considered to be recreational nodes, occurring in areas of high recreational activity.

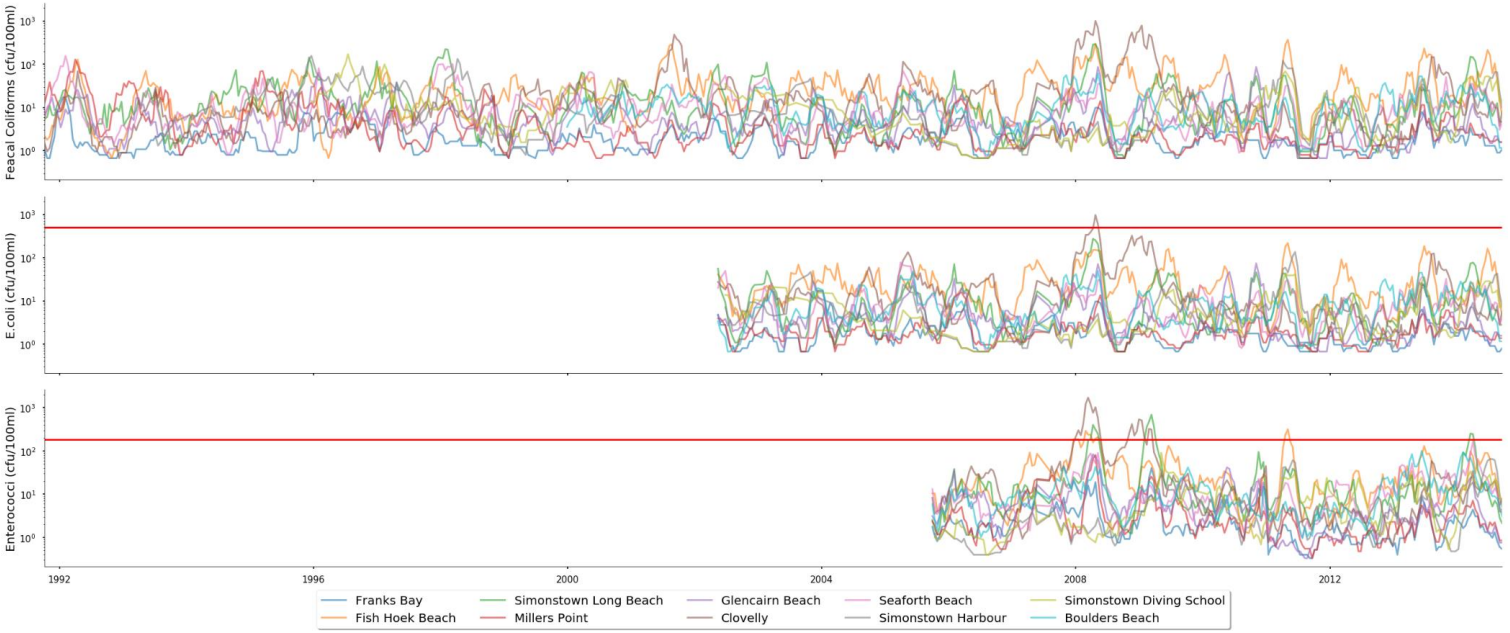

Figure 4.35: Rolling geometric means for faecal coliform, E. coli and enterococci counts at all monitoring sites within the Simons Town and Fish Hoek area for which there are historical data prior to 2014. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.7.4 Current State of Coastal Water Quality

4.7.4.1 Defined Recreational Nodes

The time series of FIB counts for recreational nodes within the Simon's Town and Fish Hoek area show that counts measured at Franks Bay and Glen Cairn have been consistently low and have only exceeded the enterococci percentile threshold on few occasions over the five-year period (Figure 4.36 and Figure 4.37). The counts at Clovelly and Fish Hoek Beach are greater, with counts exceeding the threshold frequently over the five years. Clovelly is positioned at the mouth of the Silvermine River and it is likely that contaminants are introduced to the coastal waters at this site via the river mouth. There is also a stormwater outlet at Fish Hoek Beach, which is likely contributing to the FIB load at this site. The extent of effect of these inputs will be influenced by the prevailing rainfall in the area. The frequency of exceedance, as well as the magnitude of the peaks, is greater at Fish Hoek Beach. However, counts at this site were generally lower, and below the percentile threshold, during 2018. Although displaying less frequent exceedances and variation than Clovelly and Fish Hoek Beach, frequent counts above the percentile threshold have been recorded at Simon's Town Long Beach over the time period. Seaforth Beach has not exceeded the percentile threshold since 2017.

The water quality at Franks Bay, Seaforth Beach, Boulders Beach and Glencairn Beach was classified as either Sufficient (the minimum requirement), Good or Excellent over the five-year period according to the DEA (2012) percentile guidelines (Table 4.18). The water quality at the remaining recreational nodes was classified as Poor with exceedances of the 185 cfu/100ml threshold occurring 15.9, 20.1 and 11.3% of the time at Simon's Town Long Beach, Fish Hoek Beach and Clovelly respectively. During these exceedances the water quality posed an unacceptable risk to health.

Table 4.18: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes within Simon's Town and Fish Hoek. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Franks Bay	6	10	17	31	Excellent
Seaforth Beach	87	145	99	150	Good
Boulders Beach	72	124	64	240	Sufficient
Simon's Town Long Beach	150	650	350	680	Poor
Glencairn Beach	46	85	25	89	Excellent
Fish Hoek Beach	1050	3098	680	1828	Poor
Clovelly	90	454	220	550	Poor

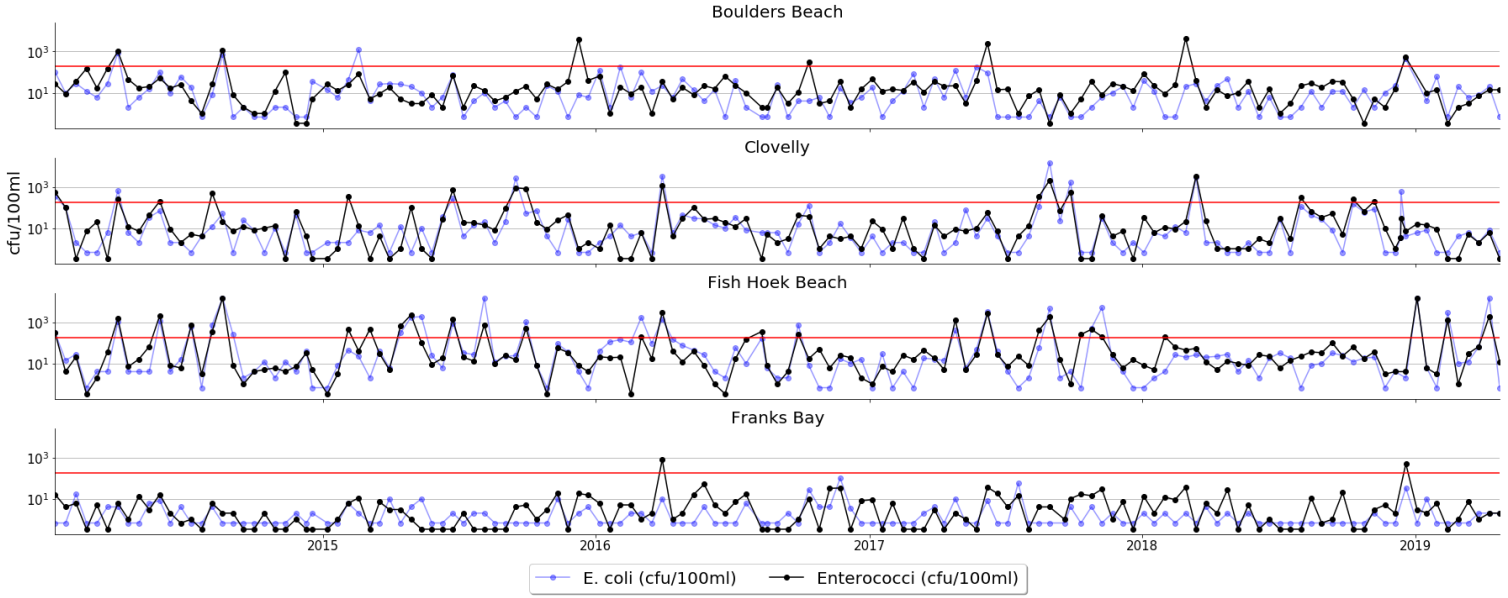

Figure 4.36: Time series of E. Coli and enterococci counts at recreational nodes within the Simon's Town and Fish Hoek area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

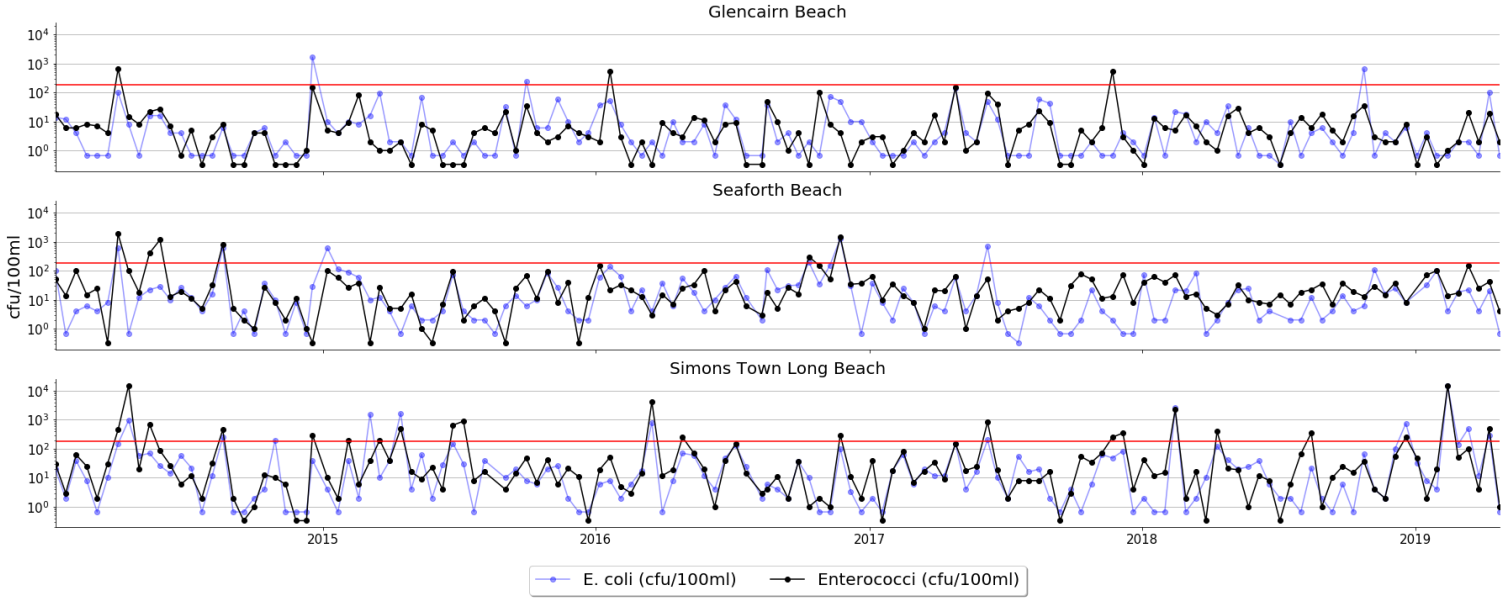

Figure 4.37: Time series of E. Coli and enterococci counts at recreational nodes within the Simon's Town and Fish Hoek area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.7.4.2 Coastal Monitoring Points

FIB counts at the coastal monitoring points over the five-year period is displayed in Figure 4.38. Counts are generally low at all three sites (Millers Point, Simon's Town Diving School and Simons Town Harbour), with only one recorded count above the threshold at Millers Point (2019). The measured exceedances at Simon's Town Diving School and Simon's Town Harbour occur at approximately the same periods in the time series (2015 and 2018). However, the peaks evident at Simon's Town Harbour are much greater (> 10,000 cfu/100 ml) than at the Diving School. This indicates a common causative factor that appears to have greater influence at the harbour site due to a nearby source, but the signal is still apparent at the diving school site.

Commented [AM13]: Will investigate when CCT provide stormwater info

The water quality at Millers Point, Simon's Town Harbour and Simon's Town Diving School was classified as either Excellent or Good over the five-year period, according to the DEA (2012) percentile guidelines (Table 4.15).

Table 4.19: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points within Simons Town and Fish Hoek. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Millers Point	12.00	17.00	21	41	Excellent
Simon's Town Harbour	62.00	90.60	54	171	Good
Simon's Town Diving School	26.00	71.90	42	74	Excellent

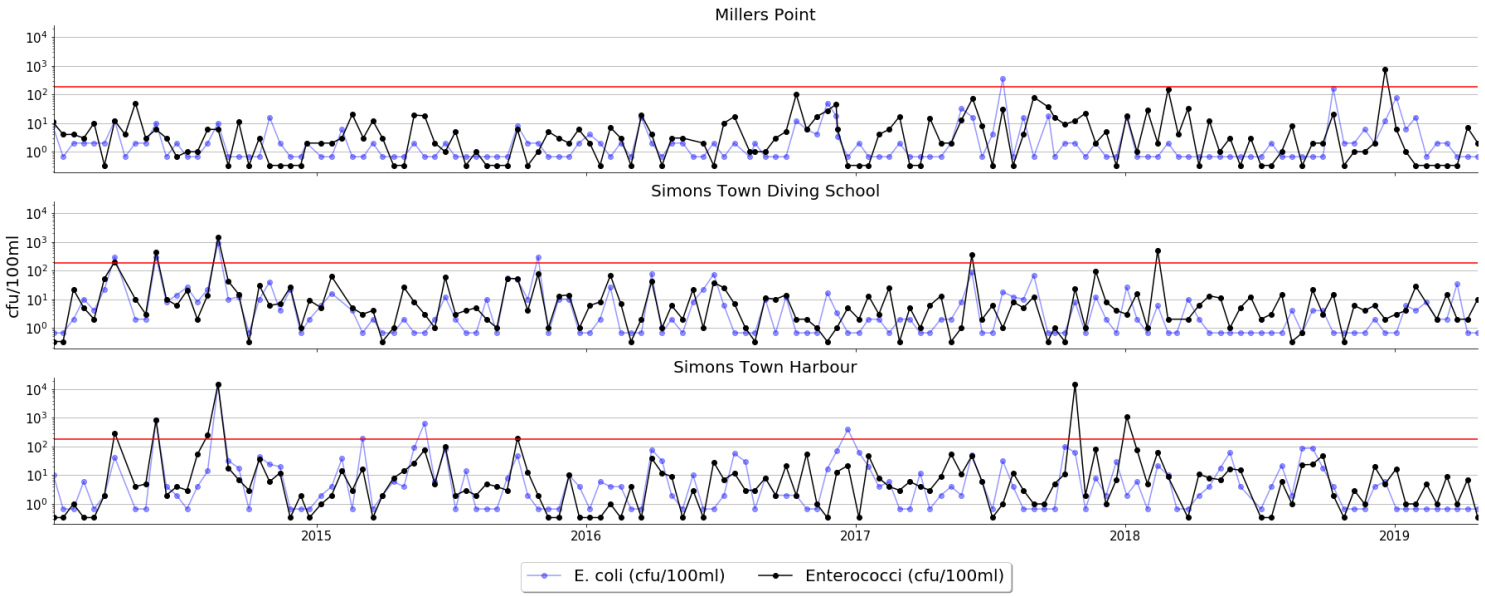

Figure 4.38: Time series of E. Coli and enterococci counts at coastal monitoring points within the Simon's Town and Fish Hoek area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.8 KALK BAY AND ST JAMES

4.8.1 Monitoring Sites

The CCT currently monitors FIB at seven sites within the Kalk Bay and St James area (Figure 4.39). Historically monitoring was also undertaken at three sites at and around Baileys Cottage. Of these ten points, four are considered to be recreational nodes, and six are considered to be coastal monitoring points, outside of popular recreational use areas. A significant portion of the monitoring points are within or just outside tidal pools which occur in the area including Kalk Bay TP, Dalebrook TP and St James TP (Table 4.20).

Table 4.20: Sites in Kalk Bay and St James monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Kalk Bay Rocks	Coastal Monitoring Point	Historical and Current
Kalk Bay Harbour	Recreational Node	Historical and Current
Kalk Bay TP	Coastal Monitoring Point	Historical and Current
Dalebrook TP	Recreational Node	Historical and Current
St James TP	Recreational Node	Historical and Current
Baileys Cottage SD	Coastal Monitoring Point	Historical
Baileys Cottage A	Coastal Monitoring Point	Historical
Baileys Cottage B	Coastal Monitoring Point	Historical
Ex Sandown Hotel Site	Coastal Monitoring Point	Historical and Current
Muizenberg Station	Recreational Node	Historical and Current

Figure 4.39: Recreational nodes and coastal monitoring points within the Kalk Bay and St James area.

4.8.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at Kalk Bay and St James is shown in Figure 4.40 below. Microbiological indicator sampling coverage improved at all sites after 2014, with most reaching between 90 and 100% coverage. Sampling at the three points located near Baileys Cottage was stopped prior to 2014.

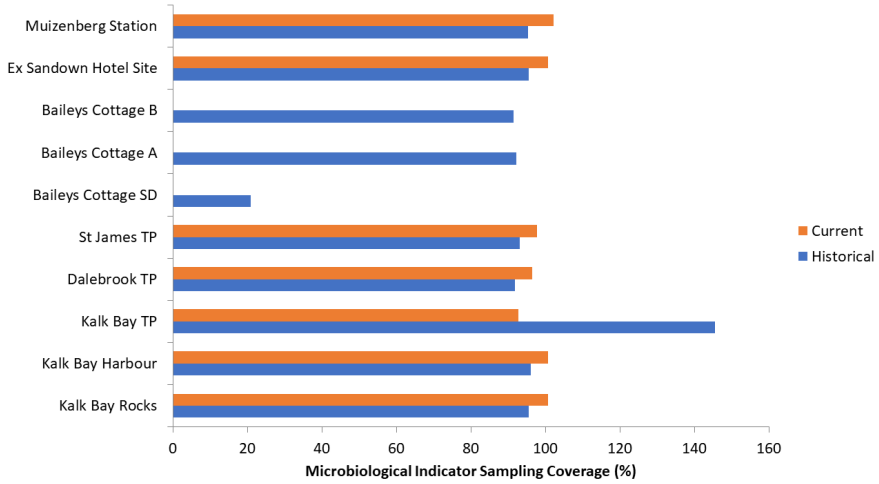

Figure 4.40: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within Kalk Bay and St James.

4.8.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Kalk Bay and St James sites for which there are historical data are shown in Figure 4.41 below. Temporally, no clear long-term trend can be seen in any of the indicator counts. Intermittent spikes in indicator counts of varying magnitude and at varying frequencies occur throughout the measurement period at all sites. However spatially, higher microbial counts consistently occurred at the Kalk Bay Harbour and at the Muizenberg Station site which are sites considered to be recreational nodes, occurring in areas of high recreational activity.

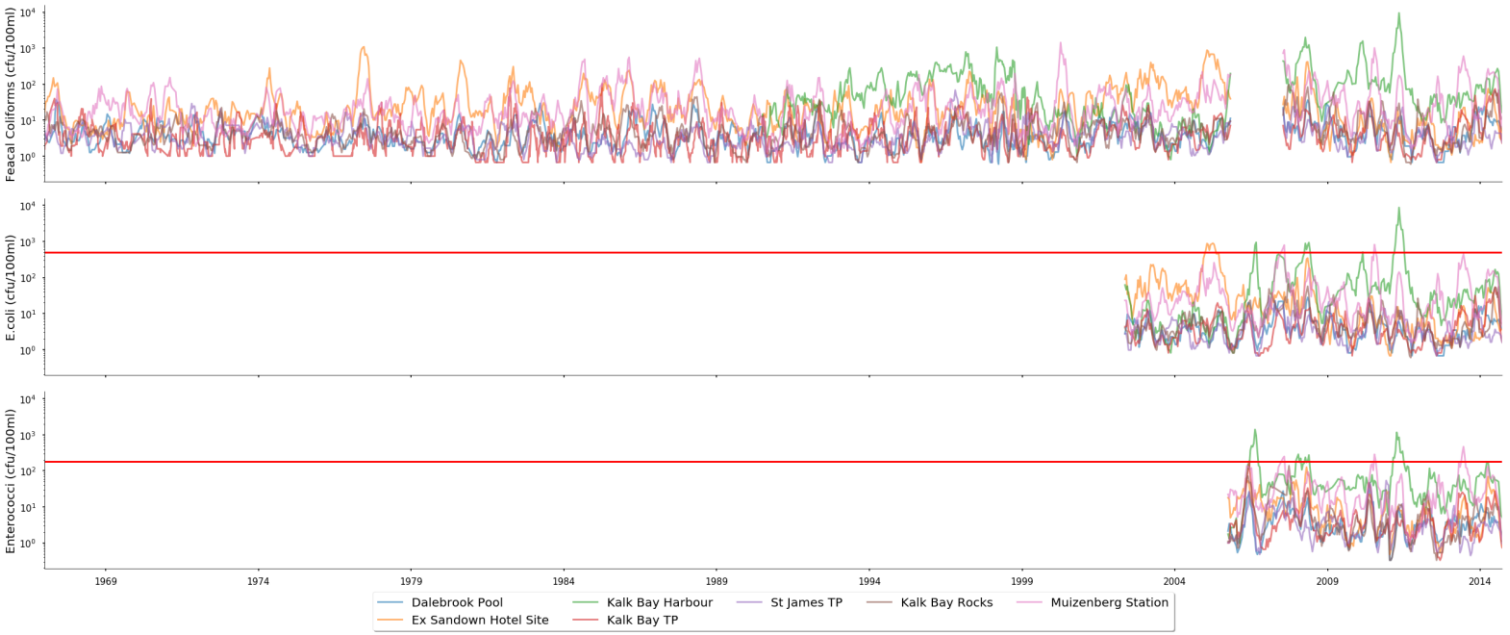

Figure 4.41: Rolling geometric means for faecal coliform, E. coli and enterococci counts at monitoring sites within the Kalk Bay and St James area for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.8.4 Current State of Coastal Water Quality

4.8.4.1 Defined Recreational Nodes

Figure 4.42 displays the time series of FIB counts for the recreational nodes within the Kalk Bay and St James area over the five-year period. FIB counts at St James (St James TP) and Dalebrook (Dalebrook TP) tidal pools were generally low with no, or very few, recorded levels above the enterococci percentile threshold. FIB counts over the five-year period at Muizenberg Station and Kalk Bay Harbour exceed the enterococci percentile threshold fairly often from 2014-2015. The frequency of the peaks and the variance at these sites is generally reduced from 2016 onwards.

The five-year water quality classification for recreational nodes, Kalk Bay Harbour and Muizenberg Station, was Poor according to the DEA (2012) percentile guidelines. At these sites measurements exceeded the 185 cfu/100ml threshold 18 and 10.6% of the time, during whicht the water quality at these sites posed an unacceptable risk. The water quality of the remaining recreational nodes within this area, Dalebrook Tidal Pool and St James Tidal Pool, was classified as Excellent (Table 4.21).

Table 4.21: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes in Kalk Bay and St James. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Kalk Bay Harbour	420	760	330	728	Poor
Dalebrook TP	32	57	40	94	Excellent
St James TP	22	63	21	42	Excellent
Muizenberg Station	113	625	200	1445	Poor

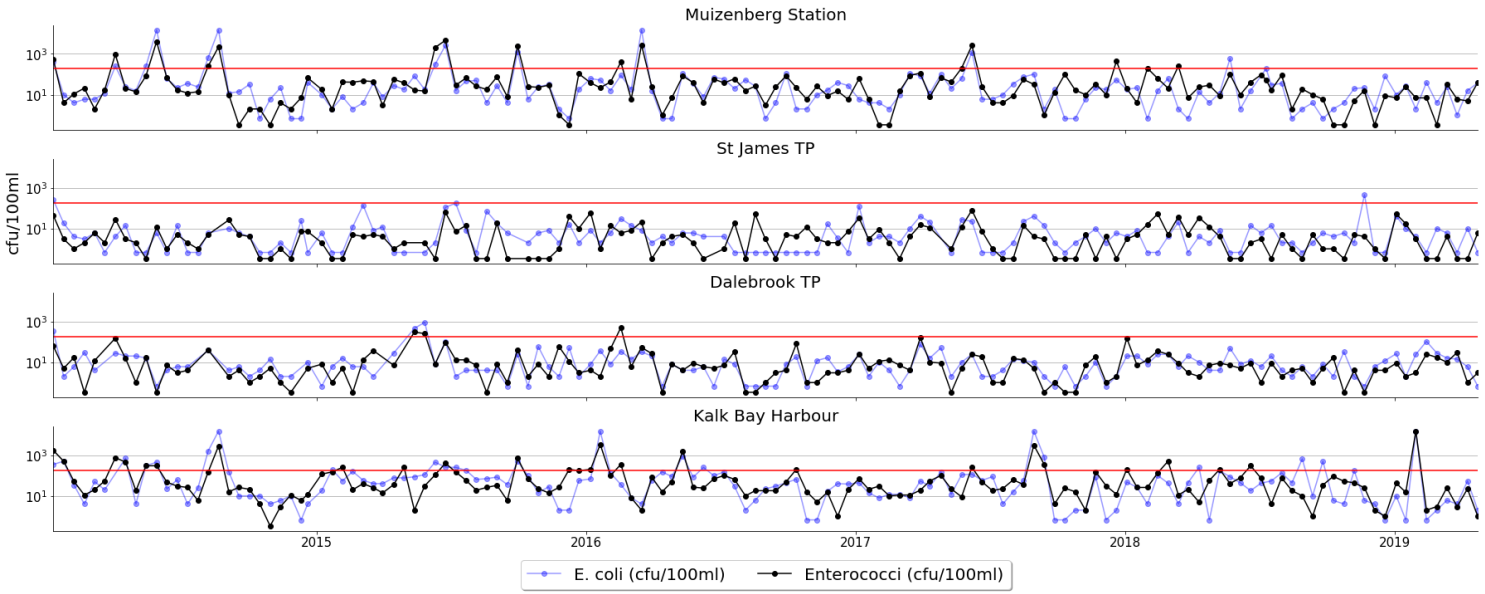

Figure 4.42: Time series of E. Coli and enterococci counts at recreational nodes within the Kalk Bay and St James area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.8.4.2 Coastal Monitoring Points

FIB count timeseries for the coastal monitoring points in the Kalk Bay and St James area are generally low, with only a few peaks above the 185 cfu/100 ml enterococci percentile threshold.. Where there are peaks, they are during the winter months, which is likely due to the introduction of FIB from stormwater flows during the rainy season. All sites have been below the threshold since the beginning of 2018.

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The five-year water quality classifications for Kalk Bay tidal pool (Kalk Bay TP) and Ex Sandown Hotel were Sufficient, which is the minimum requirement according to the DEA (2012) guidelines. The water-quality at Kalk Bay Rocks was classified as Excellent over the five-year time period (Table 4.22).

Table 4.22: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points in Kalk Bay and St James. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Kalk Bay Rocks	49	227	53	79	Excellent
Kalk Bay TP	81	355	88	710	Sufficient
Ex Sandown Hotel Site	96	178	71	225	Sufficient

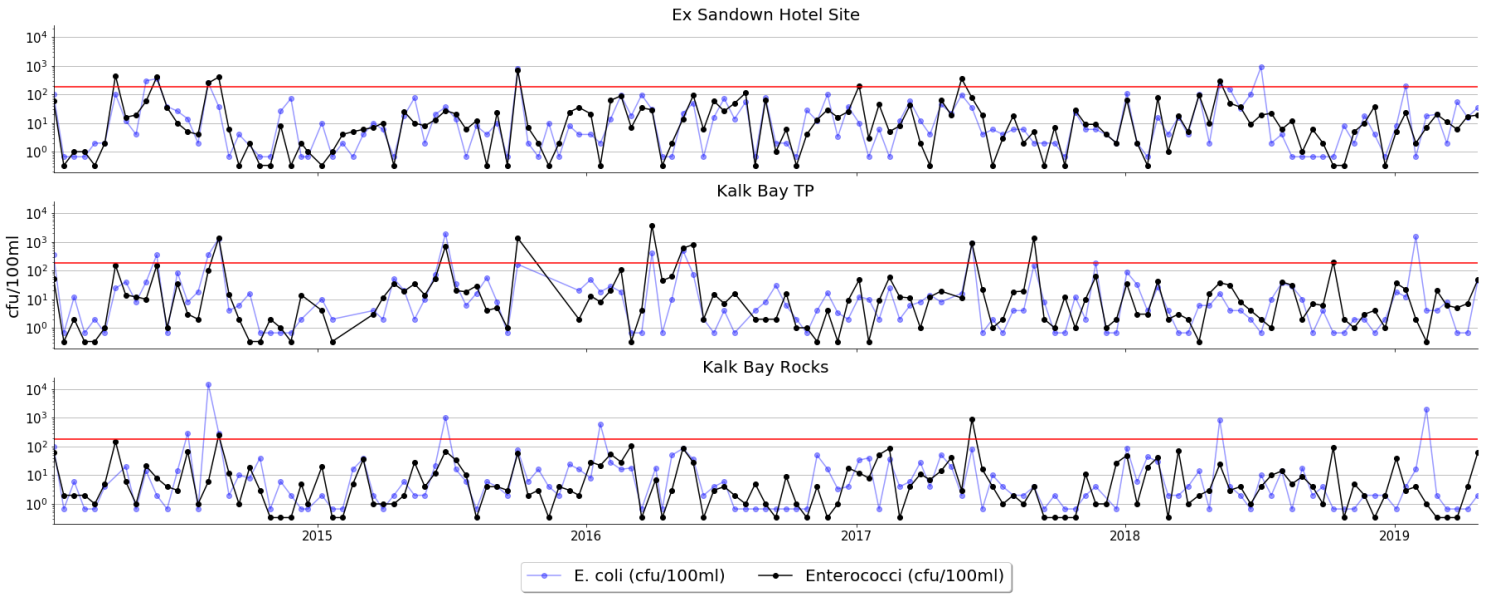

Figure 4.43: Time series of E. Coli and enterococci counts at coastal monitoring points within the Kalk Bay and St James area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.9 MUIZENBERG AND SUNRISE BEACH

4.9.1 Monitoring Sites

The CCT currently monitors FIB at nine sites within the Muizenberg and Sunrise Beach area (Figure 4.44). Of these nine points, four are considered to be recreational nodes, and five are considered to be coastal monitoring points, outside of popular recreational use areas. The Strandfontein tidal pool occurs in the area, in which one points is monitored (Table 4.23).

Table 4.23: Sites in the Muizenberg and Sunrise Beach area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Muizenberg Pavilion	Recreational Node	Historical and Current
Sunrise Beach	Recreational Node	Historical and Current
Lifebox 21	Coastal Monitoring Point	Historical and Current
Lifebox 23	Coastal Monitoring Point	Historical and Current
Sonwabe	Coastal Monitoring Point	Historical and Current
Ribbon Parking Area	Coastal Monitoring Point	Historical and Current
Lifebox 30	Coastal Monitoring Point	Historical and Current
Strandfontein	Recreational Node	Historical and Current
Strandfontein TP	Recreational Node	Historical and Current

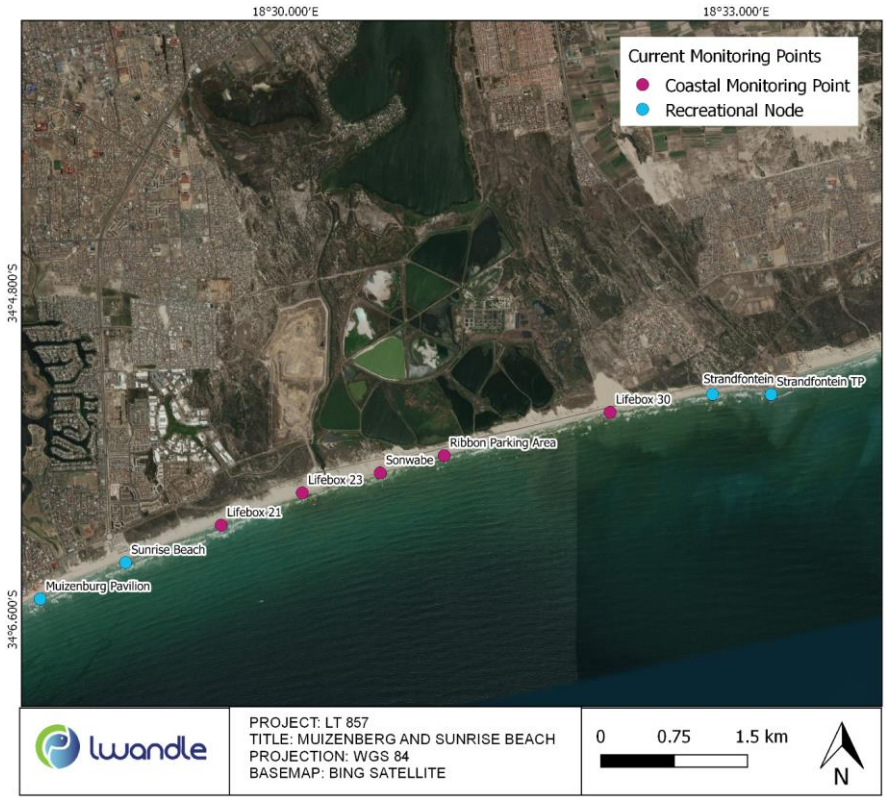

Figure 4.44: Recreational nodes and coastal monitoring points within the Muizenberg and Sunrise Beach area.

4.9.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites within Muizenberg and Sunrise Beach is shown in Figure 4.45 below. Microbiological indicator sampling coverage improved at all sites after 2014, with all reaching at least 100% coverage.

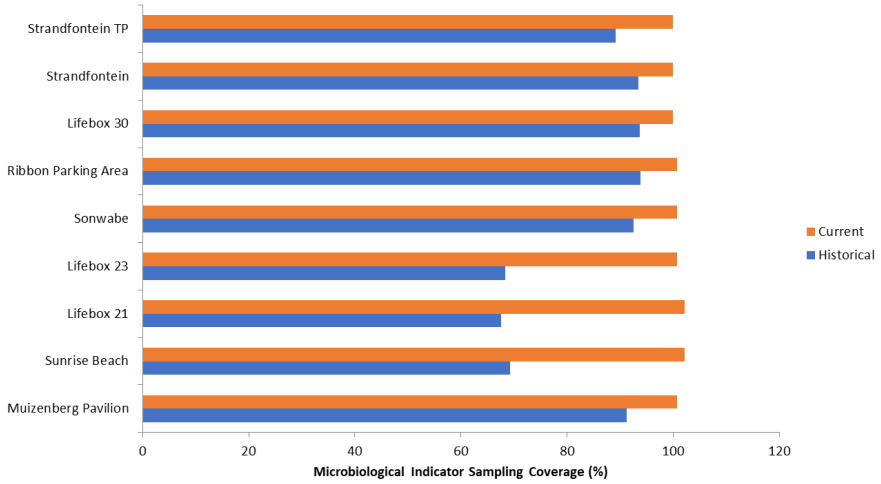

Figure 4.45: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within the Muizenberg and Sunrise Beach area.

4.9.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Muizenberg and Sunrise Beach sites for which there are historical data are shown in Figure 4.46 below. No faecal coliforms data was collected between October 2005 and July 2007 for all sites. No clear temporal trend can be seen in any of the indicator counts at any of the sampled sites. However, there appears to be an increase in the frequency of faecal coliform counts mid-1990s onwards, however this is most likely as a result of increased site coverage in this area during this time. Spatially, Lifebox 23 had the highest peaks for all three indicators.

Commented [LH15]: Add difference plots showing the increase in exceedances from the past 5 years to the current 5 years. Possibly explain in context to the vlei water quality.

CCT – do you have any data on this – when the vlei is opened and closed and pollution events? Are there any other stormwater discharges in this area?

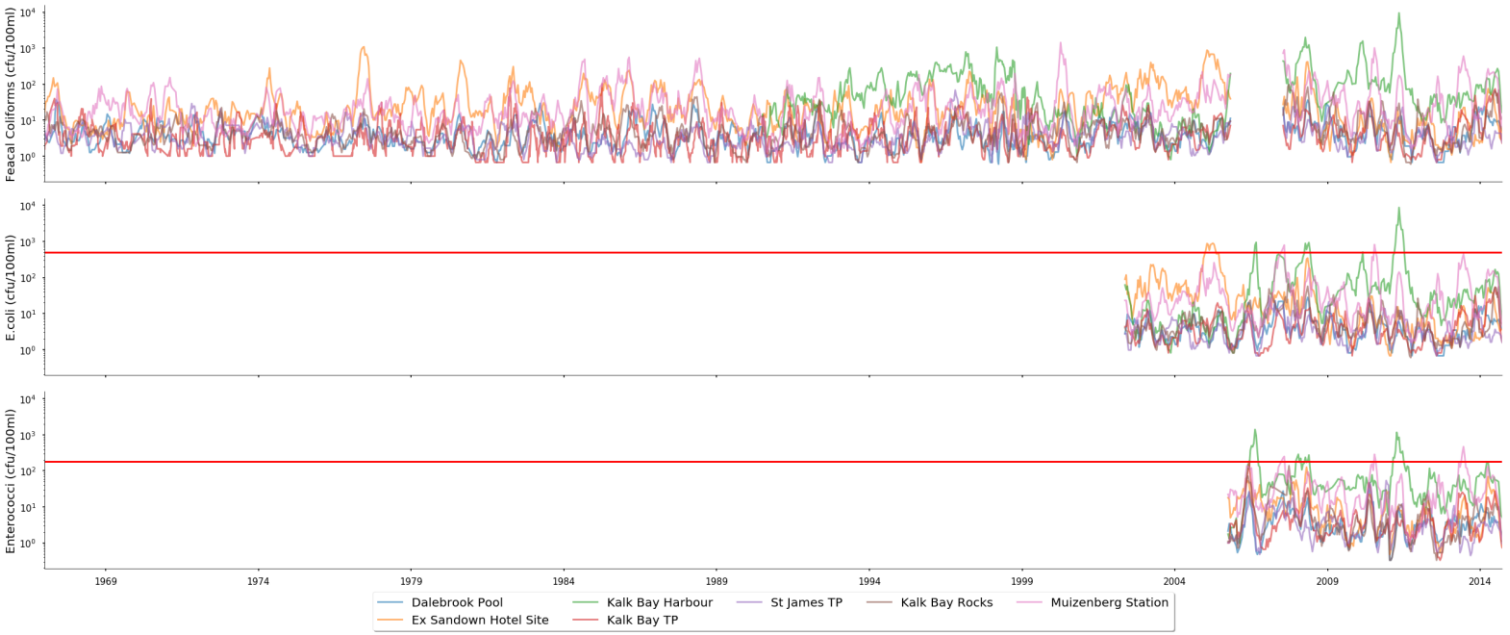

Figure 4.46: Rolling geometric means for faecal coliform, E. coli and enterococci counts at selected monitoring sites within the Muizenberg and Sunrise Beach area for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.9.4 Current State of Coastal Water Quality

4.9.4.1 Defined Recreational Nodes

The FIB counts at Sunrise Beach and Muizenberg Pavilion exceed the enterococci percentile threshold of 185 cfu/100 ml fairly regularly over the five-year period, however these events are more common in 2014 and less frequent from 2017 onwards (Figure 4.47). Although there are also exceedances at Strandfontein and Strandfontein tidal pool (Strandfontein TP), these are less frequent and seem to be isolated events.

The water quality at Muizenberg Pavilion and Sunrise Beach was classified as Poor over the five-year period, according to the DEA (2012) percentile guidelines. Measurements at these sites exceeded the 185 cfu/100ml threshold 10.8 and 15.7% of the time respectively. The water quality at the remaining two recreational nodes in Strandfontein (Standfontein beach and tidal pool), was classified as Good (Table 4.24).

Table 4.24: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes in Muizenberg and Sunrise Beach. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Muizenberg Pavilion	150	380	230	300	Poor
Sunrise Beach	150	618	300	900	Poor
Strandfontein	70	124	65.70	200	Good
Strandfontein TP	95	700	50.70	180	Good

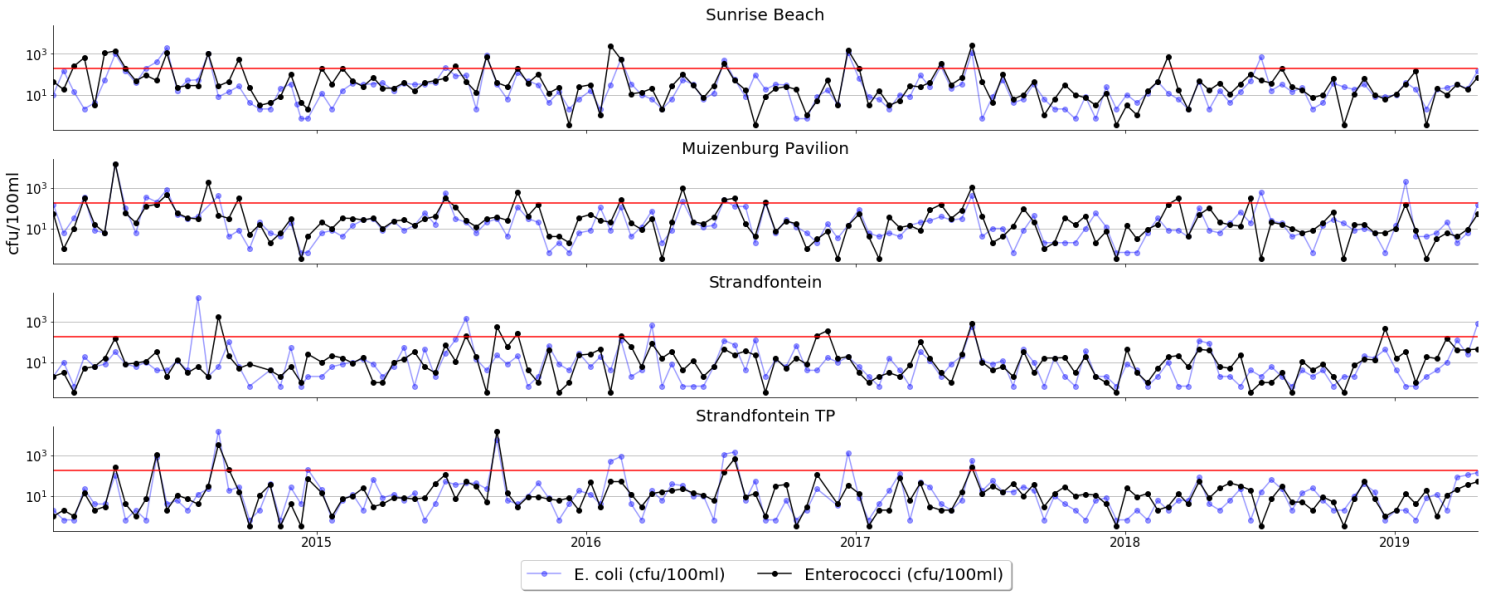

Figure 4.47: Time series of E. Coli and enterococci counts at recreational nodes within the Muizenberg and Sunrise Beach area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.9.4.2 Coastal Monitoring Points

The time series of FIB counts at the coastal monitoring points in the Muizenberg and Sunrise Beach area is displayed in Figure 4.48. The counts at all sites are generally high with most values consistently greater than 100 cfu/100 ml, exceeding the enterococci threshold regularly. There is a noticeable decrease at all sites towards the end of 2018; with counts at Lifebox 30, Ribbon Parking Area and Sonwabe remaining below the threshold since. This suggests a common environmental change or intervention at all sites.

The water quality at all coastal monitoring points within the Muizenberg and Sunrise Beach area were classified as Poor according to the DEA (2012) percentile guidelines with exceedences occurring 22% of the time at Lifebox 21, 33.3% at Lifebox 23, 15.% at Sonwabe, 10.8% at the Ribbon Parking Area and 11.8% at Lifebox 30.These percentages indicate that the water quality at these sites posed an unacceptable risk during these exceedences.

Table 4.25: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points in Muizenberg and Sunrise Beach. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Lifebox 21	600	1250	450	600	Poor
Lifebox 23	1080	2003	785	1630	Poor
Sonwabe	400	683	430	970	Poor
Ribbon Parking Area	200	305	230	605	Poor
Lifebox 30	163	500	200	520	Poor

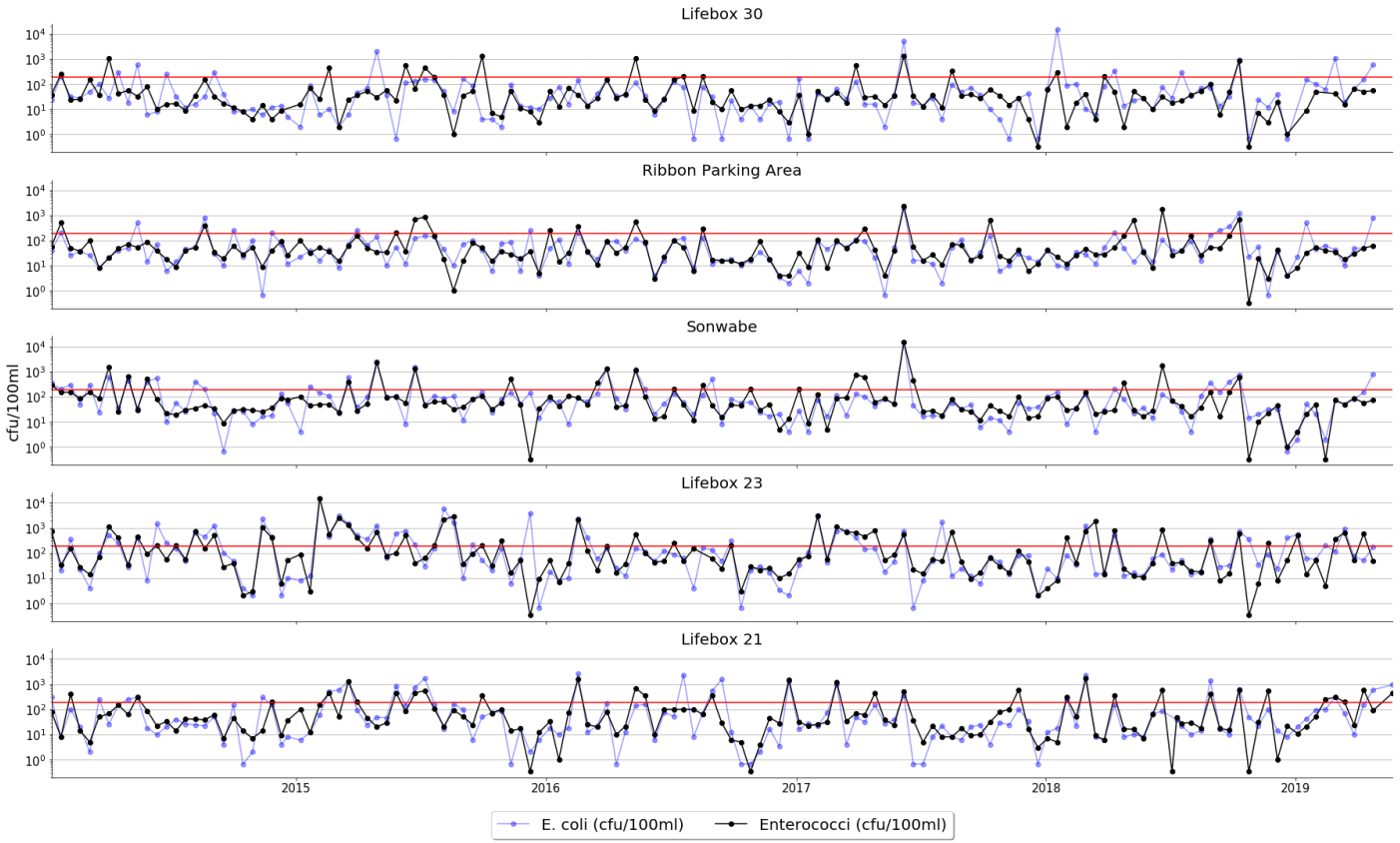

Figure 4.48: Time series of E. Coli and enterococci counts at coastal monitoring points within the Muizenberg and Sunrise Beach area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.10 MNANDI AND MONWABISI

4.10.1 Monitoring Sites

The CCT currently monitors FIB at 10 sites within the Mnandi and Monwabisi area (Figure 4.49). Of these 10 points, four are considered to be recreational nodes, and six are considered to be coastal monitoring points, outside of popular recreational use areas. The Monwabisi tidal pool occurs in the area, in which one point is monitored (Table 4.26).

Table 4.26: Sites in the Mnandi and Monwabisi area monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Lukannon Drive WWPS	Coastal Monitoring Point	Historical and Current
Mitchells Plain WWED	Coastal Monitoring Point	Historical and Current
MPSWD East	Coastal Monitoring Point	Historical and Current
MPSWD West	Coastal Monitoring Point	Historical and Current
MPSED East	Coastal Monitoring Point	Historical and Current
MPSED West	Coastal Monitoring Point	Historical and Current
Mnandi Beach West	Recreational Node	Historical and Current
Mnandi Beach East	Recreational Node	Historical and Current
Monwabisi TP	Recreational Node	Historical and Current
Monwabisi Beach	Recreational Node	Historical and Current

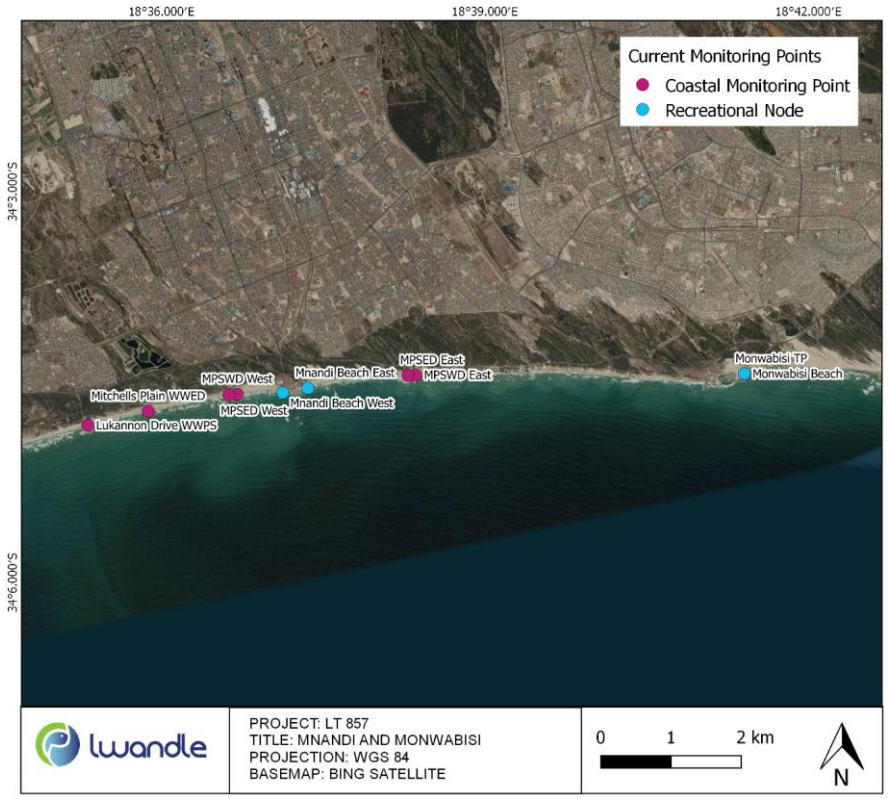

Figure 4.49: Recreational nodes and coastal monitoring points within the Mnandi and Monwabisi area.

4.10.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites within Mnandi and Monwabisi is shown in Figure 4.50 below. Microbiological indicator sampling coverage improved at all sites after 2014, with most sites reaching between 90 and 100% coverage.

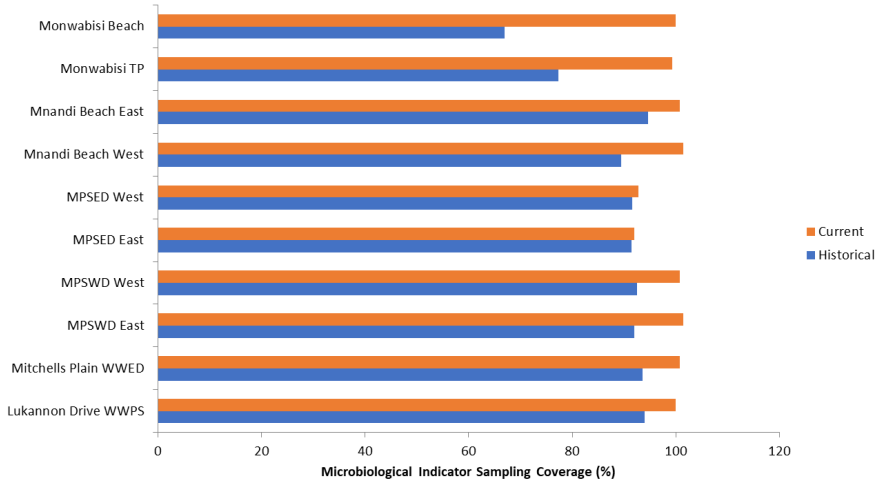

Figure 4.50: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within the Mnandi and Monwabisi area.

4.10.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Mnandi and Monwabisi sites for which there are historical data are shown in Figure 4.51 below. No clear temporal trends are shown in any of the indicators at any of the sites, with spikes in indicator counts occurring at varying magnitudes at varying frequencies over the measurement periods. FIB counts are notably higher overall in comparison to the other geographical areas in this report, with most sites having events where FIB counts exceeding 1000 cfu per 100 ml. Spatially within the area, Mitchells Plain storm water discharge (MPSD) sites had consistently higher microbiological indicator counts throughout the measured time period compared to the other sites in the area. This is most likely related to large untreated sewerage effluent discharge events.

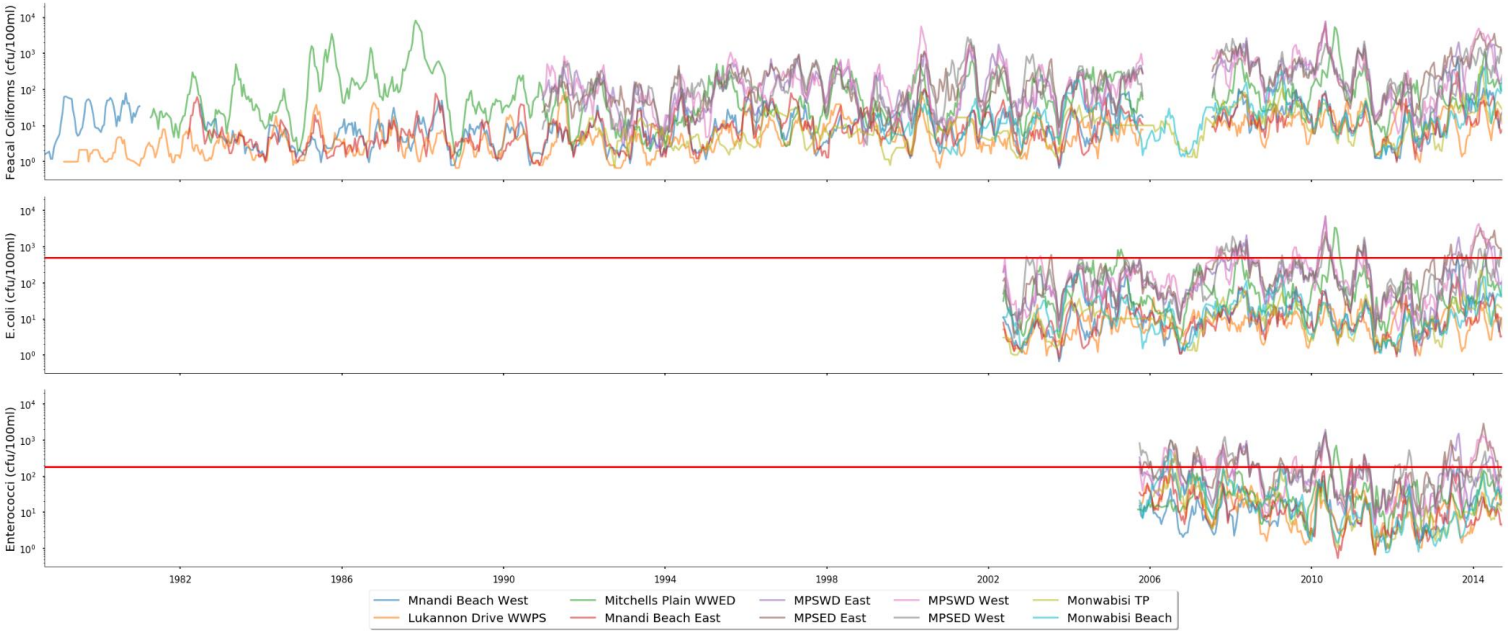

Figure 4.51: Rolling geometric means for faecal coliform, E. coli and enterococci counts at monitoring sites within the Mnandi and Monwabisi area for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.10.4 Current State of Coastal Water Quality

4.10.4.1 Defined Recreational Nodes

Figure 4.52 displays the time series of FIB counts from recreational nodes within the Mnandi and Monwabisi area. Mnandi Beach West and East show covariance, which is not surprising given their close proximities. At these sites, enterococci counts above the percentile threshold are apparent during winter months in 2015 and 2017. During 2016, although counts at these sites are below the threshold, they are consistently > 100 cfu/100 ml, while from mid-2017 onwards they are often much lower and there is more variation. The FIB counts at Monwabisi Beach exceed the enterococci threshold frequently over the five-year period. This signal is not evident at the Monwabisi tidal pool site (Monwabisi TP), although there are infrequent exceedances recorded.

The water quality at most recreational nodes within the Mnandi and Monwabisi area met the minimum requirement of a Sufficient classification over the five-year period. The Poor five-year water quality classification for Monwabisi Beach was the exception (Table 4.27) with exceedances occurring 13% of the time.

Table 4.27: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes in Mnandi and Monwabisi. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Mnandi Beach West	700	1315	76	350	Sufficient
Mnandi Beach East	550	1050	91	228	Sufficient
Monwabisi TP	290	783	94	250	Sufficient
Monwabisi Beach	1020	2300	355	640	Poor

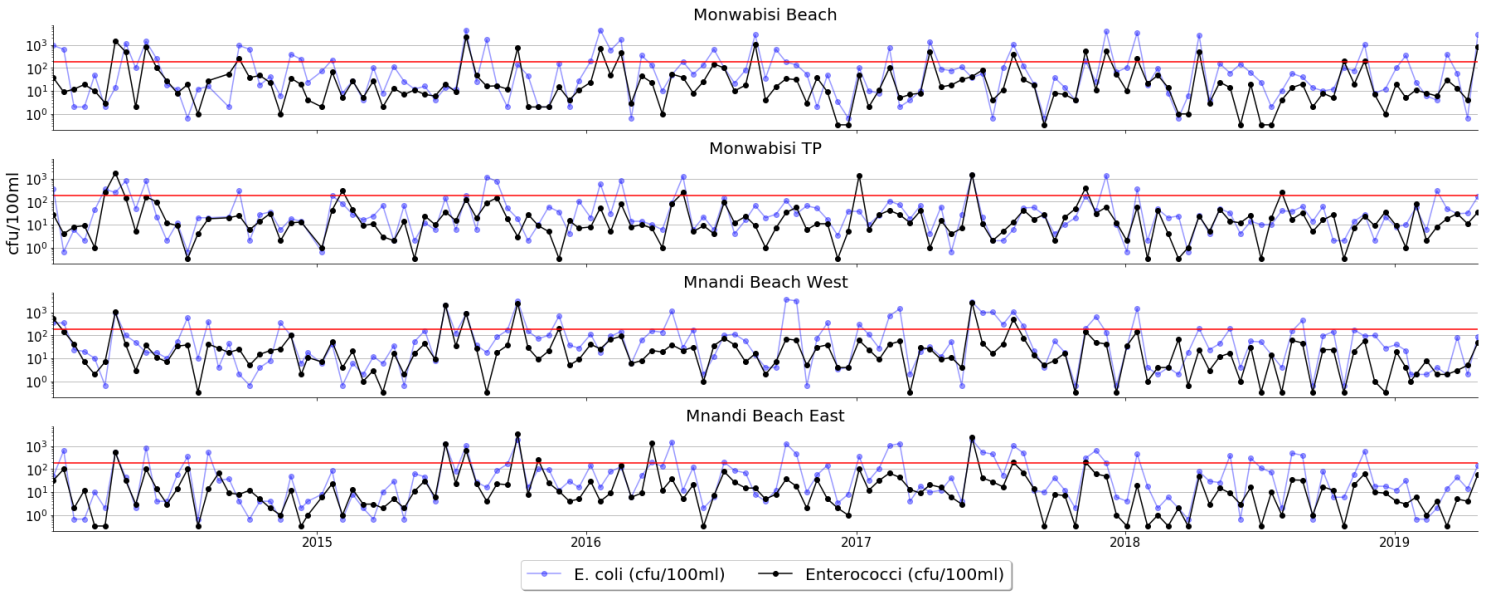

Figure 4.52: Time series of E. Coli and enterococci counts at recreational nodes within the Mnandi and Monwabisi area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.10.4.2 Coastal Monitoring Points

The time series of FIB counts at coastal monitoring points within the Mnandi and Monwabisi area are shown in Figure 4.53 and Figure 4.54. The enterococci counts at sites located to the east and west of the Mitchells Plain sewage works discharges (MPSWD and MPSED) frequently exceed the 185 cfu/100 ml limit over the five-year period. To a lesser extent, this is also true for the counts at the Mitchells Plain wastewater effluent discharge (WWED). The enterococci counts at the Lukannon Drive waste water pump station (WWPS) exceed the threshold less frequently, especially from 2017 onwards.

The water quality at all but Lukannon Drive Waste Water Pump Station (WWPS) coastal monitoring points within the Mnandi and Monwabisi area was classified as Poor over the five-year period according to the DEA (2012) percentile guidelines (Table 4.28). Exceedences above the 185 cfu/100ml threshold occur a maximum of 46.9% of the time at MPSED East indicating that the water quality at these site poses an unacceptable risk during these periods. The exceedences at Mitchells Plain WWED, MPSWD East, West and MPSED West are recorded 16.5%, 37.4%, 38.3% and 44.5% respectively. The water quality over the five-year period at site Lukannon Drive WWPS met the minimum requirement of Sufficient classification.

Table 4.28: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points in Mnandi and Monwabisi. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Lukannon Drive WWPS	250	500	66	460	Sufficient
Mitchells Plain WWED	1220	1783	430	655	Poor
MPSWD East	150000	15000	2140	15000	Poor
MPSWD West	150000	15000	1500	4125	Poor
MPSED East	150000	15000	4425	15000	Poor
MPSED West	150000	15000	2440	15000	Poor

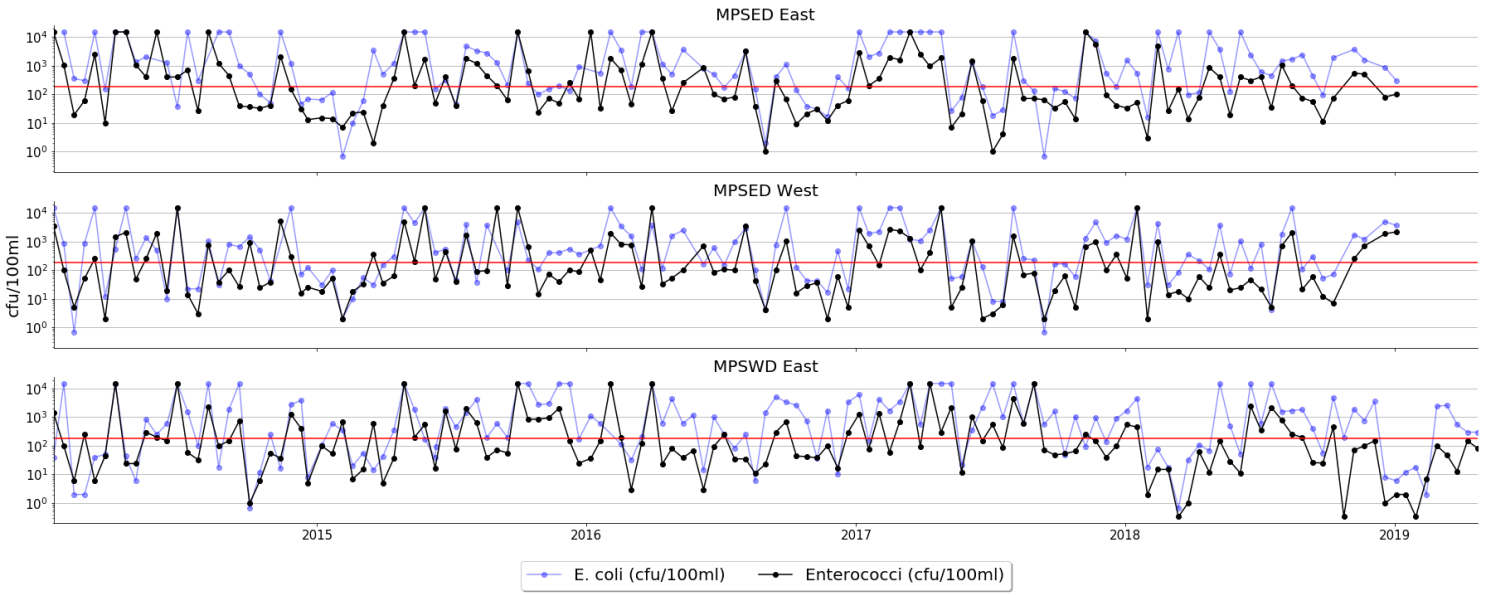

Figure 4.53: Time series of E. Coli and enterococci counts at coastal monitoring points within the Mnandi and Monwabisi area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

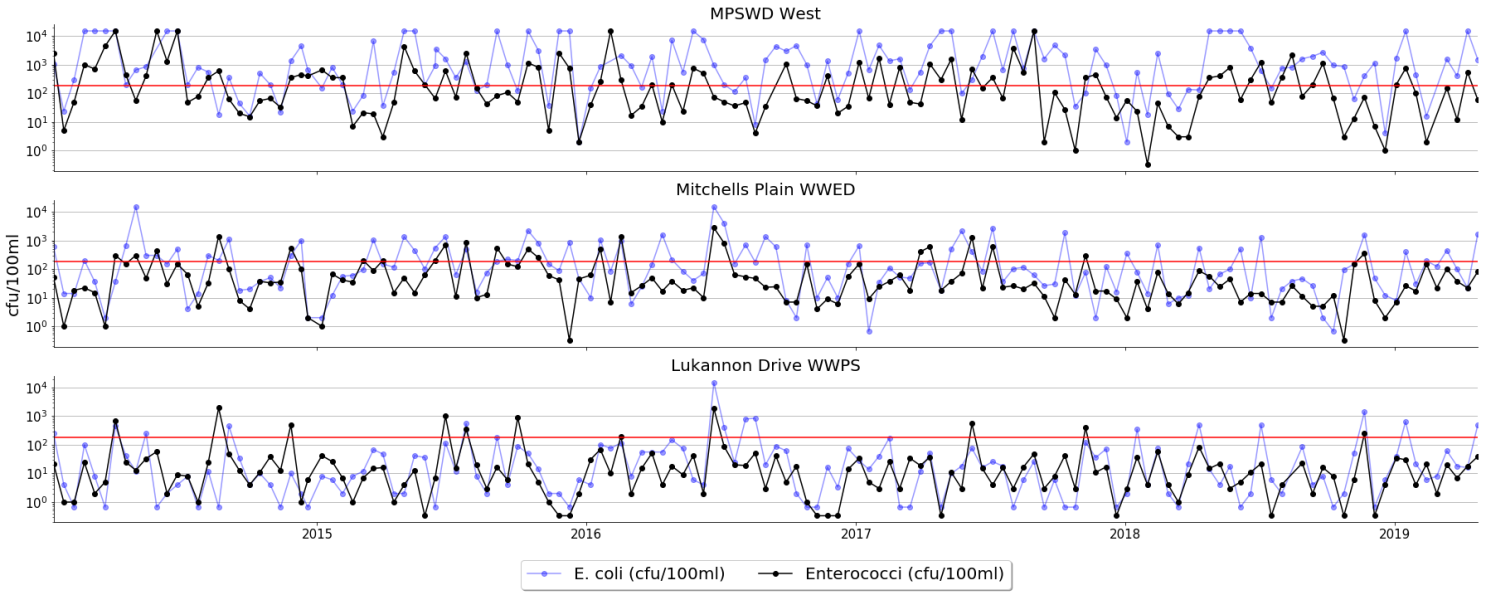

Figure 4.54: Time series of E. Coli and enterococci counts at coastal monitoring points within the Mnandi and Monwabisi area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.11 GORDON'S BAY AND STRAND

4.11.1 Monitoring Sites

The CCT currently monitors FIB at 14 sites within the Gordon's Bay and Strand area (Figure 4.55). Of these 14 points, eight are considered to be recreational nodes, and five are considered to be coastal monitoring points, outside of popular recreational use areas. The Kogel Bay tidal pool occurs in the area, in which one point is monitored (Table 4.29).

Table 4.29: Sites in Gordon's Bay and Strand monitored by the City of Cape Town. The time frame of data available and presented in this report for each site in terms of historical (prior to 2014) and current (2014 to 2019) is also shown.

Site	Type of Monitoring Point	Data Presented
Macassar Beach	Recreational Node	Historical and Current
Strand Opposite Woltemade Street	Coastal Monitoring Point	Historical and Current
Strand Beach	Recreational Node	Historical and Current
Strand Pavilion Jetty	Recreational Node	Historical and Current
Strand Harmonie Park	Recreational Node	Historical and Current
Strand Near Lourens River Mouth	Coastal Monitoring Point	Historical and Current
Gordon's Bay WWTW	Coastal Monitoring Point	Historical and Current
Gordon's Bay Harbour Island	Coastal Monitoring Point	Historical and Current
Gordon's Bay	Recreational Node	Historical and Current
Gordon's Bay Harbour	Coastal Monitoring Point	Historical and Current
Near Sir Lowrys Pass River Outlet	Coastal Monitoring Point	Historical and Current
Bikini Beach	Recreational Node	Historical and Current
Kogel Bay	Recreational Node	Historical and Current
Kogel Bay TP	Recreational Node	Historical and Current

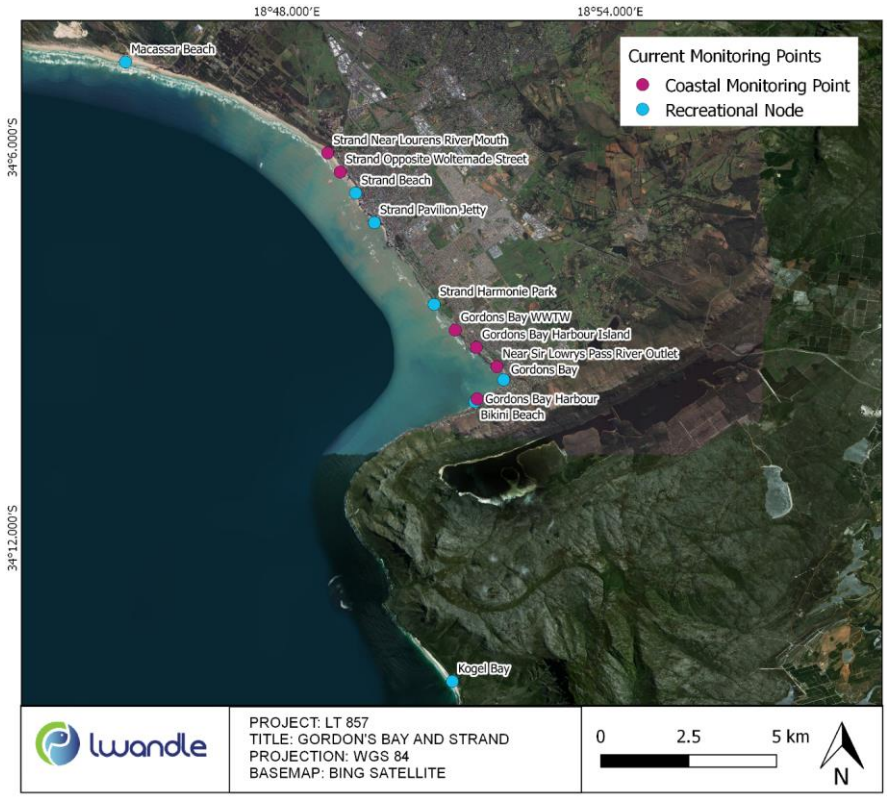

Figure 4.55: Recreational nodes and coastal monitoring points within the Gordon's Bay and Strand

4.11.2 Sample Coverage

A comparison of historical (prior to 2014) and current (2014 to 2019) sampling coverage by the City of Cape Town, based on an optimum amount of 26 samples per year (fortnightly), at sites within the Gordon's Bay and Strand region is shown in Figure 4.56 below. Microbiological indicator sampling coverage improved at all sites after 2014, with all sites reaching 100% coverage.

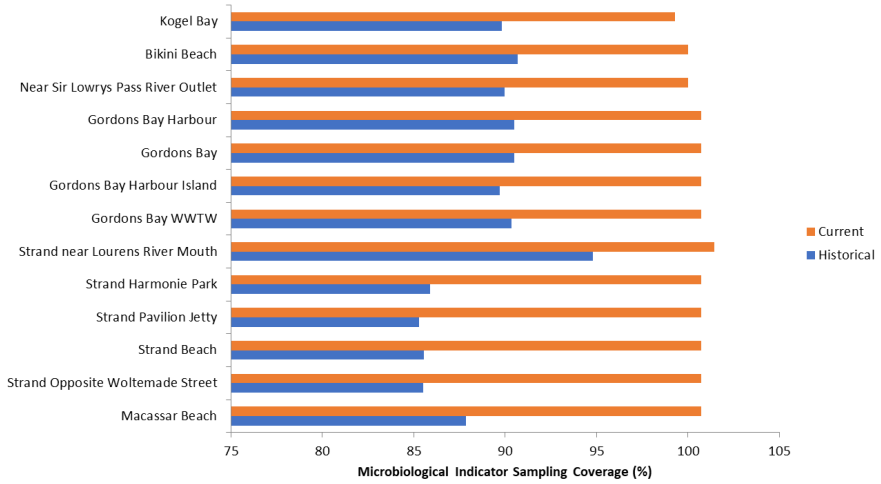

Figure 4.56: Historical and current microbiological indicator (faecal coliforms, E. coli and enterococci) sampling coverage (%) at all sites located within Gordon's Bay and Strand.

4.11.3 Historical Trends in Coastal Water Quality

Time series of running geometric mean values for FIB counts at Gordon's Bay and Strand sites for which there are historical data are shown in Figure 4.57 and **Error! Reference source not found.** below. Temporally, there appears to be a decrease in faecal coliform counts at the Gordan's Bay WWTW, Near Sir Lowry's Pass River and Gordan's Bay sites from 1992 to 2001 but no notable long-term trend thereafter. Temporally, *E. coli* and enterococci also showed no long-term trend. To an extent, spikes in *E. coli* and enterococci counts were correlated, with the signal being seen across all sites in the area.

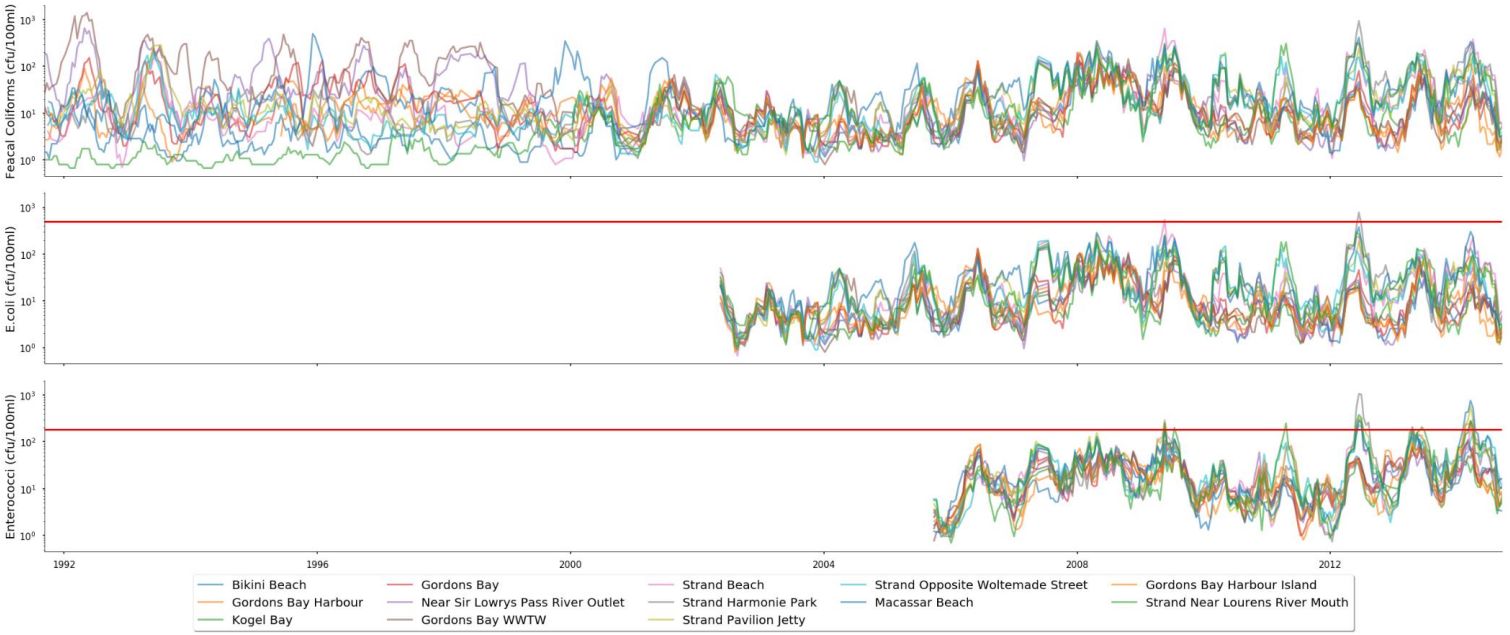

Figure 4.57: Rolling geometric means for faecal coliform, E. coli and enterococci counts at monitoring sites within the Gordon's Bay and Strand area for which there are historical data. Horizontal red lines indicate the percentile threshold levels for poor classification at 500 cfu/ml for E. coli and 185 cfu/ml for enterococci.

4.11.4 Current State of Coastal Water Quality

4.11.4.1 Defined Recreational Nodes

The time series of FIB counts at recreational nodes within the Gordon's Bay and Strand area is shown in Figure 4.58 and Figure 4.59. The counts at all sites exceed the enterococci 185 cfu/100ml percentile threshold multiple times over the five-year period. At all sites, the frequency of exceedances, as well as the count variation, is substantially reduced during 2016, but increases again during 2017. The covariance between sites indicates a common causative factor. At Kogel Bay and Bikini Beach the enterococci count is further reduced from 2018 onwards and does not exceed the threshold during this time.

The water quality at the majority of the recreational nodes was classified as Poor according to the DEA (2012) percentile guidelines (Table 4.30). Exceedances above the 185 cfu/ml threshold occurred 16.7% of the time at Macassar, 18.2% at Strand Beach, 19.6% at Strand Pavilion Jetty, 19.7% at Strand Harmonie Park and 12.9% at Gordon's Bay. During these exceedances the water quality at these sites posed an unacceptable risk.. The water quality at Bikini Beach and Kogel Bay met the minimum requirement of Sufficient classification.

Table 4.30: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at recreational nodes in Gordon's Bay and Strand. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only. Note that no enterococci data were collected from Kogel bay tidal pool.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Macassar Beach	585	1310	683	1230	Poor
Strand Beach	660	1788	700	1575	Poor
Strand Pavilion Jetty	960	1920	760	1660	Poor
Strand Harmonie Park	630	1133	910	1300	Poor
Gordon's Bay	199	578	380	738	Poor
Bikini Beach	66	148	77	583	Sufficient
Kogel Bay	84	205	89	650	Sufficient
Kogel Bay TP	150	285			

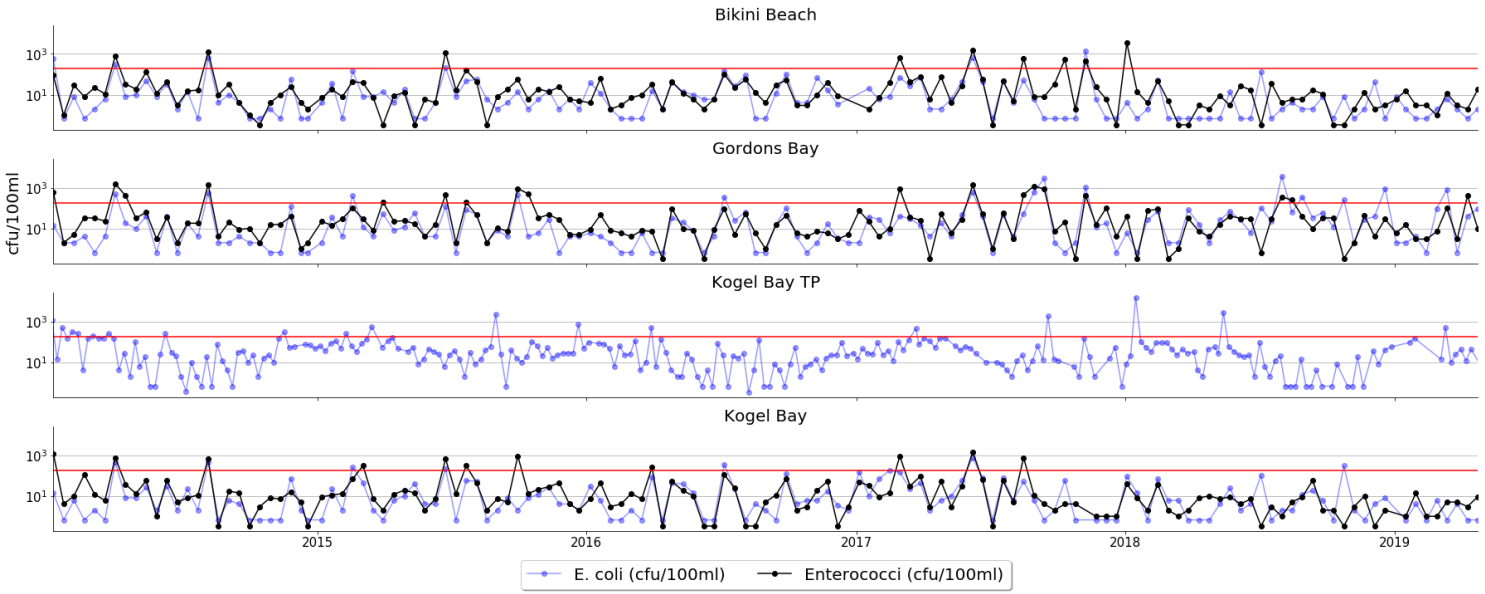

Figure 4.58: Time series of E. Coli and enterococci counts at recreational nodes within the Gordon's Bay and Strand area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

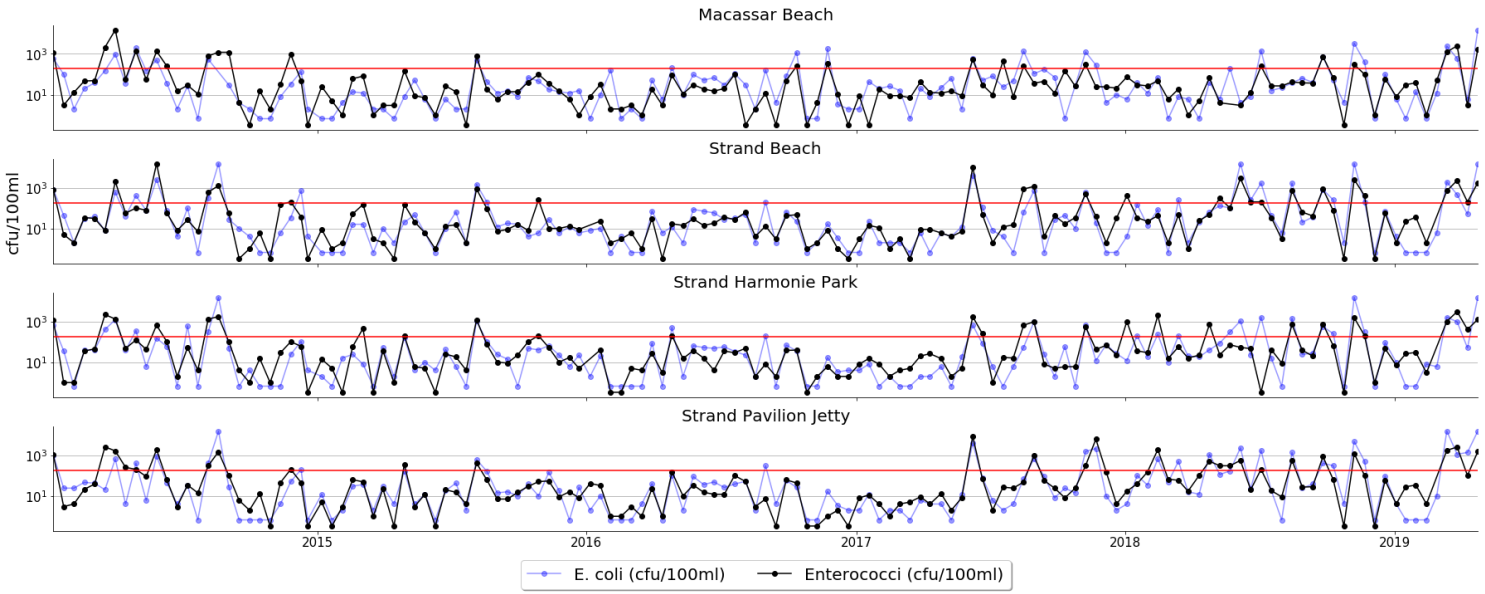

Figure 4.59: Time series of E. Coli and enterococci counts at recreational nodes within the Gordon's Bay and Strand area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

4.11.4.2 Coastal Monitoring Points

Figure 4.60 and Figure 4.61 show the FIB counts for coastal monitoring points within the Gordon's Bay and Strand area. FIB counts are generally high and exceed the enterococci threshold frequently over the five-year period at all sites. A decrease in the count variation and frequency of exceedances is clear in the data for sites at Strand (Near Lourens River Mouth and Opposite Woltemade Street). These sites show obvious co-variance over the five-year period, indicating that there is a common causative factor, most likely rainfall. FIB counts at Gordon's Bay Harbour and Harbour Island show a decrease from mid-2018 to present.

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The water quality at all coastal monitoring points within the Gordon's Bay and Strand area was classified as Poor according to the DEA (2012) percentile guidelines (Table 4.30). The 185 cfu/ml threshold was exceeded at Strand Opposite Woltemade Street, Near Lourens River Mout, Fordon's Bay WWTW, Gordon's Bay Harbour Island, Gordon's Bay Harour and Near Sir Lowrys Pass River Outlet 16.5, 18.8, 18.0, 13.7, 10.8, 18.8% of the time. During these times the the water quality at these sites posed an unacceptable risk.

Table 4.31: 90th and 95th percentile values of E. coli and enterococci calculated over a five year period from 2014 to 2019 at coastal monitoring points in Gordon's Bay and Strand. Water quality is classified at each site according to DEA (2012) and is based on enterococci values only.

Site	*E. coli*		Enterococci		Water Quality
	90th %ile	95th %ile	90th %ile	95th %ile	
Strand Opposite Woltemade Street	670	1080	630	1450	Poor
Strand Near Lourens River Mouth	800	1250	840	1260	Poor
Gordon's Bay WWTW	540	1543	830	1450	Poor
Gordon's Bay Harbour Island	181	2250	390	1655	Poor
Gordon's Bay Harbour	90	228	230	750	Poor
Near Sir Lowrys Pass River Outlet	670	1430	585	1020	Poor

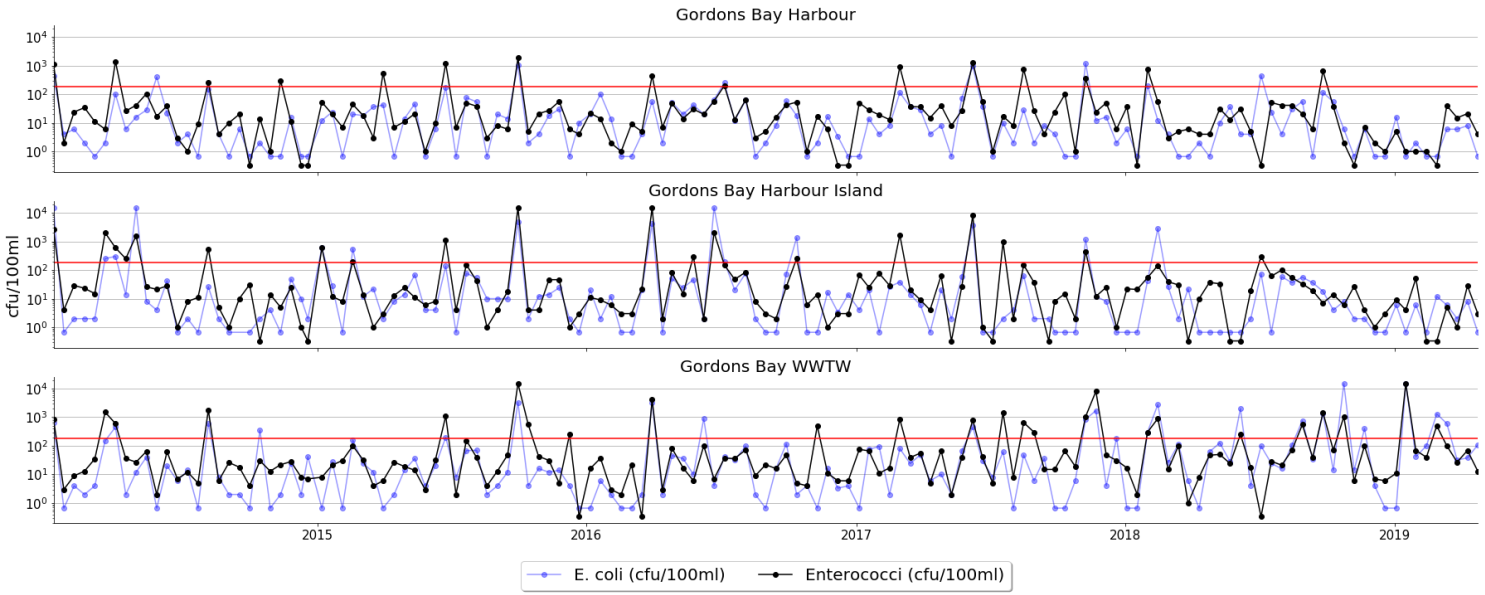

Figure 4.60: Time series of E. Coli and enterococci counts at coastal monitoring points within the Gordon's Bay and Strand area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

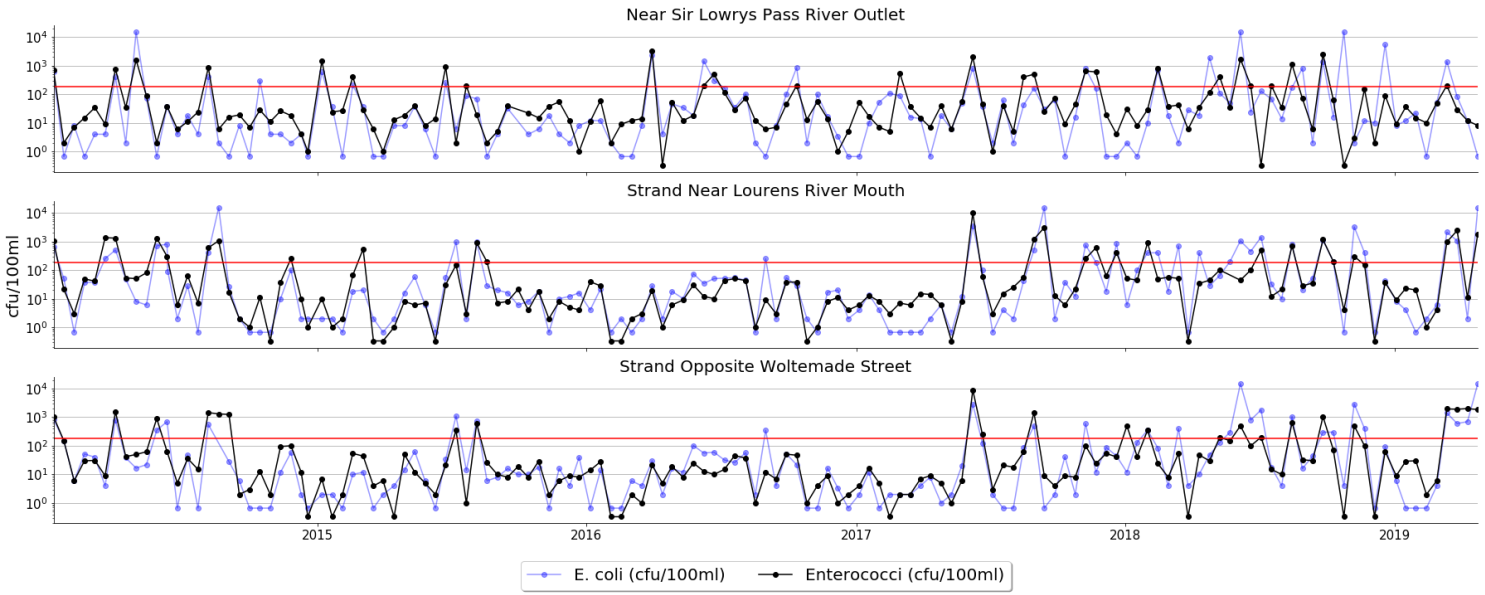

Figure 4.61: Time series of E. Coli and enterococci counts at coastal monitoring points within the Gordon's Bay and Strand area, from January 2014 to May 2019. The red line indicates the 185 cfu/100 ml threshold used to classify the water quality as Poor based on enterococci 90th percentiles (DEA, 2012). Y axis is on a logarithmic scale.

5 MARINE OUTFALL MONITORING

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From January 2016 to November 2018 the City embarked on a monitoring programme of sites in the receiving environment surrounding the three marine outfalls occurring at Green Point, Camps Bay and Hout Bay. Between 12 and 14 sites were monitored for *E. coli* and enterococci at each outfall with the results presented in the sections below.

At each outfall, the number of samples taken between 2016 and 2018 with *E. coli* counts exceeding 500 cfu /100 mland enterococci counts exceeding 200 cfu /100 ml were calculated. These two thresholds were based on the DEA (2012) guidelines with counts below each indicating water of good microbiological quality with 5% gastrointestinal risk per exposure. Conversely exceedances of the respective thresholds indicate water of poorer water quality.

The guidelines provided by the DEA (2012) are based on percentile values and therefore, the 90th and 95th percentile values at each site over three-year measurement period were also calculated. This allowed for the categorisation of the microbial quality of the water at each site.

5.1 GREEN POINT OUTFALL

At all sites at the Green Point outfall, exceedances of the respective thresholds for both *E. coli* and enterococci remained below 40%, indicating good water quality for majority of the three-year time period (Figure 5.1).

At most sites exceedances for both indicators remained below 5%. As would be expected, water quality was lower at sites in the immediate proximity of the discharge with GP-05 and GP-08 showing poorer water quality in terms of both *E. coli* and enterococci counts between 15 and 25% of the time. Lowest water quality values in terms of both *E. coli* and enterococci were shown at sites GP-03 and GP-04, with enterococci counts at G-03 showing a particularly high number of exceedances, occurring between 35 and 40% of the time. This indicates either dispersion of the plume or an additional pollution source. These findings align with those of Petrik et al. (2017) who found elevated XX concentrations XX km off the Green Point Outfall. This should be further investigated by the City.

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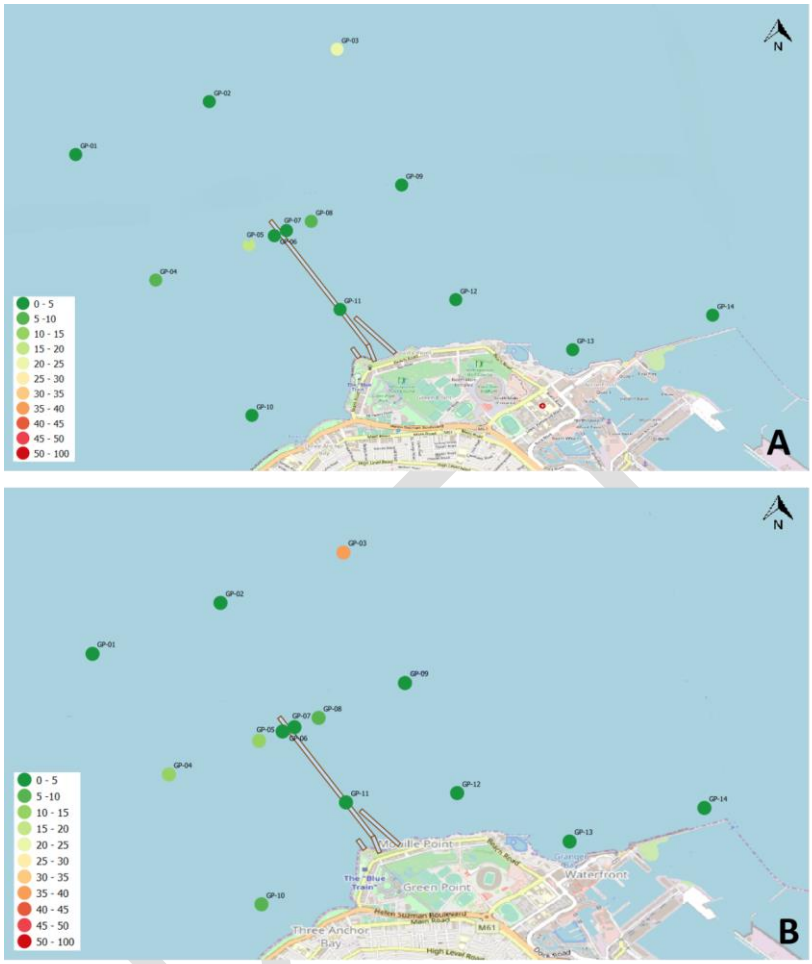

Figure 5.1: Map showing a spatial representation of the percentage of samples from sites in the receiving environment of the Green Point outfall obtained between 2016 and 2018 exceeding A. the E. coli threshold for good quality water (>500 cfu per 100 ml) and B. the enterococci threshold for good quality water (>200 cfu per 100 ml). Thresholds were based on DEA (2012). Base map source: OpenStreetMap 2019.

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5.2 CAMPS BAY OUTFALL

At all sites at the Camps Bay outfall, exceedances of the respective thresholds for both *E. coli* and enterococci remained below 25%, indicating good water quality for majority of the three-year time period (Figure 5.2).

At most sites exceedances for both indicators remained below 5%. As would be expected, water quality was lower at sites in the immediate proximity of the discharge with CB-06 and CB-07 showing poorer water quality in terms of *E. coli* counts between 15 and 20% of the time and in terms of enterococci counts between 15 and 25% of the time. Sites (CB-10, CB-11 and CB-13) near recreational nodes (Clifton, Camps Bay and Beta Beach) showed exceedances in both *E. coli* and enterococci less than 5% of the time.

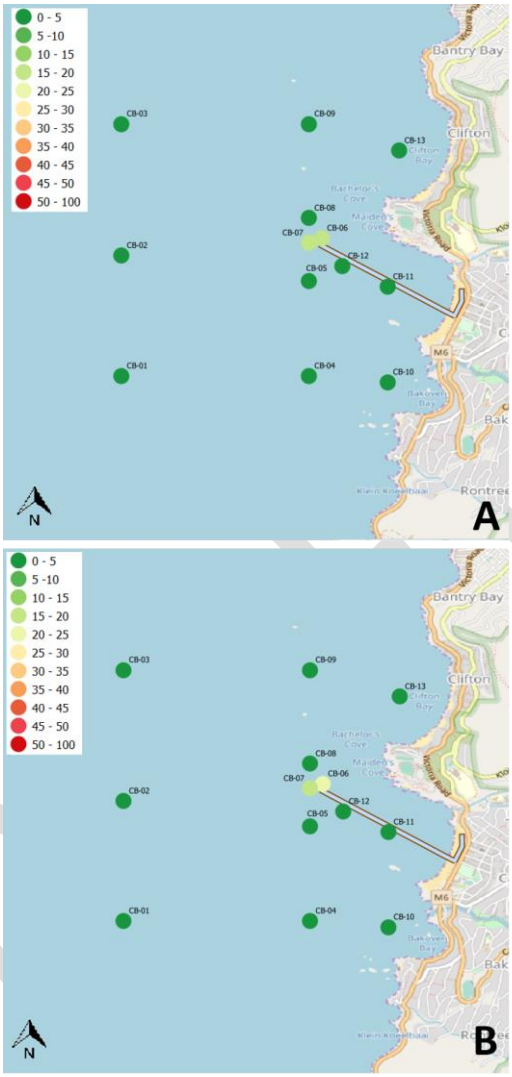


Figure 5.2: Map showing a spatial representation of the percentage of samples from sites in the receiving environment of the Camps Bay outfall obtained between 2016 and 2018 exceeding A. the E. coli threshold for good quality water (>500 cfu per 100 ml) and B. the enterococci threshold for good quality water (>200 cfu per 100 ml). Thresholds were based on DEA (2012). Base map source: OpenStreetMap 2019.

5.3 HOUT BAY OUTFALL

At all sites at the Hout Bay outfall, exceedances of the respective thresholds for both *E. coli* and enterococci remained below 50%, indicating good water quality for majority of the three-year time period (Figure 5.3).

At most sites exceedances for both indicators remained below 5%. As would be expected, water quality was lower at sites in the immediate proximity of the discharge with HB-06 and HB-07 showing poorer water quality in terms of both *E. coli* and enterococci counts between 15 and 25% of the time. A slightly higher number of exceedances (between 5 and 10%) in enterococci counts were seen at site HB-02. The poorer water quality at this site is likely due to the close proximity to the Disa River discharge. This should be further monitored by the City considering the sites location adjacent to Hout Bay beach.

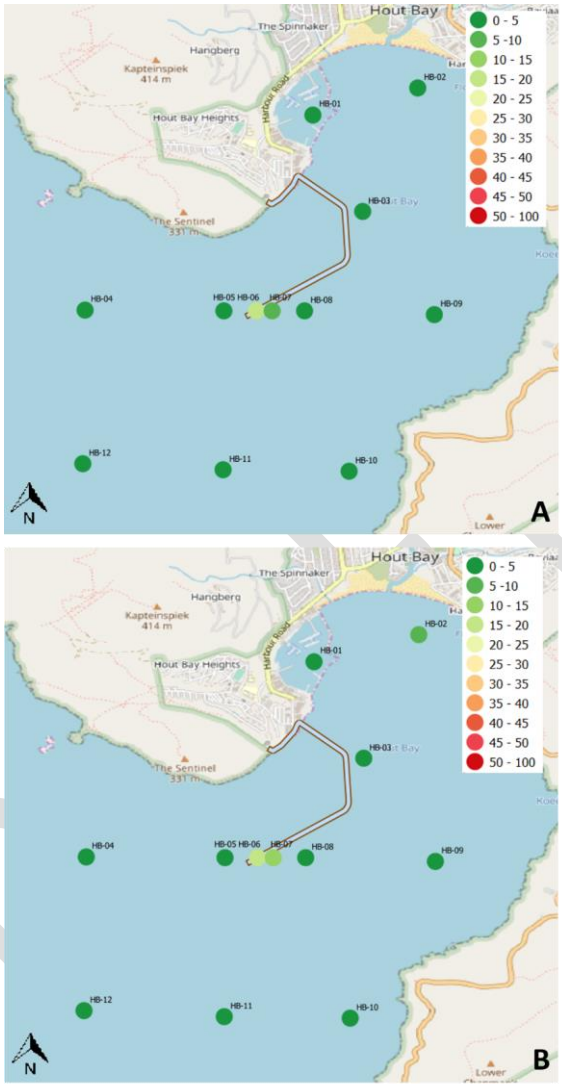


Figure 5.3: Map showing a spatial representation of the percentage of samples from sites in the receiving environment of the Hout Bay outfall obtained between 2016 and 2018 exceeding A. the E. coli threshold for good quality water (>500 cfu per 100 ml) and B. the enterococci threshold for good quality water (>200 cfu per 100 ml). Thresholds were based on DEA (2012). Base map source: OpenStreetMap 2019.

6 NATURAL OCCURRENCES

6.1 HARMFUL ALGAL BLOOMS

To be elaborated with False Bay data

The south and west coasts of South Africa, under the influence of the southern Benguela Current, are known to be frequently subjected to high accumulations of phytoplankton (Pitcher and Calder 2000). These blooms are commonly known as "red tides" because of the effect that they have in discolouring the water, however they are more accurately described as harmful algal blooms (HABs). They are usually characterised by the proliferation and occasional dominance of a particular species of toxic or harmful algae and are differentiated from normal phytoplankton productivity by having associated detrimental effects on the surrounding ecology (Stephen and Hockey 2007). These detrimental effects are either as a result of the high biomass that such blooms achieve or their toxic properties (Bernard et al. 2014). Most blooms in the southern Benguela region comprise of dinoflagellates and diatoms.

The development of these blooms results from a combination of physical, chemical and biological factors (Pitcher and Calder 2000). These aggregations are, for the most part, naturally occurring and are as a direct result of stratification of the water column in the quiescent phase of upwelling. Wind-driven upwelling is a characteristic feature in the coastal regions of the southern Benguela and results in the enrichment of inshore surface waters. During the quiescent phase of upwelling, as wind stress decreases, phytoplankton cells remain within the now nutrient rich surface waters and with the concurrent increase in light levels, are able to proliferate.

Occurrences of these blooms have been recorded in Table Bay, however False Bay appears to be a hotspot where XX recorded blooms have occurred since the 1930s (Table 6.1).

Commented [LW19]: We have contacted Grant Pitcher and Trevor Probyn and to get the number of blooms that have occurred in Table Bay and False Bay since 2005.

CCT can you provide any data?

Table 6.1: Occurrences of Harmful Algal Blooms in Table Bay and False Bay since 1930. Adapted from Stephen and Hockey (2007), with personal observations provided by XX.

Year	Location	Organism	Associated Mortality
Table Bay			
1948	Blauberg	*A. catenella*	Mussels, birds
2000	Blauberg	*A. catenella*	30 million mussels washed ashore
2003	Table Bay	*Alexandrium minutum*	Shellfish poisoning
2005	Blauberg	Unknown	Shellfish poisoning
False Bay			
1931	Gordon's Bay	*Alexandrium catenella*	Thousands of fish
1962	False Bay	*Gonyaulax polygramma*	100 tonnes of fish
1967	False Bay – Kalk Bay to Millers Point	*Noctiluca scintillans*	Dead fish "but not unusual amount"
1976	Gordon's Bay	*Gymnodinium* spp.	Hundreds of a wide variety of fish as a result of mechanical damage

1988	False Bay	*Karenia cristata*	Thousands of fish. Also gastropods, chitons, octopus and starfish
1995	False Bay	*Gymnodinium* spp.	Abalone larvae; caused toxicity in mussels. Also produced aerosol toxin.

Globally, there has been growing concern that the frequency and magnitude of these blooms is increasing. In many cases, these increases have been related to pollution. In bays within the southern Benguela such as Table Bay and False Bay, sewerage inflows result in localised nutrient input into the coastal environment which may fuel blooms. Seemingly corroborative evidence is provided for this argument where the frequency of blooms within Table Bay have increased substantially since the 1930s in line with the growth of the human population in this area (Stephen and Hockey 2007). However, despite this, a similar pattern of increasing frequency of HABs has been observed at locations along South African coast where human populations have not grown as much. Therefore, while pollution is a concern and should be considered, as of yet, there is no single cause that can be identified to explain the global increase in HABs.

6.2 ANAULUS AGGREGATIONS IN FALSE BAY

As part of the water quality monitoring programme cell counts of the surf-zone diatom *Anaulus australis* have been made biweekly at six locations within False Bay over the period March 2015 to May 2019. The six locations monitored were St James & Pool, Muizenberg Pavilion, Sunrise Beach, Strandfontein & Pool, Mnandi West and Mnandi East (Figure 4.1). Sampling for *Anaulus* cell density was conducted concurrently with the microbial sampling at ~30 cm subsurface in ~1 m water depth.

Anaulus cell densities were highly variable across the sampling programme, i.e. spatially and temporally, across the sampled sites. Figure 6.1 shows that median values varied by two orders of magnitude with a high number of data point outliers, extending from 10 000 to > 100 000 cells per litre.

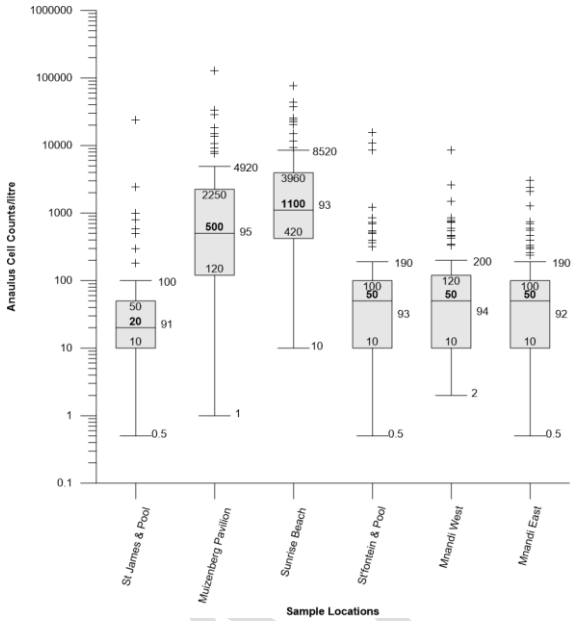
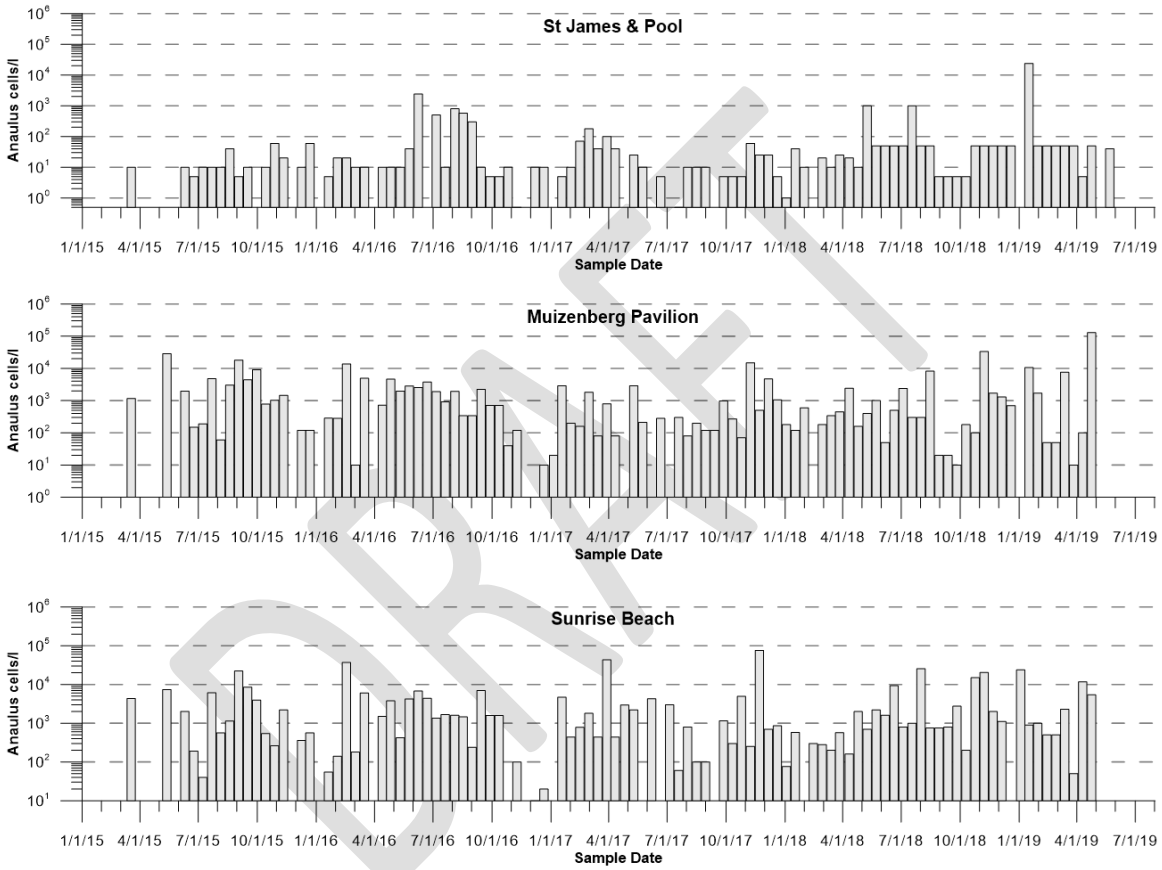


Figure 6.1: Box and whisker diagrams of Anaulus cell counts per litre for each site. Outliers are defined as cell counts > 1.5 x the upper quartile value.

Highest *Anaulus* cell concentrations were observed at Muizenberg Pavilion and Sunrise Beach with broadly similar lower values at the other four sites. All sites, however, frequently had instances when cell counts were high as indicated by the outliers in the figure. Temporal variability at all sampled sites was marked with consecutive sample dates showing up to five $\log_{10}$ units changes in cell counts (e.g. time series for Muizenberg Pavilion in Figure 6.2). Periodicity in high cell counts at Muizenberg Pavilion and Sunrise Beach broadly follows a seasonal distribution, occurring predominantly in spring to autumn when south/south-easterly winds are common. Elements of this seasonality are apparent at the other sites indicating a level of synchronicity between them.


St James & Pool
Muizenberg Pavilion
Sunrise Beach
Anaulus cells/l
Sample Date
1/1/15 4/1/15 7/1/15 10/1/15 1/1/16 4/1/16 7/1/16 10/1/16 1/1/17 4/1/17 7/1/17 10/1/17 1/1/18 4/1/18 7/1/18 10/1/18 1/1/19 4/1/19 7/1/19

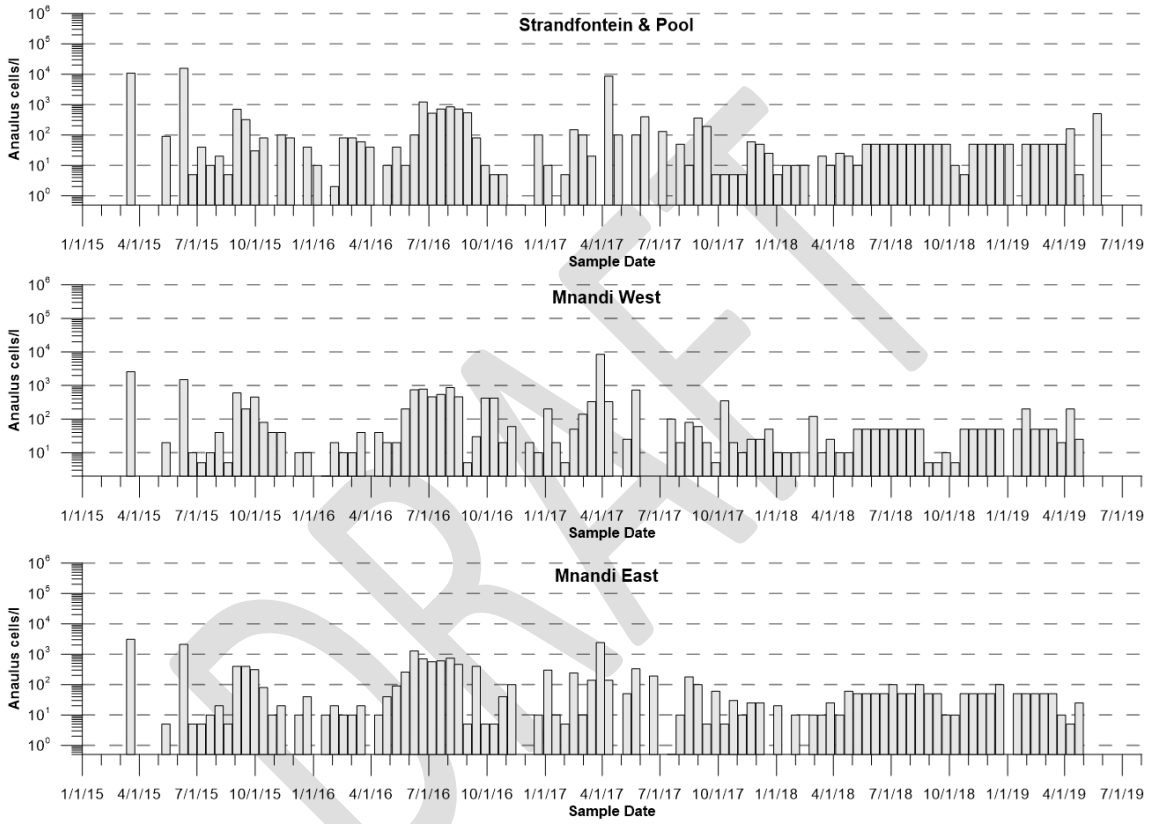


Figure 6.2: Time series of Anaulus cell counts at the six monitored sites in False Bay.

Anaulus australis is a member of a group of phytoplankton species that have physiological adaptations facilitating their retention in broad, active surf zones of dissipative sand beaches. Other genera in the group include *Asterionellopsis*, *Aulacodiscus* and *Attheys*. These phytoplankton are widely distributed on continental coasts (Figure 6.3) but occur most frequently in the southern hemisphere.

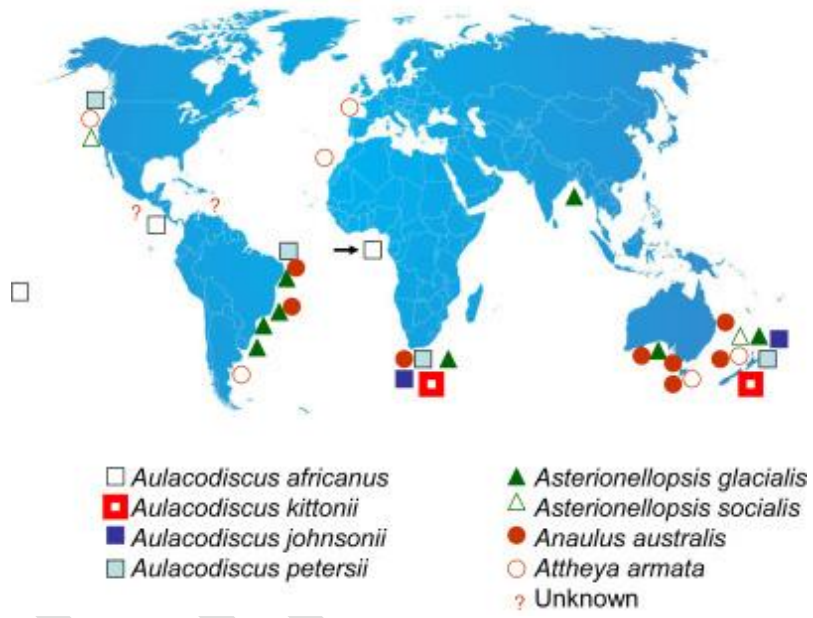


Figure 6.3: Distributions of surf zone diatom species on continental coasts (from McLachlan and Defoe 2018)

The physiological adaptations, described by the McLachlan and Defoe (2018) review of surf zone phytoplankton include the ability to alter cell buoyancy allowing cells to follow a diurnal pattern of inhabiting the sand substratum during the night, increasing buoyancy when exposed to light and moving to the sea surface where they may be associated with micro-bubbles and get trapped in foams. As the day progresses *Anaulus* cells in particular produce mucus that allows attachment to sand grains stirred up by wave action and the added mass transports the cells back to the sand seabed. Coupled with this process is the advection and concentration of individual cells by waves and currents. Wave bores transport cells shoreward, concentrating them in the inner surf zone. Opposing forces of incoming waves and outgoing rip currents lead to the aggregation of cells in discrete patches as observed at beaches around Sunrise Beach. An example is shown in Figure 6.4

Figure 6.4: Photograph of an Anaulus aggregation.

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Anaulus cell division even at high rates plays a minor role in patch formation, Talbot and Bate (1986) report that, on Algoa Bay beaches, this accounts for <25% of observed increases in cell numbers.

Temporal variability in *Anaulus* aggregations is linkable to periodicities in surf zone characteristics. In the dissipative beaches in False Bay conditions for Anaulus patch formation are best under high wave conditions and rip current development associated with onshore southerly to south easterly winds whilst offshore north westerly winds are less favourable. This is evident in FIGURE BB. Spatial variability is ascribable to beach morphology which influences water circulation patterns and rip current development. Smaller, pocket beach type surf zones do nor typically support surf zone phytoplankton patch formation and neither do rocky shores. The Strandfontein and Pool, Mnandi West and East, although sand beaches are spatially constrained. St James and Pool is a rocky shore and, according to the above, should not have surf zone phytoplankton aggregations. An explanation for the observed presence of *Anaulus* at this location is advection from Muizenberg beach via the rip current that develops on the extreme western side of the beach at Surfer's corner.

Although not appreciably material in surf zone diatom aggregation formation cell division requires inorganic nutrients, primarily nitrogen (as nitrate-nitrogen), phosphorus and silicate-silica. Measured doubling rates for *Anaulus* can reach 1.1/day (Wolmarans 2012), while rates of 3/day in culture conditions are reported for the surf zone diatom *Attheya armata* (Carballeira et al 2018). These are high when compared to more open ocean taxa (0.3/day, e.g. Parsons and Takahashi, 1978). Sources of nutrients in the surf zone of sand beaches include aquifer flows, regeneration of inorganic nutrients from particulate organic matter by interstitial organisms in beach sediments, primarily ammonium-nitrogen, and, for False Bay beaches, river outflows from Sandvlei and

Zeekoeivlei. Nitrogen isotopic enrichment in *A. armata* is indicative of a sediment as opposed to a water column source for nitrogen in this surf zone diatom species at least, implying that anthropogenic eutrophication is unimportant in sustaining populations of the species (Carballeira et al 2018). Given similarities in habitat requirements across surf zone diatoms that have been studied it is probable that this is a characteristic of this group of phytoplankton.

7 COASTAL WATER QUALITY IN THE CITY OF CAPE TOWN IN A GLOBAL CONTEXT

Contamination of coastal water bodies by domestic sewage from formal sewage outfalls and stormwater flows as indicated by FIB is a reality in most coastal cities (e.g. Stewart et al 2008, amongst others). Due to known associated human health risks regulatory bodies and/or local governmental agencies conduct FIB monitoring to quantify these and identify risk sources to enable interventions aimed at reducing or removing the risk. Monitoring data are generally reported annually, and, in some cases, coastal water quality assessments are published to inform users of coastal water bodies on the health risk status of the resource. Examples include the annual receiving waters monitoring report for the Point Loma and South Bay ocean outfalls for the City of San Diego (e.g. Stebbins 2016) and 'State of the beaches' reports for Sydney, Australia (e.g. OEH 2018).

Although not unique in either South Africa or internationally the CCT disposes primary treated domestic sewage through ocean outfalls. Thus, comparisons of coastal water status should be made against cities running similar practices and for which beach water quality data are available. Cities that meet these criteria are Perth and Sydney in Australia and San Diego in USA.

Perth operates three ocean outfalls for secondary level processed wastewater at Ocean Reef, Swanbourne and the Sepia Depression (BMT 2018). The discharging diffuser banks for these are situated at 10 m, 11 m and 20 m respectively and 1.6 km, 1.1 km and 4.2 km offshore. The proportion of samples that exceeded the Australian FIB water quality guideline concentrations in the summer of 2018 were 22% for the shoreline at the base of the Ocean reef discharge, 0% at Swanbourne and 11% at Sepia Depression (BMT 2018). Sample numbers were low for this survey (9) and it is not apparent how representative they are. Investigations into FIB concentrations in Perth stormwater discharges yielded counts >20 times the Australian guideline for secondary contact recreation and that swash zones on beaches could be >6 times the primary contact guidelines (West Australia Department of Water 2007). The non-compliances observed by BMT (2018) could be due to stormwater flows as opposed to the deep-water outfalls.

San Diego operates ocean outfalls at Loma Point and off South Bay. The former discharges advanced primary treated sewage effluent 7.2 km offshore in 94 m water depth. The South Bay outfall discharges predominantly secondary treated effluent with a small component of tertiary treated effluent 5.6 km offshore in 27 m water depth. Beach water quality at Loma in 2016 was recorded as being non-compliant for 6 of 8 samples taken. More extensive sampling around the South Bank outfall shoreline area yielded an aggregated non-compliance level of 94%. Given the distances offshore of the outfall diffusers, and modelled and measured post discharge sewage plume behaviour, and in for the South Bank outfall the high effluent treatment level, this contamination is probably due to stormwater flows.

Commented [LH21]: Find out if there is a developing country example also – with informal settlements

Commented [LH22]: Add what this is

Sydney operates offshore outfalls at North Head, Bondi and Malabar that discharge primary treated effluent at water depths between 60 m and 80 m 2-4 km offshore. Beach water quality monitoring at nine ocean beach sites in the Sydney area over 2017-2018 showed that, in dry weather conditions, ratings below 'good status' averaged 7% across the sampled sites. In wet weather conditions these increased to 19% (data from EOH 2018, Manning et al 2019).

Proportions of samples above the enterococci threshold for 'Sufficient Status' per area in the CCT metropole are summarised in Table 7.1. It is apparent that samples across all of the areas had counts above this threshold. All but one site have exceedance events where water quality reduces to a Poor level and poses an unacceptable risk to health. The observed proportions generally exceed those discussed above for the Sydney dry season period and match or exceed those recorded after rain events there.

Whether this is the case for CCT requires analysis of links with rainfall events.

Commented [LH23]: Add rain and comparison to developing country water quality with informal settlements

Table 7.1: Proportions of samples above the enterococci threshold for the minimum requirement, Sufficient, per area in the Cape Town metropole.

Area	Recreational Node	Coastal Monitoring Point
Table Bay & West Coast	1.5 - 23.2	None
Green Point	8.0 -21.9	4.4 – 11.0
Sea Point	1.7 - 3.6	3.4- 27.7
Clifton & Camps Bay	3.6 - 13.8	2.2 – 5.7
Llandudno & Hout Bay	2.2 - 9.5	None
Atlantic Peninsula	2.2 - 3.6	23.7
Simon's Town & Fish Hoek	1.4 - 20.1	0.7 – 5.1
Kalk Bay & St James	0.0 - 18.0	1.4 - 7.0
Muizenberg & Sunrise Beach	5.1 - 15.7	10.8 – 33.3
Mnandi & Monwabisi	5.7 - 13.0	8.0 – 46.9
Gordon's Bay & Strand	6.6 - 19.7	10.8 – 18.8

8 CONCLUSIONS AND RECOMMENDATIONS

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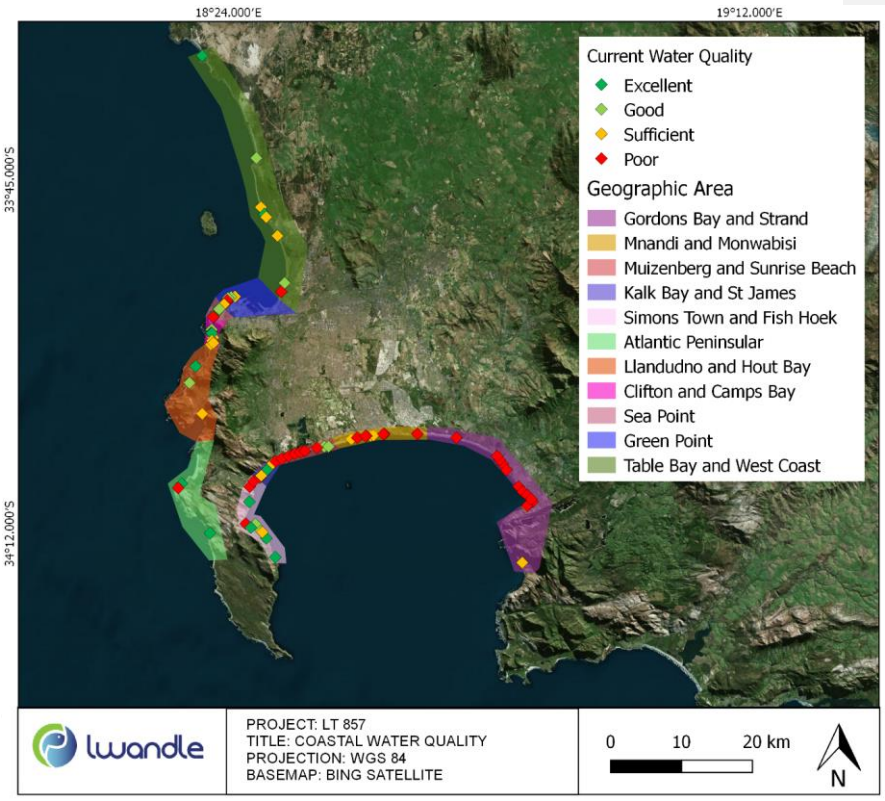

Figure 8.1 Overview map of the water quality classification according to DEA (2012) based on the 90th and 95th percentile enterococci values for the current monitoring points (2014-2019).

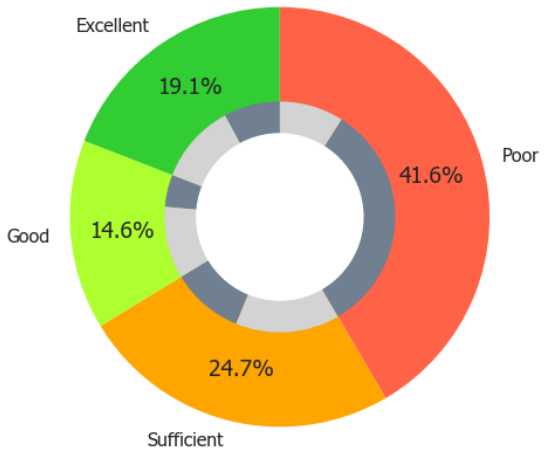

Figure 8.2 Water quality classification for all site measurements taken between 2014 and 2019. Dark grey shows the proportion of sites within each classification category located in False Bay and light grey for those located within Table Bay and along the Atlantic Peninsula.

- Discuss spatial patterns between areas and mainly the difference between False Bay and Table Bay and the likely sources and causes. Proximity to discharges and why the site of measurement skews data. Discuss blue flag and why the same beach can be poor and excellent in a short spatial scale
- Discuss sites which appear to be responding to a source and the main causes of exceedance events – link to rainfall
- Discuss outfalls vs runoff results

- Multiple recreational nodes and coastal monitoring points with poor water quality in CCT. Most of these most likely as a result of untreated runoff/stormwater
- Continued monitoring of these is required, and with this Improved curation of the data collected is required to facilitate the annual reporting of this information.
- Recommend system like FEWs for real time operational monitoring

Commented [LH25]: Check with outfall data

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Commented [AM26]: Robin, is this what you are referring to below?

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