Beachwatch Programs

Department of
Environment and Conservation (NSW)

Beachwatch Partnership Pilot Program

State of the Beaches 2002–03

our environment it's a living thing

BEACHWATCH

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Environment and Conservation (NSW)

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State of the Beaches 2002–03

Councils:

Ballina – Maclean – Pristine Waters – Coffs Harbour – Bellingen – Great Lakes – Lake Macquarie – Wyong – Shoalhaven – Eurobodalla – Pittwater – Hunters Hill – Willoughby – North Sydney – Randwick

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BEACHWATCH

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Summary

Overview

In June 2000, Premier Carr announced the NSW Government's $11.7 million Coastal Protection Package. This package provides a holistic framework for managing the coastal zone and includes a range of initiatives to ensure that the State's coastal environments are protected for future generations.

The Beachwatch Partnership Pilot Program is a key component of this package. It aims to raise awareness of beach water quality issues, streamline testing along the NSW coast and increase community access to beach water quality information.

This report presents the findings of pilot beach water quality monitoring and reporting programs conducted in partnership with 15 local councils along the NSW Coast. Ten regional councils and five councils in metropolitan Sydney participated in the pilot programs:

Regional councils – Ballina Shire Council, Maclean Shire Council, Pristine Waters Council, Coffs Harbour City Council, Bellingen Shire Council, Great Lakes Council, Lake Macquarie City Council, Wyong Shire Council, Shoalhaven City Council and Eurobodalla Shire Council.

Metropolitan councils – Pittwater Council, Municipality of Hunters Hill, Willoughby City Council, North Sydney Council and Randwick City Council.

The pilot monitoring programs ranged in size from two to 52 sampling locations, and included ocean beaches, freshwater lakes, tidal pools, bays, rivers, lagoons, harbour sites and estuarine sites. Sampling was conducted between 1 October 2002 and 31 July 2003.

Data availability

The information in this report is supported by detailed results for each beach at www.environment.nsw.gov.au / beach / cpp / ar2003. These beach pages provide a description of the swimming location; potential pollution sources; time series plots of water quality and rainfall data, and where assessed; guideline compliance results; the impact of rainfall and verification of pollution sources.

In addition, the data for each swimming location may be downloaded from SoE*direct* (www.soedirect.nsw.gov.au).

Water quality analyses and assessment

Two types of indicator bacteria, faecal coliforms and enterococci, were used to assess recreational water quality in the pilot programs, as recommended by the National Health and Medical Research Council (NHMRC). These bacteria indicate the possible presence of waterborne pathogens (organisms that pose significant risks to human health).

When local councils considered that other indicators posed potential risks to swimmers, these were included in the pilot programs. Other indicators (algae, pesticides and toxicants) were monitored in only four council areas.

The *Australian Guidelines for Recreational Use of Water* (NHMRC 1990) were used to assess recreational water quality in the Beachwatch Partnership Pilot Program.

Resourcing issues

For most councils, insufficient staff to conduct sampling was an ongoing problem over the course of the pilot programs. This meant that monitoring programs were progressively scaled back in some council areas, and in other council areas the sampling frequency was much less than originally anticipated.

Extension of pilot programs

The 2002–03 summer swimming season was particularly dry. Due to the lack of rainfall,

insufficient samples were collected to assess the effect of wet weather-related pollution sources on recreational water quality. The pilot programs were extended until the end of July 2003 in all regional council areas except Great Lakes, and in the metropolitan areas of Pittwater and North Sydney.

During the extended period, resources were focused on collecting samples during and immediately after rainfall events.

Overview of findings – regional councils

The findings of the regional council pilot monitoring programs focus on two key areas: guideline compliance and the impact of rainfall on recreational water quality.

Guideline compliance

Guideline compliance monitoring was undertaken in all regional council areas except Eurobodalla.

In general, a high level of compliance with recreational water quality guidelines was found at ocean beaches. Where compliance was assessed, 55 of the 60 ocean beaches monitored in regional areas passed the guidelines in all months of the 2002–03 summer swimming season.

The five ocean beaches which did not pass swimming guidelines in all months were:

- Brooms Head Beach in Maclean Shire Council area
- Wooli Beach and Corindi Beach in Pristine Waters Shire Council area
- Arrawarra Beach and Flat Top Beach South in Coffs Harbour City Council area.

Arrawarra Beach failed in two months of the 2002–03 summer swimming season, while the remaining four beaches failed in only one month.

Lower levels of compliance were generally recorded at estuarine and coastal lake swimming locations. Most of these locations failed in one or more months of the 2002–03 summer swimming seasons.

Several estuarine and coastal lake swimming sites passed the swimming guidelines in all months in which compliance was assessed. Such sites included:

- The Serpentine in Ballina Shire Council area
- Whiting Beach and Kolora Lake in Maclean Shire Council area
- Red Rock Estuary in Pristine Waters Shire Council area
- Wyee Point and Swansea in Lake Macquarie Shire Council area
- Chain Valley Bay in Wyong Shire Council area.

Estuarine and coastal lake swimming sites that failed in more than half the months where compliance was assessed included:

- Lake Cakora in Maclean Shire Council area
- all coastal creeks monitored in Coffs Harbour Shire Council area
- Tumbi Umbi Creek, Ourimbah Creek and Canton Beach in Wyong Shire Council area.

Compliance at Tumbi Umbi Creek and Ourimbah Creek was particularly poor, with these sites failing in all months.

Response to rainfall

As indicated by the guideline compliance results, bacterial levels remained generally low at the ocean beaches. The 2002–03 summer swimming season was quite dry, with few large or extended wet weather events. Slightly elevated bacterial levels were measured at most beaches after heavy rainfall, although bacterial levels were not indicative of sewage contamination. Until more data is available, swimming at ocean beaches should be avoided for 24 hours after heavy rainfall.

A more significant response to rainfall was recorded at estuarine and coastal lake swimming sites, with elevated bacterial levels generally measured during and after rainfall. Particularly high bacterial levels were recorded at many sites during wet weather, indicating sewage contamination.

As a precaution, swimming in estuaries and coastal lakes should be avoided during and for up to three days after rainfall.

Other indicators

Levels of blue-green algae measured in Lake Ainsworth in the Ballina Shire Council area often exceeded the State Algal Coordinating Committee (Nancarrow & Wood, 2000) high alert levels, indicating that contact with the water should be avoided. Previous monitoring in the lake by the council shows this is an ongoing seasonal trend.

Levels of organochlorine and organophosphate-based pesticides measured in Coffs Creek and Woolgoolga Lake in the Coffs Harbour council area were either less than the swimming water quality guidelines or below the laboratory analytical detection limit.

Levels of arsenic and antimony measured at the Sea Lido swimming site in the Bellingen Shire were low, indicating that the disused antimony crushing plant in the catchment had minimal impact on swimming water quality. High levels of both antimony and arsenic were measured in Station Creek.

Overview of findings – metropolitan councils

A condition of grant funding to metropolitan councils was that their work did not duplicate Beachwatch and Harbourwatch monitoring. In general, the metropolitan programs focused on two areas:

- assessment of compliance at swimming sites not included in the Beachwatch and Harbourwatch programs
- intensive monitoring of existing Beachwatch or Harbourwatch monitoring locations to study the impact of rainfall on swimming water quality.

Pittwater Council

Pittwater Council's pilot program assessed compliance with swimming water quality guidelines at four locations not included in the Beachwatch or Harbourwatch programs.

A high level of compliance was recorded at the ocean pool at Palm Beach and McCarrs Creek Reserve in Pittwater. A lower level of compliance was measured at two locations in Narrabeen Lagoon. Levels of indicator bacteria at these locations indicated sewage contamination during wet weather.

Samples were also collected at five locations in Pittwater to assess the impact of wet weather sources of pollution on swimming water quality. Elevated bacterial levels were recorded in response to rainfall and generally remained high for 48 hours after rainfall. Based on these data, swimming in the vicinity of Scotland Island should be avoided for at least two days after rain.

Municipality of Hunters Hill

This pilot program aimed to determine whether a range of new and disused swimming locations in lower Lane Cove River and lower Parramatta River were suitable for swimming. Samples were collected in response to rainfall events. On some occasions, samples were also analysed for toxicants to assess the impact of urban stormwater runoff on swimming water quality.

At the six sites monitored in lower Lane Cove River, the seven sites monitored in lower Parramatta River and the single site monitored in Port Jackson, bacterial levels were generally low during dry weather conditions. Elevated bacterial levels were measured in response to rainfall, indicating wet weather sewage contamination.

Elevated levels of aluminium and iron were also measured during wet weather at some sites.

Based on the findings of the study, water quality around the Hunters Hill peninsular is suitable for swimming during dry weather conditions. However, due to the limited amount of data collected, additional sampling should be conducted to confirm this finding. Based on data from the Harbourwatch Program, swimming in this area of the harbour should be avoided during and for at least three days after rainfall.

Willoughby City Council

Willoughby City Council conducted intensive monitoring in and around Northbridge Baths, a site included in the Harbourwatch Program. The aim of the

monitoring was to more accurately define when swimming should be avoided in the baths. This information can be used to derive a notification protocol and closure policy for the baths.

Samples were collected from eleven locations in and around the baths during rainfall and on days following rainfall until water quality returned to dry weather levels.

This study found that swimming in Northbridge Baths should be avoided for at least one day after rainfall of 10–20 mm in 72 hours, and avoided for at least two days after rainfall of more than 20 mm in 72 hours.

North Sydney Council

North Sydney Council monitored water quality in MacCallum Pool and the embayment from which water for the pool is drawn, Shell Cove. Samples were collected during and after rainfall to assess the impact of wet weather on swimming water quality.

Bacterial levels in the pool and in Shell Cove displayed little response to rainfall and indicated that water quality was suitable for swimming 24 hours after rainfall. However, due to the limited data collected under the study, additional sampling was recommended to confirm this finding.

Randwick City Council

Randwick City Council's pilot program assessed compliance with swimming water quality guidelines at two locations not included in the Beachwatch Program: Little Bay Beach North and Little Bay Beach South.

Compliance at Little Bay Beach South was high, with levels of indicator bacteria complying with swimming guidelines in all seven months of the 2002–03 summer swimming season. Bacterial levels measured at this site were generally low, providing little evidence of sewage contamination.

A lower level of compliance was measured at Little Bay Beach North, which passed swimming guidelines in only four of the seven months. Elevated levels of enterococci were measured on several occasions in response to rainfall.

Quality assurance

Quality assurance and quality control procedures were incorporated into all aspects of the 14 pilot monitoring programs, including:

- sampling (equipment preparation, sample collection and sample storage and transport)
- laboratory analysis
- data management
- community reporting.

The results of these assessments indicated that councils collected samples according to procedures, the microbiological data was reliable and information reported to the community during the pilot programs was accurate.

Appendixes

There are three appendixes to this report:

- **Appendix A** details the indicators and guidelines used to assess recreational water quality
- **Appendix B** outlines monitoring strategies and priority evaluation methods employed by local councils
- **Appendix C** lists further reading and information sources. It is intended to point the reader towards other information relating to both bacterial pollution of waterways used for recreation, and human health risks.

Chapter 1
Introduction

Overview

In June 2000, Premier Carr announced the NSW Government's $11.7 million Coastal Protection Package. This package provides a holistic framework for managing the coastal zone and includes a range of initiatives to ensure that the State's coastal environments are protected for future generations (see Appendix A). The Beachwatch Partnership Pilot Program is a key component of this package. It aims to raise awareness of beach water quality issues, streamline testing along the NSW coast and increase community access to beach water quality information.

This report presents the findings of pilot beach water quality monitoring and reporting programs conducted in partnership with 15 local councils along the NSW coast. Ten regional councils and five councils in metropolitan Sydney participated in the pilot programs:

Regional councils – Ballina Shire Council, Maclean Shire Council, Pristine Waters Council, Coffs Harbour City Council, Bellingen Shire Council, Great Lakes Council, Lake Macquarie City Council, Wyong Shire Council, Shoalhaven City Council and Eurobodalla Shire Council.

Metropolitan councils – Pittwater Council, Municipality of Hunters Hill, Willoughby City Council, North Sydney Council and Randwick City Council.

The pilot monitoring programs ranged in size from two to 52 sampling locations, and included ocean beaches, freshwater lakes, tidal pools, bays, rivers, lagoons, harbour sites and estuarine sites. Sampling was conducted between 1 October 2002 and 31 July 2003.

Report structure

Chapter 1 provides background information on the Beachwatch Partnership Pilot Program, the development of the monitoring programs in partnership with local councils, water quality indicators and guidelines used to assess beach water quality.

Chapter 2 presents the findings from water quality monitoring in the 10 local council areas in regional NSW.

Chapter 3 presents the findings from water quality monitoring in the five local council areas in metropolitan Sydney.

Chapter 4 describes the quality assurance (QA) program included in the Beachwatch Partnership Pilot Program to ensure that the data collected and presented is accurate and reliable. This includes QA of field sampling and microbiological analysis of beach water samples.

There are three appendixes to this report:

- **Appendix A** details the indicators and guidelines used to assess recreational water quality
- **Appendix B** outlines monitoring strategies and priority evaluation methods employed by local councils
- **Appendix C** lists further reading and information sources. It is intended to point the reader towards other information relating to both bacterial pollution of waterways used for recreation, and human health risks.

About the Beachwatch Partnership Pilot Program

The Department of Environment and Conservation's Beachwatch Programs section was given the responsibility of delivering the objectives of the Beachwatch Partnership Pilot Program over a two-year period.

The objectives are:

1. to raise awareness and understanding of water quality impacts associated with recreational water use
2. to improve the consistency and quality of recreational water quality monitoring undertaken by local government and other water resource managers in NSW
3. to increase community access to information on recreational water quality.

To accomplish these objectives, the program was designed around three principal components: a protocol for monitoring and reporting recreational water quality, council pilot programs and a training program.

Protocol for monitoring and reporting

A protocol for monitoring and reporting coastal recreational water quality was developed by the Department of Environment and Conservation (DEC) in May 2002. The document is a step-by-step guide to developing and implementing a targeted recreational water quality monitoring program. It includes information on waterborne pathogens and their health effects, water quality guidelines, information on indicator organisms, a risk-based methodology for prioritising swimming locations, monitoring strategies, sampling and analysis procedures, quality assurance requirements, and community reporting plans.

The protocol was provided to all coastal councils for review in May 2002, and feedback was sought during a series of workshops conducted in June and July 2002.

The protocol was then implemented and tested by the 15 councils participating in the pilot programs. Feedback from the councils was used to refine and finalise the protocol.

The protocol, *Monitoring and Reporting Coastal Recreational Water Quality: Information Package and Field Manual* (DEC 2004), is available at www.environment.nsw.gov.au/beach/cpp/index.

Pilot monitoring programs

In August 2002, all coastal councils in NSW were invited to apply for grant funding to implement pilot recreational water quality monitoring and reporting programs over the 2002–03 summer swimming season.

To apply for grant funding, local councils were required to:

1. identify all swimming locations in their local area
2. develop a conceptual model for each swimming location based on potential pollution sources and beach use information
3. prioritise swimming locations as high, medium or low
4. select appropriate monitoring strategies based on the beach prioritisations and the availability of council resources to undertake monitoring
5. develop an appropriate reporting strategy to convey beach water quality information to their community.

The methodology for each of the above steps is detailed in the protocol. Appendix B of this document outlines the procedures for developing conceptual models and beach prioritisation, and also provides an overview of monitoring strategies.

Fifteen local councils received more than $500,000 in grant funding to conduct the pilot monitoring and reporting programs. The grant funding covered the cost of sample analysis, sample transport and community reporting activities such as newspaper advertisements and website development.

The grants did not cover staff costs, and as such, existing council officers were required to manage the programs, undertake sample collection and coordinate reporting.

Training

The final component of the Beachwatch Partnership Pilot Program is the development of a training program for monitoring and reporting recreational water quality. The training program is based on the *Monitoring and Reporting Coastal Recreational Water Quality*: *Information Package and Field Manual.*

The training of local council officers will help ensure that any future monitoring of recreational waters is undertaken in a scientifically rigorous and credible manner. DEC will train local coastal councils as needed.

Data availability

The information in this report is supported by detailed results for each beach at www.environment.nsw.gov.au/beach/cpp/ar2003. These beach pages provide a description of the swimming location; potential pollution sources; time series plots of water quality and rainfall data; and where these are assessed, guideline compliance results; the impact of rainfall; and verification of pollution sources.

In addition, the data for each swimming location may be downloaded from www.soedirect.nsw.gov.au.

Water quality analyses

Bacteria

Two types of indicator bacteria, faecal coliforms and enterococci, were used to assess recreational water quality in the pilot programs, as recommended by the National Health and Medical Research Council (NHMRC). These bacteria indicate the possible presence of waterborne pathogens, organisms that pose significant risks to human health (see Appendix A).

Faecal coliforms generally survive in marine waters for between 24 and 48 hours. When elevated faecal coliform levels are detected in a water sample, this indicates the presence of recent sewage contamination at the swimming site.

Enterococci survive for much longer periods in marine waters than faecal coliforms. Elevated levels of enterococci, in conjunction with low levels of faecal coliforms, may indicate the presence of aged sewage contamination.

If neither faecal coliform nor enterococci levels are elevated, contamination of bathing waters by sewage is not indicated.

Other indicators

Where local councils considered that other indicators posed potential risks to swimmers, these were included in the pilot programs, as outlined below.

Levels of blue-green algae, or cyanobacteria, were measured in Lake Ainsworth as part of Ballina Shire Council's pilot program.

Organochlorine and organophosphate-based pesticides were sampled by the Coffs Harbour City Council in Woolgoolga Lake and Coffs Creek.

Levels of antimony and arsenic were monitored as part of Bellingen Shire Council's pilot program to assess whether a disused antimony crushing plant in the Urunga Lagoon catchment had an impact on recreational water quality.

Aluminium, iron, copper, zinc and lead were monitored in the Municipality of Hunters Hill to assess the impact of urban stormwater on recreational water quality.

Recreational water quality guidelines

Bacteria

Recreational water quality guidelines indicate the probability of swimmers developing illnesses from the water, but the actual risk depends on many factors. These factors include, in particular, the bacterial indicator to pathogen ratio, which varies with time so cannot usually be accurately predicted.

The *Australian Guidelines for Recreational Use of Water* (NHMRC 1990) were used to assess recreational water quality in the Beachwatch Partnership Pilot Program. These guidelines are currently being reviewed by NHMRC and it is anticipated that new guidelines will be released in 2004.

Under the existing NHMRC (1990) guidelines, waters are considered to be unsuitable for swimming if, for five samples taken at regular intervals over a month:

- the median faecal coliform density exceeds 150 cfu/100 mL; or

- the second highest faecal coliform density is equal or greater than 600 cfu / 100 mL; or
- the geometric mean enterococci density exceeds 33 cfu / 100 mL.

Guideline compliance was assessed on a monthly basis for each site, with compliance recorded as a pass or fail for the period.

Algae

The State Algal Coordinating Committee Interim Guidelines (endorsed in March 2000) (Nancarrow & Wood, 2000) indicate that a medium alert level should apply when the abundance of potentially toxic blue-green algae is within the range of 2000 to 15,000 cells / mL, and a high alert level should apply when levels exceed 15,000 cells / mL.

Under a medium alert, people sensitive to algae should avoid direct skin contact with the water. Under a high alert, everyone should avoid contact and use of the water.

Pesticides

Pesticide levels were assessed relative to the ANZECC (2000) water quality guidelines for recreational purposes and the NHMRC (1996) *Australian Drinking Water Quality Guidelines.*

Antinomy

As there are no recreational water quality guidelines for antinomy, the NHMRC (1996) drinking water guidelines were used as a very conservative estimate of health risk. The concentration of antinomy in drinking water should not exceed 3 µg / L.

Arsenic

The ANZECC (2000) guidelines for recreational water quality and aesthetics report that levels of arsenic in recreational waters should not exceed 50 µg / L.

Metals

The ANZECC (2000) guidelines for recreational water quality and aesthetics report that the following levels should not be exceeded in recreational waters:

- aluminium – 200 µg / L
- iron – 300 µg / L
- copper – 1000 µg / L
- zinc – 5000 µg / L
- lead – 50 µg / L.

Interpretation of results

The findings in this report focus on bacterial results, which are indicators of the possible presence of sewage contamination. Data are interpreted in terms of guideline compliance and response to rainfall.

Guideline compliance assessment

Compliance with NHMRC (1990) swimming water quality guidelines is reported as a pass or a fail for each month. Guideline compliance assessments are useful for comparing sites and looking at trends over a long period of time:

- beaches that consistently pass the guidelines generally have excellent water quality and are affected by few sources of sewage pollution
- beaches that pass the guidelines in most months generally have good water quality, but are affected by intermittent sources of pollution, generally related to rainfall
- beaches that consistently fail the guidelines have poor water quality and are generally subject to ongoing sewage pollution, such as sewage treatment plant discharges or leachate from septic tanks.

Beach water quality can vary significantly over short periods of time due to the impact of intermittent sources of pollution, such as those related to wet weather. These impacts may not be apparent from the guideline compliance results for several years, depending on the prevailing weather conditions. Guideline compliance results therefore tell only part of the story.

Response to rainfall

In order to assess the impact of wet weather-related pollution sources on swimming water quality, bacterial results were compared to daily rainfall measurements through time. Where elevated bacterial results were recorded during or immediately after rainfall, this is noted for each site.

Some councils undertook additional sampling to specifically assess the impact of wet weather sources of pollution on beach water quality. At sites where sufficient samples were collected, the following trends were assessed:

- the amount of rainfall required before elevated bacterial results were recorded
- the time for bacterial results to recover to dry weather levels after rainfall.

This information can be used to develop advice for the community as to when swimming should be avoided, such as 'avoid swimming for 24 hours after heavy rainfall'. In order to develop advice, trends in the data must be clear and unambiguous, and based on extensive monitoring. Several years of monitoring data is required to develop predictive models.

Explanation of maps

Maps have been provided to indicate the locations of beaches, sampling sites, surf clubs, roads, coastal sewage treatment plants and sewage pumping stations. The maps also include landuse classifications such as parks and reserves and built up areas, giving an indication of developed and undeveloped areas in each council region.

Explanation of compliance graphs

Compliance graphs have been generated for each council area to summarise compliance with NHMRC (1990) swimming water quality guidelines at each site. Compliance data is presented as the number of months complying with the guidelines out of the total number of months in which sufficient samples were collected to calculate compliance.

A site only passed when levels of both faecal coliforms and enterococci met the guidelines. If either bacterial indicator exceeded the guideline limits, the site failed for that month.

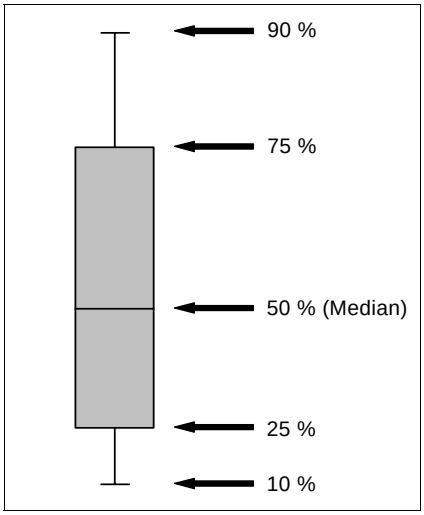
Compliance results for each month for both faecal coliforms and enterococci are presented on the beach pages for each site, which are available at www.environment.nsw.gov.au/beach/cpp/index.htm.

Explanation of box plots

Box plots display the spread, skew and distribution of data. In this report, they present the results of intensive wet weather sampling undertaken in the Willoughby Council Pilot Program (Chapter 3).

A typical example of a box plot is illustrated in Figure 1.

Figure 1: Box plot



Each part of the box plot represents a percentile value of the population:

- 10% of the population lies below the bottom whisker
- 25% of the population lies below the bottom of the box
- half the population is on each side of the middle line of the box (median)
- 75% of the population lies below the top of the box
- 90% of the population lies below the top whisker.

Chapter 2
Regional Council Pilot Programs

Overview

Of the 15 local coastal councils participating in the Beachwatch Partnership Pilot Program (BPPP), 10 were located in regional areas on the NSW coast:

- Ballina Shire Council
- Maclean Shire Council
- Pristine Waters Shire Council
- Coffs Harbour City Council
- Bellingen Shire Council
- Great Lakes Shire Council
- Lake Macquarie City Council
- Wyong Shire Council
- Shoalhaven City Council
- Eurobodalla Shire Council.

A total of 155 swimming locations were monitored in regional NSW. These included ocean beaches, freshwater lakes, bays, lagoons, river and estuarine sites, and rock pools. At some sites, samples were also collected from stormwater drains and creeks in the vicinity of the swimming location.

Monitoring was conducted in regional council areas to assess compliance with swimming water quality guidelines, the impact of rainfall on recreational water quality and potential sources of pollution.

A summary of the monitoring undertaken by each regional council is presented in Table 1. Maclean Shire Council and Pristine Waters Council jointly implemented their program.

Resourcing issues

For most councils, insufficient staff to conduct sampling was an ongoing problem over the course of the pilot programs. This meant that monitoring programs were progressively scaled back in some council areas, and in other council areas the sampling frequency was less than originally anticipated.

Extension of pilot programs

The 2002–03 summer swimming season was particularly dry. Due to the lack of rainfall, insufficient samples were collected to assess the effect of wet weather-related pollution sources on recreational water quality. The pilot programs were extended until the end of July 2003 in all regional council areas except Great Lakes.

During the extended period, resources were focused on the collection of samples during and immediately after rainfall.

Overview of findings

Below is a summary of key findings. Detailed results for each council area are provided in the following sections. This information is supported by beach pages for each site at www.environment.nsw.gov.au / beach / cpp / ar2003.

Guideline compliance

Guideline compliance monitoring was undertaken in all regional council areas except Eurobodalla Shire Council.

In general, a high level of compliance with recreational water quality guidelines was measured at ocean beaches. Where compliance was assessed, 55 of the 60 ocean beaches monitored passed the guidelines in all months of the 2002–03 summer swimming season.

The five ocean beaches that did not pass swimming guidelines in all months were:

- Brooms Head Beach in Maclean Shire Council
- Wooli Beach and Corindi Beach in Pristine Waters Shire Council
- Arrawarra Beach and Flat Top Beach South in Coffs Harbour City Council.

Arrawarra Beach failed the guidelines in two months of the 2002–03 summer

swimming season, and the remaining four beaches failed in only one month.

Lower levels of compliance were generally recorded at estuarine and coastal lake swimming locations. Most of these locations failed in one or more months of the 2002–03 summer swimming seasons.

Estuarine and coastal lake swimming sites with very high levels of compliance with swimming guidelines included:

- The Serpentine in the Ballina Shire Council area
- Whiting Beach and Kolora Lake in the Maclean Shire Council area
- Red Rock Estuary in the Pristine Waters Shire Council area
- Wyee Point and Swansea in the Lake Macquarie Shire Council area
- Chain Valley Bay in the Wyong Shire Council area.

These sites passed the guidelines in all months of the 2002–03 summer swimming season in which sufficient samples were collected to calculate compliance.

Estuarine and coastal lake swimming sites with very low levels of compliance included:

- Lake Cakora in the Maclean Shire Council area
- all coastal creeks monitored in the Coffs Harbour Shire Council area
- Tumbi Umbi Creek, Ourimbah Creek and Canton Beach in the Wyong Shire Council area.

These swimming locations failed in more than half of the months where compliance was assessed. Compliance at Tumbi Umbi Creek and Ourimbah Creek was particularly poor, with these sites failing in all months.

Response to rainfall

As indicated by the guideline compliance results, bacterial levels remained generally low at the ocean beaches. Slightly elevated bacterial levels (values above the median guideline limits) were measured at most beaches after heavy rainfall, although these levels are not considered to be indicative of sewage contamination (indicated by levels of 1000 cfu / 100 mL or more).

It should be noted that the 2002–03 summer swimming season was quite dry, with few large or extended wet weather events. A greater response to rainfall at ocean beaches may be recorded during periods with higher rainfall. Until more data is available, swimming at ocean beaches should be avoided for 24 hours after heavy rainfall.

A more significant response to rainfall was recorded at estuarine and coastal lake swimming sites, with elevated bacterial levels generally measured during and after rainfall. Particularly high bacterial levels were recorded at many sites during wet weather, indicating sewage contamination.

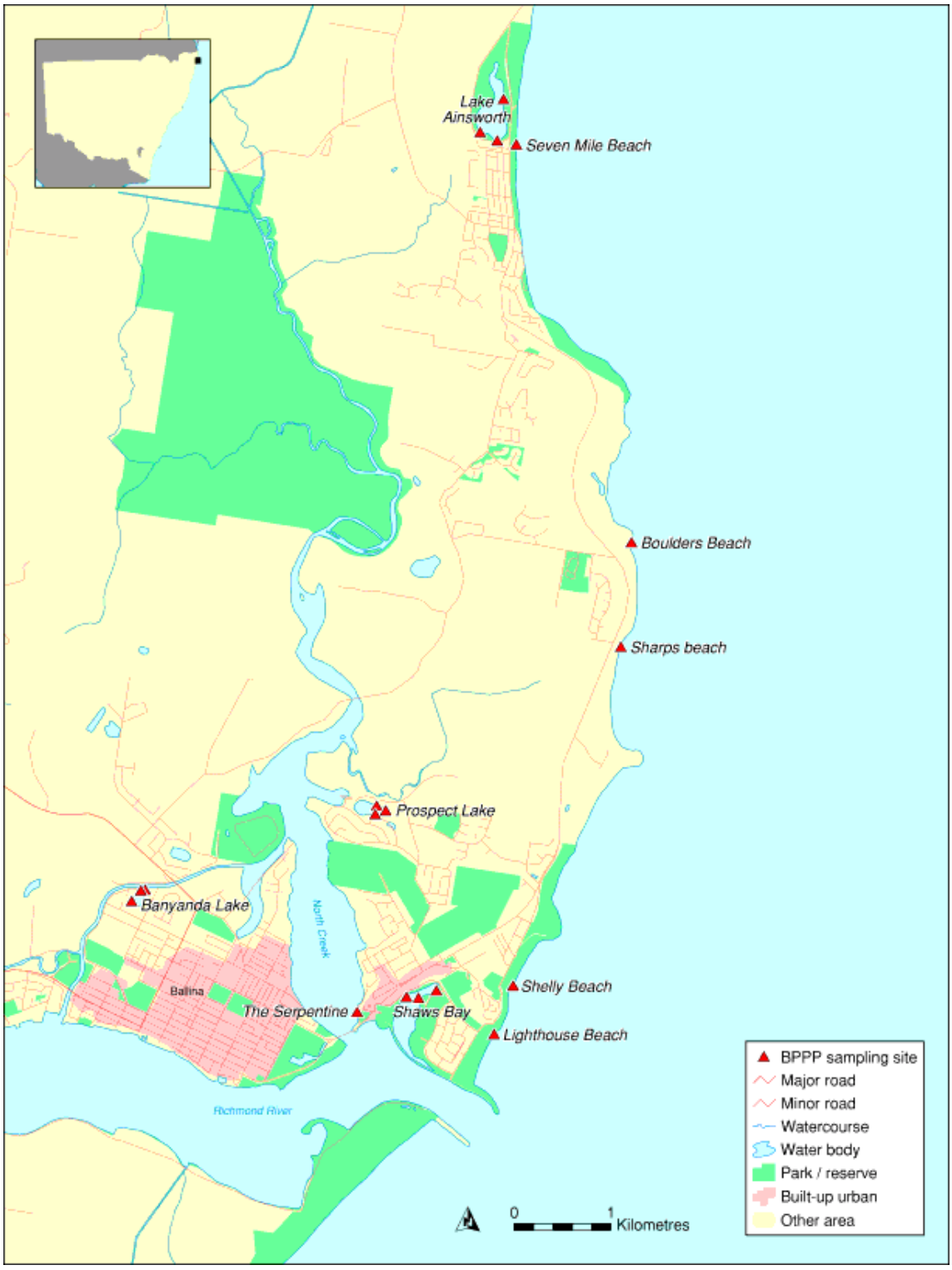
As a precaution, swimming in estuaries and coastal lakes should be avoided during and for up to three days after rainfall.

Table 1: Summary of monitoring in regional council areas

Council	Period of monitoring	Number of sites			Additional
		Guideline compliance	Rainfall response	Pollution source assessment	
Ballina	Oct 02–Jul 03	10	5	0	Algae
Maclean / Pristine Waters	Oct 02–Jul 03	14	3	0	
Coffs Harbour	Oct 02–Jul 03	37	0	5	Pesticides
Bellingen	Oct 02–Jul 03	2	2	2	Toxicants
Great Lakes	Oct 02–Apr 03	4	5	5	
Lake Macquarie	Oct 02–Jul 03	7	18	4	
Wyong	Oct 02–Jul 03	31	6	0	
Shoalhaven	Oct 02–Jul 03	5	2	2	
Eurobodalla	Oct 02–Jul 03	0	14	12	

Ballina Shire Council

Ocean beaches: Seven Mile, Boulders, Sharps, Shelly, Lighthouse. **Freshwater lake**: Lake Ainsworth. **Estuaries:** Banyanda Lake, Prospect Lake, Shaws Bay, The Serpentine.



Local government area description

Ballina Shire is located on the NSW far north coast and covers an area of 487 square kilometres. Its coastal waters extend from Seven Mile Beach in the north to Wardell in the south.

Land use is predominantly rural, with more than 80 square kilometres of rural land along the coast. The main commercial activities include agriculture, tourism and fishing with a growing sector of primary goods production.

Approximately 40,000 people live in the Shire, and population is growing by three percent each year. In 2000, there were approximately 1.9 million visitors to the area, about half of whom participated in outdoor recreational activities.

The major towns are Ballina, Lennox Head, Alstonville, Wollongbar and Wardell (Ballina Shire Council 2001).

Program outline

Ten swimming locations were monitored under the Ballina Shire Pilot Recreational Water Quality Monitoring Program:

- Seven Mile, Boulders, Sharps, Shelly and Lighthouse beaches (surf beaches)
- Lake Ainsworth (freshwater lake)
- Banyanda Lake, Prospect Lake, Shaws Bay and The Serpentine (estuarine locations).

Faecal coliform and enterococci samples were collected from all locations over the 2002–03 summer swimming season to assess compliance with the NHMRC (1990) swimming water quality guidelines. It should be noted that only four of the five samples necessary to calculate compliance were collected in December 2002 and February 2003. To calculate compliance in these two months, the closest sample in time from an adjacent month was 'borrowed' to provide the five data points required.

Monitoring was extended from May until July 2003 at Shelly Beach, Prospect Lake, Lake Banyanda, Shaws Bay and The Serpentine to assess the impact of wet weather pollution sources on swimming water quality. Samples were collected during and after rainfall events in this period.

In addition to bacterial monitoring, levels of blue-green algae were monitored in Lake Ainsworth between September 2002 and July 2003. This data was assessed to determine suitability for recreation in accordance with State Algal Coordinating Committee (SACC) specifications.

Ocean beaches

Guideline compliance assessment

Seven Mile, Boulders, Sharps, Shelly and Lighthouse beaches all complied with the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002-03 summer swimming season (see Figure 2).

The levels of indicator bacteria measured at the ocean beaches over the summer swimming season were consistently low, providing no evidence of sewage contamination. It should be noted, however, that this was a particularly dry period and beaches were rarely subject to wet weather sources of pollution. Additional monitoring is required to confirm these findings.

Response to rainfall

Shelly Beach, the main swimming beach in Ballina, was selected for additional wet weather monitoring between May and July 2003 to assess the impact of wet weather on beach water quality. The results from this monitoring indicated that levels of enterococci increased slightly in response to rainfall, but generally remained at levels suitable for swimming.

Lake Ainsworth

Guideline compliance assessment

Levels of faecal coliforms and enterococci were measured at three locations in Lake Ainsworth—in the southern corner, in the east and in the west of the lake.

Lake Ainsworth South, the main swimming location, complied with the NHMRC (1990) swimming water quality guidelines in six of

the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in February 2003 due to elevated levels of enterococci.

Lake Ainsworth West also complied with the NHMRC (1990) swimming water quality guidelines in six of the seven months, failing in October 2002 due to elevated levels of enterococci. Lake Ainsworth East complied with the guidelines in all seven months.

Blue-green algae

Levels of blue-green algae measured in the north and south of Lake Ainsworth regularly exceeded SACC (Nancarrow & Wood, 2000) medium alert levels, indicating that swimming in the lake should be avoided by those sensitive to algae. Algal levels also often exceeded the high alert level, when everyone should avoid contact with the lake water.

Previous monitoring by Ballina Shire Council has shown high levels of blue-green algae to be an ongoing seasonal trend in the lake. The very high levels measured over the 2002–03 summer swimming season were possibly exacerbated by dry weather conditions.

Prospect Lake

Guideline compliance assessment

Three locations were monitored in Prospect Lake – the north of the lake, the east of the lake adjacent to a rowing club, and the main swimming area in the south of the lake.

The locations in the north and south of Prospect Lake complied with the NHMRC (1990) swimming water quality guidelines in six of the seven months of the 2002–03 summer swimming season. Both sites did not meet the guidelines in April 2003 due to elevated levels of enterococci. A lower level of compliance was measured at Prospect Lake East, where bacterial levels exceeded the guidelines in February, March and April 2003.

Levels of indicator bacteria in Prospect Lake remained relatively low between October 2002 and January 2003, a period dominated by dry weather conditions. Rainfall during the last three months of the summer swimming season resulted in elevated levels of enterococci, with levels measured on the eastern side of the lake being particularly high and indicative of sewage contamination.

Response to rainfall

Additional samples were collected at Prospect Lake between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after five rainfall events; 13 May, 28 May, 11 June, 26 June and 19 July. The 26 June event was extreme with nearly 200 mm of rainfall falling on a single day.

Wet weather monitoring at Prospect Lake showed that bacterial levels increased with increasing rainfall in the previous 24 hours. Levels of faecal coliforms exceeded the median guideline after more than 10 mm of rainfall in the previous 24 hours, while levels of enterococci regularly exceeded the geometric mean guideline after any amount of rainfall.

The time taken for water quality to recover to dry weather levels after rainfall was also assessed. A clear decline in bacterial levels was not apparent in the data as insufficient days were sampled after rainfall ceased. The results from the events of 11 June and 26 June indicated that levels of enterococci continued to exceed the geometric mean guideline 48 hours after rainfall ceased.

Based on these results, swimming in Prospect Lake should be avoided for at least two days after rainfall. Additional sampling is required to determine the time for bacterial levels to return to levels suitable for swimming.

Lake Banyanda

Guideline compliance assessment

Three locations were monitored in Lake Banyanda – the east and west side of the entrance, and the south of the lake.

All three locations passed the NHMRC (1990) swimming guidelines in the first four months of the 2002–03 summer swimming season, a period dominated by dry weather

conditions. Elevated bacterial levels were measured in February, March and April 2003, with all three sites failing the guidelines in these months.

Response to rainfall

Additional samples were collected at Lake Banyanda between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after five rainfall events: 13 May, 28 May, 11 June, 26 June and 19 July 2003. The 26 June event was extreme with nearly 200 mm of rainfall falling on a single day.

Bacterial levels in Lake Banyanda generally remained at levels suitable for swimming in dry weather, and increased with increasing rainfall in the previous 24 hours. Levels of faecal coliforms exceeded the median guideline after more than 10 mm of rainfall in the previous 24 hours, and levels of enterococci frequently exceeded the geometric mean guideline after any amount of rainfall.

The time taken for water quality to recover to dry weather levels after rainfall was also assessed. While bacterial levels generally decreased in the days following rainfall, a clear trend was not apparent in the data as insufficient dry weather days following rainfall were sampled in most events. The results from the events of 11 June and 26 June indicated that levels of enterococci continued to exceed the geometric mean guideline 48 hours after rainfall ceased.

Based on these results, swimming in Lake Banyanda should be avoided for at least two days after rainfall. Additional sampling is required to determine the time for bacterial levels to return to levels suitable for swimming.

The Serpentine

Guideline compliance assessment

The Serpentine is a popular swimming location situated in a tributary of the Richmond River. The site passed NHMRC (1990) swimming water quality guidelines in all seven months of the 2002–03 summer swimming season.

Response to rainfall

Additional samples were collected at The Serpentine between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after five rainfall events: 13 May, 28 May, 11 June, 26 June and 19 July 2003. The 26 June event was extreme with nearly 200 mm of rainfall falling on a single day.

Levels of indicator bacteria remained below the median and geometric mean guidelines when zero rainfall was recorded in the previous 24 hours, indicating that the site is suitable for swimming during dry weather. Rainfall of more than 20 mm in the previous 24 hours resulted in faecal coliform levels occasionally exceeding the guideline and enterococci levels frequently exceeding the guideline.

The time taken for water quality to recover to dry weather levels after rainfall was also assessed. While bacterial levels generally decreased in the days following rainfall, a clear trend was not apparent in the data as insufficient dry weather days following rainfall were sampled in most events. The results from the event of 26 June 2003 indicated that bacterial levels did not fall below the median and geometric mean guideline until the fourth day after rainfall ceased.

Based on these results, swimming at The Serpentine should be avoided for at least three days after heavy rainfall. Additional sampling is required to confirm the time for bacterial levels to return to levels suitable for swimming.

Shaws Bay

Guideline compliance assessment

Shaws Bay is located at the mouth of the Richmond River. Three locations were monitored – the north, east and west sides of the bay.

A high level of compliance with NHMRC (1990) swimming guidelines was measured at Shaws Bay North and Shaws Bay West, with both sites complying in all seven months of the 2002–03 summer swimming

season. A slightly lower level of compliance was measured in Shaws Bay East, with the site failing the guidelines in March 2003 due to elevated levels of enterococci.

Response to rainfall

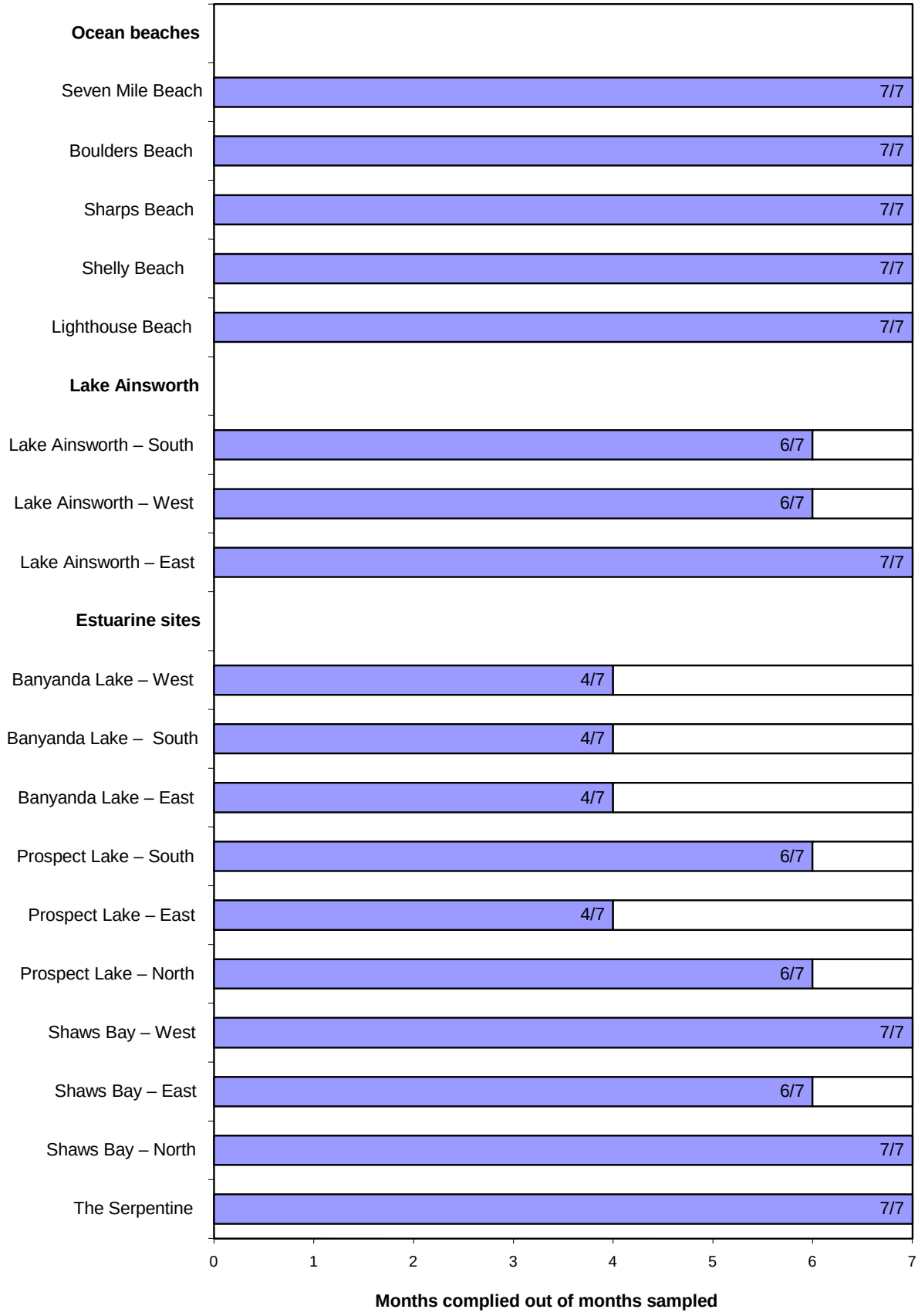
Additional samples were collected at Shaws Bay between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after five rainfall events: 13 May, 28 May, 11 June, 26 June and 19 July 2003. The 26 June event was extreme with nearly 200 mm of rainfall falling on a single day.

Bacterial levels in Shaws Bay rarely exceeded the NHMRC (1990) median or geometric mean guideline values during dry weather. Wet weather monitoring indicated that bacterial levels increased in response to rainfall. Faecal coliform levels occasionally exceeded the median guideline after more than 20 mm of rainfall in the previous 24 hours and levels of enterococci frequently exceeded the geometric mean guideline after more than 10 mm of rain in the previous 24 hours.

The time taken for water quality to recover to dry weather levels after rainfall was also assessed. While bacterial levels generally decreased in the days following rainfall, a clear trend was not apparent in the data, as insufficient dry weather days following rainfall were sampled in most events.

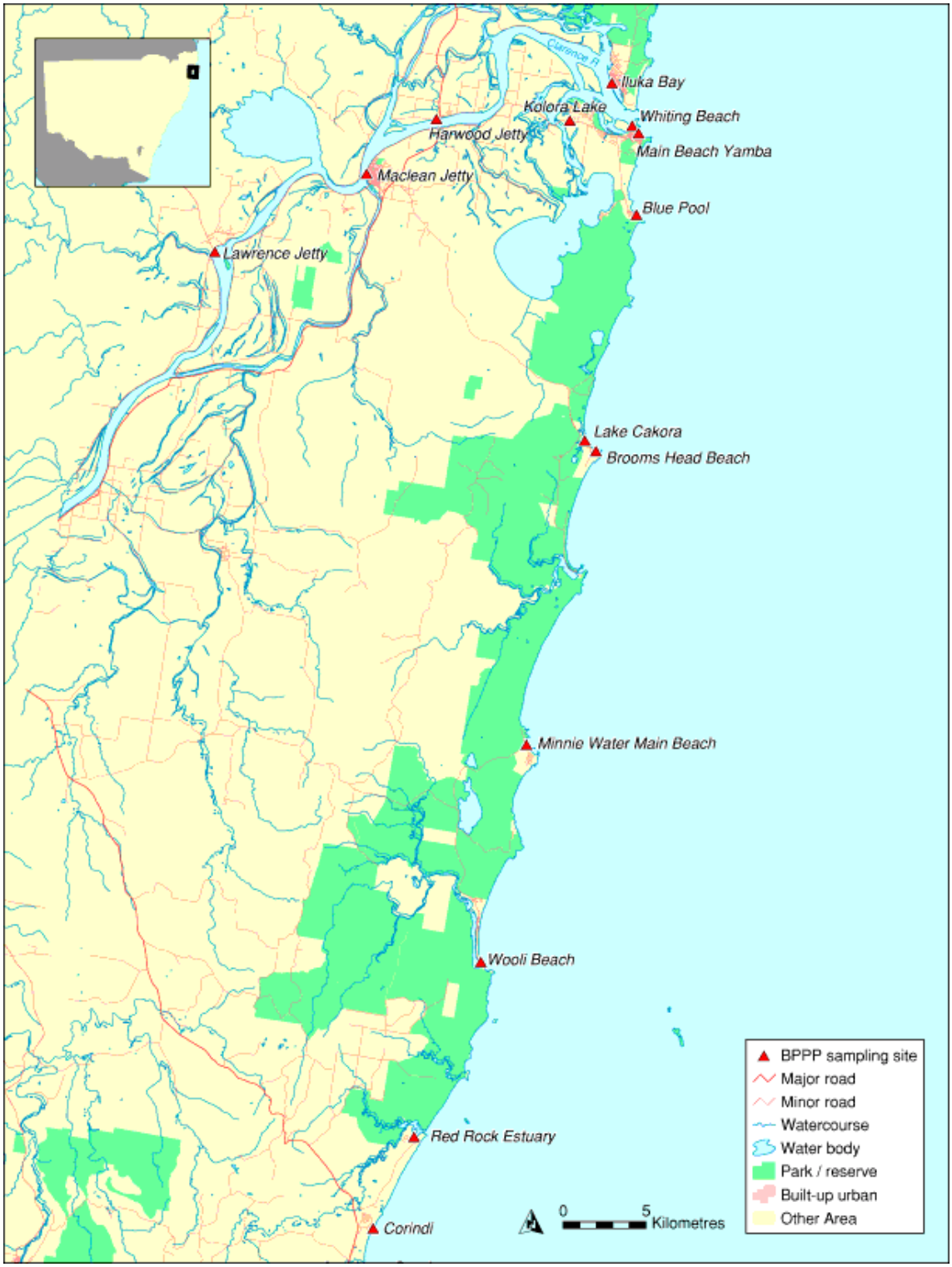
Results from 26 June indicated that bacterial levels continued to exceed guideline levels for at least two days after rainfall ceased. Based on these results, swimming in Shaws Bay should be avoided for at least two days after heavy rainfall. Additional sampling is required to determine the time for bacterial levels to return to levels suitable for swimming.

Figure 2: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Ballina Shire Council swimming sites between October 2002 and April 2003



Maclean Shire and Pristine Waters Councils

Ocean beaches: Main Beach Yamba, Brooms Head, Minnie Water Main Beach, Wooli Beach, Corindi. **Estuarine beaches:** Iluka Bay, Whiting Beach, Red Rock estuary. **Lagoons:** Kolora Lake, Lake Cakora. **Riverine swimming sites:** Harwood Jetty, Maclean Jetty, Lawrence Jetty. **Rock pool:** Blue Pool.



Local government area description

Maclean Shire Council

The Maclean Shire is located on the north coast of NSW and forms part of the Northern Rivers Region. The Shire covers an area of 1401 square kilometres, including 50 kilometres of coastline.

Land use in the area is predominantly rural. The area supports a large commercial fishery, extensive agriculture and a developing aquaculture industry.

The population of the Shire is approximately 17,000 and is growing at the rate of 1.77 percent each year. The three major towns of Yamba, Maclean and Iluka are joined by the Clarence River.

Pristine Waters Council

Pristine Waters Council is located south of the Maclean Shire, between Sandon River in the north and Corindi in the south, and forms part of the Clarence Valley. It is the largest coastal council in NSW, with an area of 6872 square kilometres.

The population of approximately 10,700 has declined marginally in recent years. The Shire is comprised of rural and coastal villages, with extensive areas of national parks and state forests, and significant open space and rural lands (Pristine Waters Council 2002).

Program outline

Maclean Shire Council and Pristine Waters Council jointly implemented the Clarence Valley Coastal Councils Pilot Beachwatch Program. The program complements existing monitoring, and forms part of the regional Clarence Valley Stormwater Improvement Strategy in which Copmanhurst Shire Council and Grafton City Council also participate.

Fourteen sites were chosen across the two local government areas, ten in Maclean Shire and four in Pristine Waters. The 14 sites include five ocean beaches, three estuarine sites, three riverine sites, two lagoons and one rock pool.

Faecal coliform and enterococci samples were collected from all locations over the 2002–03 summer swimming season to assess compliance with the NHMRC (1990) swimming water guidelines. It should be noted that the five samples necessary to calculate compliance were not collected in all months. In months with only four samples, the closest sample in time from an adjacent month was 'borrowed' to provide the five data points required.

Monitoring was extended from May until July 2003 at Iluka Bay, Kolora Lake and Maclean Jetty to assess the impact of wet weather on swimming water quality. Samples were collected during and after rainfall events in this period.

Ocean beaches

Guideline compliance

A high level of compliance with swimming water quality guidelines was recorded at the five ocean beaches (see Figure 3).

Main Beach Yamba and Minnie Water Main Beach complied with the guidelines in all seven months of the 2002–03 summer swimming season. Levels of faecal coliforms and enterococci remained consistently low at these two sites over the monitoring period, providing no evidence of sewage contamination.

Brooms Head, Wooli and Corindi beaches all complied with the swimming guidelines in six of the seven months of the 2002–03 summer swimming season. Brooms Head Beach failed the guidelines in January 2003, Wooli Beach failed in February 2003 and Corindi Beach failed in March 2003.

Levels of indicator bacteria remained generally low at Wooli Beach and Corindi Beach in dry weather conditions, with elevated results recorded after heavy rainfall.

Urban stormwater is discharged to Corindi Beach in wet weather and previous monitoring has revealed high levels of bacteria in the outflow. This contamination, thought to originate from on-site wastewater management systems, is the likely source of pollution at Corindi Beach.

It is recommended that swimming in the vicinity of the stormwater drain at Corindi Beach be avoided in wet weather.

Elevated levels of faecal coliforms and enterococci were measured at Brooms Head Beach on several occasions over the monitoring period, and did not necessarily correspond with rainfall. These results suggest that a source of contamination operates in both wet and dry weather conditions.

Clarence River

Guideline compliance

A high level of compliance was recorded at the five swimming sites monitored along the Clarence River (see Figure 3): Whiting Beach and Iluka Bay, located near the mouth of the river, and Harwood, Maclean and Lawrence jetties, located further upstream.

Whiting Beach complied with the NHMRC (1990) swimming guidelines in all seven months of the 2002–03 summer swimming season. While levels of indicator bacteria were generally low over the monitoring period, slightly elevated levels were measured on several occasions.

Iluka Bay, Harwood Jetty, Maclean Jetty and Lawrence Jetty all complied with swimming guidelines in six of the seven months of the 2002–03 summer swimming season. All sites failed the guidelines in March 2003 due to elevated levels of enterococci. Bacterial levels at these sites were generally low in dry weather conditions, indicating that water quality is suitable for swimming at these times.

Response to rainfall

Additional samples were collected at Iluka Bay and Maclean Jetty between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after two rainfall events: one in mid-May and the other at the end of June.

During the mid-May event, more than 200 mm of rain fell over a period of three days. Slightly elevated levels of enterococci were measured at Iluka Bay and Maclean Jetty during the event, declining to dry weather levels two days after rainfall. Bacterial levels showed little response to rainfall during the smaller event in June.

Based on these results, water quality at Maclean Jetty and Iluka Bay may be unsuitable for swimming for up to two days after heavy rainfall. Additional wet weather data is required to more accurately define rainfall recovery trends.

Red Rock Estuary

Guideline compliance

A high level of compliance was measured at Red Rock Estuary, at the mouth of the Corindi River (see Figure 3). This site complied with the swimming guidelines in all seven months of the 2002–03 summer swimming season. Bacterial levels at this site were low during dry weather conditions. Elevated levels were measured after heavy rainfall in late February.

Kolora Lake

Guideline compliance

Kolara Lake, located between the town of Yamba and the Clarence River, complied with the swimming water quality guidelines in all seven months of the 2002–03 summer swimming season (see Figure 3).

Bacterial levels at this site were generally low in dry weather conditions, indicating that water quality is suitable for swimming at these times.

Response to rainfall

Additional samples were collected at Kolora Lake between May and July 2003 to assess the impact of rainfall on swimming water quality. Samples were collected during and after two rainfall events; one in mid-May and the other at the end of June.

Elevated bacterial levels were recorded during both rainfall events, and declined over subsequent days. Faecal coliform levels remained elevated for one day after rainfall, while enterococci levels remained elevated for two days. Based on these findings, swimming should be avoided in Kolora Lake for at least two days after rainfall.

Additional sampling is required to more accurately define rainfall recovery trends.

Lake Cakora

Guideline compliance

The Lake Cakora swimming site is located near the mouth of the lake, which intermittently opens to the ocean.

The swimming site passed the guidelines in October, November and December 2002, a period dominated by dry weather conditions. The site did not meet the guidelines in the remaining four months, with elevated bacterial levels frequently measured during this period, suggesting intermittent sewage contamination

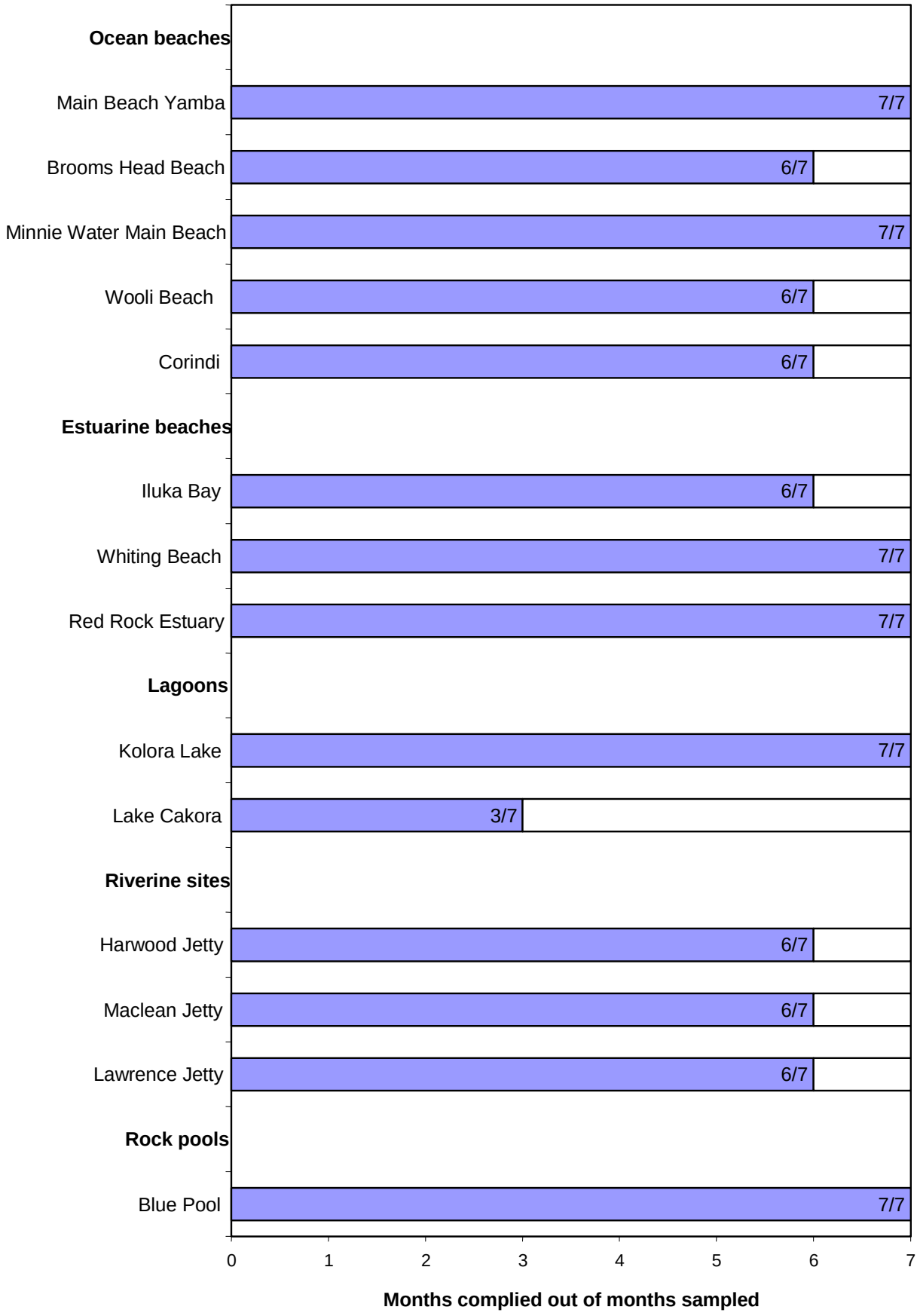
Blue Pool

Guideline compliance

Blue Pool, in the village of Angourie, passed the swimming guidelines in all seven months of the 2002–03 summer swimming season. Bacterial levels were consistently low over the monitoring period, providing no evidence of sewage pollution.

The pool is, however, subject to blue-green algal blooms, and was closed for most of the 2002–03 swimming season due to blooms.

Figure 3: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Maclean Shire Council and Pristine Waters Shire Council swimming sites between October 2002 and April 2003



Coffs Harbour City Council

Ocean beaches: Darlington Park, Arrawarra, Mullawarra, Mullaway, Cabins, Safety, Woolgoolga Main Beach, Woolgoolga Back Beach, Flat Top North, Flat Top South, Sandy Beach, Sandy Back Beach, Emerald, Shellys, Moonee, Sapphire, Campbells, Hills, Korora North, Korora South, Diggers, Macauleys, Park, North Wall, Jetty, Boambee North, Boambee South and Sawtell. **Creeks:** Arrawarra, Fiddamans, Moonee, Jordans, Coffs, Boambee and Bonville. **Lagoons:** Hearns, Woolgoolga. **Pool:** Sawtell.

Local government area description

Coffs Harbour City Council is situated on the NSW north coast, approximately 550 kilometres north of Sydney. The council area covers 51 kilometres of coastline, stretching from Arrawarra in the north to Bundagen in the south, and includes 21 beaches and 14 major coastal creeks. The Solitary Islands Marine Park encompasses much of the council's coastal waters.

The population of the area is approximately 62,000, growing at a rate of 1.6 percent each year. Approximately 91 percent of the population reside in towns along the coast. The council area is interspersed with sparsely populated rural areas, and approximately half is covered by forest. Rainfall is 1700 mm per annum, and average surface runoff is more than double the average of coastal NSW.

Agriculture is very important to the region's economy, particularly beef and dairy farming, with extensive banana cultivation in the ranges. Industrial activities are generally small in scale (Coffs Harbour City Council 2000a & 2000b).

Program outline

Forty swimming areas were monitored under the Coffs Coast Beachwatch Partnership Pilot Program: 29 ocean beaches, eight coastal creeks, two lagoons and one rock pool.

It was intended that faecal coliform and enterococci samples would be collected from all 40 locations over the 2002–03 summer swimming season to assess compliance with the NHMRC (1990) swimming water quality guidelines. However, due to resourcing issues, sampling was gradually scaled back over the course of the program. Only fourteen sites were sampled for guideline compliance in all seven months of the swimming season. The five samples needed to calculate compliance were not collected in all months. In months where only four samples were collected, the closest sample in time from an adjacent month was 'borrowed' in order to provide the five data points required.

Monitoring was extended from May until July 2003 at Fiddamans Creek, Moonee Creek, Jordans Creek, Coffs Creek and Woolgoolga Lake. Samples were collected weekly during this period. Samples were also collected at upstream locations and tributaries of these waterways during this period, to assess the impact of various sources of pollution.

In addition to bacterial monitoring, levels of pesticides were monitored in Woolgoolga Lake and Coffs Creek on 24 January 2003. This data was assessed to determine suitability for swimming in accordance with ANZECC (2000) recreational water quality guidelines.

Ocean beaches

Guideline compliance

A high level of compliance with NHMRC (1990) swimming water quality guidelines was recorded at Coffs Harbour City Council ocean beaches during the 2002–03 summer swimming season (see Figure 4).

Twenty-four of the 26 beaches complied with the guidelines in all months where sufficient samples were collected, to calculate compliance. However, it should be noted that compliance samples were collected in only two or three months at some beaches.

Failures were recorded at Flat Top South, which did not meet the guidelines in February 2003 and Arrawarra Beach, which did not meet the guidelines in March or April 2003. At both beaches, failures were recorded due to elevated levels of enterococci.

Guideline compliance could not be calculated for Darlington Park, Flat Top Beach North and Moonee Beach, as only two samples were collected from these sites.

Bacterial levels at the ocean beaches were generally low during dry weather conditions, providing no evidence of sewage contamination. Slightly elevated results were recorded at Arrawarra Beach, Woolgoolga Main Beach and Flat Top South between February and April 2003, a period

characterised by a large number of small rainfall events.

Coastal creeks

Guideline compliance

In contrast with the ocean beaches, the seven sites located in coastal creeks complied poorly with the NHMRC (1990) swimming water quality guidelines. Swimming in the coastal creeks should be avoided, particularly after rainfall.

The highest level of compliance was measured at Moonee Creek (site 1), which passed the guidelines in only three of the seven months of the 2002–03 summer swimming season (October 2002, December 2002 and March 2003). Compliance at the nearby Moonee Creek (site 2) was lower. This site passed the guidelines in only one of the six months in which sufficient samples were collected (October 2002).

Coffs Creek, Boambee Creek and Bonville Creek all passed the swimming water quality guidelines in only two of the six months in which sufficient samples were collected (October and November 2002). Levels of indicator bacteria at these sites were generally low between October and December 2002, a period dominated by dry weather conditions. Elevated levels of faecal coliforms and enterococci were measured in the latter half of the monitoring period, with particularly high levels measured in response to rainfall.

Arrawarra Creek and Fiddamans Creek passed the guidelines in only one of the seven months of the 2002–03 summer swimming season. Arrawarra Creek passed in November 2002 and Fiddamans Creek passed in January 2003. Elevated bacterial levels were routinely measured at these sites.

Jordans Creek failed the guidelines in all five months where sufficient samples were collected (October 2002, November 2002, March 2003 and April 2003). Elevated levels of faecal coliforms and enterococci were measured at this site during both dry and wet weather conditions.

Pollution source assessment

Additional sampling was undertaken in the Arrawarra, Fiddamans, Moonee, Jordans, Coffs, and Bonville creek catchments to identify potential sources of pollution. Unfortunately, this monitoring did not target specific sources of pollution and was inconclusive.

As a general trend, levels of faecal contamination were generally highest at sites in the vicinity of urban or residential development. The highest levels of indicator bacteria were also measured during rainfall events, suggesting that the sources of faecal contamination were related to wet weather, such as urban stormwater runoff and overflows from the sewage system.

Pesticides

Additional samples were collected at Coffs Creek on 24 January and analysed for a range of organochlorine and organophosphate-based pesticides. Levels of organochlorines and organophosphates were reported as less than 0.10 µg/L. These results are below the ANZECC (2000) swimming water quality guidelines, and where a guideline level is not available, below the analytical detection limit.

Lagoons

Guideline compliance

A relatively low level of compliance with the NHMRC (1990) swimming water quality guidelines was measured at the swimming locations in Hearns and Woolgoolga lakes. Both sites complied with the guidelines in only four of the seven months of the 2002–03 summer swimming season. The sites did not meet the guidelines in February, March and April 2003.

Levels of faecal coliforms and enterococci in both Hearns Lake and Woolgoolga Lake were generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Elevated bacterial levels were measured in both lakes between February and April 2003, with particularly high levels measured during rainfall events.

Pollution source assessment

Additional sampling was undertaken at three locations in the Woolgoolga Lake catchment to identify potential sources of pollution. Unfortunately, this monitoring did not target specific sources of pollution and was inconclusive.

The highest levels of bacteria were measured at Woolgoolga Creek and mid-Woolgoolga Creek, sites that are surrounded by urban and industrial development. These results suggest that the faecal contamination in the lake is derived from sources such as sewage overflows and urban stormwater runoff.

Pesticides

Additional samples were collected in Woolgoolga Lake on 24 January and analysed for a range of organochlorine and organophosphate-based pesticides. Levels of organochlorines and organophosphates were reported as less than 0.10 µg/L. These results are below the ANZECC (2000) swimming water quality guidelines, and where a guideline level is not available, below the analytical detection limit.

Sawtell Rock Pool

Guideline compliance

A high level of compliance with NHMRC (1990) swimming water quality guidelines was recorded at Sawtell Rock Pool during the summer 2002–03 summer swimming season (see Figure 4). The swimming site complied with the guidelines in all seven months.

Levels of faecal coliforms and enterococci in Sawtell Rock Pool were relatively low between October 2002 and January 2003, a period dominated by dry weather conditions. Elevated results were more frequently measured in the latter half of the monitoring period and were generally related to rainfall. These results suggest a wet weather-related source of contamination.

Figure 4: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Coffs Harbour City Council swimming sites from October 2002 to April 2003

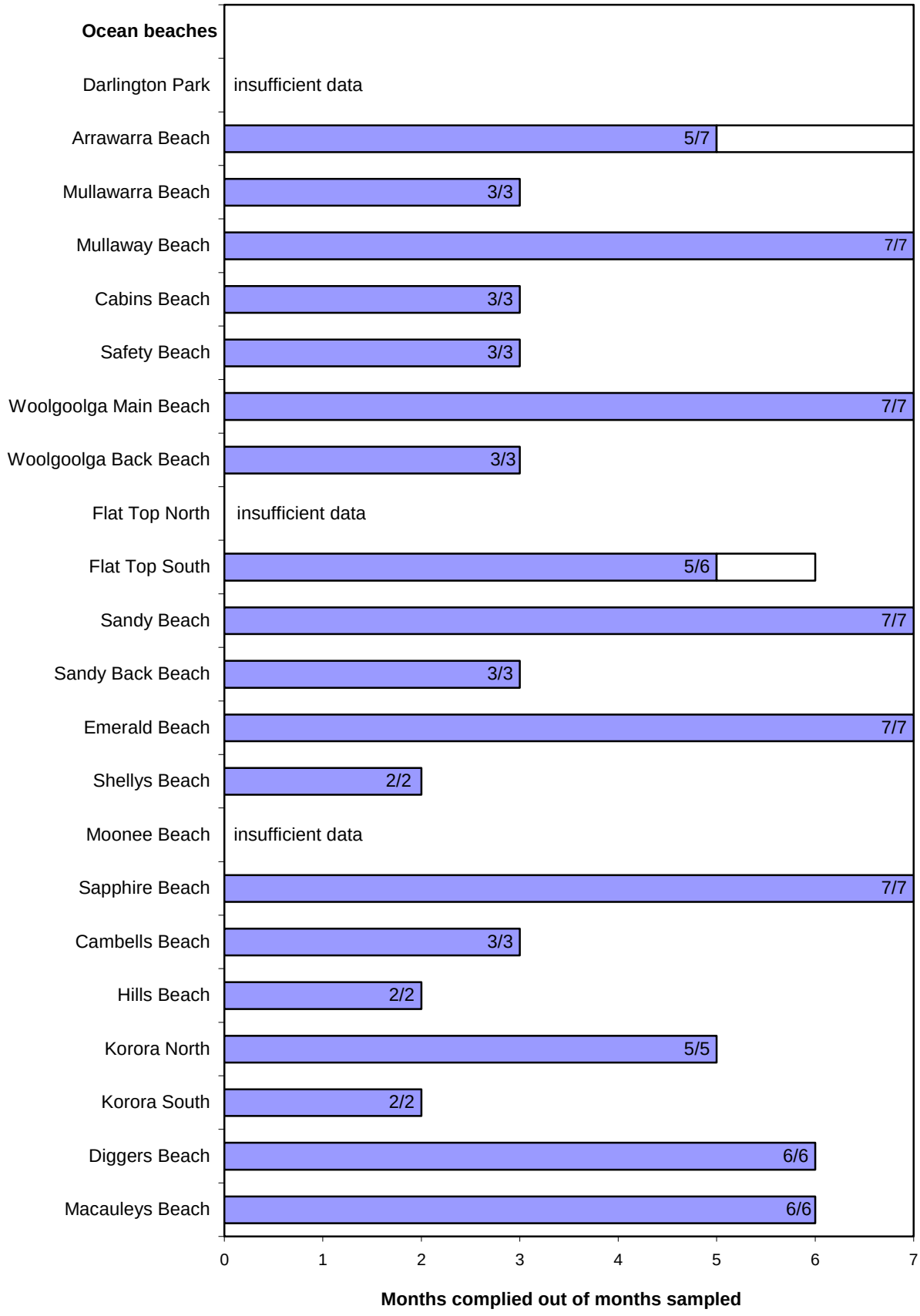
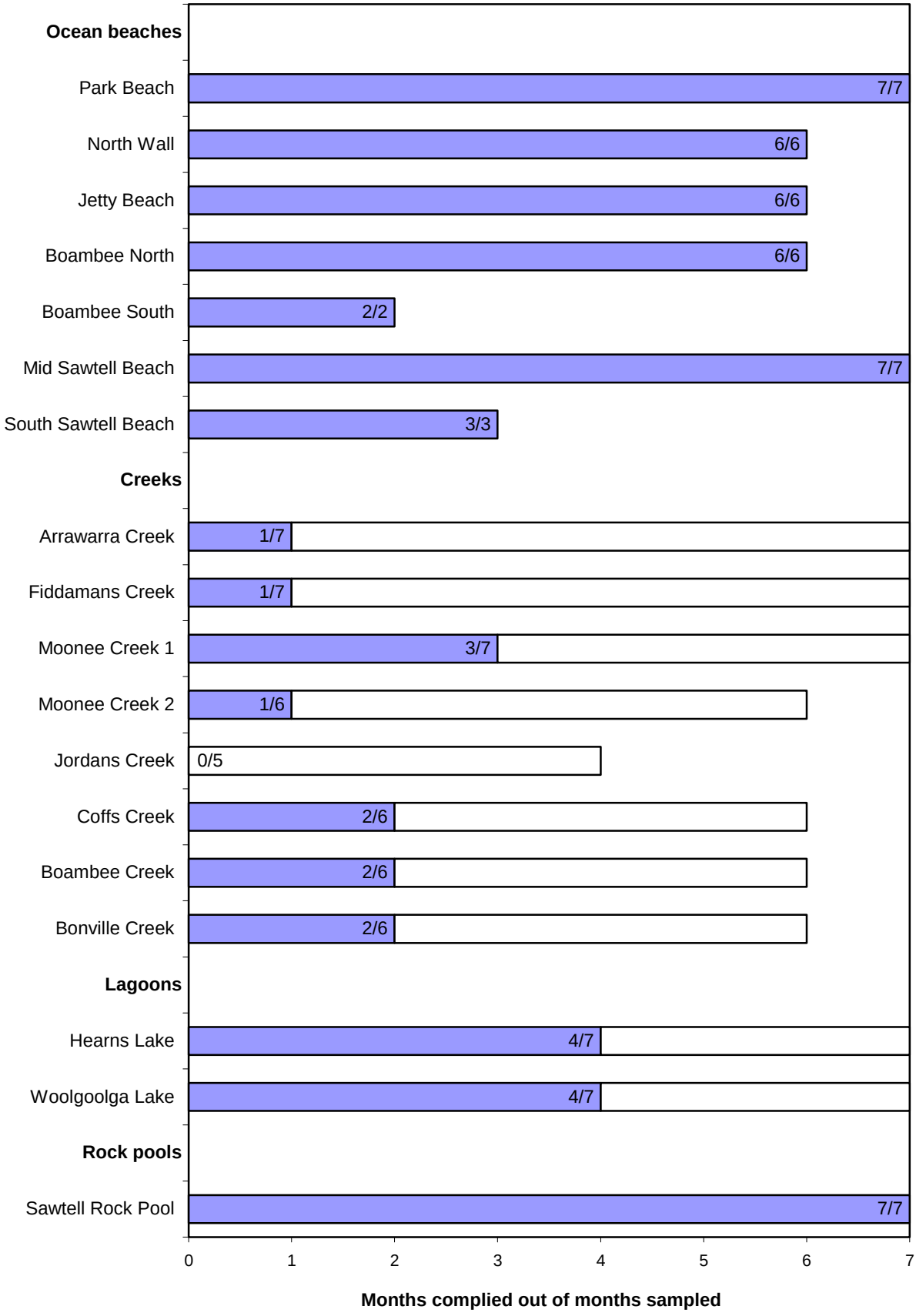


Figure 4 (continued): Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Coffs Harbour City Council swimming sites from October 2002 to April 2003



Tidal pools: Mylestom Pool, Seal Lido. **Creeks:** Station Creek, Pipe Clay Creek.

Local government area description

Bellingen Shire is on the NSW north coast, roughly 500 kilometres north of Sydney. It has 14 kilometres of coastline, extending between Mylestom in the north to Hungary Head in the south.

The Shire covers an area of 1604 square kilometres. Land use is predominately rural-residential with large tracts of national park, nature reserve and state forest (Bellingen Shire Council 2002).

The population of the area is approximately 12,000 and growing at a rate of 2.8 percent each year. The major towns in the region are Dorrigo, Bellingen, Myleston and Urunga.

The catchment of the Bellinger River covers 70 percent of the shire. The Bellinger and Kalang rivers meet adjacent to Urunga Lagoon and then flow to the ocean.

Program outline

Two estuarine swimming locations were monitored under the Recreational Water Monitoring – Bellinger / Kalang Rivers Program. These were Mylestom Pool, located on the Bellinger River, and Sea Lido, located at the entrance to Urunga Lagoon on the Kalang River.

Faecal coliform and enterococci samples were collected from both locations over the 2002–03 summer swimming season to assess compliance with the NHMRC (1990) swimming water guidelines. It should be noted that only four of the five samples necessary to calculate compliance were collected at Mylestom Pool in October 2002. To calculate compliance, the first sample collected in November was 'borrowed' to provide the five data points necessary.

Bacterial samples were also collected from a stormwater drain immediately upstream of Mylestom Pool and two tributaries of Urunga Lagoon; Station Creek and Pipe Clay Creek, to assess these locations as potential pollution sources. Bacterial monitoring was extended until July 2003 to assess the impact of wet weather sources of pollution on swimming water quality.

The impact of leachate from a disused antimony crushing plant in the Station Creek catchment on swimming water quality at Sea Lido was also assessed as part of the pilot program. Levels of arsenic and antimony were measured at Sea Lido, Station Creek and Pipe Clay Creek between October 2002 and April 2003. For arsenic, compliance was assessed against ANZECC (2000) swimming water quality guidelines. In the absence of swimming guidelines for antimony, compliance was conservatively assessed against NHMRC (1996) drinking water guidelines.

Mylestom Pool

Guideline compliance

Mylestom Pool complied with the NHMRC (1990) swimming water quality guidelines in five of the seven months of the 2002–03 summer swimming season (see Figure 5). The site did not meet the guidelines in March and April 2003 due to elevated levels of enterococci.

In general, low levels of indicator bacteria were measured between October 2002 and January 2003, a period dominated by dry weather conditions. Higher levels of enterococci were measured in the latter half of the monitoring period. Particularly high levels of bacteria were measured after rainfall in February and March 2003.

Pollution source assessment

Additional samples were collected at a stormwater outlet near Boronia Avenue between October 2002 and June 2003 to assess this as a possible source of pollution. Elevated bacterial levels were measured after rainfall events in February and March 2003, indicating that the drain is a source of faecal contamination during wet weather.

Sea Lido

Guideline compliance

Sea Lido complied with the NHMRC (1990) swimming water quality guidelines in six of the seven months of the 2002–03 summer swimming season (see Figure 5). The site did not meet the guidelines in February 2003 due to elevated levels of enterococci.

Levels of faecal coliforms and enterococci remained generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Higher levels of enterococci were measured in the latter half of the monitoring period, with particularly high levels recorded after heavy rainfall in February and March 2003.

Pollution source assessment

Additional samples were collected in Station Creek and Pipe Clay Creek, two tributaries of Urunga Lagoon, between October 2002 and June 2003, to assess these creeks as potential sources of pollution. Levels of both faecal coliforms and enterococci were higher in Station Creek and Pipe Clay Creek than the Sea Lido swimming location, suggesting that the tributaries are sources of faecal contamination.

Antimony and arsenic

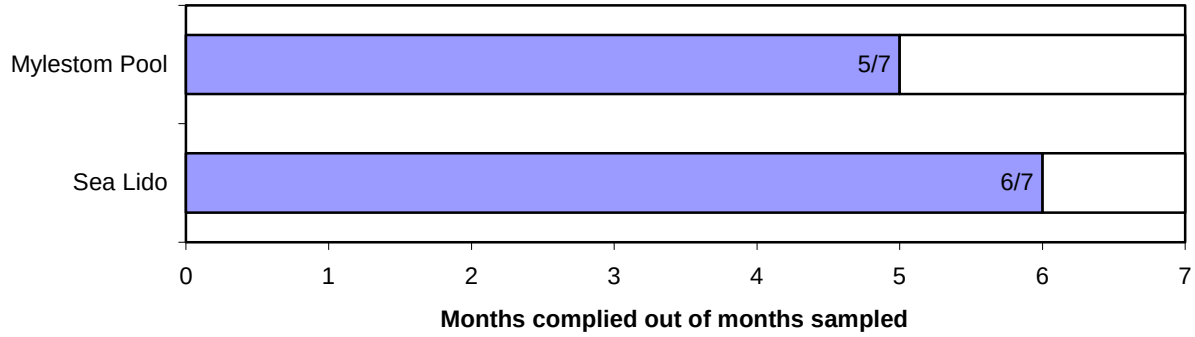
Levels of antimony and arsenic were measured at Sea Lido, Station Creek and Pipe Clay Creek between October 2002 and April 2003. The results from this monitoring indicate that the disused antimony crushing plant in the catchment has minimal impact on swimming water quality.

All levels of arsenic measured at Sea Lido were below the ANZECC (2000) swimming water quality guideline of 50 µg/L. Levels of antimony were also very low, exceeding the NHMRC (1996) drinking water guideline of 3 µg/L on only three occasions. As there is no swimming water quality guideline for antimony, the drinking water guideline was used as a conservative estimate.

Levels of arsenic and antimony measured in Pipe Clay Creek were generally low, and similar to those measured at Sea Lido.

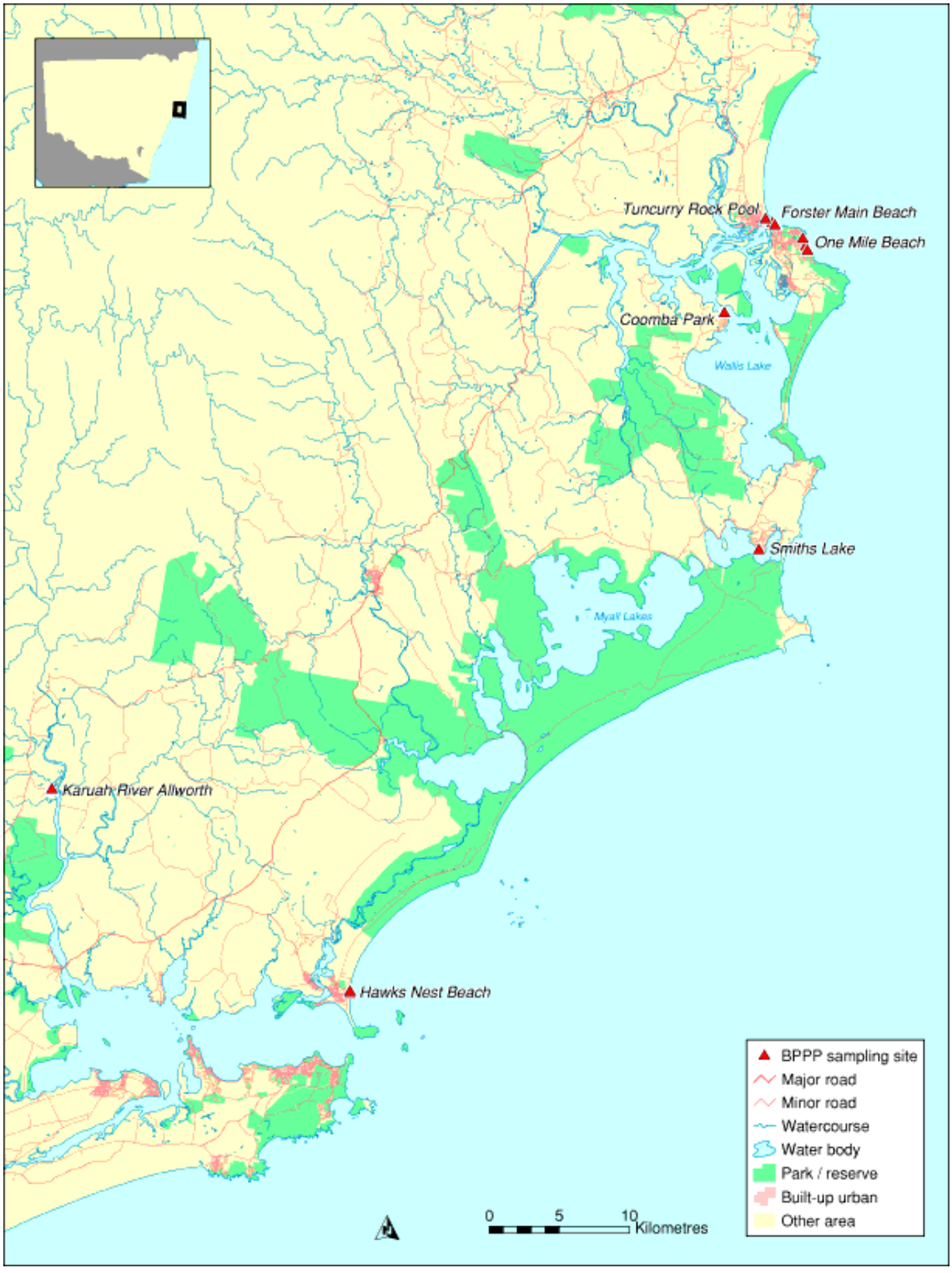
In contrast, levels of arsenic and antimony measured in Station Creek were much higher than those at Sea Lido. Antimony levels exceeded the NHMRC (1996) drinking water quality guideline of 3 µg/L on all occasions, while levels of arsenic consistently exceeded the ANZECC (2000) swimming water quality guideline of 50 µg/L between March and May 2003. Levels of both arsenic and antimony in Station Creek increased after February 2003, a period dominated by many small rainfall events. These results suggest that arsenic and antimony are washed into the creek during wet weather.

Figure 5: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Bellingen Shire Council swimming sites from October 2002 to April 2003



Great Lakes Council

Ocean beaches: Forster Main, One Mile, Hawks Nest. **Coastal Lakes:** Coomba Park, Smiths Lake. **Rock Pools:** Forster Pool, Tuncurry Rock Pool. **Riverine:** Karuah River.



Local government area description

The Great Lakes Council is located to the north of Port Stephens and has an area of 3373 square kilometres. Its coastline extends for 145 kilometres and is comprised of 27 beaches. Inland waterways are also a feature of the region, with numerous rivers and three lake systems: Wallis, Smiths and Myall lakes.

Land use in the Great Lakes region is predominantly rural, with approximately one-third of the council area made up of national parks and state forests (Great Lakes Council 2002).

The population of the area is approximately 35,000, and growing at a rate of two percent per year. Seventy five percent of the population live on the coast, with 57 percent in Forster and Tuncurry.

Program outline

Eight swimming locations were monitored as part of the Great Lakes Council Beachwatch Program. These sites included the three ocean beaches (Forster Main Beach, One Mile Beach and Hawks Nest Beach), two rock pools (Forster Pool and Tuncurry Rock Pool), two coastal lakes (Smiths Lake and Wallis Lake at Coomba Park) and a tidal pool on the Karuah River at Allworth. Sampling was not extended to July 2003 in this council area.

Faecal coliform and enterococci samples were collected from Forster Main Beach, One Mile Beach, Forster Pool and Tuncurry Rock Pool over the 2002–03 summer swimming season to assess compliance with NHMRC (1990) swimming water quality guidelines. It should be noted that the five samples necessary to calculate compliance were not collected in all months. In months with only four samples, the closest sample in time from an adjacent month was 'borrowed' to provide the five data points required.

Less intensive monitoring was carried out at two locations on Hawks Nest Beach, Smiths Lake, Coomba Park and Karuah River. Five samples were collected from all sites except Karuah River in October 2002 to assess compliance with NHMRC (1990) swimming water quality guidelines. Samples were then collected monthly and in response to rainfall events.

Additional samples were collected from stormwater outlets, creeks and upstream or surrounding waters at all locations except Hawks Nest Beach, Smiths Lake and Tuncurry Rock Pool. This monitoring was conducted to assess potential sources of faecal contamination.

Ocean beaches

Guideline compliance

A high level of compliance was recorded at Forster Main Beach and One Mile Beach (see Figure 6). Both sites complied with the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002–03 summer swimming season. Hawks Nest Beach complied with the swimming guidelines in October 2002, the only month in which sufficient samples were collected to calculate compliance.

Levels of faecal coliforms and enterococci measured at Forster Main Beach and One Mile Beach were consistently low over the swimming season, providing little evidence of sewage contamination. Similarly low levels were measured at Hawks Nest Beach.

Pollution source assessment

Additional samples were collected from the stormwater drain discharging to the southern end of Forster Main Beach, and the stormwater drain and creek discharging to One Mile Beach. These samples were collected to assess these locations as potential sources of beach pollution.

At Forster Main Beach, elevated bacterial levels were frequently measured in the stormwater drain during wet weather, with particularly high levels of enterococci recorded after heavy rainfall in early December 2002. These data indicate that the drain is a source of faecal contamination. Swimming should be avoided in the vicinity of the drain, particularly after heavy rainfall.

At One Mile Beach, elevated levels of faecal coliforms and enterococci were measured in

the drain and creek. The highest levels were recorded in early December 2002 in response to heavy rainfall. While these sources appear to have little impact on water quality in the centre of the beach, swimming near the stormwater drain outlet and in the creek should be avoided, particularly after heavy rainfall.

Rock pools

Guideline compliance

A high level of compliance was recorded at Tuncurry Rock Pool, which complied with the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002–03 summer swimming season (see Figure 6). Forster Pool complied with the swimming guidelines in five of the six months in which sufficient samples were collected. The site did not meet the guidelines in February 2003 due to slightly elevated levels of enterococci.

Coastal lakes

The swimming locations in Smiths Lake and Wallis Lake at Coomba Park complied with NHMRC (1990) swimming water quality guidelines in October 2002, the only month in which sufficient samples were collected to calculate compliance.

Levels of indicator bacteria at these locations were generally low during dry weather conditions, with slightly elevated levels measured in response to heavy rainfall in early December 2002.

Pollution source assessment

Additional samples were collected from the stormwater outlet at Coomba Park and from Wallis Lake adjacent to the Coomba Park Pool to assess these locations as potential sources of bacterial contamination. Elevated bacterial levels were measured in the stormwater drain after heavy rainfall in early December and late March. Slightly elevated bacterial levels were also measured in the pool at these times. Levels of bacteria measured in Wallis Lake were slightly lower than those in the pool, particularly after rainfall. These results suggest that the stormwater drain is the main source of bacterial contamination, however, more data is required to confirm this finding.

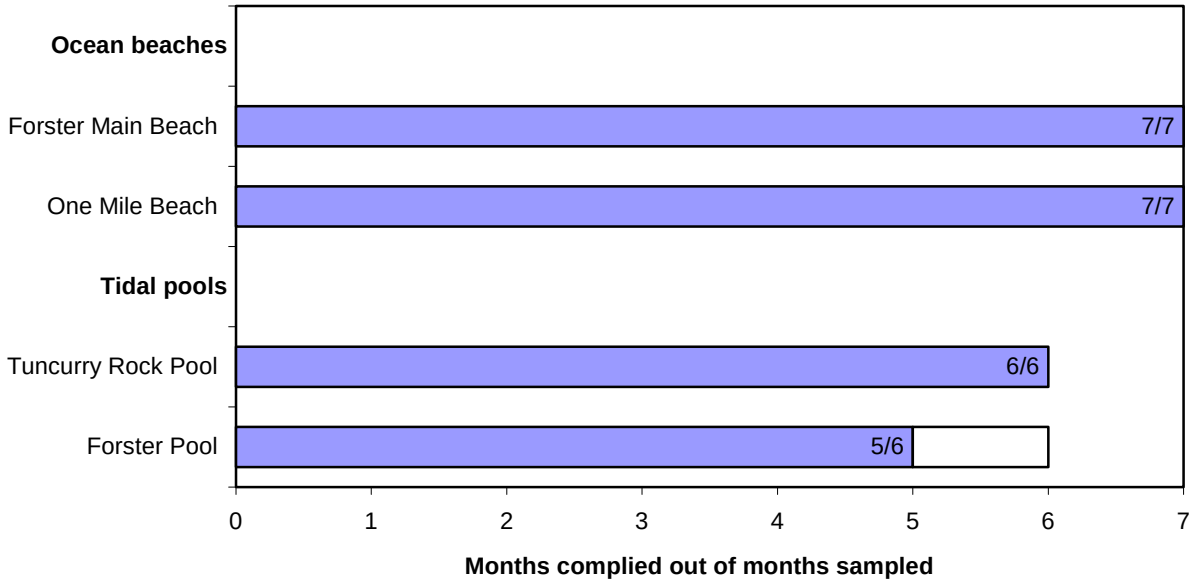
Karuah River

Levels of indicator bacteria measured in the Karuah River Tidal Pool were generally low during dry weather conditions. Very high levels of faecal coliforms and enterococci were measured after heavy rainfall in early December 2002, with slightly elevated results measured in response to rainfall between February and April 2003.

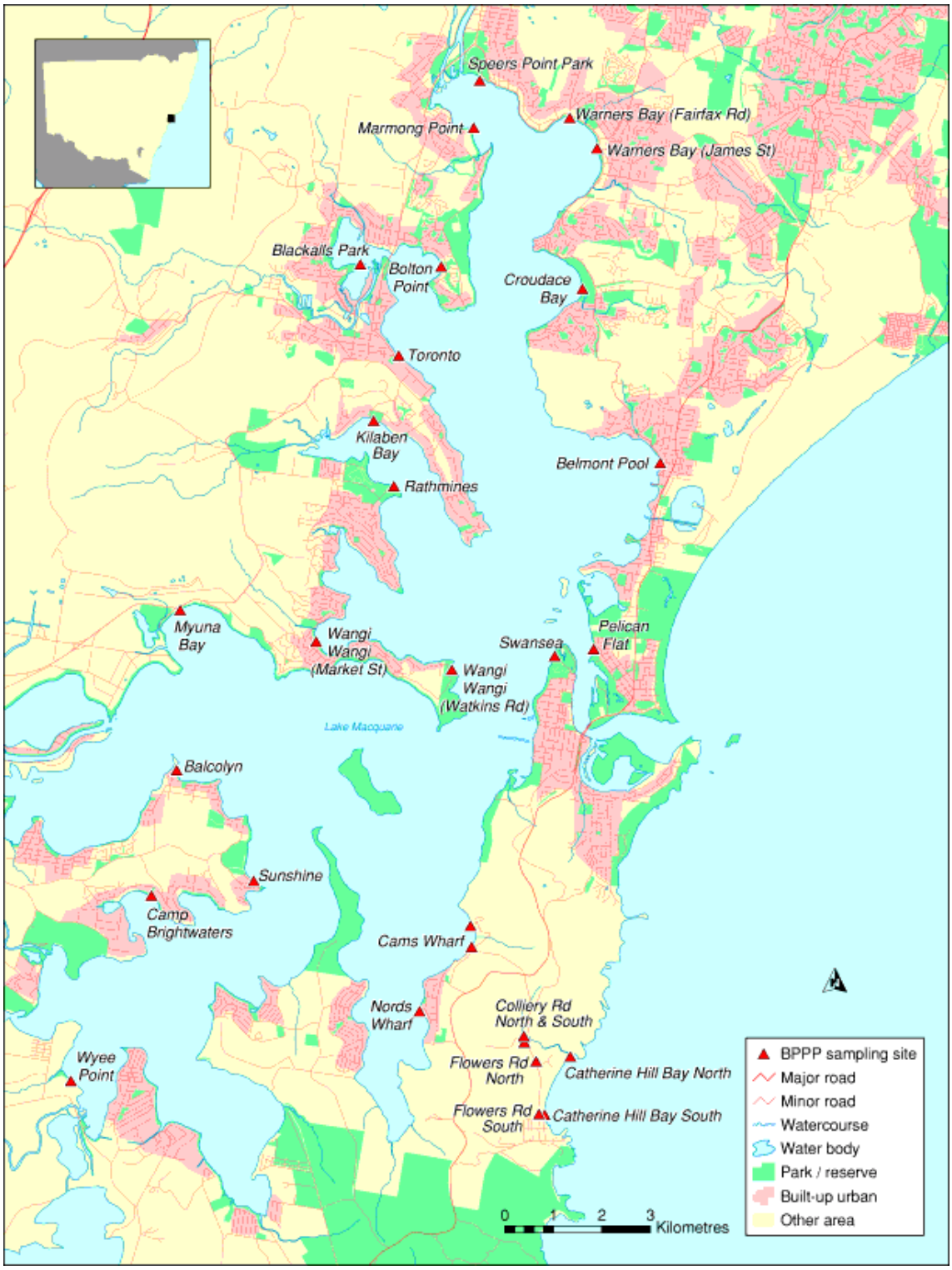
Pollution source assessment

Additional samples were collected from two stormwater outlets and the Karuah River upstream of the Tidal Pool to assess these locations as potential sources of faecal contamination. Elevated bacterial levels were measured at the stormwater outlets, with particularly high levels measured after heavy rainfall in early December 2002. Levels of indicator bacteria measured in the Karuah River were similar to those in the tidal pool.

Figure 6: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Great Lakes Council swimming sites from October 2002 to April 2003



Ocean beaches: Catherine Hill Bay North, Catherine Hill Bay South. **Lake Macquarie:** Speers Point Park, Warners Bay, Marmong Point, Blackalls Park, Bolton Point, Toronto, Kilaben Bay, Rathmines, Wangi Wangi, Swansea, Pelican Flat, Myuna Bay, Balcolyn, Sunshine, Camp Brightwaters, Cams Wharf, Nords Wharf, Wyee Point. **Tidal Pools:** Croudace Bay Pool, Belmont Pool. **Creeks:** Colliery Road, Flowers Drive.



Local government area description

The Lake Macquarie local government area is located to the south of Newcastle on the NSW central coast. It covers an area of 749 square kilometres, with the coastal salt water lake of Lake Macquarie covering an area of 110 square kilometres.

The population of the region is 186,020 and growing at the rate of 1.3 percent each year. The highest employing commercial activities of the region are retail trading and manufacturing (Lake Macquarie City Council 2002).

Program outline

A total of 29 sites were monitored under the Lake Macquarie Swim Safe Study, including 21 sites in Lake Macquarie, two ocean beaches, two tidal pools and four creek sites. The number of sampling sites was reduced from 46 at the outset of the program due to limited staff resources to undertake monitoring.

Faecal coliform and enterococci samples were collected from seven locations over the 2002–03 summer swimming season to assess compliance with NHMRC (1990) swimming water quality guidelines. The locations chosen for compliance monitoring were Catherine Hill Bay North, Catherine Hill Bay South, Wyee Point, Swansea, two locations in Warners Bay in the north of Lake Macquarie, and Myuna Bay in the south. Only two samples were collected during December 2002, which is an insufficient number to calculate guideline compliance for that month. Guideline compliance was also assessed for July 2003 at all seven locations.

At the remaining 18 locations, faecal coliform and enterococci samples were collected to assess the impact of wet weather on swimming water quality. Samples were collected in dry weather conditions, as well as during and after rainfall events. Sufficient samples to calculate compliance were collected at these sites in October 2002.

Due to the dry weather conditions over the 2002–03 summer swimming season, sampling was extended until July 2003 at all locations.

Additional samples were also collected from creeks and stormwater drains in the vicinity of several sampling sites to assess these locations as potential sources of sewage contamination.

Ocean beaches

Guideline compliance

A high level of compliance was recorded at Catherine Hill Bay North and Catherine Hill Bay South (see Figure 7). Both sites complied with NHMRC (1990) swimming water quality guidelines in all six months of the 2002–03 summer swimming season in which sufficient samples were collected. Compliance samples were also collected in July 2003, with both sites passing in this month.

Levels of indicator bacteria at Catherine Hill Bay North and Catherine Hill Bay South were generally very low throughout the monitoring period. Slightly elevated levels of enterococci were measured at Catherine Hill Bay South in response to heavy rainfall in early December 2002. Catherine Hill Bay North was not sampled during this rainfall event.

It should be noted that a further six ocean beaches in the Lake Macquarie Council area are included in the routine Beachwatch Program. Compliance results for these beaches are presented in the annual *Beachwatch and Harbourwatch State of the Beaches* reports (see Appendix C, Further Reading).

Pollution source assessment

Additional samples were collected from three sites in the Catherine Hill Bay North catchment and one site in the Catherine Hill Bay South catchment to assess these locations as potential sources of bacterial contamination. Elevated levels of indicator bacteria were measured at Colliery Road North, Colliery Road South, Flowers Drive North and Flowers Drive South, with particularly high levels recorded after

rainfall. These results indicate a source of sewage contamination in the catchments, with additional sampling required to isolate the source or sources.

Lake Macquarie – north

Fifteen sampling sites were located in the northern embayment of Lake Macquarie. These sites included Belmont Pool, Croudace Bay Pool, Warners Bay (James Street and Fairfax Road), Speers Point Park, Marmong Point, Bolton Point, Blackalls Park, Toronto, Kilaben Bay, Rathmines, Wangi Wangi Bay, Wangi Wangi Point, Swansea and Pelican Flat.

Guideline compliance

A reasonably high level of compliance was recorded at sites in the northern embayment of Lake Macquarie (see Figure 7). Wyee Point and Swansea complied with NHMRC (1990) swimming water quality guidelines in all seven months of the 2002–03 summer swimming season.

The two sites in Warners Bay, at James Street and Fairfax Road, complied with swimming water quality guidelines in five of the six months in which sufficient samples were collected to calculate compliance. Both these sites did not meet the guidelines in April 2003, a month with many small rainfall events.

At the remaining 11 sites in this area of the lake, the five samples required to calculate compliance were collected in October 2002 only. All locations passed the swimming water quality guidelines in this month.

Response to rainfall

Levels of faecal coliforms and enterococci measured at Croudace Bay Pool, Marmong Point, Toronto, Kilaben Bay, Rathmines, Wangi Wangi Bay, Wangi Wangi Point and Swansea were generally low throughout the monitoring period. Heavy rainfall in early December 2002 resulted in only small increases in bacterial levels at these sites. The data suggests that these locations are rarely affected by sewage contamination. However, additional sampling is required to confirm this finding.

Low levels of indicator bacteria were also measured at Speers Point, Blackalls Park, Bolton Point, Pelican Point and Belmont Pool during dry weather conditions. High levels of faecal coliforms and enterococci were measured at these sites during heavy rainfall in early December 2002, indicating a wet weather source of sewage contamination in the vicinity of these swimming locations. Swimming should be avoided in these areas during and after heavy rainfall.

At the two Warners Bay locations, Fairfax Road and James Street, elevated levels of indicator bacteria were measured on several occasions throughout the monitoring period. While in most instances these results were associated with rainfall events, slightly elevated levels of bacteria were also recorded during dry weather conditions. Swimming in Warners Bay should be avoided during and after rainfall.

Lake Macquarie – south

Eight sampling sites were located in the southern embayment of Lake Macquarie. These sites included Myuna Bay, Balcolyn, Sunshine, Camp Brightwaters, Wyee Point, Nords Wharf and two locations at Cams Wharf.

Guideline compliance

A reasonably high level of compliance was recorded at Myuna Bay (see Figure 7). This site complied with NHMRC (1990) swimming water quality guidelines in five of the six months of the 2002–03 summer swimming season in which sufficient samples were collected to calculate compliance. Myuna Bay failed the guidelines in January due to elevated levels of faecal coliforms. Guideline compliance sampling was also undertaken in July 2003 and Myuna Bay passed the guidelines in this month.

At the remaining seven sites in this area of the lake, the five samples required to calculate compliance were collected in October 2002 only. All locations passed the swimming water quality guidelines in this month.

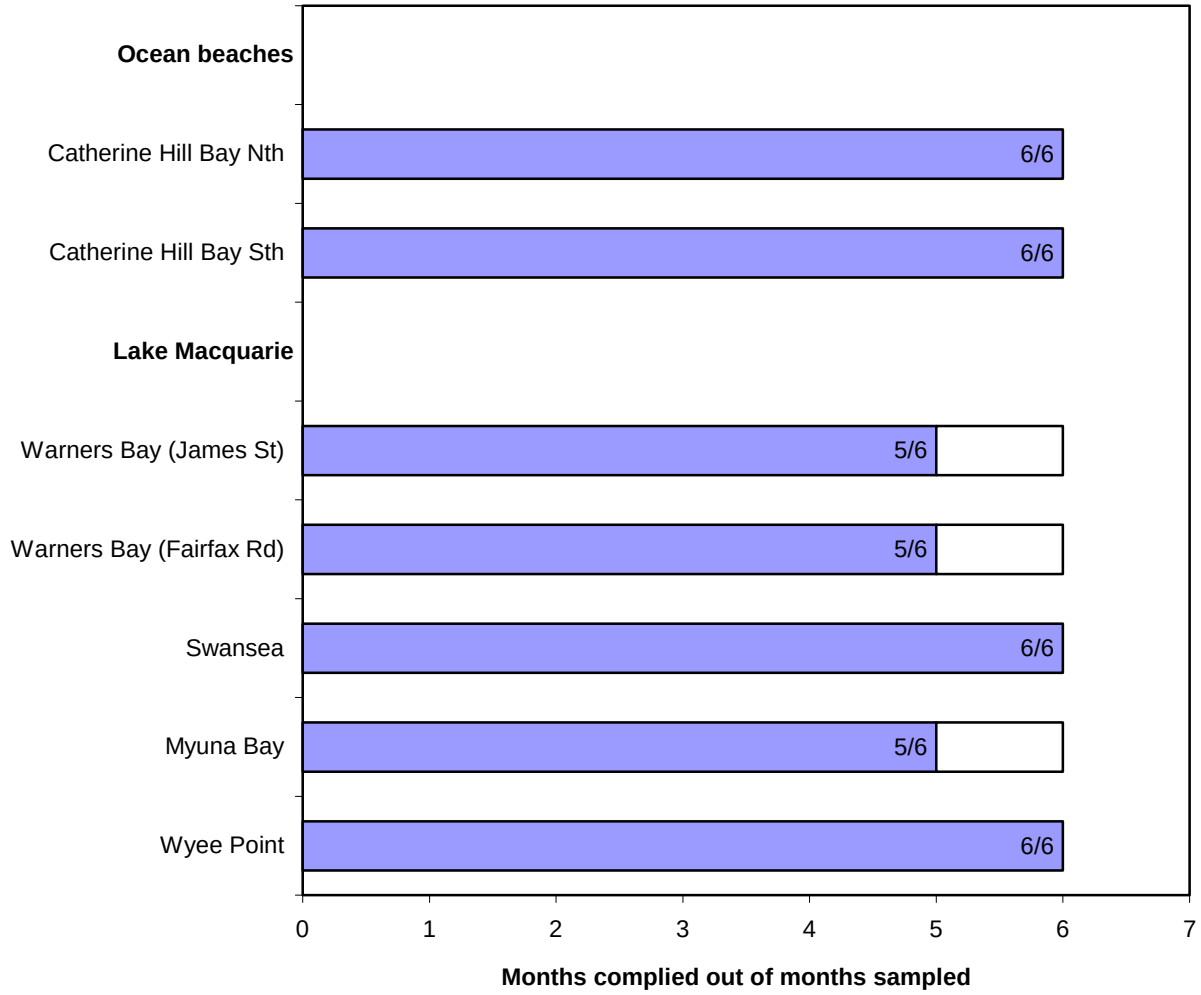
Response to rainfall

Levels of faecal coliforms and enterococci recorded at Sunshine, the two sites at Cams Wharf (Point Morisset and Wharf Road) and Nords Wharf were generally low throughout the monitoring period. Heavy rainfall in early December 2002 resulted in only slightly elevated levels of indictor bacteria. The data suggests that these sites are rarely affected by sewage contamination, however, additional sampling is required to confirm this finding.

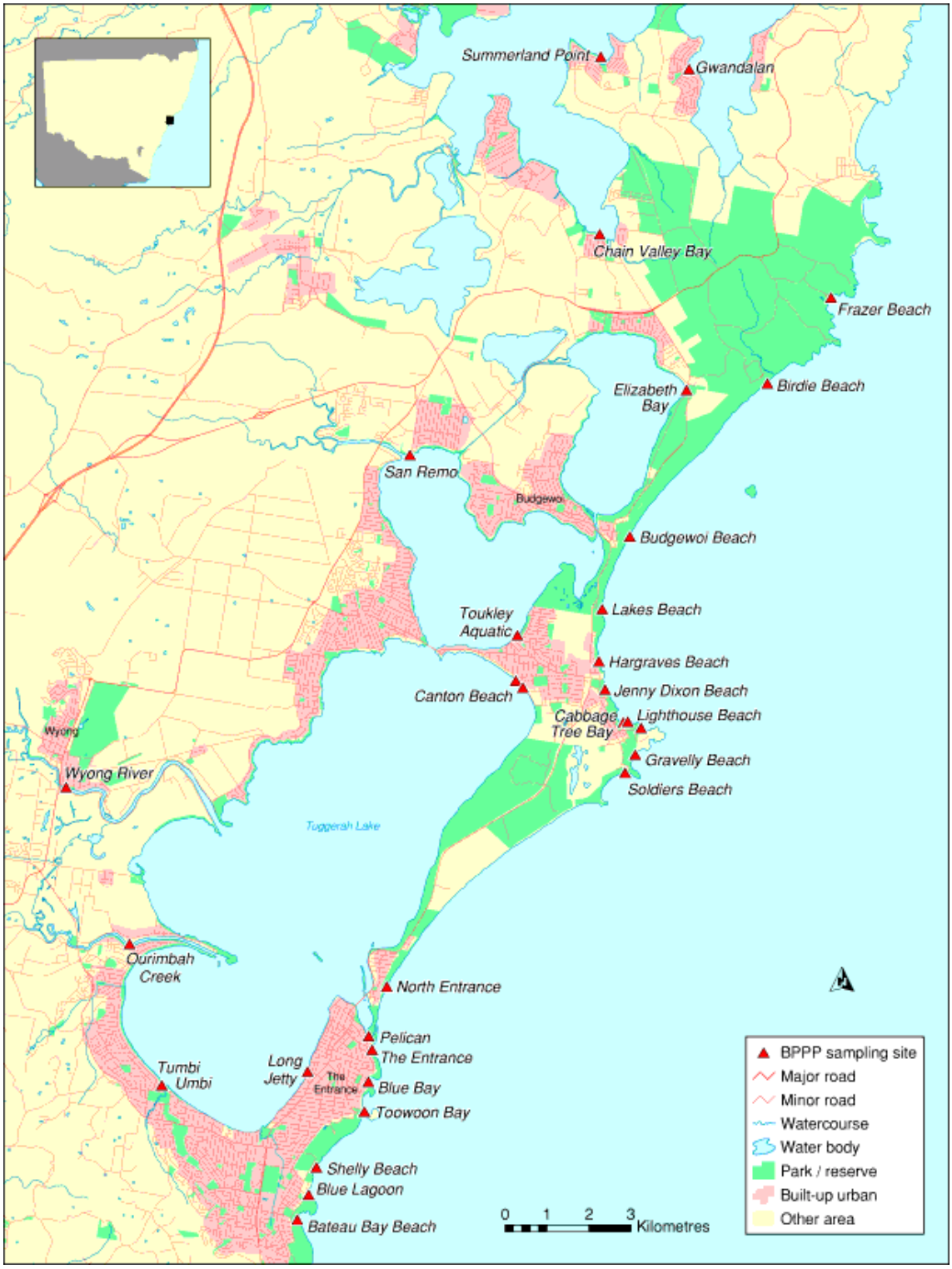
Levels of indicator bacteria were also generally low at Camp Brightwaters. Heavy rainfall in early December 2002 resulted in high levels of faecal coliforms and enterococci, suggesting that a wet weather source of sewage contamination is located in the vicinity of the site. Swimming should be avoided during and after heavy rainfall.

At Myuna Bay, Balcolyn and Wyee Point, elevated levels of faecal coliforms and enterococci were measured on several occasions throughout the monitoring period. At Myuna Bay and Balcolyn, elevated bacterial levels were measured on one or more instances in dry weather conditions. Swimming at these three sites should be avoided during and after rainfall and in dry weather if there are visual signs of pollution such as discoloured water.

Figure 7: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Lake Macquarie City Council swimming sites from October 2002 to April 2003



Ocean beaches: Frazer, Birdie, Budgewoi, Lakes, Hargraves, Jenny Dixon, Cabbage Tree, Lighthouse, Gravelly, Soldiers, North Entrance, The Entrance, Blue Bay, Toowoon Bay, Shelly, Blue Lagoon, Bateau Bay. **Estuarine river sites:** Wyong River, Ourimbah Creek, Tumbi Umbi Creek. **Coastal lakes:** Summerland Point, Gwandalan, Chain Valley Bay, Elizabeth Bay, San Remo, Toukley Aquatic, Canton Beach, Pelican, Long Jetty. **Tidal Pools:** Cabbage Tree Bay.



Local government area description

Wyong Shire Council is located 100 kilometres north of Sydney and covers an area of 827 square kilometres. The Shire extends from Gwandalan in the north, to Ourimbah in the south and has a population of approximately 135,900 growing at the rate of 3.9 percent each year. There is a considerable expansion in planned urban development within the shire.

The council area encompasses numerous ocean beaches, the southern extent of Lake Macquarie, Tuggerah Lakes and the Wyong River.

Wyong Shire is characterised by towns and villages separated by extensive areas of natural vegetation, with the three most predominant land uses being urban, agriculture and forestry (Wyong Shire Council, 2002).

Program outline

Thirty one swimming locations were monitored under the Wyong Shire Council Beachwatch Program, including 17 ocean beaches, nine coastal lake sites, two tidal pools, and three estuarine river sites in the Tuggerah Lakes catchment.

Faecal coliform and enterococci samples were collected from all 31 locations over the 2002–03 summer swimming season to assess compliance with NHMRC (1990) swimming water quality guidelines. The five samples required to assess compliance were collected in all seven months.

Monitoring was extended from May until July 2003 at Chain Valley Bay, Gwandalan, Elizabeth Bay, Wyong River and two sites at Canton Beach to assess the impact of wet weather on swimming water quality. Samples were collected during and after rainfall in this period.

Ocean beaches and rock pool

A high level of compliance with NHMRC (1990) swimming water quality guidelines was recorded at the 17 ocean beaches and Cabbage Tree Bay Rock Pool (Figure 7). All beaches, from Frazer in the north to Bateau Bay in the south, and the rock pool were suitable for swimming in all seven months of the 2002–03 summer swimming season.

Bacterial levels at all beaches were generally low throughout the monitoring period. While slightly elevated levels of bacteria were measured at most of the ocean beaches and the rock pool on one or two occasions, monitoring did not reveal evidence of sewage contamination in either dry or wet weather conditions.

Lake Macquarie

Three swimming locations were monitored in Lake Macquarie: Summerland Point, Gwandalan and Chain Valley Bay. The highest level of compliance was recorded at Chain Valley Bay, which passed the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002-03 summer swimming season (see Figure 8). While levels of faecal coliforms and enterococci at this site were mostly low throughout the monitoring period, slightly elevated levels were occasionally measured in response to heavy rainfall and occasionally measured during dry weather.

Summerland Point complied with the guidelines in six of the seven month of the 2002–03 summer swimming season. The site did not meet the guidelines in December 2002 due to elevated levels of enterococci. Bacterial levels were generally low during dry weather conditions, with elevated levels measured during wet weather conditions.

Gwandalan complied with the guidelines in five of the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in December 2002 and April 2003. Elevated bacterial levels were frequently measured during the monitoring period, with particularly high levels measured after rainfall on several occasions. These results suggest that swimming in Lake Macquarie should be avoided during and after rainfall.

Lake Munmorah

Elizabeth Bay, located in the southeast corner of Lake Munmorah, complied with the NHMRC (1990) swimming water

quality guidelines in four of the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in October 2002, March 2003 and April 2003.

Levels of faecal coliforms and enterococci at Elizabeth Bay remained relatively low in dry weather conditions. Elevated bacterial levels were measured on several occasions in response to rainfall, with the highest levels measured during heavy rainfall in mid March 2003.

Lake Budgewoi

Two swimming locations were monitored in Lake Budgewoi: San Remo in the north and Toukley Aquatic in the south.

Toukley Aquatic complied with NHMRC (1990) swimming water quality guidelines in six of the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in April 2003. Bacterial levels at this site were generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Elevated levels of faecal coliforms and enterococci were measured between March and April 2003 in response to a large number of rainfall events.

A slightly lower level of compliance was measured at San Remo, which passed the guidelines in four of the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in October 2002, March 2003 and April 2003. Elevated levels of faecal coliforms and enterococci were measured on several occasions throughout the monitoring period, with particularly high levels measured in response to heavy rainfall in early December 2002 and mid March 2003. These results indicate a wet weather source of sewage contamination in the vicinity of the swimming site.

Tuggerah Lake

Four swimming locations were monitored in Tuggerah Lake: two sites at Canton Beach in the north, Long Jetty in the south, and Pelican near the entrance to the lake.

The highest levels of compliance were recorded at Long Jetty and Pelican; both complied with the NHMRC (1990) swimming water quality guidelines in six of the seven months of the 2002–03 summer swimming season. Both sites did not meet the guidelines in April 2003.

At Long Jetty, bacterial levels were generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Elevated levels of faecal coliforms and enterococci were measured in March and April 2003 in response to heavy rainfall. At Pelican, slightly elevated bacterial levels were measured throughout the monitoring period, with the highest levels measured after heavy rainfall in mid March 2003.

Canton Beach near Lakeview Street complied with the swimming guidelines in four of the seven months of the 2002–03 summer swimming season, while Canton Beach near Belbowrie Street complied in only one month (October 2002). Elevated levels of faecal coliforms and enterococci were frequently measured at both sites during the monitoring period, with particularly high levels measured after rainfall. The data indicates that a wet weather source of sewage contamination is located in the vicinity of Canton Beach. Swimming in this area should be avoided during and after rainfall.

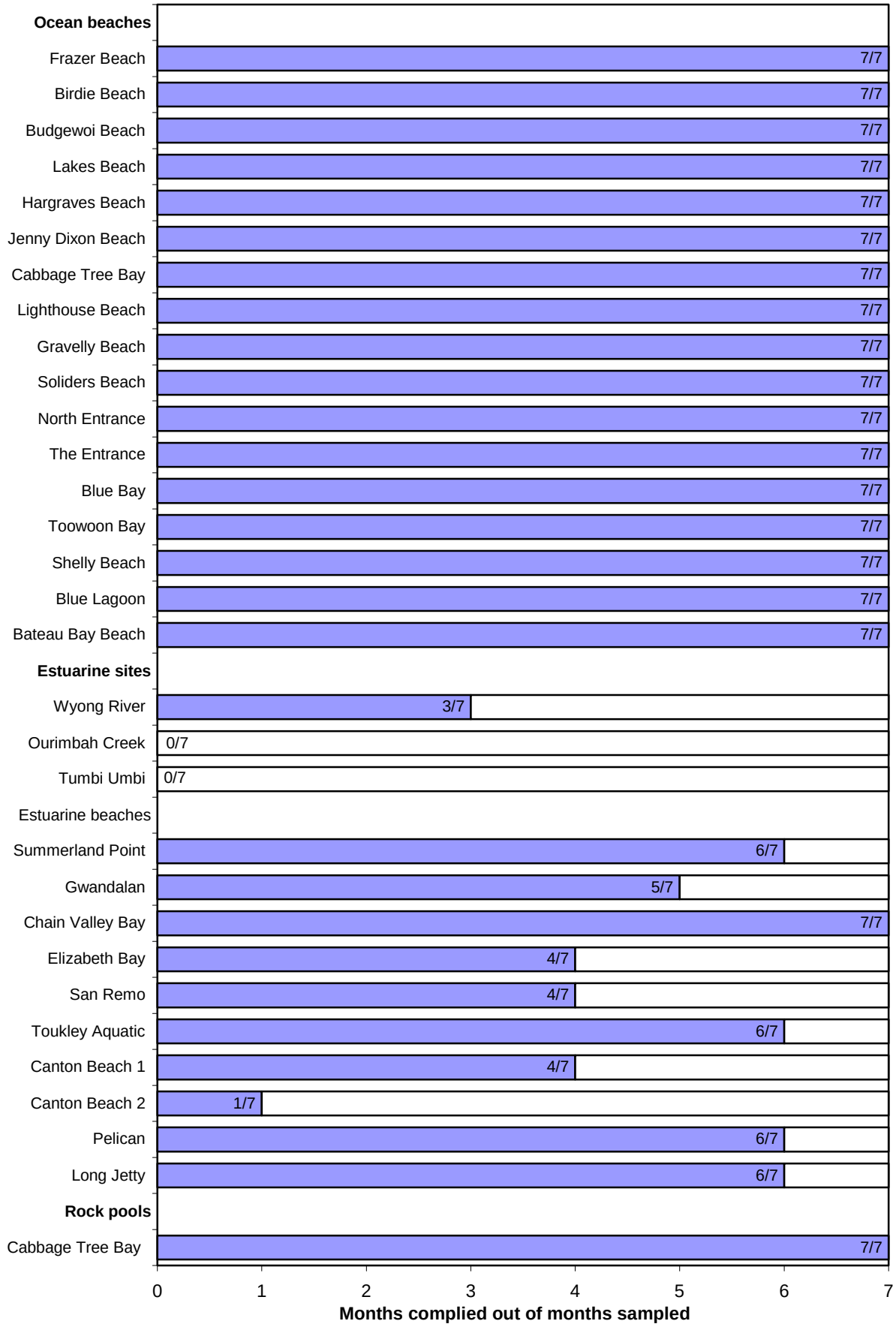
Tuggerah Lakes Catchment

Three waterways in the Tuggerah Lakes Catchment were monitored: Wyong River, Ourimbah Creek and Tumbi Umbi Creek.

Wyong River complied with the NHMRC (1990) swimming water quality guidelines in three of the seven months of the 2002–03 summer swimming season. Elevated bacterial levels were measured on a number of occasions throughout the monitoring period, with particularly high levels recorded in response to rainfall in March and April 2003.

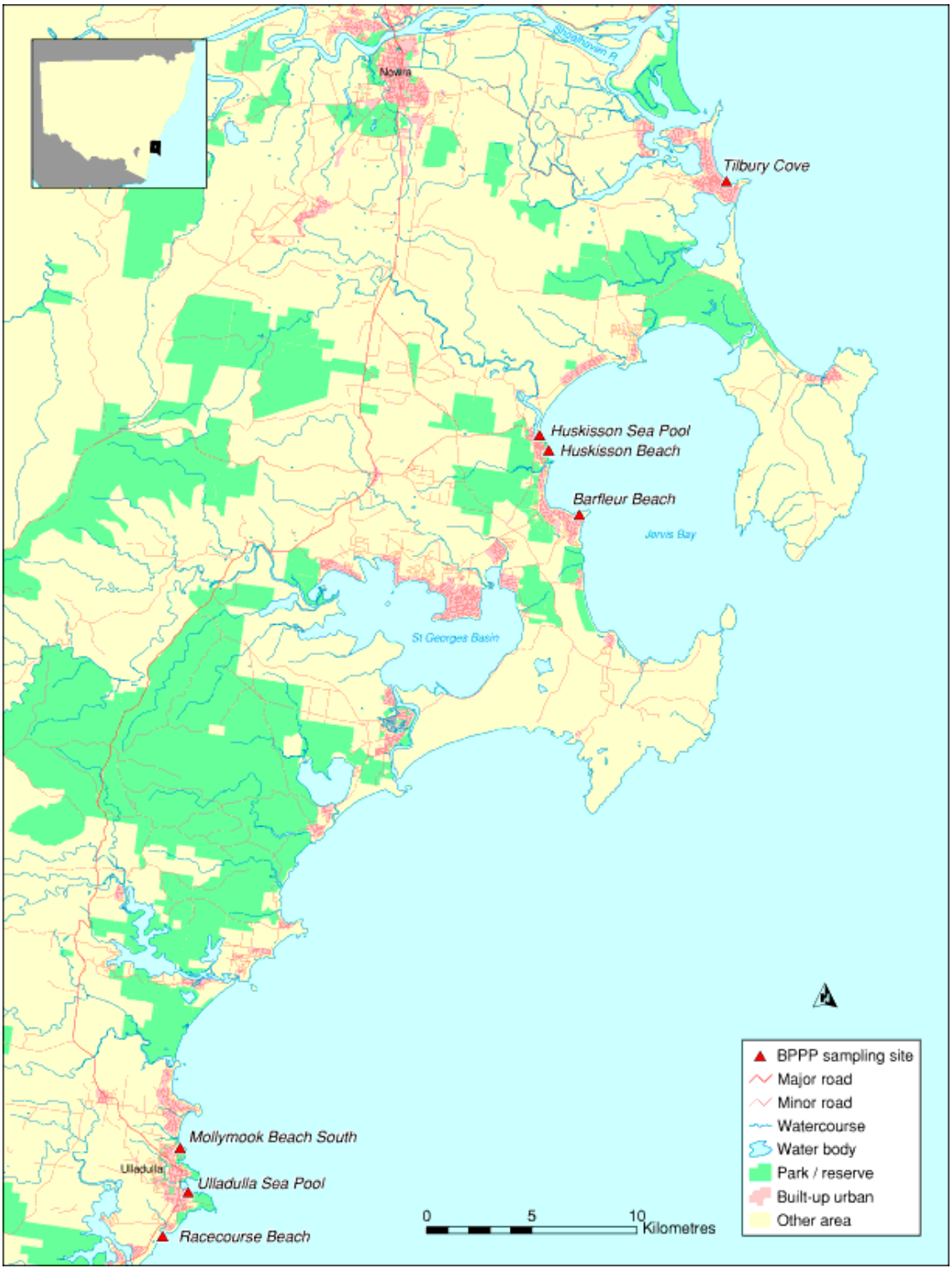
Ourimbah Creek and Tumbi Umbi Creek failed the guidelines in all seven months of the 2002–03 summer swimming season. High levels of faecal coliforms and enterococci were regularly measured at these locations, with particularly high levels measured during and after rainfall. Swimming should be avoided at Ourimbah Creek and Tumbi Umbi Creek at all times.

Figure 8: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Wyong Shire Council swimming sites from October 2002 to April 2003



Shoalhaven City Council

Ocean beaches: Tilbury Cove, Huskisson, Barfleur, Mollymook South, Racecourse.
Sea pools: Huskisson Sea Pool, Ulladulla Sea Pool.



Local government area description

Shoalhaven City Council is located on the NSW south coast and extends from Broughton in the north to North Durras in the south. The council covers an area of 4660 square kilometres and includes approximately 1000 kilometres of coastline.

The population of the region is approximately 90,400 and growing at the rate of 2.8 percent each year.

The Shoalhaven has more visitors each year than any other regional local government area in NSW, and tourism is very important to the local economy. Dairy farming, light industry and fishing are also important commercial activities in the region (Shoalhaven City Council, 2003).

Program outline

Seven sites were monitored under the Shoalhaven Council Beachwatch Partnership Pilot Program. These included the five ocean beaches (Tilbury Cove, Huskisson Beach, Balfleur Beach, Mollymook Beach South and Racecourse Beach) and two sea pools (Huskisson Sea Pool and Ulladulla Sea Pool).

Faecal coliform and enterococci samples were collected from Tilbury Cove, Huskisson Sea Pool, Balfleur Beach, Ulladulla Sea Pool and Racecourse Beach over the 2002–03 summer swimming season to assess compliance with NHMRC (1990) swimming water quality guidelines. It should be noted that the required five samples were not collected in some months. Where four samples were collected, the closest sample in time from an adjacent month was 'borrowed' to provide the five samples for the compliance calculation. Samples were not collected during April 2003 at Huskisson Sea Pool or Ulladulla Sea Pool as they were closed for the season.

At the remaining two locations, Huskisson Beach and Mollymook Beach South, faecal coliform and enterococci samples were collected to assess the impact of wet weather on swimming water quality. Samples were collected in dry weather conditions, as well as during and after rainfall events. Due to the dry weather conditions over the 2002–03 summer swimming season, few wet weather samples were collected.

Sampling was extended until July 2003 at Mollymook Beach South, Huskisson Beach and Racecourse Beach to obtain additional information on wet weather sources of pollution. During this period, samples were collected from swimming locations as well as nearby creeks and stormwater drains.

Ocean beaches

Guideline compliance

A high level of compliance was recorded at ocean beaches in the Shoalhaven. Tilbury Cove, Barfleur Beach and Racecourse Beach complied with the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002–03 summer swimming season (see Figure 9).

Levels of faecal coliforms and enterococci measured at these beaches were generally low throughout the monitoring period, showing no evidence of sewage contamination.

Sufficient samples to calculate compliance were collected from Huskisson Beach and Mollymook Beach south in October 2002. This was done to establish baseline water quality information. Both sites complied with the NHMRC (1990) swimming water quality guidelines in this month.

Bacterial levels were consistently low throughout the monitoring period at Huskisson Beach, showing no evidence of sewage contamination. Levels were also generally low at Mollymook Beach South, with a single high value recorded during heavy rainfall at the end of June 2003.

Pollution source assessment

Additional samples were collected between May and July 2003 from potential sources of pollution discharging to Mollymook Beach South, Huskisson Beach and Racecourse Beach.

At Mollymook Beach South, samples were collected from Mollymook Creek and a stormwater outlet just north of the beach

sampling site. At Racecourse Beach, samples were collected from Racecourse Creek and a stormwater outlet at the northern end of the beach.

At Huskisson Beach samples were collected from the stormwater outlets at the northern end of the beach and Moona Moona Creek at the south of the beach

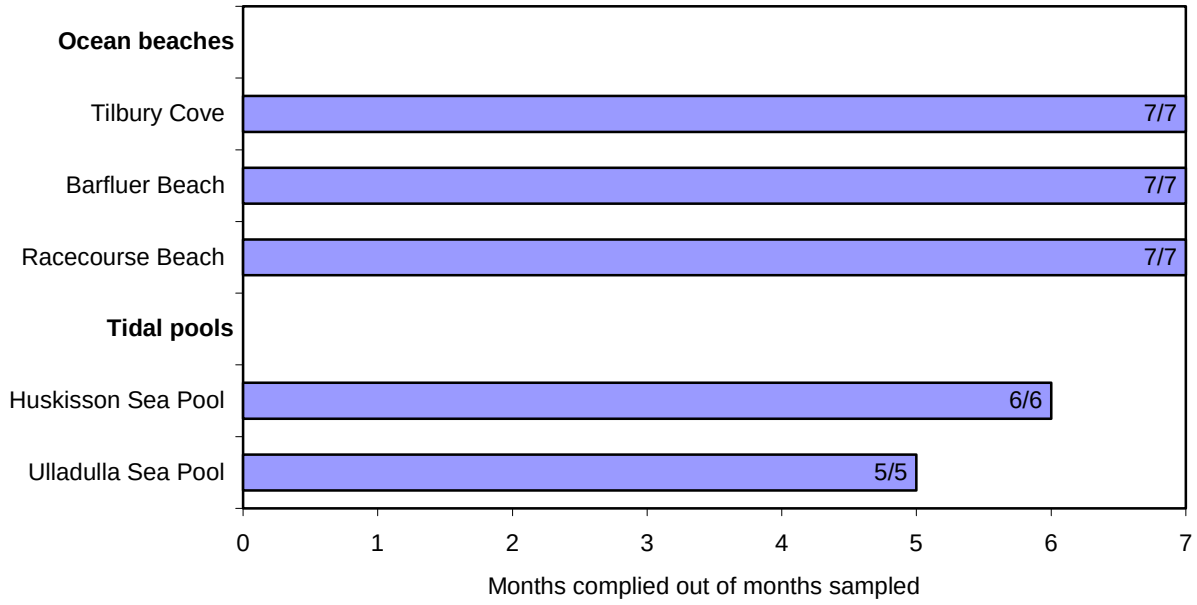
Levels in the creeks and stormwater drains were slightly elevated, although not indicative of sewage contamination. Additional monitoring is required to confirm these findings.

Sea pools

Guideline compliance

A high level of compliance was recorded at Huskisson and Ulladulla sea pools. They both complied with the NHMRC (1990) swimming water quality guidelines in each of the six months where samples were collected. This indicates no evidence of sewage contamination affecting the sea pools (see Figure 9).

Figure 9: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Shoalhaven City Council swimming sites from October 2002 to April 2003



Eurobodalla Shire Council

Ocean beaches: Cookies, Maloneys, Casey, Surf, Malua Bay, Broulee, Bengello, Shelly, Moruya South Head, Tuross Main, Brou, Narooma Main, Mystery Bay. **Tidal pool:** Wagonga Inlet.

Local government area description

Eurobodalla Shire is on the NSW south coast, located between Shoalhaven City Council to the north and Bega Valley Shire to the south. It has an area of approximately 3430 square kilometres, with 110 kilometres of coastline and 60 named beaches. There are three major river systems in the area: the Clyde, Deua and Tuross.

The population of the region is approximately 31,000 and growing at a rate of 1.4 percent each year. The major towns in the shire are Batemans Bay, Narooma and Moruya. Approximately 70 percent of the shire is comprised of state forests and national parks. The major commercial activities include dairy farming, forestry, fishing, tourism, and the building and service industries (Eurobodalla Shire Council, 2000).

Program outline

The Eurobodalla Beachwatch Partnership Pilot Program monitored 14 swimming locations in the Eurobodalla Shire. These included 13 ocean beaches and one ocean pool.

Faecal coliform and enterococci samples were collected from all locations to assess the impact of wet weather on swimming water quality. Samples were collected in dry weather conditions, as well as during and after rainfall events. Due to the dry weather conditions over the 2002–03 summer swimming season, few wet weather samples were collected. Sampling was extended until July 2003 at all but two locations to obtain additional information on wet weather sources of pollution. Sampling was not extended at Moruya South Head Beach and Maloneys Beach.

Five bacterial samples were collected from all 14 locations during October 2002, enabling compliance with NHMRC (1990) swimming water quality guidelines to be calculated for this month.

Ocean beaches

All 13 ocean beaches complied with the NHMRC (1990) swimming water quality guidelines in October 2002, the only month in which compliance was assessed.

Very low levels of faecal coliforms and enterococci were consistently measured at Maloneys Beach, Malua Bay Beach and Moruya South Head Beach throughout the 2002–03 summer swimming season. Bacterial levels did not increase with rainfall and showed no evidence of sewage contamination.

Low levels of indicator bacteria were also measured at Cookies Beach, Casey Beach, Surf Beach, Tuross Main Beach, Narooma Main Beach and Mystery Bay. Slightly elevated levels of faecal coliforms and enterococci were measured on several occasions, but were not indicative of sewage contamination.

At Broulee Beach, Bengello Beach, Shelley Beach and Brou Beach, elevated bacterial levels were measured on one or two occasions following heavy rainfall. Levels of faecal coliforms and enterococci at these beaches were generally low during dry weather conditions, showing no evidence of sewage contamination at these times.

Wagonga Inlet ocean pool

The swimming site at Wagonga Inlet complied with the NHMRC (1990) swimming water quality guidelines in October 2002, the only month in which compliance could be assessed.

Levels of faecal coliforms and enterococci at this site were generally low during dry weather conditions, showing no evidence of sewage contamination at these times. Slightly elevated bacterial levels were measured in response to rainfall, with the highest levels measured after heavy rainfall in late February 2003.

Chapter 3
Metropolitan Council Pilot Programs

Overview

Of the 15 local coastal councils participating in the Beachwatch Partnership Pilot Program (BPPP), five were in the Sydney metropolitan area:

- Pittwater Council
- Municipality of Hunters Hill
- Willoughby City Council
- North Sydney Council
- Randwick City Council.

Thirty-eight swimming locations were monitored in the Sydney metropolitan area. These included ocean beaches, bays, lagoons and rock pools. Samples were also collected from several stormwater drains and creeks to assess if these locations were potential sources of pollution. A summary of the monitoring undertaken by each council is presented in Table 2.

Beachwatch and Harbourwatch Programs

The NSW Department of Environment and Conservation (DEC) runs the Beachwatch and Harbourwatch programs in the Sydney metropolitan area. Under these programs samples are collected from 95 ocean and harbour beaches.

The pilot programs run in the metropolitan area were designed to complement the existing guideline compliance monitoring. A condition of grant funding to metropolitan councils was to ensure that their work did not duplicate the Beachwatch and Harbourwatch monitoring.

In general, the metropolitan programs focused on two areas:

- assessment of swimming sites not included in the Beachwatch and Harbourwatch Programs
- intensive monitoring of existing Beachwatch and Harbourwatch sites in order to study the impact of rainfall on swimming water quality.

Resourcing issues

For most councils, insufficient staff to conduct sampling was an ongoing problem over the course of the pilot programs. This meant that sampling frequency was less than originally anticipated in some council areas.

Extension of pilot programs

The 2002–03 summer swimming season was particularly dry. Due to the lack of rainfall, insufficient samples were collected to assess the effect of wet weather related pollution sources on recreational water quality. The pilot programs were extended until the end of July 2003 in Pittwater and North Sydney councils.

During the extended period, resources were focused on the collection of samples during and immediately after rainfall events.

Overview of findings

The findings of the metropolitan council pilot monitoring programs are summarised below for each council area. More detailed results are provided in the following sections.

Pittwater Council

Pittwater Council's pilot program assessed compliance with swimming water quality guidelines at four locations not included in the Beachwatch or Harbourwatch programs.

A high level of compliance was recorded at the ocean pool at Palm Beach and McCarrs Creek Reserve in Pittwater. A lower level of compliance was measured at two locations in Narrabeen lagoon, with levels of indicator bacteria indicating sewage contamination during wet weather.

Samples were also collected at five locations in Pittwater to assess the impact of wet

weather sources of pollution on swimming water quality. Elevated bacterial levels were recorded in response to rainfall and at sites around Scotland Island, and remained high for 48 hours after rainfall. Based on this data, swimming in the vicinity of Scotland Island should be avoided for at least two days after rain.

Municipality of Hunters Hill

This pilot program aimed to identify new swimming locations in the lower Lane Cove and lower Parramatta rivers. Samples were collected in response to rainfall events. Samples for toxicant analysis were also collected during a rainfall event in December 2002 to assess the impact of urban stormwater runoff on swimming water quality.

At the six sites monitored along the lower Lane Cove River, the seven sites monitored in lower Parramatta River and the single site monitored in Port Jackson, bacterial levels were generally low during dry weather conditions. Elevated bacterial levels were measured in response to rainfall, indicating wet weather sewage contamination.

Elevated levels of aluminium and iron were also measured during wet weather at some sites.

Based on the findings of the study, water quality around the Hunters Hill peninsular is suitable for swimming during dry weather conditions. However, due to the limited amount of data collected, additional sampling should be conducted to confirm this finding. Based on data from the Harbourwatch Program, swimming in this area of the harbour should be avoided during and for at least three days after rainfall.

Willoughby City Council

Willoughby City Council conducted intensive monitoring in and around Northbridge Baths, a site included in the Harbourwatch Program. The aim of the monitoring was to more accurately define when swimming should be avoided in the baths. This information can be used to derive a notification protocol and closure policy for the baths.

Samples were collected from eleven locations in and around the baths during rainfall and on days following rainfall until water quality returned to dry weather levels.

This study found that swimming in Northbridge Baths should be avoided for at least one day after rainfall of 10–20 mm in 72 hours, and avoided for at least two days after rainfall of more than 20 mm in 72 hours.

North Sydney Council

North Sydney Council monitored water quality in MacCallum Pool and Shell Cove, the embayment from which water for the pool is drawn. Samples were collected during and after rainfall to assess the impact of wet weather on swimming water quality.

Bacterial levels in the pool and in Shell Cove displayed little response to rainfall and indicated that water quality was suitable for swimming 24 hours after rainfall. However, due to the limited data collected under the study, additional sampling is recommended to confirm this finding.

Randwick City Council

Randwick City Council's pilot program assessed compliance with swimming water quality guidelines at two locations not included in the Beachwatch Program: Little Bay Beach North and Little Bay Beach South.

Compliance at Little Bay Beach South was high, with levels of indicator bacteria complying with swimming guidelines in all seven months of the 2002–03 summer swimming season. Bacterial levels measured at this site were generally low, showing little evidence of sewage contamination.

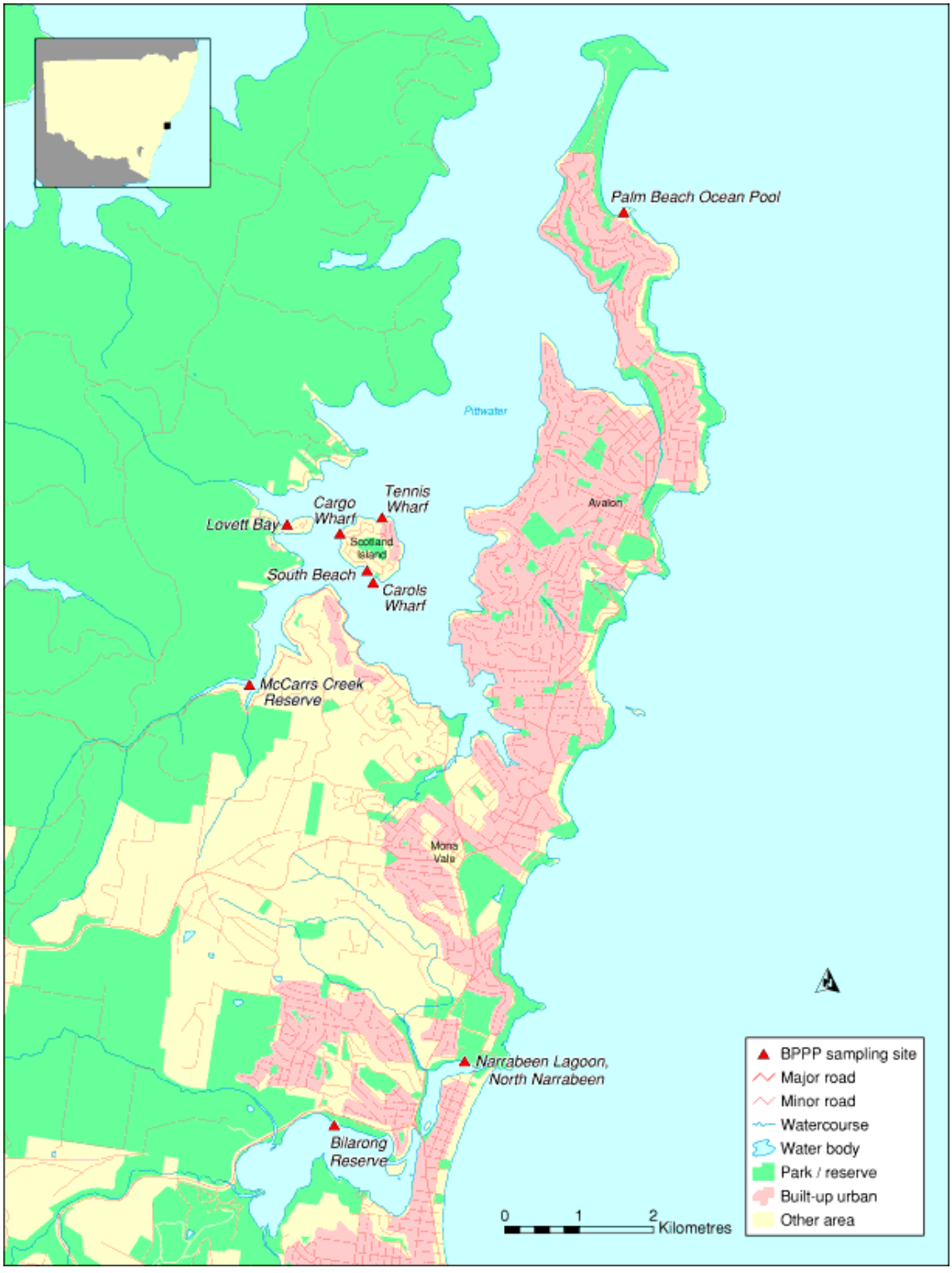
A lower level of compliance was measured at Little Bay Beach North, which passed in only four of the seven months. Elevated levels of enterococci were measured on several occasions in response to rainfall.

Table 2: Summary of monitoring in metropolitan council areas

Council	Period of monitoring	Number of sites			Additional
		Guideline compliance	Rainfall response	Pollution source assessment	
Pittwater	Oct 02–Jun 03	4	5	2	
Hunters Hill	Oct 02–Apr 03	0	14	6	Toxicants
Willoughby	Oct 02–Jun 03	0	11	0	
North Sydney	Oct 02–Apr 03	0	2	0	
Randwick	Oct 02–Apr 03	2	0	0	

Pittwater Council

Ocean pool: Palm beach. **Pittwater sites:** Lovett Bay, Carols Wharf, Cargo Wharf, Tennis Wharf, South Beach, McCarrs Creek Reserve. **Lagoons:** Bilarong Reserve, Narrabeen Lagoon



Local government area description

The Pittwater Council local government area is located 26 kilometres north of Sydney and extends between Barrenjoey Headland to the north and the entrance of Narrabeen Lagoon to the south. It covers an area of 125 square kilometres, with 18 kilometres of coastline and ten ocean beaches.

The population of the council area is 56,642 and growing at the rate of 3.6 percent each year. Approximately one quarter of the area is urban residential, a significant proportion of which is medium density housing, while approximately 40 percent of the shire is national parkland. The Pittwater estuary, Narrabeen Lagoon, and ocean beaches are frequently used by residents and visitors to the Sydney region (Pittwater Council, 2002).

Program outline

Nine swimming locations were monitored under the Pittwater Council Beachwatch Partnership Pilot Program. These included six locations in Pittwater (Lovett Bay, McCarrs Creek Reserve, Cargo Wharf, Tennis Wharf, Carols Wharf and South Beach), two locations in Narrabeen Lagoon (Billarong Reserve and North Narrabeen) and the ocean pool at Palm Beach.

Faecal coliform and enterococci samples were collected from McCarrs Creek Reserve, the two sites in Narrabeen Lagoon and Palm Beach ocean pool over the 2002-03 summer swimming season to assess compliance with the NHMRC (1990) swimming water quality guidelines. It should be noted that only four of the five samples necessary to calculate compliance were collected in December 2002 and April 2003. In order to calculate compliance in these two months, the closest sample in time from an adjacent month was 'borrowed' to provide the five data points required.

Less intensive monitoring was carried out at the four locations around Scotland Island in Pittwater (Cargo Wharf, Tennis Wharf, Carols Wharf and South Beach) and in Lovett Bay. Five samples were collected from these sites in October 2002 to assess compliance with NHMRC (1990) swimming water quality guidelines. Samples were then collected monthly and in response to rainfall events to assess the impact of wet weather sources of pollution on swimming water quality. Due to the dry weather conditions over the 2002–03 summer swimming season, few wet weather samples were collected. Sampling was extended until July 2003 to obtain additional information on the impact of rainfall.

Additional samples were collected from stormwater outlets and creeks near the swimming location in northern Narrabeen Lagoon. This monitoring was conducted to assess potential sources of faecal contamination.

Palm Beach ocean pool

A high level of compliance with NHMRC (1990) swimming water quality guidelines was measured at Palm Beach Ocean Pool, with levels of indicator bacteria complying in all seven months of the 2002–03 summer swimming season (see Figure 10).

Levels of indicator bacteria measured at the site were consistently low, showing no evidence of sewage contamination.

Pittwater

A high level of compliance was measured at McCarrs Creek Reserve in the southern end of Pittwater (Figure 10). Levels of faecal coliforms and enterococci complied with NHMRC (1990) swimming water quality guidelines in all seven months of the 2002-03 summer swimming season. Levels of indicator bacteria were generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Slightly elevated levels of faecal coliforms and enterococci were measured in March and April 2003 in response to a series of rainfall events.

Compliance with NHMRC (1990) guidelines was assessed at Lovett Bay during October 2002 only, and the site passed in this month. Levels of faecal coliforms and enterococci were generally low during dry weather

conditions, with elevated levels measured during heavy rainfall in early December 2002.

Pittwater – Scotland Island

Four locations around Scotland Island were monitored during the 2002–03 summer swimming season. All four locations passed the NHMRC (1990) guidelines in October 2002, the only month in which sufficient samples were collected to calculate compliance.

Levels of indicator bacteria in the waters around Scotland Island were generally low during dry weather conditions. Slightly elevated levels of bacteria were measured in response to rainfall at Carols Wharf, Cargo Wharf and South Beach, with a particularly high level of faecal coliforms and enterococci measured during heavy rainfall in early December 2002 at Tennis Wharf.

The data from the Scotland Island sites was assessed to determine the time required for water quality to return to dry weather levels after rainfall. Data from three rainfall events was employed in the analysis: a 76 mm rainfall event on 10 December 2002, a 63 mm rainfall event on 12 March 2003 and a 26 mm rainfall event on 24 March 2003.

Bacterial levels decreased in the days following rainfall at all sites. In all cases, bacterial levels were at levels suitable for swimming two days after rainfall. Based on these results, swimming around Scotland Island should be avoided for 48 hours after rainfall. During very heavy rainfall or rainfall events extended over several days, the recovery time may be longer. In these cases, swimming should be avoided if there are signs of stormwater pollution such as discoloured water or litter in the water.

Narrabeen Lagoon

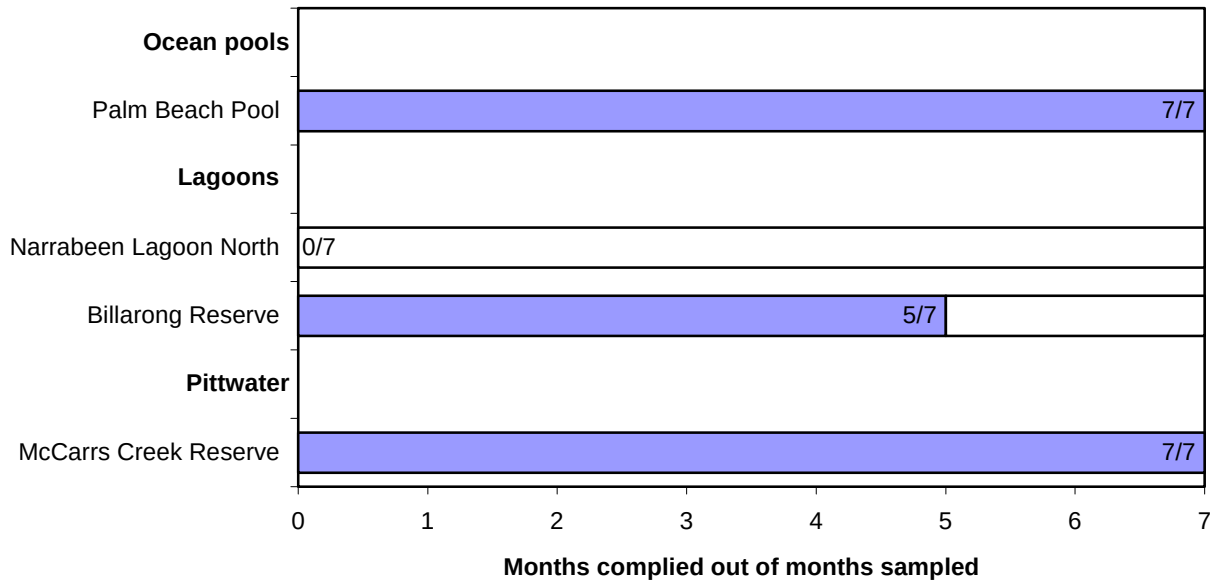
Samples were collected at Billarong Reserve on the western side of Narrabeen Lagoon and North Narrabeen on the northern side of the lagoon.

Billarong Reserve complied with the NHMRC (1990) swimming water quality guidelines in the first five months of the 2002–03 summer swimming season. The site did not meet the guidelines in March and April 2003. Levels of faecal coliforms and enterococci were generally low between October 2002 and January 2003, a period dominated by dry weather conditions. Elevated bacterial levels were measured in response to rainfall in the latter half of the monitoring period. This data indicates that Billarong Reserve may be impacted by a wet weather source of pollution.

Compliance at North Narrabeen was very low, with levels of faecal coliforms and enterococci not meeting the guidelines in all seven months of the 2002–03 summer swimming season. Elevated levels of indicator bacteria were measured throughout the monitoring period in both dry and wet weather conditions. This data suggests that there may be a source of sewage contamination in the vicinity of the sampling location.

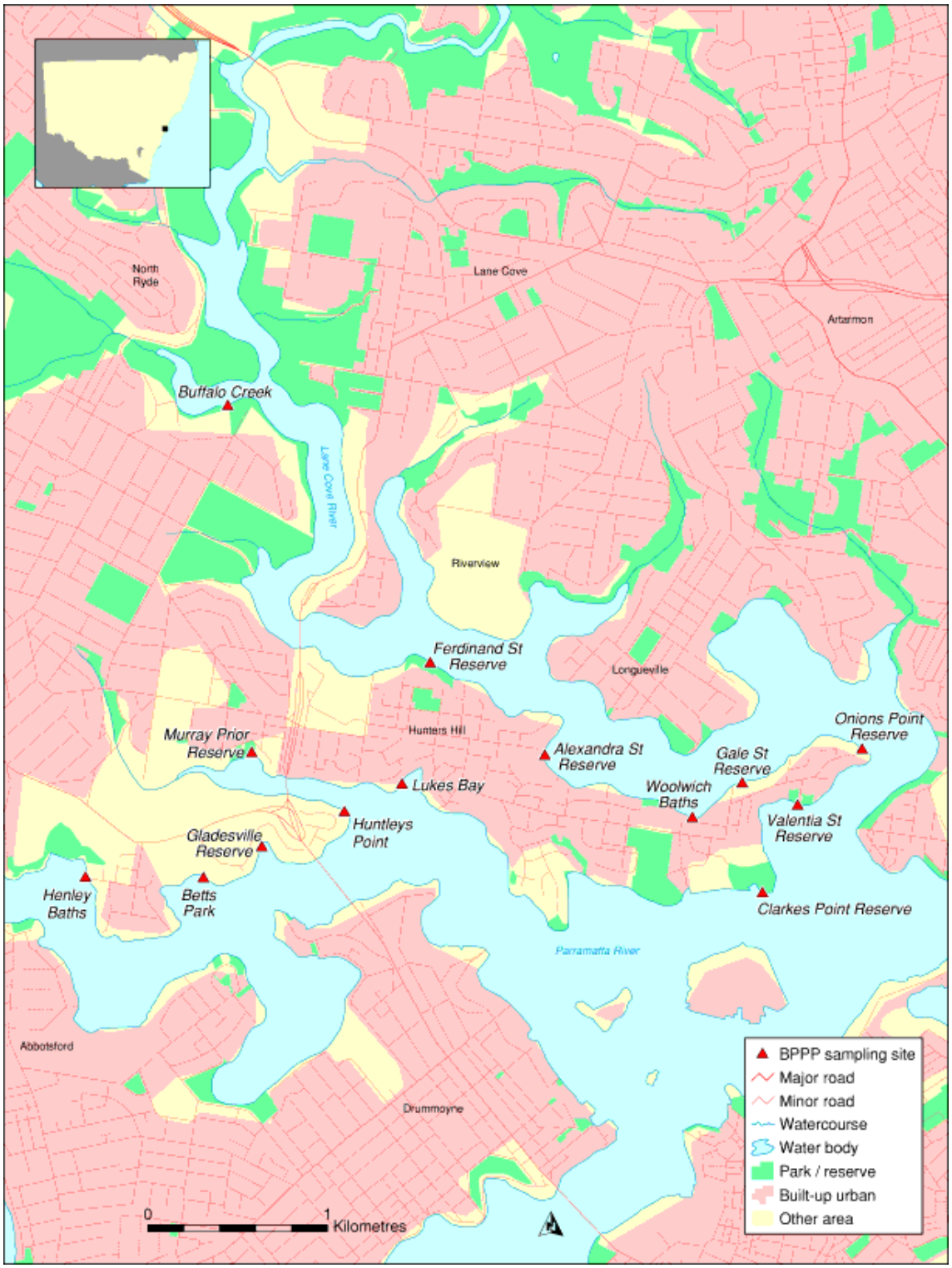
Samples were collected from stormwater drains and creeks in the vicinity of the North Narrabeen sampling location to assess potential sources of pollution. High levels of indicator bacteria were measured at all locations during rainfall, with elevated levels also recorded for several days following rainfall in most creeks and drains. Additional sampling is required to isolate the source of sewage contamination.

Figure 10: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Pittwater Council swimming sites from October 2002 to April 2003



Municipality of Hunters Hill

Riverine sites: Buffalo Creek, Ferdinand Street Reserve, Alexandra Street Reserve, Gale Street Reserve, Onions Point Reserve, Valentia Street Reserve, Lukes Bay, Huntleys Point, Murray Prior Reserve, Gladesville Reserve, Betts Park. **Tidal pools:** Woolich Baths, Henley Baths. **Sydney Harbour:** Clarkes Point Reserve.



Local government area description

The Municipality of Hunters Hill is situated within the Sydney metropolitan area northeast of the central business district. It is comprised of an east-west lying peninsula bounded by the Lane Cove River to the north and the Parramatta River to the south.

The municipality covers an area of 5.75 square kilometres and has a population of approximately 12,500. The character of the municipality is predominantly freestanding residential houses (Hunters Hill Council, 2003).

Program outline

The Recreational Water Quality Monitoring in the Hunters Hill Local Government Area Project monitored 14 sampling sites, including six locations in the lower Lane Cover River, seven locations in the lower Parramatta River and one location in Port Jackson. The program aimed to identify potential new swimming locations in these areas of Sydney Harbour.

Faecal coliform and enterococci samples were collected from all locations between October 2002 and April 2003 to assess the impact of wet weather on swimming water quality. Samples were collected during dry weather conditions, as well as during wet weather events.

Five bacterial samples were collected from each of the 14 locations during October 2002, enabling compliance with NHMRC (1990) swimming water quality guidelines to be calculated for the month.

Two samples were collected from each of the stormwater drains in the vicinity of Ferdinand Street Reserve, Alexandra Street Reserve, Woolwich Baths, Gale Street Reserve, Murray Prior Reserve and Betts Park during heavy rainfall in early December 2002.

To assess the impact of urban stormwater runoff on swimming water quality, a sample collected from Ferdinand Street Reserve, Woolwich Baths and Betts Park in early December was analysed for a range of toxicants, including aluminium, iron, copper, zinc and lead. Samples collected from nearby stormwater drains during the December 2002 rainfall event were also analysed for toxicants. The results were compared to ANZECC (2000) recreational water quality guidelines.

Lane Cove River

The six sites located in the lower Lane Cove River included Buffalo Creek, Ferdinand Street Reserve, Alexandra Street Reserve, Woolwich Baths, Gale Street Reserve, and Onions Point Reserve.

Guideline compliance

Sufficient samples for guideline compliance assessment were collected only in October 2002. All sites complied with NHMRC (1990) swimming water quality guidelines in this month.

Response to rainfall

Levels of faecal coliforms and enterococci remained generally low during dry weather conditions at all sites in the lower Lane Cove River. Elevated bacterial levels were measured in response to rainfall, indicating sewage contamination during wet weather events. Based on these results, swimming in the lower Lane Cove River should be avoided after rainfall. While additional data is required to confirm this finding, data collected under the Harbourwatch Program indicates that swimming in this area of the harbour should be avoided for at least three days after rainfall.

Pollution source assessment

Elevated levels of faecal coliforms and enterococci were measured in samples collected from the stormwater drains in the vicinity of Ferdinand Street Reserve, Alexandra Street Reserve, Woolwich Baths and Gale Street Reserve during heavy rainfall in early December. While the results were indicative of sewage contamination in the stormwater, additional sampling is required to confirm this finding.

Toxicants assessment

Samples collected from Ferdinand Street Reserve and Woolwich Baths on 12 December 2002 indicated that levels of

aluminium and iron exceeded the ANZECC (2000) recreational water quality guidelines at both locations. Elevated levels of aluminium and iron were also measured in the stormwater draining to these locations. Due to the limited amount of data collected, additional sampling, particularly during dry weather conditions, is required to confirm these findings.

Parramatta River

The seven sites located in the lower Parramatta River included Lukes Bay, Murray Prior Reserve, Huntleys Point, Gladesville Reserve, Valentia Street Reserve Betts Park and Henley Baths.

Guideline compliance

Sufficient samples for guideline compliance assessment were collected only in October 2002. All sites complied with NHMRC (1990) swimming water quality guidelines in this month.

Response to rainfall

Levels of faecal coliforms and enterococci remained generally low during dry weather conditions at all sites in the lower Parramatta River. Elevated bacterial levels were measured in response to rainfall, indicating sewage contamination during wet weather events. Based on these results, swimming in the lower Parramatta River should be avoided after rainfall. While additional data is required to confirm this finding, data collected under the Harbourwatch Program indicates that swimming in this area of the harbour should be avoided for at least three days after rainfall.

Pollution source assessment

Elevated levels of faecal coliforms and enterococci were measured in samples collected from the stormwater drains in the vicinity of Murray Prior Reserve and Betts Park during heavy rainfall in early December. While the results were indicative of sewage contamination of the stormwater, additional sampling is required to confirm this finding.

Toxicants assessment

Levels of aluminium at Betts Park on 12 December 2002 exceeded the ANZECC (2000) recreational water quality guidelines. Elevated levels of aluminium and iron were also measured in the main stormwater drain and the overflow outlet located in the vicinity of Betts Park. Due to the limited amount of data collected, additional sampling, particularly during dry weather conditions, is required to confirm these findings.

Port Jackson

Clarkes Point Reserve is located in Port Jackson at the confluence of the Lane Cove and Parramatta rivers.

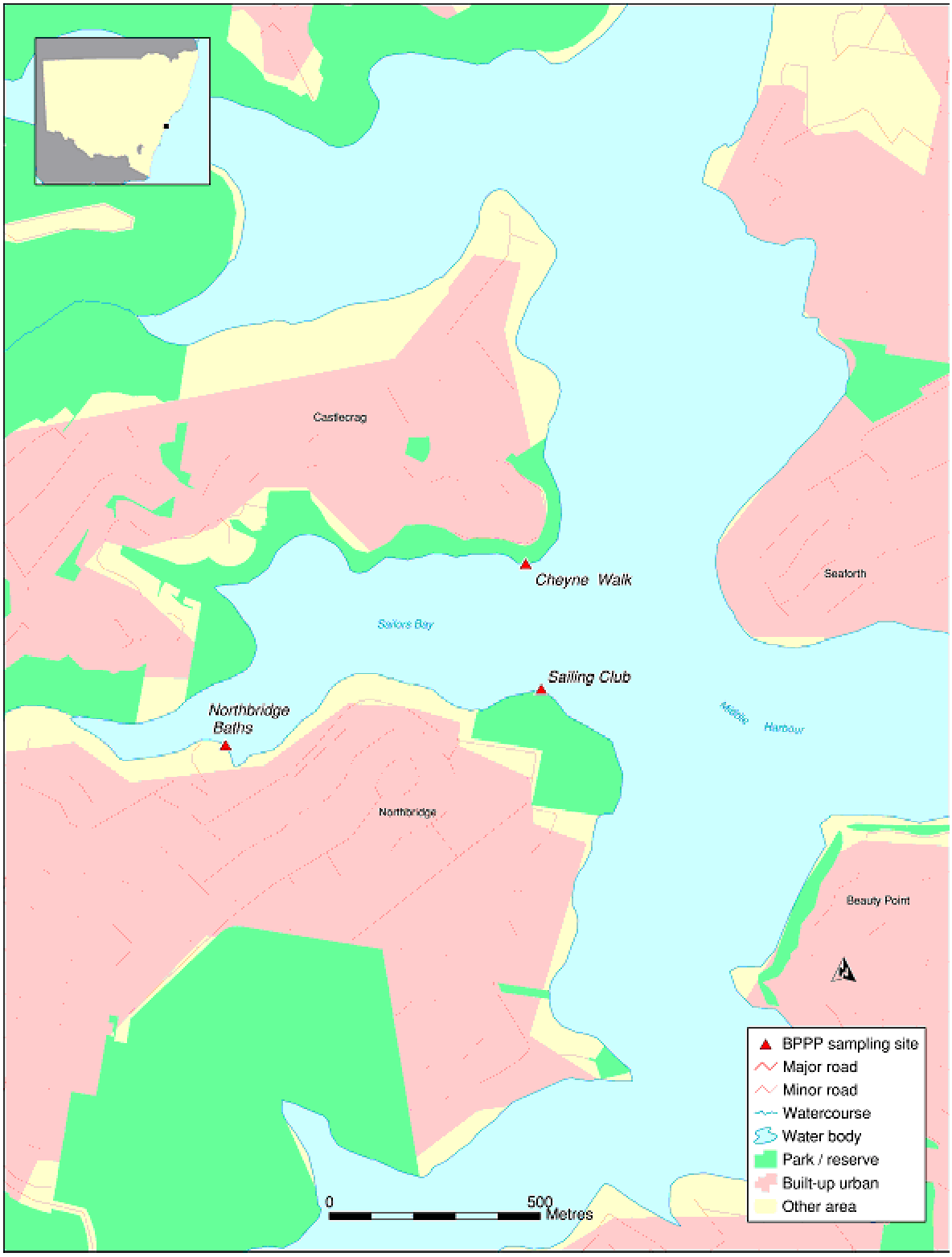
Guideline compliance

Sufficient samples to assess guideline compliance at Clarkes Point Reserve were collected in October 2002 only. The site passed the NHMRC (1990) swimming water quality guidelines in this month.

Response to rainfall

Levels of faecal coliforms and enterococci at Clarkes Point Reserve remained generally low during dry weather conditions. Elevated bacterial levels were measured in response to rainfall, indicating sewage contamination during wet weather events. Based on these results, swimming in this area of Port Jackson should be avoided after rainfall. While additional data is required to confirm this finding, data collected under the Harbourwatch Program indicates that swimming in this area of the harbour should be avoided for at least three days after rainfall.

Tidal pool: Northbridge Baths.



Local government area description

The Willoughby City Council area extends over two catchments: the Lane Cove River catchment and the Middle Harbour catchment. The population of the area is approximately 59,400 and growing at a rate of 2.1 percent each year. There is significant residential development within the council area, along with some commercial and industrial activities.

Program outline

Northbridge Baths is a popular swimming location in Sailors Bay in Middle Harbour. In accordance with Willoughby Council's directive, the baths are closed to the public when the Department of Environment and Conservation's daily Harbourwatch Bulletin predicts that pollution is 'likely' in Middle Harbour. A 'likely' prediction is made for three days after rainfall of more than 4 mm, and can result in the baths being closed frequently and for extended periods during the summer period.

As the Harbourwatch pollution predictions are made for Middle Harbour as a whole, they are not necessarily accurate for Northbridge Baths. Pollution levels may be higher or lower in the baths than the rest of the waterway.

The Northbridge Baths Recovery Study was conducted to assess the impact of rainfall on the swimming water quality in Northbridge Baths and the subsequent time required for water quality to return to levels suitable for swimming. This information could be used by Willoughby Council to determine when to open and close the baths.

Eleven sites were monitored as part of the study, including:

- four sites within the Northbridge Baths netted swimming enclosure
- three sites immediately outside the netted swimming enclosure
- two sites at a stormwater outlet adjacent to Northbridge Baths
- two control sites located at the entrance to Sailors Bay, approximately one kilometre east of the baths (Cheyne Walk and the Sailing Club).

Faecal coliform and enterococci samples were collected at all 11 sites during rainfall events. Follow-up sampling was conducted on the days following rainfall until water quality returned to dry weather levels. Samples were also collected in response to dry weather sewage overflow incidents, as reported by Sydney Water Corporation.

Due to the dry weather conditions over the 2002–03 summer swimming season, monitoring was extended until July 2003 at all sites.

Northbridge Baths description

Northbridge Baths is an enclosed tidal swimming area in Sailors Bay. The baths are patrolled between October and March and are used by children, adults and the elderly.

The baths are surrounded by residential development, with boat moorings and a marina located within Sailors Bay. Sailors Bay Creek discharges to the west of the baths, and a stormwater outlet discharges immediately behind the baths.

Water quality in Northbridge Baths may be affected by urban runoff discharged from the stormwater drain and Sailors Bay Creek. Overflows from a nearby sewage pumping station and recreational boating activities may also contribute to faecal contamination at the baths.

Response to rainfall

Inside Northbridge Baths

Levels of faecal coliforms in Northbridge Baths generally exceeded the median guideline limit after more than 20 mm of rain in the previous 24 hours (see Figure 11). Levels of enterococci exceeded the geometric mean guideline after more than 10 mm of rainfall in the previous 24 hours, and occasionally did so after less than 10 mm. Based on this data, swimming in Northbridge Baths should be avoided after more than 10 mm of rainfall in the previous 24 hours.

Outside Northbridge Baths

Higher levels of indicator bacteria were recorded outside Northbridge Baths than inside. Faecal coliform levels generally

exceeded the median guideline limit after more than 10 mm of rain in the previous 24 hours, while levels of enterococci frequently exceeded the geometric mean guideline after less than 10 mm of rain (see Figure 12).

Stormwater drain

Very high levels of faecal coliforms and enterococci were measured in the stormwater drain in both wet and dry weather conditions (see Figure 13). Based on these results, swimming in the vicinity of the drain should be avoided at all times.

Entrance to Sailors Bay

At the entrance to Sailors Bay, faecal coliform levels exceeded the median guideline limit after more than 20 mm of rain in the previous 24 hours (see Figure 14). Enterococci levels occasionally exceeded the geometric mean guideline after less than 10 mm of rain in the previous 24 hours and regularly did so after more than 10 mm of rain.

Recovery after rainfall

Recovery of water quality after rainfall was assessed using data collected from six rainfall events of 10–20 mm and eight rainfall events of more than 20 mm. The geometric mean values for inside, outside, and control sites on the day of the rainfall events and the three consecutive days following the events are presented in Figures 15 and 16.

Bacterial levels were observed to decrease in the days following rainfall. For rainfall events of 10–20 mm, bacterial levels in the baths, outside the baths and at the entrance to Sailors Bay fell below the guideline limits 24 hours after the event (see Figure 15). For events of more than 20 mm, bacterial levels inside and outside the baths fell below the guideline limits 48 hours after the event (see Figure 16). At the entrance to Sailors Bay, bacterial levels fell below the guideline limit 72 hours after more than 20 mm of rain.

Based on this data, water quality in Northbridge Baths should be suitable for swimming 24 hours after a rainfall event of 10–20 mm, and 48 hours after a rainfall event of more than 20 mm.

Figure 11: Response to rainfall inside Northbridge Baths

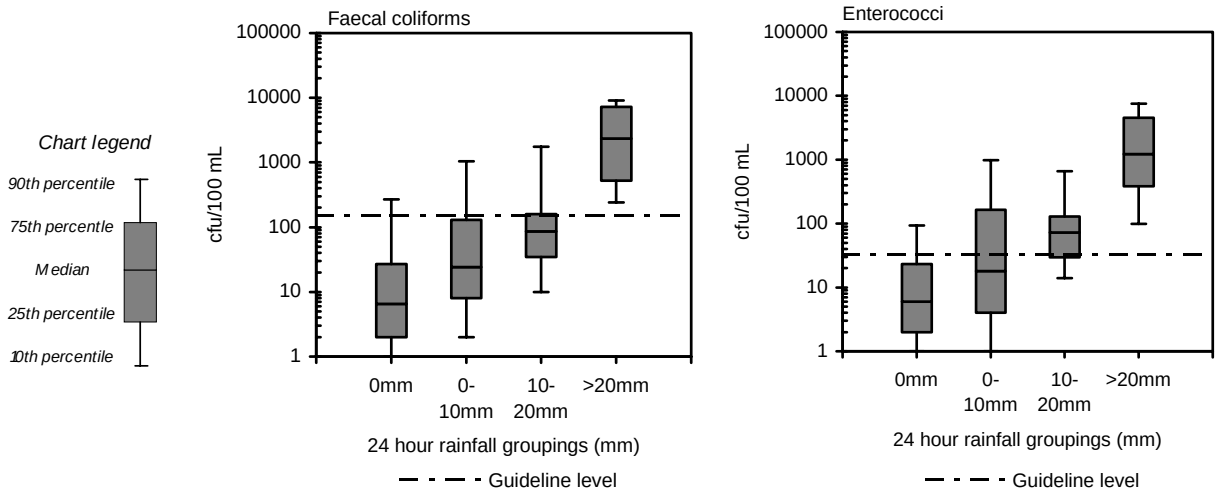


Figure 12: Response to rainfall outside Northbridge Baths

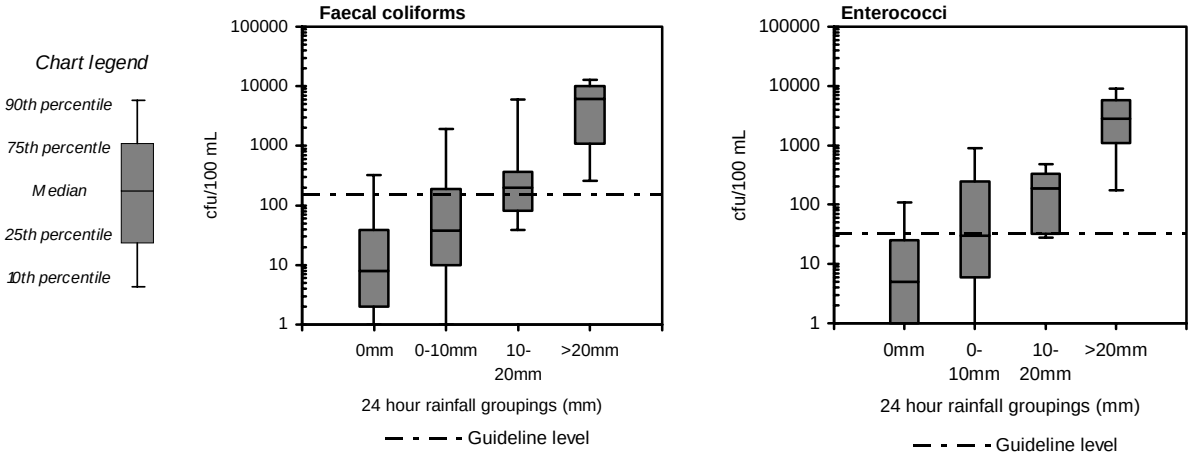


Figure 13: Response to rainfall at the stormwater drain

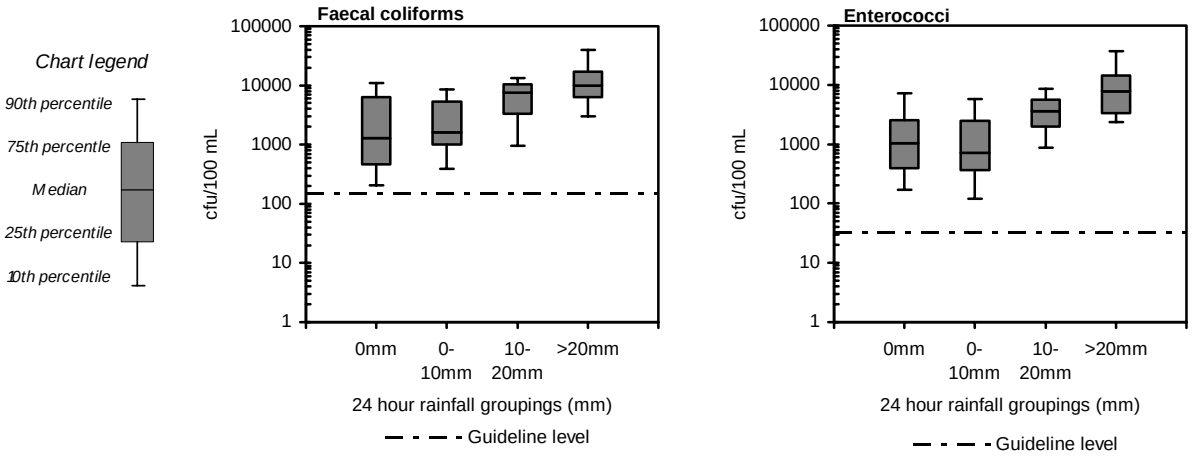


Figure 14: Response to rainfall at the entrance to Sailors Bay

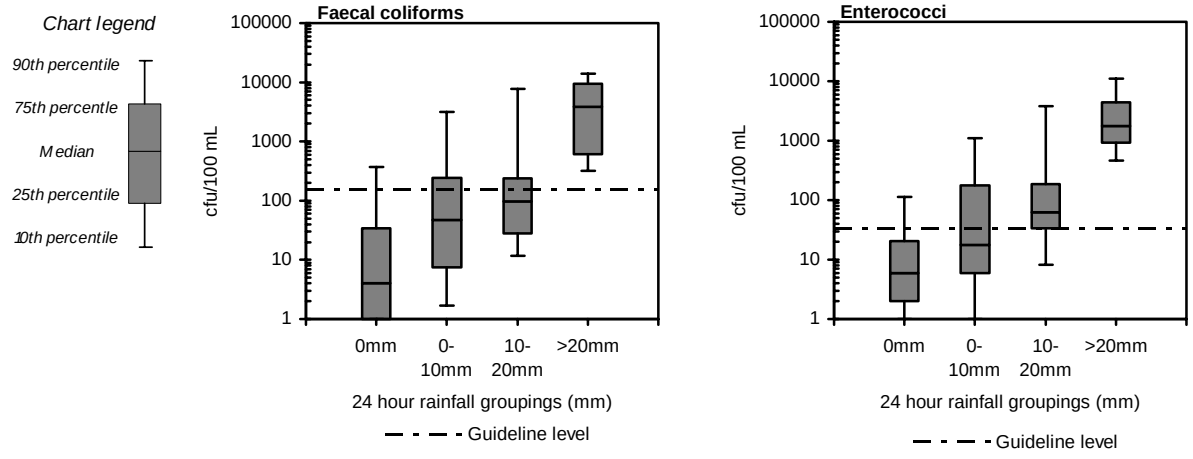
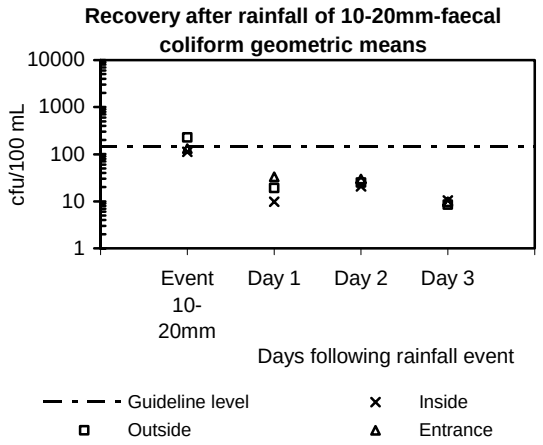


Figure 15: Northbridge Baths recovery after 10–20 mm of rainfall



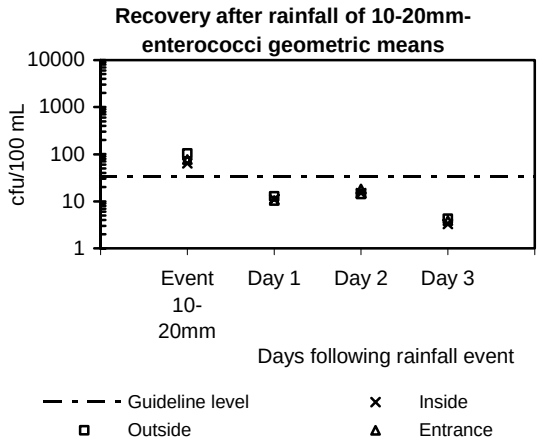
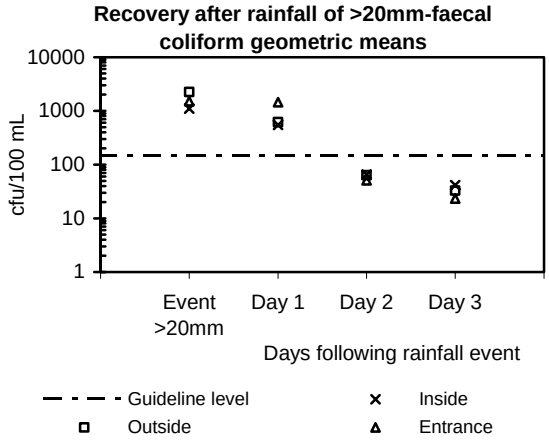
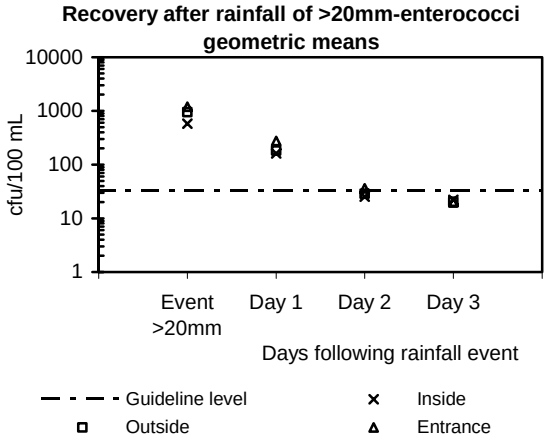


Figure 16: Northbridge Baths recovery after greater than 20 mm of rainfall





North Sydney Council

Harbour: McCallums Pool, Shell Cove.

Location government area description

North Sydney Council is located on the northern shore of Sydney Harbour, between Wollstonecraft in the west and Cremorne Point in the east. The area is highly urbanised, with a population of approximately 56,000 that is growing at a rate of 5.1 percent each year. In addition, approximately 65,600 people visit the area each day for work or education (North Sydney Council, 2002).

Program outline

Two locations were monitored under North Sydney Council's program: MacCallum Pool and Shell Cove.

Faecal coliform and enterococci samples were collected from both locations between October 2002 and April 2003 to assess the impact of wet weather on swimming water quality. Samples were collected in dry weather conditions, as well as during and after rainfall events.

Five bacterial samples were collected from both locations in October 2002, enabling compliance with NHMRC (1990) swimming water quality guidelines to be assessed for that month.

MacCallum Pool

Generally low levels of indicator bacteria were measured at MacCallum Pool throughout the monitoring period, indicating that the pool is rarely impacted by sewage contamination. The site complied with NHMRC (1990) swimming water quality guidelines in October 2002, the only month where this was assessed.

Samples collected during and after two wet weather events in March 2003 indicate that bacterial levels in MacCallum Pool were slightly elevated in response to rainfall, and that swimming should be avoided 24 hours after rainfall. However, due to the limited data used in this assessment, additional sampling is required to confirm this finding.

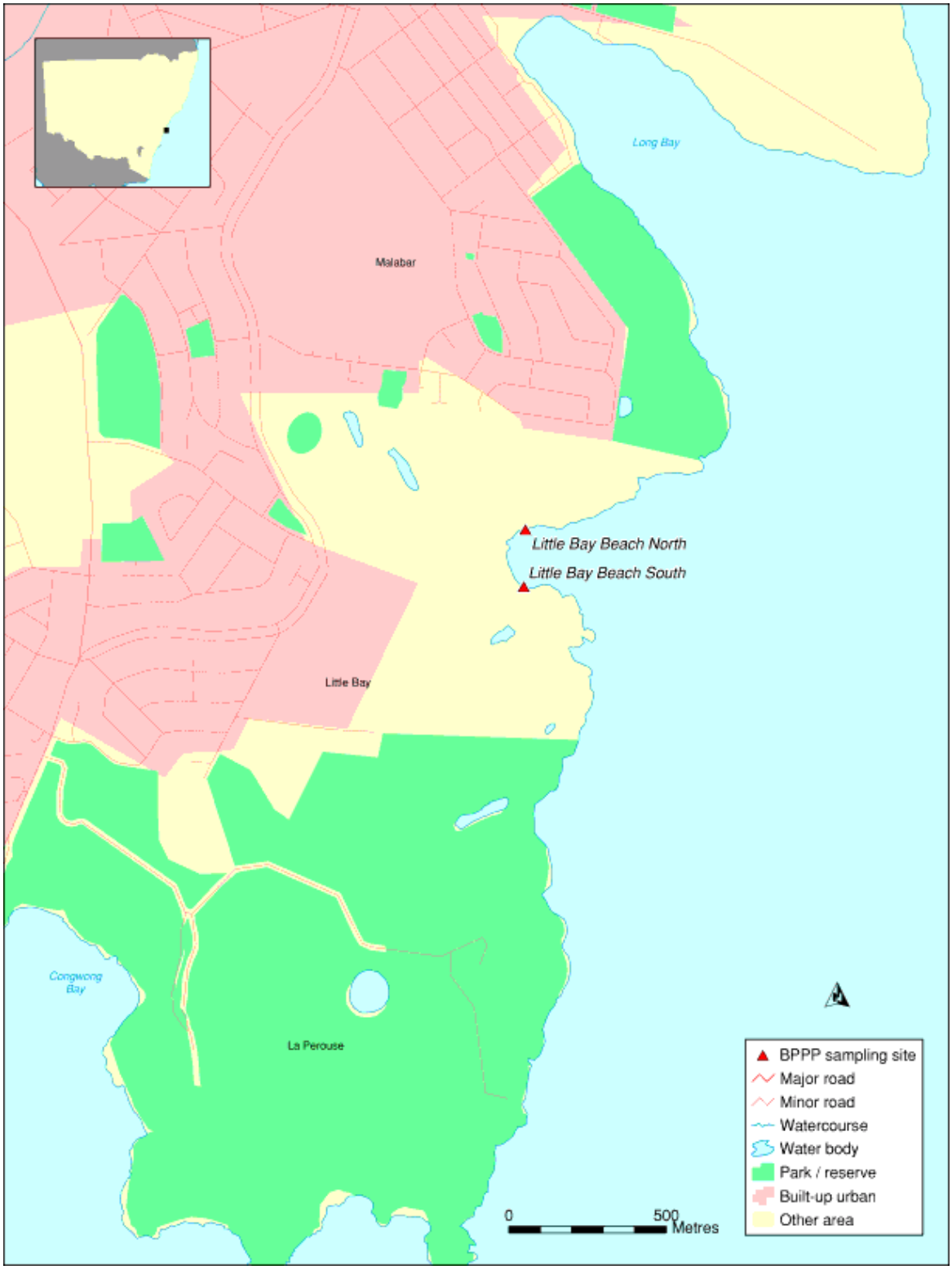
Shell Cove

Generally low levels of faecal coliforms and enterococci were measured in Shell Cove throughout the monitoring period, indicating that the bay is rarely impacted by sewage contamination. The site complied with NHMRC (1990) swimming water quality guidelines in October 2002, the only month where this was assessed.

Samples collected during and after two wet weather events in March 2003 indicate that bacterial levels in Shell Cove show little response to rainfall and that water from Shell Cove could be used to fill MacCallum Pool 24 hours after rainfall. However, due to the limited data used in the assessment, additional sampling is required to confirm this finding.

Randwick City Council

Sampling sites: Little Bay Beach North and Little Bay Beach South.



Local government area description

Randwick City Council covers an area of 3650 square kilometres and extends from Clovelly Bay in the north, to Cape Banks in the south, and Yarra Bay to the west. The council area has approximately 25 kilometres of coastline consisting of seven ocean beaches, three beaches in Botany Bay and three baths.

The population of the area is 127,849 and growing at the rate of 1.4 percent each year. The council is highly urbanised, comprised of residential and medium density development (Randwick City Council, 2002).

Program outline

Two locations were monitored under Randwick City Council's program: Little Bay Beach North and Little Bay Beach South, both within Little Bay. Little Bay beach is owned and managed by the NSW government as part of the former Prince Henry Hospital site.

Faecal coliform and enterococci samples were collected from both locations over the 2002–03 summer swimming season to assess compliance with NHMRC (1990) swimming water quality guidelines.

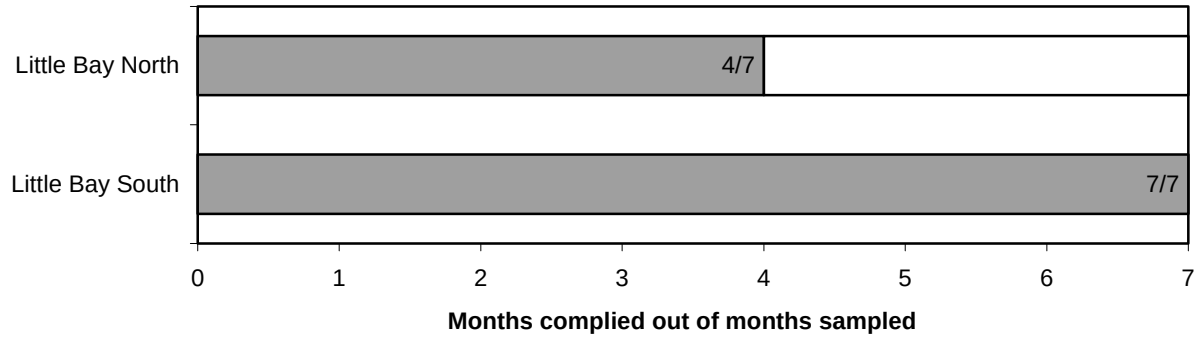
It should be noted that only four of the five samples necessary to calculate compliance were collected in December 2002 and March 2003. To calculate compliance, the nearest sample from an adjacent month was 'borrowed' to provide the five data points necessary.

Guideline compliance

A high level of compliance was measured at Little Bay Beach South, with levels of faecal coliforms and enterococci complying with the NHMRC (1990) swimming water quality guidelines in all seven months of the 2002-03 summer swimming season (see Figure 17). Bacterial levels measured at this site were generally low throughout the monitoring period, showing little evidence of sewage contamination.

A lower level of compliance was measured at Little Bay Beach North. This site met the NHMRC (1990) swimming water quality guidelines in only four of the seven months of the 2002–03 summer swimming season. The site did not meet the guidelines in October 2002, March and April 2003 due to elevated levels of enterococci.

Figure 17: Summary of compliance with NHMRC (1990) microbiological guidelines for swimming at Randwick City Council swimming sites from October 2002 to April 2003



Chapter 4
Quality Assurance and Quality Control

Overview

Quality assurance and quality control procedures were incorporated into all aspects of the 14 pilot monitoring programs, including:

- sampling (equipment preparation, sample collection and sample storage and transport)
- laboratory analysis
- data management
- community reporting.

The results of these assessments are discussed in this section.

Definitions

In general, quality control refers to all actions, procedures, checks and decisions undertaken to ensure the representativeness and integrity of samples, and the accuracy and reliability of analytical results. Quality assurance refers to all actions that monitor and measure the effectiveness of quality control procedures.

Sampling

Water sampling activities in each pilot program were quality checked on an ongoing basis. Container blanks, field blanks and trip blanks were used to detect contamination arising from the sample container, poor aseptic sampling technique and sample storage and transport.

In addition to the preparation of 'blanks', the Department of Environment and Conservation (DEC) staff conducted regular quality reviews with council staff to ensure that sample collection and data management was conducted in accordance with recommended and accepted procedures.

A summary of the sampling quality assurance carried out by each council is listed in Table 3.

Initially, not all councils adhered to their proposed quality assurance and quality control procedures. This was detected through the review process. Where councils stated in their proposal that blank samples would be taken and they did not do so, or where inadequate quality assurance samples were taken, the council's Program Manager was notified. The Program Manager was then advised to include or increase the number of 'blank' samples to ensure the data was reliable for analysis and community reporting. Regular reviews ensured that quality assurance was incorporated into all programs.

Results from container, field and trip blanks indicated no sample contamination. Results were in the range of zero to less than 10 cfu / 100 mL. A 'less than' result was obtained when less than 100 mL of sample was analysed and results were factored up.

Results or replicate samples showed that the laboratories produced precise and reliable analysis of the samples on a regular basis.

Program reviews

All councils were visited three times by DEC staff during the monitoring period to conduct quality assurance reviews. These reviews involved an audit of water sampling techniques in the field. An audit of documentation, data management and community reporting procedures was conducted at the council office.

The quality assurance reviews provided the opportunity for informal training of council staff and recommendations for program improvement.

As a result of the program reviews, a number of recommendations were made to individual Program Managers, including:

Table 3: A summary of the quality assurance carried out by each council area

Council	Container	Field	Trip	Duplicate
Ballina	✓	✓	✓	
Pristine Waters		✓	✓	✓
Maclean		✓	✓	✓
Coffs Harbour	✳	✓	✓	
Bellingen		✓	✓	
Great Lakes		✓	✓	
Lake Macquarie	✓	✓	✓	✓
Wyong	✓	✓	✓	✓
Pittwater	✓	✓	✓	
Willoughby	✓	✓	✓	
North Sydney		✓	✓	
Randwick		✓	✓	
Hunters Hill		✓	✓	✓
Shoalhaven	✓	✓	✓	
Eurobodalla		✓	✓	

✓ = Stated in the proposal that it would be carried out and is being sampled at the prescribed rate.

blank cell= Not stated in the proposal that it would be carried out.

✳ = Performed routinely by the laboratory

- training sessions for staff in sampling procedures
- training and advice in data management procedures
- development and use of appropriate field sheets
- improvements to, or development of, a field manual.

All the councils implemented the recommendations from the reviews.

Data management systems and reporting processes improved significantly during the course of the program. The QA / QC reviews proved to be an effective mechanism to ensure program reliability and ongoing improvement.

Data management

Data was produced by each of the programs for a number of different outcomes, all of which require robust and valid data. Some of the outcomes identified by councils included identification of problem areas, the influence of stormwater on water quality and the communication of recreational water quality to the public. To do this, data must be managed in an appropriate way.

All partner councils were required to transfer water quality data to the DEC on a regular basis for centralised storage on the Beachwatch water quality database (BACTO). All partner councils were supplied with a simple spreadsheet to assist with the transfer process. In some cases, data was emailed directly from the analysis laboratory and in others from the council.

Quality assurance procedures for the storage of data on the centralised database followed a rigorous protocol that was developed as part of the Beachwatch Program. This included data validation

procedures to identify anomalous results. Validated data was regularly used for the production of 'Star Ratings' and monthly compliances, and the upload of data to the SoE*direct* website.

Star Ratings

During the summer, Wyong, Coffs Harbour, Shoalhaven, Maclean, Pristine Waters and Ballina Councils reported water quality data on a weekly basis as Star Rating advertisements in local newspapers. A number of these councils successfully developed project specific web pages and reported Star Ratings on these as well.

The method for calculating Star Ratings was supplied to councils in the form of a spreadsheet and step-by-step explanation. To ensure the consistency and accuracy of the Star Ratings, both the local council and DEC staff produced the results and compared them carefully each week. On agreement of the results, DEC staff approved the advertisements through an arranged sign-off procedure.

Monthly Compliance

The NHMRC (1990) guidelines were used to calculate monthly compliances. A quality assurance process similar to the Star Ratings was implemented for reporting monthly compliances. A calculation tool and a step-by-step explanation was supplied to councils.

To ensure quality, both the local council and DEC staff produced the results and compared them. A sign-off procedure was also put in place for this process before the results were released to the community.

SoE*direct*

The State of Environment website (www.soedirect.nsw.gov.au) provides online access to important environmental monitoring data resources and assists councils to prepare their State of the Environment reports.

Water quality data collected during the BPPP was uploaded to the SoE*direct* website on a monthly basis, together with Beachwatch data from the Sydney, Hunter and the Illawarra regions. Prior to upload, all water quality data was checked using in-house Beachwatch validation procedures.

Laboratory analysis

Laboratory accreditation

A total of 11 laboratories were used in the pilot programs. All the laboratories, except Maclean Shire Council laboratory, were National Association of Testing Authorities (NATA) accredited. This includes the accreditation of relevant laboratory methods, including analysis of indicator bacteria, algae, metals and pesticides.

Maclean Shire Council laboratory was included in the pilot program to assess differences between NATA-accredited and non NATA-accredited laboratories.

Inter-laboratory comparison methodology

In order to test the quality of sample analysis of each laboratory, an inter-laboratory comparison study was undertaken. This involved the submission of three replicate samples to each laboratory on a monthly basis between October 2002 and June 2003 (except the month of December 2002). Replicate samples were sent by overnight courier and analysed for faecal coliforms and enterococci. The distribution of replicate sample results was then used to assess laboratory performance.

The replicate samples in October and November 2002 were prepared in the field. A single large water sample was collected, shaken to ensure homogeneity and then sub sampled. Dilutions were then made for the three sets of replicate samples that were sent to the laboratories.

Replicate samples prepared from January 2003 to June 2003 were prepared in a laboratory with laboratory strains of bacteria diluted in sterile saline solution. The concentrations of bacteria in each sample reflected a low and high concentration of indicator bacteria as well as a concentration at or about the NHMRC (1990) guideline values.

Data collected in the inter-laboratory comparison study was analysed in two

ways: deviation from the consensus mean and analysis of variance.

Deviation from the consensus mean

The geometric mean of each replicate sample was calculated from the results of all laboratories. This consensus mean was taken to represent the true level of bacteria in the sample. The individual results from each laboratory were then compared to the consensus means to calculate the relative deviation.

By definition, this form of analysis will always result in some laboratories being above the consensus mean and others below. Over a large number of samples, a trend develops for each laboratory of being, over, under or similar to the consensus mean.

Laboratories that consistently report results within 0.3 log units of the consensus mean are considered to be acceptable. This is equivalent to a range from half to double the consensus mean on a linear scale.

In general, there was a greater consistency in enterococci results than faecal coliform results. Enterococci results from most laboratories were within 0.3 log units of the consensus mean for 85 percent or more of samples. For faecal coliforms, most laboratories were within 0.3 log units of the consensus mean for 69 percent or more of samples.

Analysis of variance

The results generated by each laboratory were statistically analysed to determine if there were significant differences between results from different laboratories. This analysis found that there were no significant differences for faecal coliform or enterococci results (p-value<0.05).

A sensitivity analysis was also conducted to determine if there were differences between laboratory results close to the guideline limits for swimming. Replicate samples with faecal coliform consensus means greater than 150 cfu / 100mL and enterococci consensus means greater than 33 cfu / 100mL were excluded from the analysis. Again, no significant differences between laboratories were found (p-value<0.05). However, it should be noted that for faecal coliforms, an almost-significant difference was found (p-value=0.08).

Conclusion

While most laboratories generated some faecal coliform and enterococci results outside the 0.3 log unit range from the consensus mean, the laboratories produced results that were not significantly different. It is likely that the wide variation in results produced by individual laboratories mask variations between laboratories.

A number of factors may be influencing variation between laboratories:

1. Laboratory methods used in the 11 laboratories may vary causing differences in results.
2. Overnight delivery of samples may allow too much opportunity for variation in viability of the bacteria and therefore a significant variability in the results.
3. The preparation of samples was not homogeneous in nature and this caused the difference in results.
4. Faecal coliforms may be affected by some other means not yet identified.

The purpose of the inter-laboratory comparison is to identify issues associated with point one above, however it is difficult to draw conclusions given the uncertainties associated with points two, three and four.

In order to minimise this uncertainty, local proficiency testing may need to be implemented in regional areas. This would largely overcome any effects associated with overnight and long distance transportation. In addition to this, an assessment of existing proficiency testing programs and other laboratory quality assurance programs would be beneficial.

Public communication

Communication of recreational water quality data and associated issues is an essential part of raising the community's awareness and increasing the understanding of the potential pollution

sources and health risks associated with recreational water use.

To this end, each council program developed a communication strategy. As part of the quality assurance and quality control procedures a number of contingencies were integrated into the communication activities of participating councils. These included:

- development and review of the communication plan for each pilot program
- a contract that stipulated that all formal public communication processes should be approved by the DEC before their public dissemination
- assistance and sign-off procedures for the production and distribution of the Beachwatch Report, Star Ratings and monthly compliance
- assistance and approval of the production and content of web pages and media releases.

Table 4 outlines the public communication processes that pilot programs were involved with on a regular basis.

Table 4: Public communication of pilot programs conducted on a regular basis.

Council	Beachwatch Web Page	Weekly Star Ratings	Monthly Compliance	Regular Media Releases
Ballina		✓	✓	
Pristine Waters	✓	✓		
Maclean	✓	✓		✓
Coffs Harbour	✓	✓	✓	
Bellingen	✓			✓
Great Lakes	✓		✓	
Lake Macquarie	✓		✓	
Wyong	✓	✓		
Pittwater				✓
Willoughby				✓
North Sydney	✓			
Randwick				✓
Hunters Hill	✓			✓
Shoalhaven	✓	✓	✓	
Eurobodalla	✓			✓

Appendix A
Indicators and Guidelines

Bacterial indicators

The assessment of water quality during the BPPP was generally based on the level of bacterial contamination. Faecal coliforms and enterococci were the bacterial indicators used.

Faecal coliforms, also known as thermo-tolerant coliforms, are a group comprised of the organisms *Escherichia coli*, *Klebsiella pneumonia* and *Enterobacter aerogenes*. Faecal coliforms are strongly associated with faecal waste, and therefore are excellent indicators of recent faecal contamination. Faecal coliforms are not a reliable indicator for aged faecal contamination due to their short survival times in marine waters.

Enterococci are a subgroup of faecal streptococci and include four streptococci species: S. faecalis, S. faecium, S. gallinarium and S. avium. In contrast to faecal coliforms, enterococci survive for longer periods in seawater and are thus good indicators of the presence of aged faecal contamination.

Most pathogens are not easily detected in water. Where reliable laboratory methods exist, they generally require the collection of large volumes of water, analysis is costly, and it can take a week or more to obtain a result. In addition, decisions about how many and which specific pathogens to test for need to be made.

Owing to these difficulties, indicator organisms are used as a fundamental monitoring tool for assessing the potential presence of pathogenic organisms. An indicator organism should:

1. be easily detectable by using simple laboratory tests
2. generally not be present in unpolluted waters
3. appear in concentrations that can be correlated with the extent of the contamination
4. survive under similar conditions as the pathogens of concern.

The most common indicator organisms are enteric bacteria, such as faecal coliforms and enterococci. These bacteria are excreted in faeces, usually harmless and rarely present in unpolluted waters. Bacteria are much easier to detect than viruses and protozoans, and enumeration methods have been developed for commercial-scale analysis.

Limitations

Bacterial indicators are an imperfect measure of the health risks associated with swimming in recreational waters. Limitations associated with the use of bacterial indicators include the following:

1. Bacterial indicators demonstrate the presence of faecal material, not necessarily the presence of viable pathogens.
2. Analysis of bacterial indicators takes 24 to 48 hours, and so it is not possible to know the potential risk at time of swimming.

3. Bacterial indicators vary in their ability to predict potential risks to human health. Some indicators have been shown to have a greater statistical relationship **to disease than others.**

Australian guidelines

Recreational water quality guidelines provide an indication of the probability of swimmers developing illnesses derived from the water, but the actual risk depends on many factors. These factors include, in particular, the bacterial indicator to pathogen ration, which varies with time and is usually unknown.

At present, two guidelines for assessing recreational water quality are currently available in Australia:

- *Australian Guidelines for Recreational Use of Water* (NHMRC 1990).
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Chapter 5 – Guidelines for recreational water quality and aesthetics) (ANZECC 2000).

These guidelines include criteria for microbiological, physical and chemical parameters.

Bacterial monitoring data from the Beachwatch Partnership Pilot Program (BPPP) were assessed against the NHMRC (1990) *Australian Guidelines for Recreational Use of Water*.

The NHMRC (1990) microbiological guidelines are presented in Table A1, and the ANZECC (2000) guidelines for primary contact recreation in Table A2.

In Australia, a single guideline document for recreational water quality is currently being drafted under the National Water Quality Monitoring Strategy. At the time of writing the guidelines had not yet been released for comment and review.

Table A1: NHMRC (1990) guidelines used for compliance assessment in the BPPP

Marine or estuarine waters are considered unsuitable for swimming if, for five samples taken at regular intervals over a period not exceeding one month:

- the median faecal coliform density exceeds 150 cfu / 100 mL, or
- the second highest faecal coliform density is equal to or greater than 600 cfu / mL, or
- the geometric mean enterococci density exceeds 33 cfu / 100mL.

Note: the guideline for enterococci appears as *Note 1* in the NHMRC (1990) guidelines

Table A2: ANZECC (2000) microbiological guidelines

The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed:

- 150 faecal coliform organisms / 100 ml (minimum of 5 samples taken at regular intervals no > 1 month, with 4 out of 5 samples containing < 600 organisms / 100ml
- 35 enterococci / 100 ml (maximum number in any one sample = 60-100 organisms / 100 ml).

Other indicators

Algae

The presence of algae or cyanobacteria (also called blue-green algae) presents a potential health risk to recreational swimmers. Algae pose a health risk through the presence of algae themselves, the production of toxins by some species, and the changes in water quality induced by algae.

As part of the BPPP, blue-green algae was monitored at a single swimming location, Lake Ainsworth in the Ballina Shire.

Interim guidelines for recreational waters in NSW impacted by blue-green algae (Metropolitan-South Coast Regional Algal Coordinating Committee, 2001: Nancarrow & Wood, 2000), as endorsed by the State Algal Coordinating Committee in March 2000, are outlined in Table A3. The Interim Guideline uses total biovolume as an additional measure with which to assess blue-green algae. However this measure was not used during monitoring and thus is not considered in the assessment of blue-green algae in this report.

Pesticides

Organochlorine and organophosphate based pesticides were sampled by the Coffs Harbour City Council at two sites, Woolgoolga Lake and Coffs Creek. The pesticides are assessed against the ANZECC (2000) water quality guidelines for recreational purposes, and the NHMRC (1996) *Australian Drinking Water Quality Guideline*s. Within these guidelines pesticides include agricultural chemicals such as insecticides, herbicides, nematicides, rodenticides, and miticides.

Antimony

Antimony was monitored at three sites in the Bellingen Shire pilot program. This toxicant has occasionally been detected in natural source waters with occurrences more common in areas near lead or copper smelting operations.

As there is no recreational water quality guideline for antimony the NHMRC (1996) drinking water quality guideline is used as a precaution. Based on health considerations, the concentration of antimony in drinking water should not exceed 3 µg/L.

Arsenic

Arsenic was monitored at three sites in the Bellingen Shire. Arsenic is a naturally occurring element, which can be introduced into water through the dissolution of minerals and ores or from industrial effluent, atmospheric deposition through the burning of fossil fuels and waste incineration, drainage from old gold mines, or the use of some types of sheep dip. Natural sources can also make a significant contribution to the arsenic concentration in drinking water.

The ANZECC (2000) guideline for recreational water quality for arsenic is 50 µg/L. This level is adopted in this report for the assessment of arsenic level.

Metals

Aluminium, iron, copper, zinc, and lead were monitored in the Hunters Hill Municipality at both swimming locations and suspected pollution sources. The levels used in this report for the assessment of these toxicants were adopted from the

ANZECC (2000) guidelines for recreational water quality and are 200 µg / L, 300 µg / L, 1000 µg / L, 5000 µg / L, and 50 µg / L, respectively.

Table A3: SACC (2000) Interim Guideline for recreation in waters impacted by blue-green algae in NSW

Interim Guideline for recreation in waters impacted by cyanobacteria in NSW

1. A high alert level should apply when the abundance of species (or genera) of cyanobacteria know to be potentially toxic (e.g. Microcystis aeruginosa, Anabaena circinalis) exceeds 15,000 cells / ml.
2. Where total cyanobacteria cell numbers exceed 15,000 cell / mL, but the number of potentially toxic species is less than 15,000 cell / mL, a high alert will apply unless the total biovolume of the sample is less than $2mm^3$ / L. Where the total biovolume of all cyanobacterial species exceeds $2mm^3$ / L a high alert should apply.
3. Local authorities may take a conservative approach, and continue to declare a high alert when the total cyanobacteria cell numbers exceed 15,000 cell / mL if biovolume data are not available (or where low recreational use does not justify the additional laboratory expense of biovolume analysis).

Appendix B
Beach Prioritisation and Monitoring Strategies

Beach prioritisation

A priority evaluation and classification approach was used by councils participating in the BPPP to determine their monitoring needs and help allocate monitoring resources. The approach was based on a qualitative assessment of priority using readily available information on pollution sources and swimming locations. By evaluating this information, swimming locations were classified as 'high', 'medium' or 'low' priority.

The classification of swimming locations according to priority provided the basis for determining resource allocation. Locations that were classified as high priority on the basis of potential pollution and level of use were given a high priority. In situations where resources were limited, available resources were focused on high-priority locations ensuring that the greatest benefit was obtained from the resources available for each monitoring program.

The priority evaluation for each location was determined through the development of conceptual models and by using a rating matrix (see Table B1) based on the following information:

- The *likelihood* of a contamination hazard at a swimming location as determined by a review of the potential pollution sources.
- The *consequence* of the contamination hazard as determined by a review of location use information.
- The priority of the site was evaluated by combining the likelihood and consequence of pollution across the rating matrix.

Steps in a priority evaluation are, for example:

- the likelihood of pollution at a location is 'likely'
- the consequence is 'moderate'
- therefore, the priority of the location is 'high'.

The likelihood of pollution and consequence from pollution are explained in the following sections.

Likelihood of pollution

The likelihood of contamination or pollution was determined by assessing the overall impact of all identified pollution sources at a swimming location. Examples of pollution sources considered during this process included:

- sewage treatment plants
- discharges from stormwater drains, creeks, rivers and lagoons
- discharges from sewer overflows
- discharges from boats
- toilet facilities at the beach
- domestic and wild animals.

Table B1 Rating matrix used to determine swimming location classification

	Likelihood of pollution		
Consequence	*Rare*	*Possible*	*Likely*
Minor	Low priority	Low priority	Medium priority
Moderate	Low priority	Medium priority	High priority
Major	Medium priority	High priority	High priority

Source: Adapted from AS/NZS (1999)

For the purposes of the BPPP the likelihood is determined for each individual source, and then all likelihoods considered together to determine an overall likelihood of contamination for each site. Characteristics used to derive the likelihood of contamination from stormwater drains, creeks, rivers and lagoons included:

- development within the catchment
- volume of discharge
- existing water quality data
- visible signs of stormwater pollution.

Additional characteristics used to derive the likelihood of contamination from sewage treatment plants included:

- location of the outfall
- level of sewage treatment
- history of sewage treatment bypasses
- visible signs of sewage pollution.

This list is not exhaustive, and where necessary, additional known pollution sources were included in the assessment. The likelihood of pollution for the site was then rated as 'rare', 'possible' or 'likely' in accordance with the qualitative definitions provided in table B2.

Table B2 Qualitative measure of likelihood of pollution

Rating	**Description**
Rare	• may occur in exceptional circumstances
Possible	• might occur at some time • some opportunity, reason or means to occur • infrequent or random recorded incidents • little anecdotal evidence
Likely	• expected to occur in most circumstances • considerable opportunity, reason and means to occur • regular reported incidents • good anecdotal evidence

Source: Adapted from AS/NZS Standard for Risk Management (1999)

Evaluation of consequence

Following determination of the likelihood of pollution the consequence of that pollution hazard was evaluated. The consequences of pollution are likely to be greater at a very popular swimming location where more people will potentially come into contact with pathogens, or at tourist swimming locations where reports of a disease outbreak may affect the local economy. The consequences may also be greater at beaches used by people with weaker immune systems, such as small children or the elderly. Therefore factors used in assessing the consequence of a pollution hazard at a swimming location included:

- the number of users
- the age of those using the swimming location
- the effect upon the local economy.

Consequences were rated as 'minor', 'moderate' or 'major' in accordance with the qualitative definitions provided in Table B3. Not all elements of the description will necessarily match swimming location use data. Categories were selected by councils that were considered to best suit the importance of the swimming location to the local community.

Table B3 Qualitative descriptions of consequences

Rating	Description
Minor	• Location rarely used on weekdays • Location occasionally used on weekends or holidays • Few beach users enter the water • Location not popular with children or the elderly • Of little importance to local economy
Moderate	• Location occasionally used on weekdays • Location frequently used on weekends or holidays • Most beach users enter the water • Location often used by children or the elderly • Location of some importance to the local economy
Major	• Location frequently used on weekdays, weekends and holidays • Most beach users enter the water • Location very popular with children or the elderly • Location of great importance to the local economy

Source: Adapted from AS/NZS Standard for Risk Management (1999)

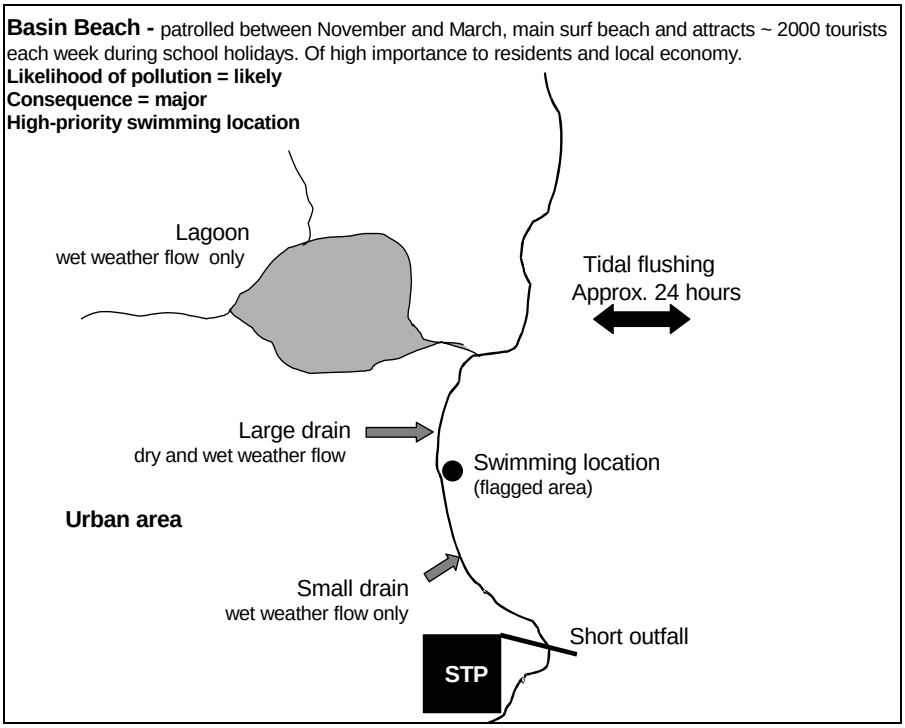
Conceptual model

The information compiled during the risk assessment also forms the basis of a conceptual model. A conceptual model was developed by participating councils for each swimming location in their monitoring program. Information from the models are incorporated into diagrammatical maps of each swimming area. The model is usually a map that illustrates the components and linkages within the system such as that presented in Figure B1. The format should include all identified pollution

sources, information on the timing and extent of their impact, beach use information and the findings of the priority evaluation.

The conceptual model is used to further define the monitoring needs determined from the risk evaluation. The model highlights the important components of the system, the key processes, the cause–effect relationships, the spatial boundary, and any time or seasonal consideration.

Figure B1: Map-based conceptual model for a hypothetical beach



Appendix C
Further Reading

This section provides additional sources of information on monitoring and assessment of bacteriological water pollution and recreational water quality. The information given here is not comprehensive. The intention is to provide a starting point and to list some of the most recent resources available relating specifically to the Sydney region.

1. Reports and texts

ANZECC (Australian and New Zealand Environment and Conservation Council) (2000). *Core environmental indicators for reporting on the State of the Environment*, ANZECC, Canberra.

(Guideline information for recreational water quality indicators)

Apte, S. C., Batley, G. E. and Ashbolt, N. J. (1993). 'Rapid detection of faecal coliforms in coastal waters'. *Australian Water and Wastewater Association 15th Federal Convention 18–23 April 1993*, Technical Papers Vol. 2.

(Research and development – monitoring faecal coliforms in marine waters – rapid assessment for early warning)

Ashbolt, N. J. (1995). 'Health-related water microbiology: Australia leads: But where next?' *Water Journal*, Vol. 22 No. 2 May / June 1995, Australian Water and Wastewater Association, Sydney.

(Discussion on research and development for recreational and drinking water quality indicators and guidelines – includes alternative health-related indicators)

Ashbolt, N. J., Riedy, C. and Haas, C. N. (1997). 'Microbial health risk at Sydney's coastal bathing beaches'. *Australian Water and Wastewater Association 15th Federal Convention 16–21 March 1997* Vol. 2, pp. 104–111.

(Microbial quantitative risk assessment at Sydney's urban coastal beaches using historical microbial data – models used to estimate exposure to pathogenic bacteria, protozoa and a model virus – enteric viruses pose the highest risk to bathers at Sydney ocean beaches)

Australian Water Technologies (1993). *Long Term Beach Water Quality Reporting Series — Reports 1–8*. Water Board, Sydney.

Report 1—*Sampling Strategies and Methods of Analysis* 1965–1992
(Summary of bacteriological data held by AWT for the period 1965–1992 from Sydney and Illawarra regions.)

Report 2—*Assessment of Water Quality of Sydney's Metropolitan Beaches*
(Beach water quality for the period 1969–1991 for Sydney beaches — assessments are based on appropriate bacteriological water quality guidelines — likely pollution sources are discussed.)

Report 3—*Trends in Densities of Faecal Coliforms at Seven Target Beaches in Sydney*
(Examination of trends in faecal coliform levels at seven Sydney beaches between 1969 and 1991 — comparisons are made between pre- and post-deepwater ocean outfall commissioning bacterial counts.)

Report 4—*Assessment of Water Quality of Beaches in the Illawarra Region*
(Review of current water quality of Illawarra beaches)

Report 5—*Spatial and Temporal Variations in Bacterial Densities at Selected Sydney Beaches*
(Determination of the major sources of variation associated with faecal coliform sampling.)

Report 6—*The Influence of Some Environmental Factors on Densities of Faecal Coliforms at Fourteen Sydney Beaches*
(Twenty-four hour rainfall, hours of sunshine, wind direction and speed and tide are examined for influence on faecal coliform counts.)

Report 7—*Trends in Visual Sewage Pollution and Densities of Faecal Coliform Bacteria and their Use as Indicators of Bathing Water Quality at 14 Sydney Beaches*
(Visual sewage pollution between the years 1969 and 1990 — associations between faecal coliform counts and visual sewage pollution indicators.)

Report 8—*Trends in the Concentration of Grease at 13 Sydney Beaches*

Australian Water Technologies, Sydney Water, NSW Environment Protection Authority (2000). *Offshore Sediment Program 2000: Report – Final*, AWT, Sydney.

Bartram, J., Rees, G. (2000). *Monitoring Bathing Waters: A Practical Guide to the Design and Implementation of Assessments and Pilot monitoring programs*. European Commission, World Health Organization, and United States Environmental Protection Agency, E & F Spon, London.

(European guide to developing a recreational water quality monitoring program)

Beachwatch (1995). *Beachwatch Winter Season 1994*. EPA (NSW), Sydney.

(Bacterial monitoring results for Sydney ocean beaches, Winter 1994 – visible sewage pollution indicators – correlation study between faecal coliforms and rainfall for ocean beaches)

Beachwatch (1995). *Beachwatch 1995 Season Report*. EPA (NSW), Sydney.

(Bacterial monitoring results for Sydney ocean beaches, Summer 1994–1995 – visible sewage and stormwater pollution indicators – correlation between visible indicators and bacteria – correlations between rainfall and bacteria – effluent and plume distribution study from Cronulla and Warriewood shoreline outfalls)

Beachwatch (1996). *Harbourwatch 1995 Season Report*. EPA (NSW), Sydney.

(Bacterial monitoring results for Sydney Harbour, Botany Bay, Georges River and Port Hacking beaches, Summer 1994–1995 – background to Harbourwatch program – pollution in Sydney Harbour – factors affecting water quality in Sydney Harbour)

Beachwatch (1996). *Beachwatch and Harbourwatch 1996 Season Report*. EPA (NSW), Sydney.

(Bacterial monitoring results for Sydney ocean, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking beaches, Summer 1995–1996 – changes to

Bulletin criteria – impact of drains on flagged areas – sediment bag monitoring of faecal coliforms – Secchi disk – community expectations of Beachwatch)

Beachwatch (1997). *Beachwatch and Harbourwatch 1997 Season Report*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – communications initiatives – microbiological quality assurance program – post–rainfall recovery study.

Beachwatch (1998). *Beachwatch and Harbourwatch 1997–1998 State of the Beaches. Sydney, Hunter, Illawarra*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – communications initiatives – microbiological quality assurance program – post–rainfall recovery study – Olympic study)

Beachwatch (1999). *Beachwatch and Harbourwatch 1998–1999 State of the Beaches. Sydney, Hunter, Illawarra*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – microbiological quality assurance program – effect of rainfall on Sydney beach compliance – post–rainfall recovery study – Olympic study)

Beachwatch (2000). *Beachwatch and Harbourwatch 1999–2000 State of the Beaches. Sydney, Hunter, Illawarra*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – microbiological quality assurance program – effect of rainfall on Sydney beach compliance – post–rainfall recovery study – Olympic study)

Beachwatch (2001). *Beachwatch and Harbourwatch 2000–2001 State of the Beaches. Sydney, Hunter, Illawarra*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – microbiological quality assurance program – Beachwatch on the Web - effect of rainfall on Sydney beach compliance – post–rainfall recovery study – Olympic study)

Beachwatch (2002). *Beachwatch and Harbourwatch 2000–2001 State of the Beaches. Sydney, Hunter, Illawarra*. EPA (NSW), Sydney.

(Bacterial monitoring of Sydney, Hunter and Illawarra ocean beaches, Sydney Harbour, Pittwater, Botany Bay, Georges River and Port Hacking – microbiological quality assurance program – Beachwatch on the Web - effect of rainfall on Sydney beach compliance – post–rainfall recovery study – Olympic study)

Guest, C., Douglas, R. and Woodruff, R. (1999) *Health and the Environment*. Australian Conservation Foundation, Australian Medical Association, Fitzroy, Vic.

(Public Health - Environmental Health – Environmental Study - Health Planning, Australia)

Healthy Rivers Commission (2000). *Independent Inquiry into the Georges River – Botany Bay System*. HRC, Sydney.

(Analysis and assessment of water quality of Georges River – Botany Bay catchment health)

Healthy Rivers Commission (2000). *Securing Healthy Coastal Rivers: A Strategic Perspective.* HRC, Sydney.

Healthy Rivers Commission (2002). *Independent Inquiry into Coastal Lakes.* HRC, Sydney.

(Analysis and assessment of water quality of NSW Coastal Lake health)

Kirby, A., Van Roo, S. and Collie, T. (1995). *Georges River and Botany Bay Faecal Coliform Monitoring Program, February 1993 – March 1994, Interpretive Report No. 94/104*, Sydney Water Corporation, Sydney.

(Analysis of trends in faecal coliforms in Georges River and Botany Bay – development of sampling strategies for faecal coliforms specifically for Georges River and Botany Bay – correlations with rainfall – pilot faecal coliforms recovery study)

Laws, E. A. (2000). *Aquatic Pollution: An Introductory Text – 3rd Edition*. John Wiley and Sons Inc, New York.

(Background information of marine water pollution issues in a global context)

Leeming, R., Nichols, P. D. and Ashbolt, N. J. (CSIRO Division of Marine Research) (1998). *Distinguishing Sources of Faecal Pollution in Australian Inland and Coastal Waters using Sterol Biomarkers and Microbial Faecal Indicators.* Urban Research Association Australia, Melbourne.

Legge-Wilkinson, M. (1996). *Human Impact on Australian Beaches.* Surfrider Foundation Australia Limited, Sydney.

(Analysis of results from the SOS95 Beach Questionnaire organised by Surfrider Foundation Australia, which documented and assessed human impacts on beaches around Australia)

NSW Department of Land and Water Conservation (2000). *NSW Conservation Strategy*. NSW DLWC, Sydney.

NSW Environment Protection Authority (2000a). *NSW State of the Environment Report 2000*. EPA (NSW), Sydney.

NSW Environment Protection Authority (2000b). *NSW State of the Environment Report 2000: Water Backgrounder*. EPA (NSW), Sydney.

NSW Environment Protection Authority (1995). *Provisional Water Quality Investigations Manual: Preferred Methods for Sampling and Analysis.* EPA (NSW), Sydney.

(Aimed at water quality professionals – standardised monitoring for State of the Environment reporting – management of water quality investigations – sampling procedures – parameters (physico-chemical and biological) and analytical methods – quality assurance and quality control – budgeting – data handling)

NSW Environment Protection Authority (1996). *Sydney Deep Water Outfalls Environmental Monitoring Program: Final Report Series Volumes 1–7*. EPA (NSW), Sydney.

(Provides background information, overall assessment and results of the Sydney Deep Ocean Outfalls program)

Raffensperger, C. and Tickner, J. A. (1999) *Protecting Public Health and the Environment: Implementing the Precautionary Principle*, Island Press, Washington

(Precautionary principle – environment protection – government policy, United States – health risk assessment)

Roberts, E. R. (2000). *Water Quality Control Handbook*, McGraw-Hill. New York.

Salmon, I. (2002). *Water (NSW) A to Z, covering all NSW waters , Inland-Estuarune-Marine*. Lablex Pty Ltd, Main Beach, QLD.

(Aimed at water industry specialists, this manual provides an up-to-date A to Z directory of information about NSW receiving waters – covers everything from algae to zone of aeration – includes notes on Water and the Law)

Short, A. D. (1993). *Beaches of the New South Wales Coast – a Guide to their Nature, Characteristics, Surf and Safety*. Australian Beach Safety Management Program, Sydney.

(Comprehensive guide to NSW beaches – Includes beach dynamics, rip profiles, surf characteristics, Surf Life Saving Club information, surf rescue and water safety)

Southern Sydney Regional Organisation of Councils (2001). *The Tide Is Turning – Final report on the Botany Bay Program*. SSROC, Sydney.

(Provides information, results and discussion strategies on the 18-month Botany Bay Program which aim was to develop a framework for the integrated management plan for Botany Bay catchment)

Sydney Water (1998). *Annual Environment Report*. Sydney Water Corporation, Sydney.

(Provides information on Sydney Water's environmental performance during 1997–98. Includes water supply operations, sewage and stormwater transport, sewage treatment and resource conservation)

Sydney Water (1999). *Annual Environment Compliance Report*. Sydney Water Corporation, Sydney.

(Provides information on Sydney Water's environmental compliance during 1998–1999)

Sydney Water (2000). *Annual Environment and Public Health Report 2000*. Sydney Water Corporation, Sydney.

(Provides information about Sydney Water's performance in managing a range of environmental and social impacts.)

Sydney Water (1998). *Environmental Indicators Monitoring Program Methods Report*. Sydney Water Corporation, Sydney.

(Outlines the methodology for collection, analysis and storage of data collected for Sydney Water's Environmental Indicators Monitoring Program. Also describes the quality system associated with the program and provides detail of indicators used.)

Sydney Water (2000). *Environmental Indicators Monitoring Program Compliance Data 2000*. Sydney Water Corporation, Sydney.

(Contains raw data gathered from Sydney Water's Environmental Indicators Monitoring Program.)

Sydney Water (2000). *2000–2005 Environment Plan*. Sydney Water Corporation, Sydney.

(Provides information on the long term strategic plan for Sydney Water Corporation)

Van Roo, S. and Collie, T. (1993). *Port Jackson Faecal Coliform Monitoring*. AWT Science and Environment Division, Dec 1993. Prepared for Clean Waterways Program, Pollution Abatement Branch, Sydney Water Board, Sydney.

(Background, assessment and analysis of trends of bacteria monitoring of Sydney Harbour)

Van Roo, S., Garforth, S., Kirby, A. and Collie, T. (1995). *Port Jackson Faecal Coliform Monitoring Program – December 1992 – March 1994, Interpretive Report No. 94/103*. SWC, Sydney.

(Analysis of trends in faecal coliforms for Port Jackson – development of sampling strategies for faecal coliforms specifically for Port Jackson – correlations with rainfall and other physico-chemical parameters – pilot faecal coliforms recovery study)

Water EcoScience Pty Ltd: Urban Research Association of Australia (1999). *Alternative Micriobiological Indicators of Water Quality*. Urban Water Research Association Australia, Melbourne.

Waterways Authority (2000). *Sewerage Pollution from Vessels Discussion Paper – Findings and Proposed Actions*. Waterways Authority, Sydney.

(Outlines current situation, legislation – boat populations – infrastructure – other jurisdictions – key findings – public health – environment – pump out facilities – monitoring, compliance and education – proposed actions)

Wong, T. H. F., Breen, P. F., Somes D and Nicholas, L. G. (1999*). Managing Urban Stormwater using Constructed Wetlands*. Cooperative Research Centre for Catchment Hydrology and Monash University, Department of Civil Engineering, Monash University, Victoria.

2. Internet Sites

www.ballinashire.com.au—Ballina Shire Council

http://bellingen.local-e.nsw.gov.au—Bellingen Shire Council

www.chcc.nsw.gov.au—Coffs Harbour City Council

www.environment.nsw.gov.au—Department of Environment and Conservation (NSW)

(Information regarding environmental legislation, DEC programs, and other environmental information. Links to other sites relating to the environment.)

www.environment.nsw.gov.au/beach/cpp/index.htm—Beachwatch Partnership Pilot Program Overview

(Starting point for accessing Beachwatch Partnership Pilot Program resources and information)

www.environment.nsw.gov.au/beach/index.asp—Beachwatch

(Summary of Beachwatch and Harbourwatch programs, state of the beaches, pollution causes, health information and links to other relevant sites.)

www.environment.nsw.gov.au/stormwater

(Describes the urban stormwater program and stormwater treatment devices as well as Stormwater Trust applications and conditions of funding.)

www.environment.nsw.gov.au/stormwater/resourceskit

(This site contains ideas and tools to assist councils implement their stormwater education campaigns.)

www.dsnr.nsw.gov.au/index1.html—The Department of Infrastructure, Planning and Natural Resources

(DIPNR drives, coordinates and streamlines land-use and transport planning, infrastructure development and natural resource management in New South Wales. Incorporates the departments previously known as Land and Water Conservation (DLWC) and PlanningNSW).

www.erin.gov.au—Environment Australia

(This Federal Government environment site provides information on national environmental issues, programs, legislation, policy and new initiatives for environmental management.)

www.esc.nsw.gov.au—Eurobodalla Shire Council

www.fisheries.nsw.gov.au—NSW Fisheries

www.greatlakes.nsw.gov.au—Great Lakes Council

www.health.nsw.gov.au—NSW Department of Health

(This site contains information on public health issues)

www.health.gov.au/nhmrc—National Health and Medical Research Council

(Health information in relation to recreational water use)

www.hrc.nsw.gov.au—Healthy Rivers Commission

(This site contains information on independent public Inquiries into selected NSW waterways, and makes recommendations on the key decisions and actions needed to ensure their future health)

www.huntershill.nsw.gov.au—Municipality of Hunters Hill

www.hunterwater.com.au—Hunter Water Corporation

(Water quality and sewage treatment / disposal information for the Hunter region)

www.lakemac.com.au—Lake Macquarie City Council

www.livingthing.net.au—NSW Environment Service Sector

(This site provides a comprehensive listing of environment online information services.)

www.ea.gov.au/water/quality/nwqms/index—National Water Quality Management Strategy

(This site contains information on water quality monitoring processes, policies and guidelines)

www.maclean.local-e.nsw.gov.au—Maclean Shire Council

www.northsydney.nsw.gov.au—North Sydney Council

www.ozemail.com.au/~mccnet/—Marine and Coastal Community Network

(Provides information on marine and coastal environmental issues Australia wide. The network promotes information sharing between community groups, government agencies and industry.)

www.pittwaterlga.com.au—Pittwater Shire Council

www.pristinewaters.nsw.gov.au—Pristine Waters Council

www.randwick.nsw.gov.au—Randwick City Council

www.slsa.asn.au—Surf Lifesaving Australia

(General beach information, surf safety and patrol dates)

www.realsurf.com.au

(Daily surf reports and information for surfers)

www.shoalhaven.nsw.gov.au—Shoalhaven City Council

http://soedirect.nsw.gov.au/app/index.jsp—SOEdirect

(an interface enabling community access to State of the Environment information)

www.streamwatch.org.au/—Streamwatch

(State community water quality and action network)

www.sydneywater.com.au—Sydney Water Corporation

(Water quality and sewage treatment / disposal information for the Sydney – Illawarra region. Introduces 'WaterPlan 21', the corporation's vision for sustainable wastewater management.)

www.wr.com.au/tnd/surfrider/—Australian Surfrider Foundation

(Aimed at surfers. Provides information on pressures and issues affecting the coastal environment.)

www.au.riversinfo.org

(This Australian-wide catchment management directory contains information about rivers and catchments.)

www.waterwatch.org.au—Waterwatch Australia

(This site contains national information on water quality monitoring and education programs that develop strategies to address water problems.)

www.waterways.nsw.gov.au—NSW Waterways Authority

(Contains information regarding NSW coastal conditions, the Annual Report, Corporate Plan and a discussion paper on sewage from vessels. Describes pollutant sources for waterways.)

www.who.int/water_sanitation_health/Water_quality/recreat2.htm—World Health Organization Guidelines for Safe Recreational Water Environments

(International health information in relation to recreational water use)

www.willoughby.nsw.gov.au—Willoughby City Council website

www.wyongsc.nsw.gov.au—Wyong shire Council

3. Other sources

A list of DEC publications is available from Pollution Line on 131 555. Alternatively, the list can be viewed on the DEC website at www.environment.nsw.gov.au.

Other sources of information on water quality are State of the Environment reports published by local councils, and the NSW State of the Environment Report, published every three years (see www.environment.nsw.gov.au/soe/).

The DEC library holds books, reports and journals relating to most aspects of water quality monitoring and assessment. The library is open to academics, researchers, postgraduate students, environment groups, council officers and other government employees. An appointment to use the library resources is essential and can be made by phoning (02) 9995 5000.

In the Sydney region there are other specialist libraries and information centres that hold information on water quality and related issues. These libraries include the Coastal Environment Centre, Water Reference Library and the Manly Environment Centre. Government authorities and agencies engaged in water resources management, such as the Department of Infrastructure, Planning and Natural Resources and Sydney Water, also have libraries open for research purposes.

References

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra

APHA (1998). *Standard Methods for the Examination of Water and Wastewater*, 20th edition. American Public Health Association, Washington, D.C.

AS / NZS (1999). *Standard for Risk Management AS/NZS 4360:1999*. Standards Australia, Homebush, NSW.

Ballina Shire Council (2001). *State of the Environment Report 2001*—Ballina Shire Council. Ballina Shire Council, Ballina, NSW.

Bellingen Shire Council (2002). *2001–2002 State of the Environment Report – Bellingen LGA*. Bellingen Shire Council, Bellingen, NSW.

Coffs Harbour City Council (2002a). *State of the Environment Report 2002*. Coffs Harbour City Council, Coffs Harbour, NSW.

Coffs Harbour City Council (2002b). *State of the Environment Supplementary Report 2002*. Coffs Harbour City Council, Coffs Harbour, NSW.

DEC (2004). *Monitoring and Reporting Coastal Recreational Water Quality: Information Package and Field Manual*. Department of Environment and Conservation, Sydney.

Environment Protection Authority (2003). *Draft Information Package and Field Manual for Monitoring and Reporting Coastal Recreational Water Quality*. EPA (NSW), Sydney.

Environment Protection Authority (2002). *Draft Information Package and Field Manual for Monitoring and Reporting Coastal Recreational Water Quality*. EPA (NSW), Sydney.

Great lakes Council (2002). *Supplementary State of the Environment Report 2001–2001*. Great Lakes Council, Forster, NSW.

Eurobodalla Shire Council (2000). Eurobodalla State of the Environment Report 2000, In *State of the Environment Report—Australian Capital Region 2000*. Eurobodalla Shire Council, Moruya, NSW.

Hunters Hill Council (2003). Internet page *Development and Environment*, accessed 12th September 2003. (www.huntershill.nsw.gov.au / d&e / index.html)

Lake Macquarie City Council (2002). *2002 State of the Environment Report – City of Lake Macquarie*. Lake Macquarie City Council, SpeersPoint, NSW.

Metropolitan / South Coast Regional Algal Coordinating Committee (2001). *Media fact sheet—New interim guidelines for recreational exposure to waters contaminated by blue-green algae*. 28th February 2001.

Nancarrow S, & Wood J (2000). *Algal Contingency Plan—Metropolitan/South Coast Regional Algal Coordinating Committee*. May 2000, NSW Department of Land and Water Conservation, Parramatta.

NHMRC (1990). *Australian Guidelines for Recreational Use of Water*. Australian Government Publishing Service, Canberra.

NHMRC (1996). *Australian Drinking Water Guidelines*. Australian Government Publishing Service, Canberra.

North Sydney Council (2002). *State of the Environment Report 2002 – North Sydney Council*. Nroth Sydney Council, North Sydney, NSW.

Pittwater Council (2002). *Pittwater State of the Environment Report 2002*. Pittwater Council, Warriewood, NSW.

Pristine Waters Council (2002). *Pristine Waters Council State of the Environment Report 2001/2002*. Pristine Waters Council, Ulmurra, NSW.

Randwick City Council (2002). *2002 State of the Environment Report*. Randwick City Council, Maroubra Junction, NSW.

Shoalhaven City Council (2003). *Shoalhaven City Council 2000/3 State of the Environment Report*. Shoalhaven City Council, Nowra, NSW.

Short, A. D. (1993). *Beaches of the New South Wales Coast – a Guide to their Nature, Characteristics, Surf and Safety*. Australian Beach Safety Management Program, Sydney.

Willoughby City Council (2002). *2001–2002 Supplementary State of the Environment Report*. Willoughby City Council, Chatswood, NSW.

Wyong Shire Council (2002). *2001/2002 State of the Environment Report – Wyong Shire*. Wyong Shire Council, Wyong, NSW.

Glossary

Algae: Comparatively simple chlorophyll-bearing plants which are capable of photosynthesis. They occur in the aquatic environment, and can be microscopic in size.

Algal bloom: Discolouration of the water environment due to a change in species composition and abundance of marine and estuarine microalgae.

Bacteria: See enterococci and faecal coliforms.

Bloom: An unusually large composition and abundance of organisms, usually algae, made up of one or a few species.

Blue-green algae (also referred to as cyanobacteria): A photosynthetic bacteria, which can occur in fresh and salt water and can produce substances toxic to animals. The blue-green is due to the presence of phycocyanin pigments. Includes *Anabaena* and *Microcystis spp*. High concentrations affect suitability of water for recreation and potable supplies.

Catchment: The area that drains surface runoff from precipitation into a stream, river and / or tributaries or urban stormwater drainage system.

Colony forming unit (CFU): A microorganism propagule (spore or cell) from which a colony has grown. For purposes of analysis, one CFU represents one viable organism.

Contaminant: a substance, chemical, or microorganism that makes a medium (water) impure, infected, radioactive, or lower in quality.

Contamination: the process by which any physical, chemical or biological substance (usually human-made / anthropogenic) is introduced into the environment.

Compliance, bacteriological: The finding that waters for *primary contact recreation* (see below) contain a lower density of CFUs (see above) than the maximum set down in guidelines.

Criteria: Standards based on the analysis of scientific data that provide guidelines for the appropriate use of water.

Cyanobacteria: See blue-green algae.

Detection Limit: The minimum concentration, which can be detected under ideal analytical conditions.

Enterococci: Bacteria of the genus *Enterococcus* that may be used to determine the extent of faecal contamination of recreational waters. The *Enterococcus* group is a sub-group of faecal streptococci. It is differentiated from other faecal streptococci by growth at higher temperatures and salt concentrations in the laboratory, and the ability to survive in marine waters under conditions that are unfavourable for most other faecal micro-organisms.

Estuary: A partially enclosed coastal water body open to the ocean, characterised by tidal effects and the mixing of freshwater and seawater.

Faecal coliforms: Mesophilic bacteria that inhabit the intestines of humans and other warm-blooded animals. Faecal coliforms are abundant in bird and mammal faeces and are used as indicators of sewage pollution in marine and fresh waters. These organisms have a relatively short life span in marine waters, indicating the presence of relatively recent sewage contamination.

Freshwater: Water with a low concentration of dissolved salts (salinity less than 0.5 parts per thousand).

Indicator micro-organisms: Bacteria (generally faecal coliforms and / or enterococci) that indicate the relative degree of faecal contamination in waterways. Indicators are generally used to monitor recreational water quality, because searching for specific micro-organisms that cause disease, such as viruses, is both difficult and costly.

Influent: Wastewater entering a sewage treatment plant.

Median: The middle point in a set of data. Defined as the number relative to which half of the scores are greater and half of the scores are lower.

Pathogens: Disease-causing organisms such as bacteria, viruses and fungi, which can cause diseases in plants and animals. Pathogens can be present in high concentrations in municipal sewage, industrial and other type of discharges.

Percentile, e.g. 80th: Within a sample set of five samples, the value below which four of the five values (i.e. 80%) used to calculate the median (see above), fall.

Plume: A stream of water containing a high concentration of suspended materials and / or pollutants (see below) entering a water body.

Pollutants: Chemicals, biological substances, particles, or thermal changes discharged into bodies of water that are potentially detrimental to the environment.

Primary contact recreation: Recreational use of waters that involves bodily immersion or submersion, facilitating direct contact with water; includes activities such as swimming, diving, water skiing and surfing.

Primary sewage treatment: The physical treatment of sewage, designed to remove solids (sludge) via settling floatable solids such as oil, fats and grease by first screening and then ponding the effluent.

Quality assurance/quality control (QA/QC): Procedures and checks used to ensure accurate and reliable results are obtained from environmental sampling and analysis.

Secondary contact recreation: Recreational use of waters that involves some direct contact with water, but the probability of swallowing water is unlikely. It includes activities such as paddling, wading, boating and fishing.

Secondary sewage treatment: Biological and / or chemical treatment of sewage designed to remove the majority of organic matter and solids through several possible processes by using anaerobic bacteria, chemicals and settling ponds.

Sewage treatment plant (STP): The site of convergence and treatment for household, commercial and industrial sewage via the sewerage system. Sewage is treated at an STP to either primary, secondary, or tertiary level before being discharged as effluent to receiving waters.

Tidal flushing: The process by which water in an estuary is replaced with oceanic water due to the flow of water caused by the tides.

Toxicant: An agent or material capable of producing an adverse response in a biological system, seriously injuring structure or function, or resulting in death.

Waste water management systems: Systems designed for the treatment of domestic waste water in a septic environment, used generally in residential settings.

Water quality: The characteristics of water in regard to its physical, chemical and biological properties.