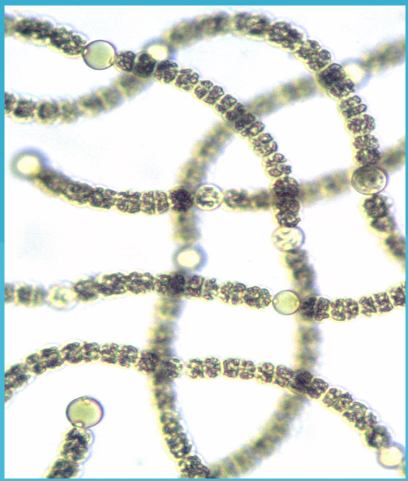
Sewage Treatment System Impact Monitoring Program



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1. Introduction

Sydney Water operates 23 distinct sewage treatment systems (STSs) across the Greater Sydney, Blue Mountains and Illawarra area. Each STS consists of a sewage treatment plant (STP) and its reticulation system. However the Malabar STS includes three Georges River STPs, and the Wollongong STS includes the Bellambi and Port Kembla STPs. These provide an integrated and effective wastewater treatment service to more than 4 million people. One of Sydney Water's principle corporate objectives is to minimise the impact of its activities on the environment. Sydney Water is supported in this capacity by a comprehensive regulatory framework. Each STS has an Environmental Protection Licence (EPL), developed in consultation with the NSW Department of Environment, Climate Change and Water (DECCW), which specifies the performance standards and environmental indicators Sydney Water monitors. The outcomes of this monitoring are reported annually to the DECCW.

The physical environment in which Sydney Water conducts its discharge operations varies widely across its area of operations. Monitoring activities cover a broad range of receiving water environments including marine, shoreline, estuarine and freshwater riverine environments. These systems are distinct in terms of the nature of the discharge operations, the nature of environmental processes and the management objectives. This distinctiveness is reflected in the design of the monitoring programs targeting the respective systems.

The Sydney-Blue Mountains-Illawarra region is a major centre of economic, industrial and agricultural activity. These diverse activities all contribute to environmental health outcomes and Sydney Water's discharge activities represent just one input to the complex local riverine, estuarine and coastal environments. One overarching challenge faced by Sydney Water's monitoring program is differentiating the impacts of Sydney Water's activities from the impacts of all other anthropogenic activities occurring concurrently.

Sydney Water aims to address this challenge, to the extent possible, by supporting sophisticated, robust and well-designed monitoring programs that target key impact indicators that are sensitive to Sydney Water's activities.

In summarising Sydney Water's monitoring programs, this document identifies the individual monitoring programs, their strategic purpose, geographical extent, target species, and frequency of sampling and reporting.

Sydney Water's monitoring activities are designed to meet several strategic objectives:

- fulfill Sydney Water's regulatory obligations to monitor as specified in the Environmental Protection Licences (issued by the DECCW) and Sydney Water's Operating Licence
- contribute to, and support interagency programs which monitor ambient environmental conditions in the key waterways
- contribute to Sydney Water's continuous business improvement by incorporating the outcomes of environmental monitoring into the business planning cycle.

The Sewage Treatment System Impact Monitoring Program (STSIMP) is the successor to Sydney Water's previous waterways monitoring plan, the Environmental Indicators Monitoring Program (EIMP; Sydney Water, 1995), and followed an extensive review and consultation period. This new program was implemented in the 2008-2009 financial year and a minor variation in one of its sub-programs was implemented from July 2010. Sydney Water is committed to adding value to the monitoring program through rigorous scientific analysis of monitoring data, and through sharing monitoring data with government agencies. The new insights and understanding generated by these activities will inform future refinement of the STSIMP.

2. Drivers for Sydney Water's Environmental Monitoring Programs

2.1 DECCW Monitoring Framework

In 2003 the DECCW provided Sydney Water with a *Framework for DECCW Decisions on Sydney Water Licensed Monitoring Requirements* document which outlined key principles, purposes and approaches for a framework for negotiations between Sydney Water and the DECCW regarding monitoring requirements. The framework was used to facilitate the development of robust and cost-effective monitoring programs across Sydney Water's breadth of operational activities.

Sydney Water continuously reviews its monitoring programs, and occasionally identifies opportunities to modify existing programs to improve efficiency. Under the framework, Sydney Water is to submit any proposals to modify its monitoring programs to the DECCW for consideration and endorsement, before any changes are made to the existing programs.

Section 66 of the *Protection of the Environment Operations (POEO) Act 1997* permits the DECCW to require a licensee, in this case Sydney Water, to carry out monitoring of:

- the operation and maintenance of premises or plant
- discharges from premises
- relevant ambient conditions prevailing on or outside the premises
- anything else required by the conditions of the licence.

Section 66 also allows the DECCW to require monitoring data to be analysed, reported and retained.

The DECCW's overarching concern in relation to the transport, treatment and discharge of wastewater in general is in relation to sustainable environmental outcomes ie ensuring the impacts by licensee's operations to humans and receiving ecosystem health are effectively managed, both in the present and in the future. More specifically, discharges have the potential to impact on:

- poor primary and secondary contact recreational water quality
- ecosystem health
- eutrophication potential
- toxicity from exposure to constituent chemicals
- accumulation of contaminants in organisms and sediments
- changes or disturbance to biological communities.

In accordance with this, Sydney Water has aligned the STSIMP to the general purposes for monitoring requirements within the framework as outlined below:

2.1.1 Compliance Assessment

Compliance monitoring associated with discharges, either treated or untreated, from sewage treatment plants and sewerage systems will:

- assess compliance with licence limits and requirements, including an implied limit of 'nil' if necessary
- determine trends to prompt planning for continued compliance

- provide community confidence in both the regulatory system, the sewerage system and plant performance.

Demonstration of consistent compliance provides a potential to review the amount of monitoring required and opportunities for resultant information to inform regulatory change through review. Trends obtained through compliance monitoring can also inform the business and asset planning processes and assist Sydney Water in optimising or modifying its operations.

2.1.2 Monitoring Ambient Outcomes

Ambient monitoring is designed to provide an ongoing assessment of ecological and human health issues especially where Sydney Water is a significant contributor of the anthropogenic pollutant loading to a system (e.g. faecal indicator monitoring at recreational sites, primary treated effluent on marine sediments and benthic fauna).

The DECCW generally requires ambient monitoring to assess chronic or cumulative effects, where Sydney Water is a significant contributor of the anthropogenic pollutant loading and the environmental problem is poorly understood.

Sydney Water's long-term goal is to minimise the impact of our activities and to contribute to healthy waterways and clean beaches and harbours in our area of operations through effective management of our wastewater system. These goals and objectives align with government and public expectations for access to fresh and marine waters for recreation and for sustainable aquatic ecosystems.

2.1.3 Community 'right to know'

Through Sydney Water's reporting framework, the community will have access to the monitoring information summaries that underpins both the above purposes.

2.1.4 Special Investigations

The STSIMP also includes special monitoring investigations that are designed to assist in filling key knowledge gaps. Such special investigations are occasionally commissioned and they are outside the formal statutory scope of routine compliance monitoring. For example, the 2008 STSIMP included the Hawkesbury-Nepean River Macrophyte pilot investigation and on-going SCAMP (Sewerage Catchment Area Management Plan) assessments. These are designed to inform specific aspects of the compliance monitoring and may be one-off studies.

2.1.5 Sewage Treatment Plant Discharge Impacts

Sewage Treatment Plants (STPs) release treated sewage into the environment. STPs have a range of treatment levels from primary to tertiary and discharge into two very different receiving water environments: freshwater inland waterways and the ocean. Therefore, the ambient impact of Sydney Water's STPs differ and is dependent upon the receiving water environment. However, nutrient enrichment and ecosystem health are the main potential impacts assessed in the following programs.

Protection of aquatic ecosystems is defined in ANZECC (2000) as "maintain and enhance the 'ecological integrity' of freshwater and marine ecosystems, including biological diversity, relative abundance and ecological processes". Sydney Water's key corporate objective to 'protect the environment' aligns with this ANZECC goal of ecosystem protection. The STSIMP used biological indicators of ecological integrity in conjunction with physical or chemical indicators to determine STP impacts on receiving waters.

A major aim of the STSIMP is to measure the frequency and intensity of phytoplankton blooms in freshwater locations where Sydney Water STPs are the major contributor and to assess the ocean STP contribution to nutrients in ocean waters outside the dilution or mixing zone using ANZECC (2000) or site specific guidelines.

2.2 Licensing Considerations

The monitoring undertaken is based on requirements under the EPLs issued for each Sewage Treatment System (STP and its reticulation system) by the DECCW. This monitoring falls into the compliance assessment program component. Sydney Water manages three distinct forms of discharge into marine, estuarine and riverine waters:

- sewage treatment plant discharge
- reticulation system discharge (wet and dry weather overflows or leaks)
- stormwater discharge.

To assess the possible impacts of these discharges on environmental and public health outcomes, Sydney Water monitors these discharge operations under two broad programs:

- compliance monitoring - monitoring of compliance against the conditions stipulated in the Environmental Protection Licences
- ambient monitoring - monitoring of water quality and ecosystem in receiving waters as a response to Sydney Water contributions.

The specific statutory instruments covering each of the above are briefly described below.

2.2.1 Environmental Protection Licences

The principle statutory instrument for each STS is the EPL. Each EPL specifies licence conditions under five broad categories:

1. administrative conditions;
2. limit conditions (volume, mass, load and concentration limits for water quality constituents in discharged effluent);
3. operating conditions (dealing with processes and equipment);
4. monitoring conditions; and
5. reporting conditions.

For this STSIMP document conditions 2 and 4 are most relevant. While limit conditions define the water quality of discharged effluent (compliance), monitoring conditions involve monitoring the ecosystem's response to the discharged effluent (ambient environmental condition). The EPL prescribes the category (2) (compliance) conditions in detail. However, for category (4) (ambient environmental condition), the EPL cross-references to another document, the Sewage Treatment System Impact Monitoring Program (STSIMP), for the details regarding this monitoring component.

The EPL reporting requirements for this program is in the form of a three yearly interpretive report (2011, 2014 etc.) and annual data report in other years (2009, 2010, 2012, 2013 etc.)

2.2.2 Environmental Indicator Monitoring Program

The original Environmental Indicators Monitoring Program (EIMP), in turn, was developed as a requirement of the Water Board (Corporatisation) Act 1994 (Sydney Water, 1995). It was originally a requirement stipulated in Sydney Water's Operating Licence. The aim of this program was to provide information on long-term environmental quality and the effects of Sydney Water's discharge operations on the environment. The EIMP was developed in 1995 after extensive consultation, and a final suite of ecosystem health indicators was gazetted in December 1995, adding further statutory weight to these monitoring requirements.

The original EIMP identified indicators in four discrete categories:

- discharge quality
- water quality (receiving waters)
- biota
- sediment.

This STSIMP has replaced the EIMP from July 2008 onwards. Key monitoring indicators for this program remained same as the EIMP. However, now the program is based on four catchment based sub-programs:

- Hawkesbury-Nepean River and Tributaries
- Estuaries
- Coastal Lagoons
- Ocean and Beaches.

2.2.3 Sewer Licensing

The sewage overflow and leakage from the reticulation system is also subject to licence conditions. Targets for the frequency and volume of sewer overflow events are embedded into the EPL for each STS. In order to meet these system performance targets, Sydney Water has developed a program of works (Overflow Abatement Program, OAP) to mitigate both dry-and wet-weather sewer overflows. Sydney Water has also developed a sewer overflow monitoring program to track compliance against the system performance targets, and to assess ecosystem response. The details of the monitoring program are contained in subsequent parts of this document.

2.2.4 Stormwater Discharges

Stormwater discharges are not currently subject to a specific licensing framework.

3. Changes to the Monitoring Program and other Relevant Monitoring Programs

3.1 Changes to the Previous Program

This document (the STSIMP) is the successor to the 1995 EIMP. The STSIMP has been developed following an extensive review of the EIMP, consultation with key internal and external stakeholders, and the shifting of EIMP requirements from Sydney Water's Operating Licence to its EPL. The STSIMP provides a consolidated framework for all statutory monitoring of discharge operations undertaken by Sydney Water, including both compliance and ambient monitoring programs.

The indicators selected for the new program are based on current knowledge of the relationship between pollutants and ecological or human health impacts. The program is consistent with national water quality guidelines (ANZECC, 2000; NHMRC 2008) and NSW State of the Environment reporting, as well as the objectives of previous monitoring programs undertaken by Sydney Water, DECCW and other agencies. Sydney Water will monitor and report annually the outcomes of these programs and where possible use comparable historical data to determine long term trends and changes.

The STSIMP is a refinement of its predecessor the EIMP. The key changes to the program are outlined below:

- The monitoring undertaken at the sewage treatment plants is based on our requirements under the Environment Protection Licences issued by DECCW. This monitoring falls into the compliance assessment program component. The introduction of Whole Effluent Toxicity (WET) testing (which better defines the biological impact of toxicants in effluent) and chemical licence limits replaced the PRT program which required the measurement of 114 chemicals as listed under Schedule 10 of the Sydney Water Act.
- Sydney Water's new ambient monitoring program was developed via a lengthy process of internal stakeholder consultation and review of data from the EIMP and other relevant programs. This includes optimisation of estuarine sites and the inclusion of campaign style monitoring in coastal lagoons, and increased focus on potential eutrophication impacts in the Hawkesbury-Nepean River. Sydney Water's key activities and their potential impacts were identified and draft environmental objectives developed.
- The ambient monitoring program has an increased emphasis on bio-indicators to monitor the ecological health of receiving waters. The advantage of bio-indicators over the grab sampling programs to monitor the physico-chemical characteristics of water quality is that bio-indicators integrate impact over a long period of time. Biological changes in accessible areas like the intertidal zone (ie the recovery of Sydney Rock Oysters), provides easily identifiable evidence of ecological improvement. Such ecological improvements are easy for the community to understand.
- Rationalisation of sampling through collaborative activities with DECCW's Harbourwatch and Beachwatch programs to achieve significant cost efficiencies and improved information sharing opportunities.
- Expansion of Sydney Water's Overflow Abatement Monitoring Program.
- Some special investigations include: dry weather sewage leakage program to identify, locate and repair dry weather leaks from the sewer system, a program to assess the impact of near shore STP effluent outfalls on rocky intertidal communities and a pilot program to determine the feasibility of field measurement of Sydney Water's impact on macrophyte growth in the freshwater section of the Hawkesbury-Nepean River.

The scope of the ambient monitoring of receiving waters has been altered to reflect the findings of the previous work. Inappropriate or redundant sites have been replaced by more relevant sites in all the bio-indicator studies. Overlap in monitoring effort with other agencies has been removed from the recreational water quality program.

The challenge in using some bio-indicator methods is that they can be more complex to quantify and more open to scientific debate. Sydney Water will be rigorous in its analysis of bio-indicator results and report in a transparent and accessible fashion in the public and scientific domains.

In May 2010, the Ocean Sediment Program (OSP) has been revised in an agreement between Sydney Water and DECCW. The new program has a refined number of monitoring sites in comparison to earlier program. It is also agreed to collect and analyse a rationalised number of samples especially during the surveillance years. The new OSP has been implemented from July 2010.

3.2 Other Relevant Monitoring Programs

Whilst not described in this document, other major Sydney Water and government monitoring initiatives are run either in parallel or operate in synergy (being recipients or providers of complementary monitoring information) with the STSIMP. The programs include:

- Marine and Estuarine Monitoring Program (MEMP) to monitor the impact of construction and operation of Sydney Water’s Desalination Plant on environment.
- Hawkesbury-Nepean River Integrated monitoring Project, as outlined in the Metropolitan Water Plan and currently being coordinated by DECCW.
- Replacement Flow Project: Western Sydney Recycled Water Initiative (WSWRI) Monitoring Plan to monitor the impact from construction and operation.
- Other monitoring programs to measure the impact from constructions and operations of Sydney Water’s capital projects eg Priority Sewerage Programs, STP amplification or upgrades etc.
- Beachwatch and Harbourwatch programs measuring potential contamination due to stormwater and sewage pollution coordinated by DECCW.

4. Monitoring Programs

This section of the document describes all monitoring programs including rationale and key changes in relation to past programs. An overview of all components of STSIMP are outlined in Table 1. Three special investigations or short-term monitoring programs are included in section 4.5. More specific details of the monitoring sites, sampling methods and analyses are presented in Appendix 2. All sampling and analysis is undertaken according to detailed work specifications. The quality control measures undertaken are summarised in Appendix 3.

4.1 Hawkesbury-Nepean River and Tributaries

4.1.1 Inland Sewage Treatment Plants: Effluent Quantity, Quality and Toxicity

Currently, there are 13 STPs and 2 sewage treatment and recycled water plants (STRWPs, Picton and Rouse Hill) operating in the greater Hawkesbury-Nepean catchments including 3 discharging to the lower estuarine environments (West Hornsby, Hornsby Heights and Brooklyn) (Appendix 2: Table A-1 and Figure A-1). Effluent from all these STPs is treated to tertiary standard. This effluent has low levels of biochemical oxygen demand (BOD) and suspended solids. This in turn ensures that oxygen levels are not depleted in the stream receiving the effluent and that the water clarity is at least comparable with the receiving water if not better.

Effluent from the Picton STRWP is completely re-used for agricultural irrigation and there is no discharge to the river except in severe wet weather. The majority of flow from Richmond STP is also used for irrigation by the University of Western Sydney and the golf course. Rouse Hill STRWP supply treated effluent to households for use on gardens and toilet flushing. A number of other STPs (eg Penrith) have re-use schemes, mostly providing water for playing fields.

An Advanced Recycled Water Treatment Plant (ARWTP) was recently constructed and is undergoing a proving period at St Marys STP. This ARWTP is treating existing tertiary treated effluent from St Marys, Quakers Hill and Penrith STPs to produce up to 50 ML/day of highly treated recycled water. This water is being discharged to the Nepean River to replace environmental releases from Warragamba Dam.

Sydney Water measures a range of constituents in effluent discharges. For the inland STPs substances such as ammonia nitrogen, total nitrogen, total phosphorus, residual chlorine, faecal coliform bacteria, suspended solids, BOD and heavy metals are measured.

Discharge volume is monitored daily and combined with effluent quality data to produce pollutant load estimates.

Effective from 1st April 2004, the DECCW introduced changes to STS licences and removed targets for substances listed in Schedule 10 of the Sydney Water Act 1995 and replaced them with effluent toxicity requirements and specific chemical limits for compounds noted above.

The toxicity test uses the water flea, *Ceriodaphnia dubia,* for inland STPs to test the effect of STP effluent on immobilization after a specified period.

Effluent quantity, quality and toxicity monitoring is undertaken according to the terms of the EPLs issued by the DECCW for each STS. The details on Inland STP effluent quantity, quality and toxicity monitoring program and method of analysis is given in Appendix 2 (Table A-1 and Table A-2). It should be noted that STP monitoring program varies from time to time as per each EPL.

Table 1: Summary of STSIMP

Receiving waters	Ecosystem types	Sydney Water activities	Monitoring programs (Chapters)	Summary of monitoring
Hawkesbury-Nepean River and tributaries	Freshwater and Estuarine	STP discharges (all disinfected) and some level of overflows	STP Effluent Quantity, Quality and Toxicity (4.1.1)	13 STPs and 2 STRWPs (Appendix 2: Table A-1 and Figure A-1), Effluent quantity: on line monitoring; effluent quality: ammonia nitrogen, total nitrogen, total phosphorus, residual chlorine (for STPs with disinfection systems), faecal coliforms, suspended solids and CBOD, every 6 days; Toxicity testing by *Ceriodaphnia dubia*, every month; Heavy metals and organics, every month. Minor STP specific variations and other requirements as per EPL.
			Ecosystem Health: Eutrophication –Algal Growth (4.1.2)	18 sites (Appendix 2: Table A- 3: and Figure A-2), every 3 weeks; chlorophyll-a, algal identification and counting triggered by elevated chlorophyll-a (7 µg/L), associated nutrients and physico-chemical measurements.
			Ecosystem Health: Freshwater Macroinvertebrates (4.1.3)	42 sites (Appendix 2: Table A- 5 and Figure A-3), 2 times per year; macroinvertebrates diversity, calculation of SIGNAL.
Estuaries: Georges River, Cooks River, Parramatta River, Lane Cove River, Port Jackson	Fresh water	Overflows	STP Effluent Quantity, Quality and Toxicity (4.2.1)	2 STPs and 1 storm sewage treatment plant (SSTP, Appendix 2: Figure A-1 and Table A- 6), Effluent quantity: on line monitoring; effluent quality: CBOD and suspended solids, every month at Liverpool only.
			Ecosystem Health: Freshwater Macroinvertebrates (4.2.2)	10 sites (Appendix 2: Table A- 7 and Figure A-4) of major rivers feeding the Sydney estuaries, 2 times per year, macroinvertebrates diversity, calculation of SIGNAL-SG.
	Estuarine	Overflows, Sydney Water owned stromwater systems	Public Health: Recreational Water Quality (4.2.3)	55 Harbourwatch sites (Appendix 2: Table A- 8, Figure A-5 and Figure A-6, Figure A- 7); every 6 days and monthly during winter months (May to September); conductivity and enterococci.
			Ecosystem Health: Eutrophication (4.2.4)	16 sites (Appendix 2: Table A- 10 and Figure A-8), every month, chlorophyll-a only.
			Ecosystem Health: Intertidal Community (4.2.5)	27 sites (Appendix 2: Table A- 11 and Figure A-9) of Port Jackson, Botany Bay, Port Hacking once per annum (spring/ summer).
			Dry Weather Overflows (4.2.6)	Determine total number of overflows per SCAMP and the proportion that reach receiving waters.
			Wet Weather Modelled Overflows (4.2.7)	Annual model runs to determine overflow frequency and volume information.

Receiving waters	Ecosystem types	Sydney Water activities	Monitoring programs (Chapters)	Summary of monitoring
Coastal Lagoons	Estuarine	Overflows	Public Health: Recreational Water Quality (4.3.1)	8 sites (Appendix 2: Table A-12 and Figure A-10), every month during routine years and every 6 days during campaign year; conductivity and enterococci.
			Ecosystem Health: Eutrophication (4.3.2)	7 sites excluding new DECCW sites (Appendix 2: Table A-12 and Figure A-10), every month, chlorophyll-*a* only.
Ocean and Beaches	Near Shore Water	STP discharges, overflows	STP Effluent Quantity, Quality and Toxicity (4.4.1)	7 STPs, 2 SSTPs and 1 STRWP (Appendix 2: Figure A-1 and Table A-13), Effluent quantity: on line monitoring; effluent quality: CBOD, oil and grease, suspended solids, every 6 days; Toxicity testing by sea urchin sperm and eggs, every month; Heavy metals and organics: every fortnight where applicable . Minor STP specific variations and other requirements as per EPL.
			Public Health: Recreational Water Quality (4.4.2)	36 sites Sydney ocean beaches (Appendix 2: Table A- 14, Figure A- 11); every 6 days; enterococci only. 18 sites in the Illawarra region (Appendix 2: Table A- 15 and Figure A-12); every 6 days, 15 sites throughout the year, Austinmer, Thirrul and Kiama for Oct to April period only; conductivity and enterococci.
	Offshore Water	Deepwater ocean outfalls	Ocean Reference Station (4.4.3)	Impact of ocean outfall on water quality: predicted by numerical modelling of dispersion of the effluent plume using ocean reference centre data.
			Ecosystem Health: Shoreline Outfall Program (4.4.4)	3 sites (Appendix 2: Table A-16 and Figure A- 13), once every year; composition and abundance of intertidal biota.
			Ecosystem Health: Marine Benthic and Sediment Quality (4.4.5)	18 sites (Appendix 2: Table A-17 and Figure A-14), surveillance once each year and assessment every third year; Benthic community and associated contaminants in sediments.

4.1.2 Ecosystem Health: Eutrophication – Algal Growth

Rationale

The Hawkesbury-Nepean River system is one of the longest coastal rivers in eastern Australia with a catchment area of approximately 22,000 km^2. The river drains most of the fastest growing developing areas to the west of Sydney. This development and associated activities in the catchment can adversely affect the health of the river due to changes to natural flows and nutrient inputs. A significant volume of sewage effluent is discharged to the river system from 16 Sydney Water STPs (Sydney Water, 2005a). There are also numerous point and diffuse sources of pollution to the river such as sewage effluent from council STPs and agricultural runoff. Sydney Water's Hawkesbury-Nepean River eutrophication monitoring program is designed to monitor the direct impacts of Sydney Water activities and also to monitor ambient environmental conditions at sites where Sydney Water may be a major contributor. Sydney Water has significantly reduced the load of phosphorus entering receiving waters in the Hawkesbury-Nepean River basin from STPs. Reduction in nitrogen loads from STPs has also decreased but to a lesser extent.

Unlike the ocean waters, algal blooms in the Hawkesbury-Nepean River has been an acknowledge river management issue in the past. The key drivers for these blooms are a combination of flow, temperature, light penetration, water clarity and nutrient levels. Sydney Water has significantly reduced the amount of phosphorus discharged to the river from its STPs, resulting in changed algal dynamics in the river (Hassan *et al.*, 2005). A review of the EIMP in 2002 found that the climax of phytoplankton community composition as well as abundance did not necessarily occur immediately downstream of STPs as physical factors like flow rate and light penetration were also important determinants of the potential for phytoplankton growth.

The intent of the eutrophication monitoring program for inland waters is to measure the dynamics of algal growth, standing crop and diversity of aquatic plant and micro-algal (phytoplankton) assemblages.

The program focuses on monitoring phytoplankton at sites in the main stream of the Hawkesbury-Nepean River which have a history of phytoplankton blooms. Sydney Water's potential impact on the biomass and diversity of the phytoplankton community in the Hawkesbury-Nepean River is to be assessed in this program.

Monitoring Program

Field measurements and samples are collected on a three weekly basis from 18 sites as listed in Appendix 2 (Table A- 3 and Figure A-2). From each site two replicate samples are collected for analysis in order to verify local variability. Depending on the waterway and local conditions, replicate samples are obtained either by one of two methods – the first method is to obtain samples approximately 100 metres apart, the second method is to obtain sample from one site approximately five minutes apart. Each replicate is made up of a composite of two samples collected, where possible, at a depth of 0.5 metres below the surface.

Field measurements (Appendix 2: Table A- 4) are taken at each site after sample collection on one of the replicate sample only. All replicate samples (duplicate from each site) are analysed in Sydney Water Laboratories by NATA (National Association of Testing Authorities) accredited methods for the selected water quality variables that can affect phytoplankton growth (Appendix 2: Table A- 4). Phytoplankton abundance is determined during elevated chlorophyll-*a* concentrations. The phytoplankton is identified to genus level whenever the chlorophyll-*a* level exceeds 7 µg/L. This level is a site-specific trigger based on the Healthy Rivers Commission water quality objective for the Hawkesbury-Nepean River (HRC, 1998).

Quality control samples are also collected and analysed. A duplicate is collected on each run and field blank/ trip blank is collected on alternate runs. That is, if one month a field blank is collected and the following month a trip blank should be collected.

4.1.3 Ecosystem Health: Freshwater Macroinvertebrates

Rationale

Biological indicators for assessing aquatic ecosystem health can be based on community structure (diversity) or key ecological processes e.g. respiration or production (ANZECC, 2000). Biological communities can be very useful indicators of the condition of aquatic systems because of the differential sensitivity of individual species to environmental stressors (Niemi *et al.*, 2004). The structure of biological communities is shaped by the exposure of animals and plants to stressors over time. Thus community structure is a direct and often visible expression of the ecological health of the system.

Since 1994, Sydney Water has developed indicators of aquatic ecosystem health in the Sydney region based on the structure of freshwater macroinvertebrate communities and estuarine intertidal communities. These bio-indicators are responsive to ecosystem stressors such as toxicants, organic material or eutrophication which may enter the system as a result of Sydney Water's activities.

Freshwater macroinvertebrates are widely used as indicators of water quality and ecosystem health and have been utilised for this purpose in the Monitoring River Health Initiative (1994 to 2001), which was part of the National River Health Program (DEH, 2005).

The aim of this program is to assess the impact of Sydney Water's STP discharges to freshwaters on the health of aquatic ecosystem by monitoring the freshwater macroinvertebrate community.

Monitoring Program

Aquatic macroinvertebrates are monitored to assess impacts on the aquatic ecosystem from the regular effluent discharges. Monitoring of the freshwater macroinvertebrates is being carried out at 42 sites of the Hawkesbury-Nepean River and tributaries listed in Appendix 2 (Table A- 5 and Figure A-3).

Collection of macroinvertebrates is based on relatively inexpensive but efficient rapid assessment methods (e.g. Chessman, 1995; Turak *et al.*, 2004). Macroinvertebrates are collected in autumn and spring from up to four distinct habitats (pool edges, pool rock, macrophytes, and riffles) of the river or stream. Different groups of animals occur within these habitats and the most sensitive assessment is achieved by sampling as many habitats as possible at each study site.

Freshwater macroinvertebrate samples are sorted in the field to obtain the range of animals present at each site. Sorted collections of freshwater macroinvertebrates are then returned to Sydney Water's laboratory facility for identification. All samples are examined using high magnification to identify and count all organisms up to genus level using published keys (Hawking, 2000), or using descriptions and reference specimens maintained by the Sydney Water Laboratory (accreditation number 610 issued by NATA).

After identification and enumeration, macroinvertebrates data are analysed, using the genus taxonomic version of the Stream Invertebrate Grade Number Average Level (SIGNAL-SG) biotic index to provide a surrogate measure of ecosystem health (Chessman *et al.*, 2007). Calculation of SIGNAL-SG scores and analysis techniques are outlined in Besley and Chessman (2008).

A comparison of average SIGNAL-SG scores are made to fulfil the following two key objectives:

- to determine the relative health of the locality in comparison to other reference sites
- to identify any impact from the operation of STPs by assessing the upstream and downstream data.

4.2 Estuaries

4.2.1 Georges River Sewage Treatment Plants: Effluent Quantity, Quality and Toxicity

There are two STPs and one SSTP (Appendix 2: Figure A-1) operating in the estuarine catchment which occasionally discharge into the Georges river and its tributaries. Liverpool and Glenfield STPs are secondary treatment plants which discharge to the Northern Georges River sub-main (NGRS) then onto Malabar via the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS). Fairfield is a SSTP and provides primary treatment and disinfection before discharging to Orphan School Creek when the NGR is at capacity.

Effluent quantity and quality monitoring is undertaken according to the terms of the EPLs issued by DECCW for the Southern Sydney STS. Details for the Georges River STPs are given in Appendix 2 (Table A- 6 and Figure A-1). It should be noted that STP monitoring program varies time to time as per each EPL.

4.2.2 Ecosystem Health: Freshwater Macroinvertebrates

Freshwater macroinvertebrates communities are measured at 10 sites in the major rivers feeding the Sydney estuaries. These are assessed in the freshwater reaches of Lane Cove, Parramatta and Georges Rivers as well as key reference sites (Appendix 2: Table A- 7 and Figure A-4). The monitoring is continuing twice per annum (autumn and spring). The methods of sampling and analysis are the same as those described for the Hawkesbury-Nepean River System (Section 4.1.3) with test sites compared against reference sites.

4.2.3 Public Health: Recreational Water Quality

Rationale

Between 1995 and 2008 Sydney Water has sampled 26 sites in Port Jackson (including Parramatta River, Middle Harbour and Lane Cove River), Botany Bay (including Georges River and Cooks River) and Port Hacking on an on-going monthly basis as well as three wet weather events per annum as a component of the old EIMP.

Sampling and analysis was undertaken for a range of physico-chemical, biological and indicator microbiological analytes. The broader program aim was to assess overall impacts in relation to sewer overflows, not simply microbiological impacts. As the frequency of sampling occurred at monthly intervals, the program was not consistent with the requirements of the National Health and Medical Research Council (NHMRC) Recreational Water Quality Guidelines (NHMRC, 2008). It was noted however that Sydney Water monitoring sites were, for the most part, not considered primary contact recreational sites and where these were, they overlap with existing Harbourwatch sites, which are monitored by DECCW in accordance with guideline frequency.

Furthermore, there were a number of EIMP sites that relate to the assessment of the North-side Storage Tunnel (NSST) upgrade and were not selected for recreational water quality purposes. These sites comprise impact sites and a number of control sites (including urban impacted controls).

After discussion and negotiation between Sydney Water and DECCW, a revised recreational water quality monitoring program was endorsed in 2008. Sydney Water would no longer monitor recreational water quality in Sydney Harbour, Botany Bay, lower Georges River and Port Hacking, but would report the results from DECCW's Harbourwatch Program.

Monitoring Program

The DECCW Harbourwatch program currently collects routine microbiological samples from 55 swimming locations in Botany Bay, lower Georges River, Port Hacking, Port Jackson, Middle Harbour and Pittwater (Appendix 2: Table A-8, Figure A-5, Figure A-6 and Figure A- 7). Four sites in Sydney Harbour were removed from the original Harbourwatch Program in 2009-2010 on advice from local councils (Little Sirius Cove, Sangrado Baths, Henley Baths and Darling Harbour). These sites were rarely used for swimming and/or were in a state of disrepair.

DECCW collects enterococci samples at estuarine swimming locations every six days during swimming season (October to April) and monthly for the reminder of the year. Enterococci samples are sent to an independent contracted laboratory for analysis. Sydney Water provides DECCW sampling bottles for conductivity monitoring, and these samples are sent to Sydney Water laboratory for analysis.

In line with the National Health and Medical Research Councils Guidelines for Managing Risks in Recreational Waters (NHMRC, 2008), DECCW has completed sanitary inspections for all 55 estuarine swimming locations. The Sanitary Inspection Category reflects the degree of influence of faecal material at a site and, along with microbial water quality information, is used to determine a Beach Suitability Grade for the swimming location.

4.2.4 Ecosystem Health: Eutrophication

Rationale

Prior to July 2008, Sydney Water used EIMP site data to report information on trophic status in the estuaries and their reaches. As such, data from 26 sites were collected and collated for 15 combined monthly and wet weather events per annum.

In 2004-2005 Sydney Water commissioned Commonwealth Scientific and Industrial Research Organisation (CSIRO) to analyse ten years of estuarine and lagoon eutrophication-related data (1995-2004) as part of a review of the long-term assessment of Sydney Water operational impacts on estuarine trophic status. Based on the data provided, this review concluded by finding that there was no statistically significant evidence of nuisance phytoplankton growth in the estuaries and no direct evidence that sewer overflows have increased the trophic status of estuarine receiving waters (CSIRO, 2005).

It was proposed that the eutrophication monitoring program should be rationalised to incorporate key sites in the estuaries, which would be sampled and analysed on a monthly basis (with no targeted wet weather events). Chlorophyll-*a* was to be used as the sole indicator for eutrophication impacts. In many cases, and where possible, key sites have been chosen at or near existing Harbourwatch sites in consideration of links to algal blooms and adverse public health outcomes should the former occur. In these cases, Sydney Water bears the cost of additional sampling bottles and other necessary equipment as well as full costs for analysis and transportation of water quality samples.

Monitoring Program

The estuarine sampling sites (16 sites) for eutrophication monitoring are listed and shown in Appendix 2 (Table A- 10 and Figure A-8) including responsibility of sampling. Sangrado Bath (PJSB) was removed from the original Harbourwatch Program in 2009-2010. It is noted that should Harbourwatch sampling sites be enclosed bathing areas, then sampling is to be undertaken in open waters, in the vicinity of nominated sites. All samples are analysed for chlorophyll-*a* only. Sampling frequency is monthly. There is no requirement that all sites have to be sampled on the same day. However, if multiple subsequent runs are arranged then these should be within one week from each other. No extra wet weather samples are collected.

4.2.5 Ecosystem Health: Intertidal Community

Rationale

The objective of this program is to measure general ambient condition of the Sydney estuaries that may be impacted by Sydney Water activities.

Under the old EIMP program Sydney Water assessed intertidal community assemblages on rocky reef substrates as an indicator of general ecosystem health. Ecological data were collected from 32 sites once per annum. The sites were originally related to the assessment of the North-Side Storage Tunnel (NSST) upgrade. These sites included impact locations and a number of control locations (including urban impacted controls). The NSST upgrade was complete and the recovery of ecosystem health that correlates to this upgrade had been demonstrated (Sydney Water 2004; Courtney *et. al.,* 2005).

In 2008, DECCW has approved that the ecosystem health monitoring program be continued with some limited rationalisation to incorporate key estuarine sites that are most representative of impacted areas around the harbour.

Monitoring Program

This monitoring program assesses the community assemblages on rocky substrates in the intertidal zone at 27 sites of Port Jackson, Botany Bay, Port Hacking and the Lower Hawkesbury once per annum (spring/ summer) (Appendix 2: Table A- 11 and Figure A-9).

The species types and abundance of organisms are measured on suitable intertidal rocky substrates at each site. The method focuses on the oyster habitat, in the mid tide area of the littoral zone. Quadrat sites are re-randomised on each occasion. The quadrat technique for sampling an intertidal community has been a standard method in Marine Ecology for at least two decades. For a more detailed description of the technique refer to Kingsford and Battershill (1998).

All settlement organisms within each quadrat are identified to the lowest taxonomic level that is practical in the field using a standard taxonomic reference (Edgar, 1997). Seven randomly allocated quadrats are measured at each site.

At each site sessile organisms living on intertidal hard substrates are measured using $0.25m^2$ quadrats. If possible, artificial substrates (hardwood panels) are also introduced so that recruitment of intertidal organisms can be monitored.

Intertidal assemblages: Measurements are made using $0.25m^2$ (0.5m x 0.5m) quadrats on suitable intertidal rock or erosion protection retaining walls of each site.

Intertidal settlement: Intertidal settlement onto four hardwood panels is measured after four months exposure (January to May and July to November each year) in the intertidal zone. The majority of settling organisms are clearly visible without a microscope and are either barnacles (predominantly *Balanus* spp. but with a number of other genera belonging to the suborder Balanomorpha, eg *Elminius* and *Hexaminius*), tube worms (*Galeolaria* spp.) or green algae (dominated by *Entromorpha* spp and *Ulva lactuca*).

4.2.6 Dry Weather Overflows

Dry weather overflows are mainly caused by blockages or chokes in the system (often due to tree roots in the pipes). Some leakage from sewer occurs (often due to damaged or faulty pipes) and sewage pumping stations can fail (often due to failure of mechanical or electrical equipment). These overflows tend to be sporadic and impact a localised area in the vicinity of the discharge. The occurrence of overflows due to chokes is being maintained and the number of these that discharge to waters is being reduced. Sydney Water does ambient monitoring of stormwater outlet quality to detect leakage (detail in section 4.5.1). Upgrades to pumping stations and improvements in early identification of pending failure and incident response (commenced in 2000) is continuing.

The DECCW and Sydney Water have set limits for the total dry weather overflows due to chokes and targets for the overflows that result in discharge to waters for each *Sewerage Catchment Area Management Plan* (SCAMP).

Sydney Water is recording the total number of overflows per SCAMP and the proportion that reach receiving waters.

The DECCW requires Sydney Water to report when the dry weather overflow abatement plan has not been achieved over the past year in its Annual Returns.

4.2.7 Wet Weather Modelled Overflows

The 23 sewage treatment systems in the Sydney, Illawarra and Blue Mountains areas comprise more than 21,000 kilometres of trunk and reticulation sewers. A similar length of privately owned house sewers connect households to Sydney Water's sewerage system.

Sewage overflows are any discharge of untreated or partially treated sewage or diluted sewage from the sewerage system in dry or wet weather.

The environmental impacts of sewage overflows were assessed by Sydney Water as part of the investigations carried out for the licensing of sewerage overflows (Sydney Water, 1998). The Environmental Impact Statements documented the extent of overflows, their impacts, and the level of overflow reduction that will help achieve the community's desired environmental objectives. Part of the licensing of sewerage overflows is a requirement in Sydney Water's EPLs to develop and maintain hydraulic sewer system model for each sewerage system. These models are yearly updated and calibrated to DECCW's specified requirements and model runs are undertaken to provide overflow frequency and volume information. This information is provided annually to the DECCW as part of the annual returns and to calculate the annual fee .

4.3 Coastal Lagoons

4.3.1 Public Health: Recreational Water Quality

Rationale

Under the old EIMP Sydney Water used to sample at seven sites in Narrabeen, Dee Why, Curl Curl, Manly and Wattamolla lagoons monthly sampling plus three wet weather events per year. Sampling and analysis was undertaken for a range of physicochemical, biological and indicator microbiological analytes (Sydney Water, 1995).

Long-term recreational water quality in the lagoons has been clearly established from the data collected over thirteen years between 1995 and 2008. From 2008, routine and campaign monitoring was introduced in coastal lagoons monitoring program. At that time DECCW agreed that these long-term data sets would be used to generate baseline response curves which will then be used for future comparison with upcoming campaign results. The program was designed to assist in the compilation of an adequate data set for recreational water quality assessment in accordance with the requirements of the NHMRC recreational water quality guidelines (NHMRC, 2008). Campaign monitoring was to be undertaken to verify improved water quality performance in lagoons following sewage system improvements and/or on a three-year basis to compile adequate data points to determine recreational waters classification under the NHMRC guidelines.

Monitoring Program

The eight coastal lagoon monitoring sites are listed and map locations shown in Appendix 2 (Table A-12 and Figure A-10). For seven Sydney Water sites, only conductivity, faecal coliforms and enterococci are used as the indicators for recreational water quality monitoring (Appendix 2:).

It is proposed that from July 2011, Sydney Water will discontinue monitoring of faecal coliforms from these seven lagoon monitoring sites. The latest National Health and Medical Research Council's guidelines for Managing Risks in Recreational Waters (NHMRC, 2008) suggests that faecal coliforms are not a suitable indicator in classifying recreational water bodies. Based on the new guidelines, sanitary inspections (categorise site based on the assessment of the degree of influence of faecal material) will be included at all of these lagoon monitoring sites.

The following two types of monitoring has started from July 2008:

- **Routine:** Monthly samples are collected during eutrophication sampling to assist in the development of a recreational water quality baseline during non-campaign years.
- **Campaign:** Campaign monitoring provides detailed updates on trends in recreational water quality for a year in a three year cycle. Sampling is more frequent (every 6 days). This one-in-three year monitoring will allow the collection of sufficient rainfall event data for indicator organisms. Campaign years are proposed to take place at the conclusion of every three year period. Sufficient data to be collected during the Campaign to provide for the production of an appropriate response curve.

The first campaign monitoring was conducted during 2009-10. Further campaign monitoring programs are to be followed during 2012-13, 2015-16 and so on.

4.3.2 Ecosystem Health: Eutrophication

Rationale

Prior to July 2008, Sydney Water used to monitor a range of physico-chemical parameters and chlorophyll-a at seven sites in Narrabeen, Dee Why, Curl Curl, Manly and Wattamolla lagoons at a monthly rate plus three wet weather events per year (Sydney Water, 1995).

Analysis of ten years of lagoon eutrophication-related data (1995 to 2004) generally showed no increase in trophic status over ten years of monitoring (CSIRO, 2005).

Monitoring Program

The revised coastal lagoons eutrophication program is continuing from July 2008 to monitor only chlorophyll-*a* at monthly intervals. Wet weather sampling is no longer undertaken. All monitoring sites are listed and shown in Appendix 2 (Table A-12 and Figure A-10).

4.4 Ocean and Beaches

4.4.1 Ocean Sewage Treatment Plants: Effluent Quantity, Quality and Toxicity

There are 7 Sydney Water STPs, 2 SSTPs and 1 STRWP mostly discharging to the ocean via Deep Ocean Outfalls (DOOFs) (Appendix 2: Figure A-1 and Table A- 13). The three major sewage treatment plants (STPs) in the Sydney region are located at North Head, Malabar and Bondi. The effluent from these high rate primary sewage treatment plants is discharged from DOOFs approximately between 2 and 4 km offshore in depths between 60 and 80 metres. A small volume of untreated sewage is discharged from cliff face outfalls at Vaucluse and Diamond Bay. Sydney Water is currently working on a two-staged project to transfer wastewater away from these ocean outfalls.

Secondary treated effluent is discharged to the ocean from Warriewood, Shellharbour, Bombo and Wollongong STPs. As part of the Illawarra Wastewater Strategy (IWWS), Bellambi and Port Kembla STPs were converted to storm flow plants and their dry weather flow diverted to the upgraded Wollongong STP to discharge tertiary treated effluent via a DOOF, 1.2km offshore.

Warriewood STP discharges through a shoreline outfall. Shellharbour and Bombo STPs discharge near the shoreline in water depth less than 9 metres.

Cronulla is another coastal STP with tertiary treatment. The discharge is to the near shore from a shoreline outfall about 1m above the sea floor (average water depth approximately 6m).

Sydney Water measures a range of constituents in effluent discharges. For STPs that discharge to the ocean, these generally include substances such as suspended solids, oil and grease. In addition a range of heavy metals, nonyl-phenol ethoxylates, pesticides and toxicity are monitored according to the terms of the EPLs issued by the DECCW for each STS.

The toxicity test uses sea urchin sperm and eggs for ocean STPs to test the effect of STP effluent on fertilisation after a specified period.

The details on Ocean STP effluent quantity, quality and toxicity monitoring program and method of analysis is given in Appendix 2 (Table A- 13 and Figure A-1). It should be noted that STP monitoring program varies from time to time as per each EPL.

4.4.2 Public Health: Recreational Water Quality

During 2008, discussions between Sydney Water and DECCW concluded that Sydney beaches will be monitored by DECCW under the Beachwatch program and Sydney Water will continue monitoring at the Illawarra beaches.

The details of 36 Sydney beaches (monitored by DECCW) are given in Appendix 2 (Table A- 14 and Figure A- 11). All of these sites are monitored for enterococci at every six days intervals throughout the year.

The Illawarra recreational water quality monitoring sites are shown in Appendix 2. (Table A- 15 and Figure A-12). All 18 sites are monitored at six days intervals and samples analysed for conductivity and enterococci (Appendix 2: Table A- 9). Among these, 15 sites are monitored throughout the year and three sites (Austinmer, Thirrul and Kiama) are monitored for October to April period only.

From August 2009, the program also included sanitary inspections at each site based on the new National Health and Medical Research Council's 2008 guidelines for Managing the Risks in Recreational Waters (NHMRC 2008). Faecal coliforms monitoring was discontinued from this time.

4.4.3 Ocean Receiving Water

In oceans the water quality conditions are predicted from effluent quality data and dilution factors determined by hydraulic modelling of effluent plume dispersion.

The impact of Deep Ocean Outfalls (DOOFs) on water quality is predicted by numerical modelling. The concentrations of substances derived from the sewage effluent are calculated from their concentrations in effluent and the dilution factors determined from the numerical modelling. These results are reported as an annual average distribution of concentrations around the DOOF, based on monthly runs of the near field models.

The near field models are calibrated using data from the Ocean Reference station, which collects data on current direction and physical variables like temperature so that plume behaviour can be calculated. This is a requirement for the North Head discharge licence.

More detailed description of the data collection processes that support the numerical modelling are provided in Appendix 2.

4.4.4 Ecosystem Health: Shoreline Outfall Program

Rationale

The aim of the shoreline outfall program is to estimate any significant change in ecological communities from STPs discharging into the near shore ocean environment.

Sydney Water operates 5 discharges of sewage effluent of differing qualities into near shore marine environments. Sydney Water's license permits an impact within the effluent mixing zone (ie a zone in which the salinity is below that of normal seawater). Nevertheless, Sydney Water's shoreline outfalls may impact the local aquatic ecology outside the mixing zone. Other studies of impacts of sewage discharges on intertidal biota in NSW have shown the responses by the marine organisms are site specific and highly variable. The extent of the impact differs with level of treatment, type of disinfection process and the dilution of the effluent around the discharge site.

Whole Effluent Toxicity (WET) testing undertaken between 1998 and 2007 to determine the toxicity of effluent has shown no acute toxicity (LC_{50}) at the edge of the mixing zone around Sydney Water shoreline discharges. Effluent data have shown that concentrations of nitrogen and phosphorus at the edge of the mixing zones exceeded trigger values described in ANZECC (2000) at some STPs. There are no data available on the intertidal communities to assess whether these nutrients levels are causing an impact.

Studies in NSW have found nutrients from sewage discharges usually increase the percentage cover of the green marine macro-alga *Ulva lactuca* near shoreline outfalls and decrease the diversity and extent of cover of brown and red macro algae. Thus these macro-algae assemblages can be indicators of the eutrophying effect of shoreline outfalls (EP, 2003).

Monitoring Program

An initial assessment of accessibility to the discharge sites has revealed a large number of OHS issues. The rock platform at Turimetta Headland (Warriewood STP discharge area) is very flat with frequent wave wash up to and then bouncing off a vertical cliff. On the day of inspection the waves were only about 1 metre and this was sufficient to produce regular inundation of the site. Similarly, Diamond Bay, Cronulla and Bombo discharge to inaccessible sites that cannot be safely measured. Hence these sites will not be assessed.

Measurements will be taken under suitable weather and tidal conditions at Shellharbour and from two control sites used in previous assessment of upgrades in the Illawarra Region. An underlying assumption of this study is that the extent of the impacted area is solely determined by the quality and/or volume of the sewage discharge. Thus before instigating the study a check of confounding from stormwater discharges was made.

To assess if any significant ecological change has occurred, the littoral flora and fauna composition and abundance were measured as an indicator ecological health. The littoral flora and fauna composition of natural communities at reference sites were used to provide a baseline for calibrating the degree and the scale of any change.

Seasonal variation is expected to be low because the dominant processes in the littoral community are competition for space and grazing through most of the year. Monitoring is undertaken at Shellharbour and two reference sites at the same time each year to minimise this variability (Appendix 2: Table A-16, Figure A- 13). The optimum time for monitoring is just before recruitment (Spring) to allow competition to flatten the community structure back to the dominant organisms.

4.4.5 Ecosystem Health: Marine Benthic and Sediment Quality

Rationale

Sydney Water is continuing the Ocean Sediment Program (OSP) as a condition of the DECCW licence for the Malabar, Bondi and North Head Sewage Treatment Systems. The OSP was developed through discussions between members of the DECCW and Sydney Water and is based on recommendations in Study Design for Long-term Monitoring of Benthic Ecosystems Near Sydney's Deepwater Ocean Outfalls (EPA, 1998).

The objectives of the program are to determine:

- any chronic impact of effluent from Sydney's deepwater ocean outfalls; and
- if the impact from effluent discharge from the Malabar outfall is increasing in spatial extent.

Monitoring Program

The methods used in the OSP are described in Sydney Water 2005b. In brief, the sampling is conducted under two regimes:

- "**Assessment**" monitoring includes a biotic component, the identification and counting of the benthic macrofauna; and a physico-chemical component, the analysis of sediment quality (metals, organic compounds, nutrients and physical parameters) at all sites. "Assessment" sampling is triennial (1999, 2002, 2005, 2008, 2011 and so on) with the next program scheduled for 2011.
- "**Surveillance**" monitoring has a reduced suite of physico-chemical parameters (particle size distribution and total organic carbon) and the biotic component is only assessed at the Malabar outfall site. "Surveillance" monitoring is conducted in non Assessment years (ie 2000, 2001, 2003, 2004, 2006. 2007, 2009, 2010, 2012, 2013 etc).

If the DECCW trigger value for total organic carbon (TOC) at Malabar is exceeded (EPA, 1998), further investigation of sediment quality may be instigated such as the analysis of some / all of the archived samples from the surveillance sampling.

Sampling was conducted for sediments at 24 sites between Terrigal in the north and Shoalhaven Bight in the south (see Appendix 2, Table A-17 and Figure A-14). As this is a long-term program aimed at assessing sediment characteristics and looking for impacts in a broad temporal context, the data at this point is considered to be representative of the mid stages of the program.

Sydney Water has more than 10 years of monitoring data collected under the OSP. Analysis of the benthic communities sampled during this program have remained diverse and abundant with no evidence of a measurable impact from effluent of the Malabar ocean outfall or Bondi and North Head (Sydney Water 2008). The program to date has built a significant amount of accumulated data as well as collection of archived samples which provides a robust baseline to assess any future problem if it were to arise.

Accordingly, in May 2010, it was agreed between DECCW and Sydney Water that the overall program be refined. The revised OSP sampling and analytical program was implemented from July 2010. The new program will sample at a reduced number of sites (18) and also collect a reduced number of sub-samples from some sites, particularly during the surveillance years (see Table A- 18 for details). The change in sites is removal of the two distant reference sites (Terrigal and Shoalhaven Bight). The three closer reference sites have been retained (Long Reef, Port Hacking and Marley Beach).

4.5 Special Investigations

4.5.1 Sewer Overflows – Overflow Abatement Program

Overflows from the sewerage system can occur in wet weather, when system capacity is exceeded by stormwater inflows and during dry weather from chokes and leaks from damaged sewers. In 1998 Sydney Water completed the Sewer Overflow Licensing Project Environmental Impact Statements (SOLP EIS) on each sewer system and developed a preferred program of works to address dry and wet weather sewer overflows. Environmental and human health impacts of both wet and dry weather overflows were determined. Impacts on human health were related to the ability to swim at harbour and ocean beaches after rainfall whereas ecosystem health impacts were less clearly defined and essentially insufficient information/data was available to assess impacts.

Unlike STP discharges, which are continuous inputs into the environment, sewer overflows are sporadic and event driven. Wet weather sewage overflow impacts result in broad waterway increases in faecal contamination whereas dry weather leakage from the sewer system may result in localised faecal contamination of waterways. The bacterial indicator, faecal coliforms is the most suitable (ease of detection and presence) for detecting the presence of sewage in waterways.

Sydney Water's program of works to meet the SOLP EIS targets includes a leakage reduction program to address dry weather issues and a wet weather overflow abatement program. The following monitoring programs, in combination with general ambient programs (earlier sections 4.2 to 4.3), are used to provide an overall assessment of the effectiveness of these programs of works (Overflow Abatement Program - OAP).

The dry weather sewage leakage program aims to minimise the risk to human and ecosystem health of dry weather leakage by identifying stormwater systems, recreational areas and waterways that have elevated indicator bacteria levels due to dry weather sewer leakage and initiate rehabilitation or repair to the system.

Dry Weather Sewage Leakage Program

Sydney Water has divided its sewer system into 214 Sewer Catchments, each equivalent to approximately 100km of sewer. Dry weather leakage from these catchments has the potential to impact on recreational quality at designated swimming areas and impact biological communities in receiving waters.

The following Sewage Leakage program is undertaken to identify, locate and repair dry weather leaks from the sewer system on a SCAMP basis. The Sewage Leakage program is an ambient monitoring program that consists of three components:

- Sydney Water's SCAMP based dry weather sewage leakage to stormwater monitoring (section below);
- recreational water quality programs undertaken by Sydney Water and the DECCW (Harbourwatch and Beachwatch) and monitoring of the lagoons (section 4.2.3 and 4.4.2); and
- ecosystem health impact (freshwater and estuarine biota) (section 4.1.3, 4.2.2 and 4.2.5).

The information from this program is used to reduce the risk to public health and receiving water ecosystems by identifying dry weather leakage, enabling repairs to the system and providing an overall assessment of the condition of the sewers in each SCAMP. The dry weather component of this program aligns with the EPL conditions (M12 and M13) that require dry weather leakage monitoring, investigation and remedial actions.

The objectives of the program are to protect public and ecosystem health by:

- detecting significant dry weather leakage from faults in the system which may flow into waterways and impact recreational and sensitive site areas
- providing information to target and prioritise the repair of dry weather leaks.

SCAMP Dry Weather Leakage Detection Monitoring Program

The 214 SCAMPs are the basis for site selection for this Sewer Leakage Program. Usually, one sampling site has been identified for each SCAMP. These have been designed to best represent the stormwater quality draining the SCAMP and to enable the detection of sewage leakage to the stormwater system. However, there are 4 exceptions where no sites have been allocated yet as these are the new systems where all residents are not connected yet and leaks are not expected in these new structures. Also while some residents are still on septic, the stormwater quality may be impacted by contamination from septic systems not from Sydney Water system.

The current 210 dry weather leakage detection monitoring sites are identified in Appendix 2 (Table A-19; Figure A-15, Figure A-16, Figure A-17, Figure A-18, Figure A-19, Figure A-20 and Figure A-21).

Routine Surveillance: All 210 SCAMP sites are sampled at least once every 12 months. Within this requirement, the timing of sampling is spread out throughout the year to balance sampling workloads and is dependent on dry weather. Routine monitoring is for faecal coliform densities, laboratory ammonia and field conductivity as well as any observations on the flow and water quality at the time of sampling (Appendix 2: Table A- 20).

Quarterly sampling of previously positive sites: Where a sampling site's faecal coliform result exceeds the threshold value of 5,000 cfu/100mL three years in a row, the sampling frequency increases for that site and it is then monitored on a quarterly basis. When three consecutive quarterly monitoring results are below the threshold, the site returns to annual routine surveillance.

Source Detection: Where faecal coliform results are above the threshold (5,000 cfu/100ml) at the routine surveillance monitoring sites and are not due to a reported overflow incident (sewer choke), a source detection investigation is undertaken to find the leaking infrastructure.

The process involves a "catchment walk", sampling for ammonia by use of a Nessler ammonia test kit (near instant reading) firstly at the catchment outlet, then walking up the stormwater channel looking for any obvious signs of contamination at each branch in the stormwater line. At key points (eg branches in the line) replicate samples are collected for faecal coliform analysis. These sampling points are geocoded and described for future reference to site locations.

If the investigation determines that the leak is emanating from Sydney Water's reticulation system, remedial action is required. If the leak is due to house service lines, the appropriate authorities responsible are notified and repairs requested.

Each quarter, DECCW is notified by email of all the sites that had faecal coliform densities in excess of 10,000 cfu/100mL.

Sampling Condition: All samplings and the source detection process is undertaken in dry weather conditions using the following criterion:

For the purpose of this study 'dry weather' is defined as a period when less than 2 mm of rain has fallen in the previous 24 hrs and an Antecedent Wetness Index (AWI) of less than 5 mm. The Antecedent Wetness Index is calculated using the following method:

AWI (today) = 0.7 * (RAIN(24hr) + (AWI(yesterday)).

Daily rainfall data is obtained for each SCAMP from the nearest pluviometer data available.

The AWI is calculated and when both the AWI<5 mm and 24 hr rainfall <2 mm for a SCAMP, these SCAMP sites are flagged as suitable for dry weather sampling.

For all sites affected by tidal influence samples are collected at low tide to ensure stormwater is representative of the catchment and is not affected by incoming tides.

Sampling Method: All routine surveillance monitoring and quarterly monitoring of previously positive sites involve collection of the following samples or information at each sampling site:

- faecal coliform, replicate grab samples collected 5 minutes apart

- ammonia, replicate grab samples collected 5 minutes apart
- field conductivity measurement

4.5.2 Macroinvertebrate Pilot Study

A pilot program is designed to determine whether wet weather overflow impacts on freshwater ecosystems can be measured using freshwater macroinvertebrate communities. This program aimed to determine if intermittent wet weather sewer overflows impact ecosystem health in urban streams with upstream pollution catchment transport. Urban streams have depressed ecosystem health from upstream activities within a catchment. The level of depressed ecosystem health varies by catchment activities.

Comparison of upstream and downstream ecosystem health assessment results will be made with modelled overflow frequency and discharge volumes for each studied sewer overflow point source discharge location. This will provide an indication if the level of overflow performance (such as modelled frequency of 40 overflows in 10 years) is suitable to protect freshwater ecosystem health in urban streams.

Macroinvertebrate samples are collected and analysed from five sewer overflow point source discharges with varying modelled overflow frequencies (Appendix 2: Table A- 21 and Figure A-22). Of the original five sewer overflow locations selected two were found to be unsuitable for sample collection. Hence another two sites have been adopted for this pilot study. This study is being conducted for a period of three years (2008-09 to 2011-12). Macroinvertebrates are collected quarterly to allow an adequate incorporation of natural variation of the upstream site before conclusions are made. The findings of this pilot study will inform the sewer overflow abatement planning processes.

4.5.3 Macrophyte Pilot

Sydney Water completed two pilot studies in 2007 with an aim to develop trialling methods that can differentiate the contributions of nutrients from sewage effluent (Sydney Water impact) and nutrients from other catchment sources to macrophyte growth in the Hawkesbury-Nepean River.

The first study was commissioned to ANSTO (Australian Nuclear Science and Technology Organisation) to investigate a suitable technique to determine the relative contribution of STP-derived nutrient discharges to excessive growth of macrophytes in the Hawkesbury-Nepean. The outcome of the trial was not conclusive and further, more detailed investigations were recommended (Szymczak and Mazumder, 2007).

Another pilot investigation for monitoring of the effects of STP discharges on macrophytes in the Nepean River was outsourced to BIOSIS (Beitzel and Ryan, 2007). The objective of this study was to assess the feasibility of fluvial macrophytes as an indicator taxon suitable for incorporation into Sydney Water's long term monitoring program. The method trialled by BIOSIS for assessing the impacts of STP discharge upon macrophyte condition in the Hawkesbury-Nepean River system was also not suitable for general incorporation into Sydney Water's STSIMP monitoring framework in its current form. This was due to the following:

- Difficulty in defining an objective method for quantifying macrophyte cover and/or abundance;
- Lack of repeatability of the methods used to assess macrophyte cover and/or abundance;
- Lack of sufficient reference sites relative to whole-of-system characteristics in the Sydney biogeographic region.

For these reasons, the ability of the trialled method to detect changes through time is assessed as low, as is the ability to identify causal factors. The field-based method employed by BIOSIS is labour-intensive and expensive relative to the value of the information collected.

Sydney Water is currently continuing macrophyte investigations through the Replacement Flow Project, Western Sydney Recycled Water Initiative (WSRWI). For this project, Sydney Water has worked with the Department of Primary Industries (DPI) to develop the field method for macrophyte sampling.

The monitoring program for the Replacement Flow Project will continue for 3 years. At the completion of these 3 years, monitoring results (including the macrophyte component) will be reviewed in consultation with DECCW and other stakeholders.

Weather conditions need to be standardised in order to make ‘before’ and ‘after’ comparisons of the performance of upgraded assets. This will be done by applying a weather correction procedure.

5. Data Management and Reporting

All field measurements and analytical results generated from the STSIMP are captured by Sydney Water's standard data management system. All physico-chemical and biological data are entered, verified and stored in various databases using Sydney Water's Business Intelligence (BI) Tools. These data are also shared with other government stakeholders from time to time when required.

The final STSIMP document as well as the associated annual data and interpretive reports will be available to Sydney Water's public website. The link for 2008-09 report is given below:

http://www.sydneywater.com.au/Publications/Reports/Sewage_Treatment_System_Impact_Monitoring_Program_(STSIMP)_Annual_Report_2008-09.pdf

Sydney Water will continue to report the results of any modified monitoring activities via the same avenue.

Both annual and three yearly interpretive reports are prepared using data from various monitoring programs. These reports assess the performance of various STPs/STSs as per EPL and the impacts of both STP effluent discharges and the sewer overflow abatement works.

The reporting and publication requirements for the STSIMP are summarised below. All reports are checked for technical accuracy, style, format and layout through a review process, to ensure quality standards are met.

Reports/Publications	Description	Timetable
Annual Return: STP	Summary on effluent quantity, quality and load calculation as per each EPL Influent quality where applicable as per EPL. Beach water quality Sydney and Illawarra as per EPL	July-August each year
Annual Return: Sewer overflows	Performance on SCAMP annual dry weather overflow abatement plan Outcome of annual model runs on wet weather overflow volume and frequency.	July-August each year
STSIMP Annual Data Report: All Catchments (River, Estuaries, Lagoons and Ocean)	Annual data summary providing summary statistics, a brief commentary commensurate with the results, comparison between upstream and downstream sites, 10 yearly trend plot on each site (if available).	September-October, each year, when there is no interpretive report.
Exception Report: SCAMP Dry Weather Leakage Detection program	Exceedance report when faecal coliforms exceed specified limits.	When triggered
Special Report: Ocean Sediment Program*	Yearly data report and assessment year report	Next assessment report due end of 2011
STSIMP: Interpretive Report	Interpretive report on all components of STSIMP, data analysis, describing outcomes in relation to set objectives of each program and guidelines, providing recommendations on continuity or modification of each program.	Every three year. (first due 2011)

Note: Beachwatch also provide periodic reports on recreational water quality and performance against guidelines.

* From 2011, these reports will be merged with the STSIMP annual data and interpretive reports.

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Appendix 1: Glossary

Acronyms/Abbreviations	Full Meanings
ARWTP	Advanced Recycled Water Treatment Plant
Aquatic ecosystem	Community of aquatic plants and animals together with the physical and chemical environment in which they live
APHA	American Public Health Association
Biomass	The mass of living matter
Biota	All living things including plants animals, and other microorganims.
BOD	Biochemical Oxygen Demand
BOOS	Bondi Ocean Outfall Sewer
Campaign Monitoring	More intensive monitoring during a pre-selected year to establish trends in monitored water quality indices
Catchment	(1) The land area drained by a river or body of water; (2) the land area drained by a Sewage Treatment System (STS)
cfu	colony forming unit
CBOD	Carbonaceous biochemical oxygen demand
COOS	Cronulla Ocean Outfall Sewer
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECCW	Department of Environment, Climate Change and Water
DPI	Department of Primary Industries
DOOF	Deep Ocean Outfall
d/s	Downstream
EC_{50}	Median effective concentrations; the concentration of poison/chemical (or intensity of other stimulus), which produces some selected response in one half of population of test organisms.
EIMP	Environmental Indicators Monitoring Program
Effluent	Liquid discharge from a sewage treatment plant after treatment.
EPA	Environment Protection Authority, now DECCW
EPL	Environmental Protection Licence: Regulations provided by DECCW stipulating the concentrations and load for contaminants in the effluent from the STPs.
Estuary	The lower course of a river where it flows into the sea. Estuaries experience tidal flows and their water is a changing mixture of fresh and salt.
Eutrophication	Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.
Faecal coliform	Bacteria, which inhabit the intestines of humans and other mammals, and are present in faeces. Used as indicators of the presence of faecal material in waterways.
HRC	Healthy River Commission
Indicators	A physical, chemical or biological feature that can be usefully monitored to measure a change in an environmental value.
Intertidal	The area lying between high tide and low tide mark.
IWWS	Illawarra Waste Water strategy
Km	Kilometre
L	litre(s)
LC_{50}	Median lethal concentrations; the concentration of a poison/chemical lethal to one half of population of test organisms

Acronyms/Abbreviations	Full Meanings
m	Metre (s)
Macrophyte	Aquatic plants, such as seaweed, seagrasses, mangroves and other large aquatic plants.
MEMP	Marine and Estuarine Monitoring Program
mg/L	milligrams per litre
mL	Millilitre
ML	Megalitre
mm	millimetre(s)
NATA	National Association of Testing Authority
n/a	Not applicable
NGR	Northern Georges River
NHMRC	National Health and Medical Research Council
NSOOS	Northern Suburbs Ocean Outfall Sewer
NSST	North-Side Storage Tunnel
NSW	New South Wales
NTU	nephelometric turbidity units
Nutrients	Compounds required for growth of plants.
OHS	Occupational Health and Safety
OAP	Overflow Abatement Project
ORS	Ocean Reference Station
OSP	Ocean Sediment Program
Organism	An individual form of life, such as a plant, animal, bacterium or fungus.
Parameters	One of a set of measurable factors that define a system and determine its behaviour, and are varied in an investigation.
pH	A measure of how acidic or alkaline a solution is. The pH scale is 0-14
Plume	A space in air, water or soil containing pollutants released from a point source.
POEO Act	Protection of the Environment Operations Act (1997)
PRT	Pollution Reduction Target
Receiving water	A stream, river, pond, lake or ocean into which effluent is discharged
Reference site	A sampling site assumed to be unaffected by the ecological impact factors against which environmental changes in impacted sites can be measured (also called a control site).
Riverine	System of inland wetlands associated with non tidal flowing water.
Sampling	A procedure to collect samples for testing for a variety of biological and chemical indicators.
Sanitary Inspection	A procedure to categorise sampling site based on the assessment of the degree of influence of faecal materials.
SCAMP	Sewerage Catchment Area Management Plan
Sediment	Particulate organic and inorganic matter that settles to the bottom of lakes, rivers, oceans and other waters
Sewer overflow	(also called sewage overflow) A relief point in the sewerage system, or the actual overflow of sewage from a relief point to avoid back-flow of sewage into houses.
SIGNAL-SG	Stream Invertebrate Grade Number Average Level - Genus taxonomic level for the greater Sydney region. Which is a biotic index based on freshwater macroinvertebrate diversity, abundance and tolerance to organic pollution
SOLP EIS	Sewer Overflow Licensing Project Environmental Impact Statements

Acronyms/Abbreviations	Full Meanings
Stormwater	Rainwater which runs off urban and agricultural catchments, often polluted by rubbish, animal droppings, sewage overflows, grass clippings and heavy metals from car exhausts. This untreated water is carried in stormwater channels and discharges into creeks, rivers, the harbour and the ocean.
SSTP	Storm Sewage Treatment Plant
STRWP	Sewage Treatment and Recycled Water Plant
STS	Sewage Treatment System
STP	Sewage Treatment Plant
STSIMP	Sewage Treatment System Impact Monitoring Program
Suspended solids	Particles in sewage that can be removed by sedimentation or filtration.
SWOOS	Southern and Western Suburbs Ocean Outfall Sewer
TOC	Total Organic Carbon
u/s	Upstream
USEPA	United States Environment Protection Authority.
Wastewater	Water that contains waste products, such as sewage, or urban and agricultural catchment runoff.
WET	Whole Effluent Toxicity
WSRWI	Western Sydney Recycling Water Initiative
µg/L	micrograms per litre
µS/cm	micro-siemens per centimetre (unit of conductivity)

Appendix 2: Monitoring Sites and Methods

Hawkesbury-Nepean River and Tributaries

Inland Sewage Treatment Plants: Hawkesbury-Nepean River - Effluent Quantity, Quality and Toxicity

Table A-1: Summary of inland STP/STRWP effluent and quantity monitoring requirements

STP or STRWP	Analytes/ Variables	Frequency of monitoring
Brooklyn, Castle Hill, Hornsby Heights, North Richmond, Penrith, Picton, Quakers Hill, Richmond, Riverstone, Rouse Hill, St Marys, Wallacia, West Camden, West Hornsby and Winmalee	Effluent volume, bypass etc.	In-situ monitoring (on-line)
	Ammonia nitrogen, total nitrogen, total phosphorus, residual chlorine (for STPs with disinfection systems), faecal coliforms, suspended solids and CBOD	Every 6 days
	Toxicity testing by *Ceriodaphnia dubia*, (48hr immobilisation)	Every month
	A range of heavy metals and organics.	Every month

Table A-2: List of analytes and methods, STP/STRWP effluent quantity, quality and toxicity

Analytes	Detection limit	Unit of measurements	Reference
Conventional major analytes			
Ammonia (low level)	0.01	mg/L	APHA (2005) 4500-NH_3 H
Ammonia (high level)	0.1	mg/L	As above
CBOD	2	mg/L	APHA (2005) 5210B
Enterococci	0	cfu/100mL	AS/NZS (2007) 4276.9
Faecal coliforms	0	cfu/100mL	APHA (2005) 9222D
Oil and grease	5	mg/L	APHA (2005) 5520 D
Total chlorine (HACH)	0.05	mg/L	APHA (2005) 4500-Cl G
Total nitrogen (by FIA)	0.05	mg/L	APHA (2005) 4500- N_{org}/NO_3^- I/J
Total phosphorus	0.01	mg/L	APHA (2005) 4500-P – H/J
Total suspended solids	2	mg/L	APHA (2005) 2540D
Toxicity testing			
Ecotoxicological Endpoint: 48 hrs Water Flea $EC_{50\ immobilisation}$	n/a	% effluent	Based on methods described by USEPA (2002a) and ESA SOP 101 and adapted for use with the locally collected *Ceriodaphnia dubia* by Bailey *et al.* (2000).
Ecotoxicological Endpoint: 1 hr Sea Urchin $EC_{50\ fertilisation}$	n/a	% effluent	Based on methods described by USEPA (2002b) and ESA SOP 104 and adapted for use with *H. tuberculata* by Simon and Laginestra (1997) and Doyle *et al.*, (2003).
Heavy metals			
Aluminium	20	µg/L	USEPA (1994) 6020
Arsenic	1	µg/L	USEPA (1994) 6020
Barium	1	µg/L	USEPA (1994) 6020
Boron	5	µg/L	USEPA (1994) 6020

Analytes	Detection limit	Unit of measurements	Reference
Cadmium	0.1	µg/L	USEPA (1994) 6020
Chromiuim	1	µg/L	USEPA (1994) 6020
Cobalt	0.1	µg/L	USEPA (1994) 6020
Copper	1	µg/L	USEPA (1994) 6020
Iron	10	µg/L	USEPA (1996) 6020
Lead	1	µg/L	USEPA (1994) 6020
Manganese	1	µg/L	USEPA (1994) 6020
Mercury	0.1	µg/L	APHA (2005) 3112 B
Molybdenum	1	µg/L	USEPA (1994) 6020
Nickel	1	µg/L	USEPA (1994) 6020
Selenium	5	µg/L	USEPA (1994) 6020
Silver	0.1	µg/L	USEPA (1994) 6020
Tin	1	µg/L	USEPA (1994) 6020
Vanadium	1	µg/L	USEPA (1994) 6020
Zinc	5	µg/L	USEPA (1994) 6020
Other chemicals and organics			
Aldrin	0.01	µg/L	USEPA (1998b) 8081B
Chloramines (HACH)	0.02	mg/L	APHA (2005) 4500-Cl G
Cyanide	0.005	µg/L	APHA (2005) 4500CN-C and E
Dieldrin	0.01	µg/L	USEPA (1998b) 8081B
Diazinon	0.1	µg/L	USEPA (1998a) 8141B
Endosulfan (a,b)	0.01	µg/L	USEPA (1998b) 8081B
Ethyl Chlorpyrifos	0.05	µg/L	USEPA (1998a) 8141B
Heptachlor	0.005	µg/L	USEPA (1998b) 8081B
Lindane	0.010	µg/L	USEPA (1998b) 8081B
Malathion	0.05	µg/L	USEPA (1998a) 8141B
Nonyl phenol ethoxylates	5	µg/L	Naaim *et al.* 1996
Parathion	0.1	µg/L	USEPA (1998a) 8141B
pp-DDE(4,4)	0.01	µg/L	USEPA (1998b) 8081B
pp-DDT(4,4)	0.01	µg/L	USEPA (1998b) 8081B
Total chlordane	0.01	µg/L	USEPA (1998b) 8081B
Total PCB's	0.1	µg/L	USEPA (2000) 8082A
Unionised hydrogen sulphide	0.005	mg/L	APHA (2005) 4500 S2 H

Figure A-1: Location of Sydney Water's sewage treatment plants

Hawkesbury-Nepean River and Tributaries: Ecosystem Health-Eutrophication

Table A- 3: List of eutrophication - algal growth monitoring sites, Hawkesbury-Nepean River and Tributaries Eutrophication Program

Site codes	Description	Longitude	Latitude
N92	Maldon Weir, u/s of all Sydney Water STPs, Reference site	150.630	34.2036
N75	Sharpes Weir, d/s of Matahil Ck and West Camden STP	150.677	34.0415
N67	Wallacia Bridge, u/s Upstream of Warragamba River	150.636	33.8670
N57	Penrith Weir, u/s of Penrith STP	150.684	33.7432
N51	Jackson Lane, d/s of Penrith STP	150.657	33.7150
N48	Smith St , u/s of Winmalee STP	150.663	33.6701
N44	Yarramundi Bridge., d/s of Winmalee STP	150.698	33.6146
N42	North Richmond, d/s of Grose River	150.723	33.5868
N39	Freemans Reach, d/s of North Richmond STP	150.747	33.5700
NS04	South Ck , lower South Ck at Fitzroy Bridge, Windsor	150.825	33.6067
N35	Wilberforce, d/s of South Ck	150.838	33.5730
NC11	Cattai Ck , lower Cattai Ck at Cattai Road	150.908	33.5576
N3001	Off Cattai SRA, d/s of Cattai Ck	150.889	33.5583
N26	Sackville Ferry, d/s of Cattai Ck	150.876	33.5007
N2201	Colo River. at Putty Road, Reference site	150.829	33.4325
N18	Leetsvale, d/s of Colo River	150.948	33.4280
NB13	Berowra Ck , Cunio Point	151.118	33.5869
NB11	Berowra Ck , Off Square Bay	151.148	33.5667

Table A- 4: List of analytes, Hawkesbury-Nepean River and tributaries Eutrophication-Algal Growth Program

Water quality variable	Detection limit	Unit of measurements	Method/Reference	Place of measurement
Temperature	-	^{o}C	Yeo-Kal Meter or WTW	Field
Dissolved oxygen	-	mg/L and % sat	Yeo-Kal Meter	Field
pH	-	pH unit	Yeo-Kal Meter	Field
Conductivity	-	µS/cm	Yeo-Kal Meter	Field
Turbidity	-	NTU	Hach Turbidity Meter (White light)	Field
Ammonia nitrogen	0.01	mg/L	APHA (2005) 4500-NH_3 H	Laboratory
Oxidised nitrogen	0.01	mg/L	APHA (2005) 4500 NO_3^{-}I	Laboratory
Total nitrogen	0.05	mg/L	APHA (2005) 4500- N_{org}/NO_3^{-}	Laboratory
Total phosphorus	0.002	mg/L	APHA (2005) 4500-P – H	Laboratory
Total filterable phosphorus	0.002	mg/L	APHA (2005) 4500-P – H	Laboratory
Chlorophyll-*a*	0.2	µg/L	APHA (2005) 10200-H ½	Laboratory
Algal biovolume and cell count *	-	mm^3/L and cells/mL	APHA (2005) 10200-F	Laboratory

* when chlorophyll-a exceeds 7 µg/L

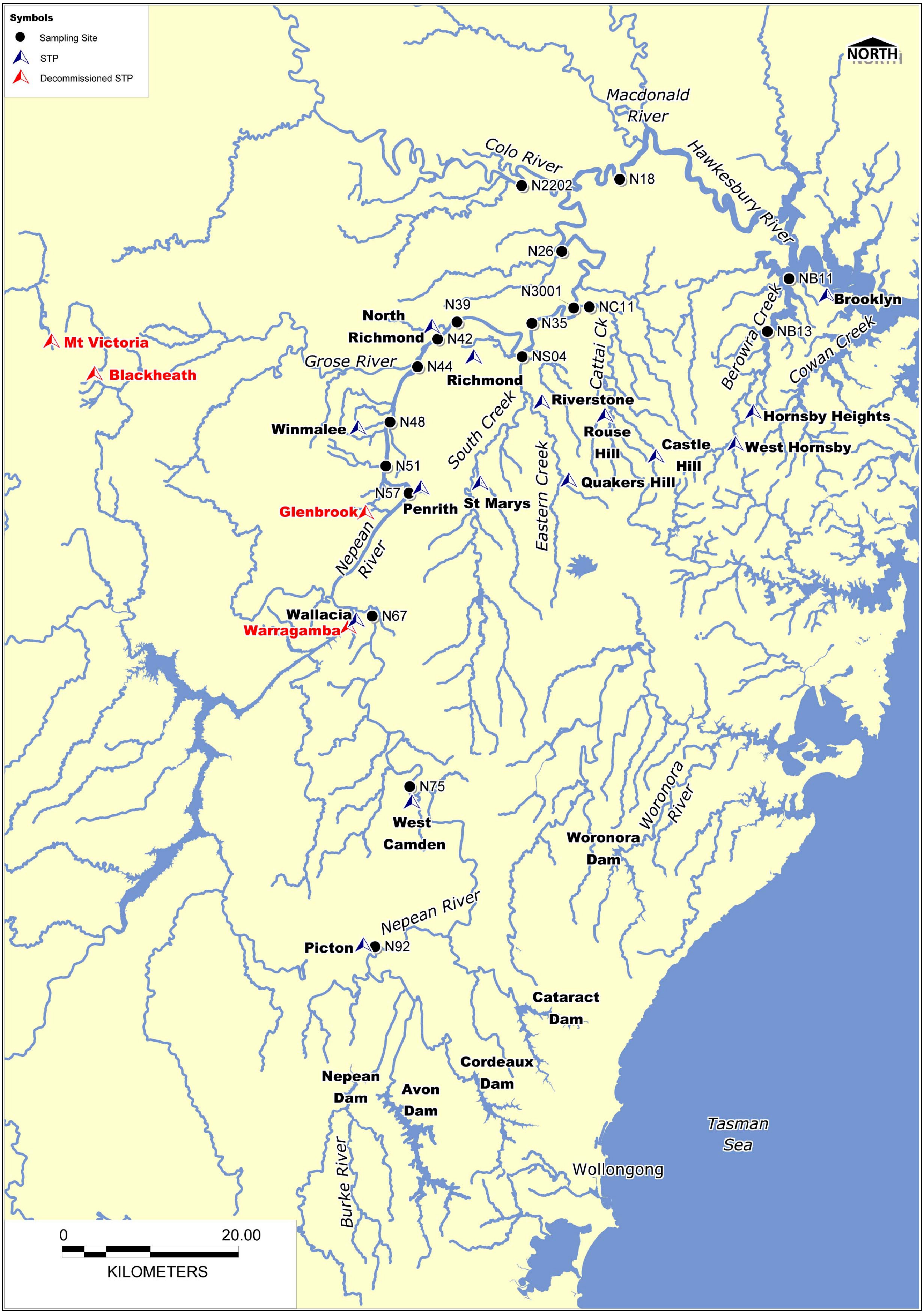

Figure A-2: Eutrophication - algal growth monitoring sites, Hawkesbury-Nepean River and tributaries

Hawkesbury-Nepean River and Tributaries: Ecosystem Health- Freshwater Macroinvertebrates

Table A- 5: Freshwater macroinvertebrates sampling sites of the Hawkesbury-Nepean River and tributaries

Site codes	Site description	Longitude	Latitude
N7825	Matahil Ck, u/s West Camden STP	150.679	34.0640
N7824	Matahil Ck, d/s West Camden STP	150.684	34.0578
N78	Nepean R at Macquarie Grove Rd, u/s West Camden STP	150.694	34.0430
N75	Nepean R at Sharpes Weir, d/s West Camden STP	150.677	34.0415
N67**	Nepean R. at Wallacia Bridge, u/s of Warragamba River	150.637	33.8651
N642A	Warragamba R u/s riparian release pt, u/s Wallacia STP	150.607	33.8761
N641	Warragamba R. Norton Basin, d/s of Wallacia STP	150.611	33.8618
N57	Nepean R at Penrith Weir, u/s Penrith STP	150.684	33.7432
N53	Nepean R at BMG Causeway, d/s Penrith STP	150.666	33.7366
N542	Boundary Ck, u/s Penrith STP	150.702	33.7444
N541	Boundary Ck, d/s Penrith STP	150.692	33.7433
N526*	Brookside Ck, u/s Glenbrook STP	150.637	33.7567
N525*	Brookside Ck, d/s Glenbrook STP	150.641	33.7553
N48	Nepean R at Smith St, u/s Winmalee STP	150.663	33.6701
N44	Nepean R at Yarramundi Bridge, d/s Winmalee STP	150.698	33.6146
N462	Unnamed Ck, d/s Winmalee STP	150.638	33.6563
N461	Unnamed Ck 3km d/s N462, further d/s of Winmalee STP	150.656	33.6704
N451	Lynch’s Ck, reference site	150.662	33.6522
N42	Nepean R at North Richmond, u/s North Richmond STP	150.723	33.5868
N40	Nepean R, d/s North Richmond STP	150.744	33.5705
N412	Redbank Ck, u/s North Richmond STP	150.710	33.5777
N411	Redbank Ck, d/s North Richmond STP	150.719	33.5774
E099	Fairy Dell Ck, u/s Mt Victoria STP	150.254	33.5821
E101	Fairy Dell Ck, d/s Mt Victoria STP	150.252	33.5749
GS4359	Hat Hill Ck, u/s Blackheath STP	150.304	33.6140
GS4358	Hat Hill Ck, d/s Blackheath STP	150.319	33.5978
N38	Hawkesbury River at Windsor Bridge, u/s South Creek	150.816	33.6064
NS082	Eastern Ck, u/s Riverstone STP	150.851	33.6695
NS081	Eastern Ck, d/s Riverstone STP	150.846	33.6680
NS090	Breakfast Ck, u/s Quakers Hill STP	150.884	33.7450
NS087	Breakfast Ck, d/s Quakers Hill STP	150.872	33.7361
NS26	South Ck, u/s St Marys STP	150.758	33.7428
NS23	South Ck, d/s St Marys STP	150.760	33.7333
N35	Hawkesbury R at Wilberforce, d/s South Ck, u/s Cattai Ck	150.838	33.5730
NC8	Cattai Ck, u/s Castle Hill STP	150.982	33.7143
NC75	Cattai Ck, d/s Castle Hill STP	150.982	33.7084
NC53	Second Pond Ck, u/s Rouse Hill STP	150.912	33.6805
NC515	Second Pond Ck, d/s Rouse Hill STP	150.923	33.6662

Site codes	Site description	Longitude	Latitude
NC5	Cattai Ck Annangrove Road, d/s of both Rouse Hill and Castle Hill STP	150.929	33.6603
N26	Hawkesbury R at Sackville Ferry, d/s Cattai Creek	150.876	33.5007
NB83	Waitara Ck, u/s West Hornsby STP	151.079	33.7045
NB825	Waitara Ck, d/s West Hornsby STP	151.080	33.7028
NB43	Calna Ck, u/s Hornsby Heights STP	151.101	33.6714
NB42	Calna Ck, d/s Hornsby Heights STP	151.103	33.6688

* not sampled after Spring 2008

** sampling started from Spring 2008

Figure A-3: Freshwater macroinvertebrates sampling sites of the Hawkesbury-Nepean River and tributaries

Estuaries

Georges River Sewage Treatment Plants: Effluent Quantity, Quality and Toxicity

Table A- 6: Summary of Georges River STP/SSTP monitoring requirements

STP or SSTP	Analytes/ Variables	Frequency of monitoring
Liverpool, Glenfield and Fairfield	Effluent volume, bypass etc.	In-situ monitoring (on-line)
	Suspended solids and CBOD (Liverpool only),	Every month
	A range of heavy metals and organics	During Bypass

Ecosystem Health: Freshwater Macroinvertebrates

Table A- 7: Freshwater macroinvertebrates sampling sites, rivers feeding to estuaries

Site codes	Site description	Easting	Northing
GE510	O'Hares Ck u/s confluence with Georges R, Reference site	301027	6224389
GR22	Georges R, u/s of Liverpool Weir	308472	6244159
GR23	Georges R, Cambridge Causeway	307005	6239026
GR24	Georges R at Ingleburn Reserve Weir, Reference site	304800	6233877
PH22	Hacking R at McKell Avenue, Reference site	319954	6224049
PJLC	Lane Cove R, u/s of Lane Cove Weir	329102	6259263
PJPR	Parramatta R, u/s of Parramatta Weir	315722	6256618
LC2421	Unnamed tributary of Devlin's Ck, Lane Cove R, Reference site	322350	6263722
NP001	McCarrs Ck, Reference site	337564	6273621
N628**	Bedford Creek	268400	6260300

** sampling started from Spring 2008

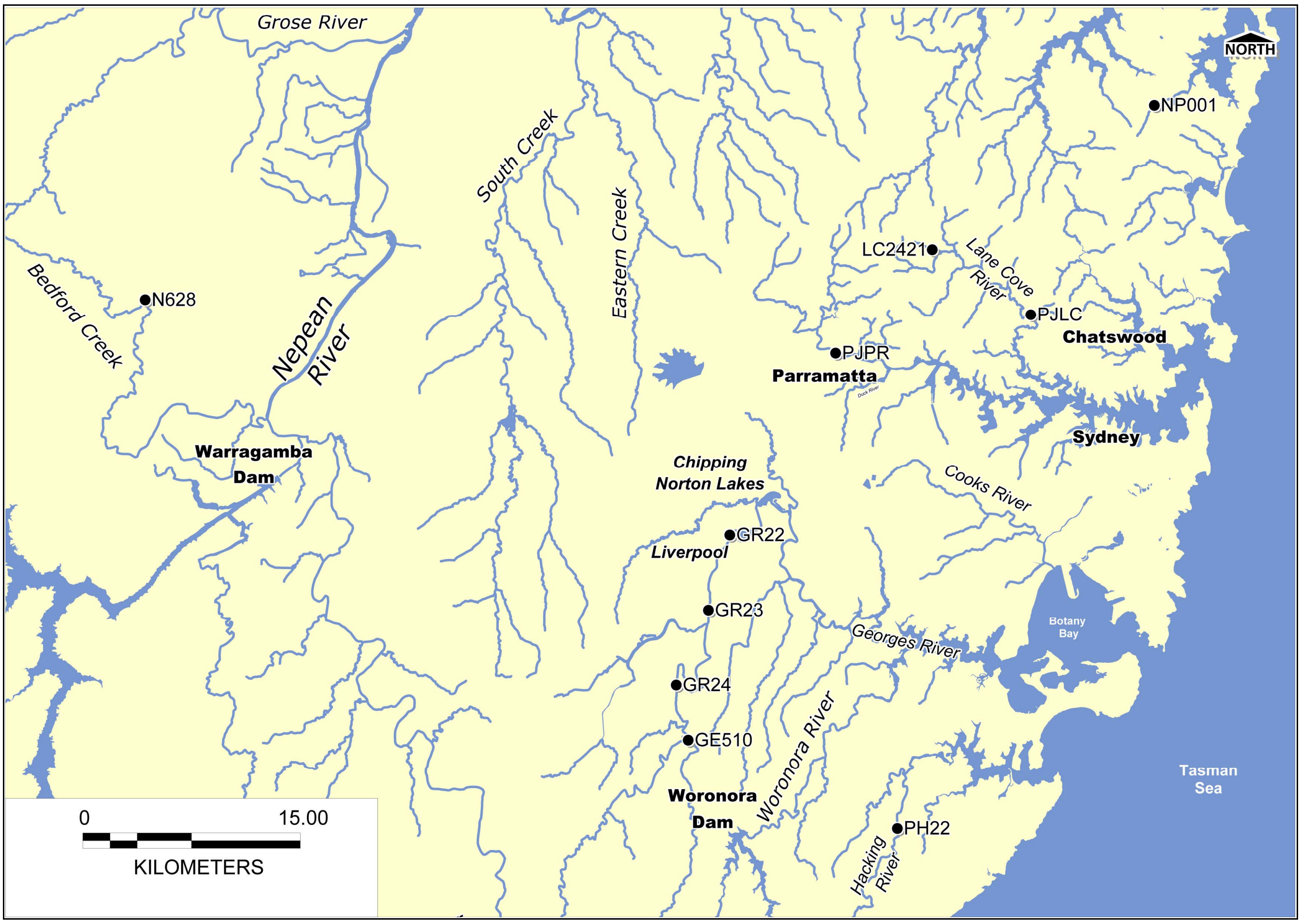

Figure A-4: Macroinvertebrate monitoring sites, rivers feeding to estuaries

Public Health: Recreational Water Quality

Table A- 8: List of recreational water quality sites, Harbourwatch Program (DECCW)

Catchment	Site name
Botany Bay	Brighton Le Sands Bath
	Congwong Bay
	Foreshores Beach
	Frenchmans Bay
	Kyeemagh Baths
	Monterey Baths
	Ramsgate Bath
	Silver Beach
	Yarra Bay
Georges River	Carss Point Baths
	Como Baths
	Dolls Point Bath
	Jew Fish Bay Baths
	Oatley Bay Baths
	Sandringham Baths
Port Hacking	Gunamatta Bay Baths
	Gymea Bay Bath
	Hordens Beach
	Jibbon Beach
	Lilli Pilli Baths
Inner Port Jackson	Cabarita Beach
	Chiswick Baths
	Darling Harbour*
	Dawn Fraser Pool
	Greenwich Baths
	Henley Baths*
	Tambourine Bay
	Woodford Bay
	Woolwich Baths
Outer Port Jackson	Clifton Garden
	Hayes St Beach
	Little Sirius Cove*
	Nielsen Park
	Parsley Bay
	Redleaf Pool
	Rose Bay Beach
	Watsons Bay
	Balmoral Baths
	Chinamans Beach
	Clontarf Pool

Catchment	Site name
Middle Harbour	Davidson Reserve
	Edwards Beach
	Gurney Cr baths
	Northbridge Baths
	Sangrado Baths*
	Fairlight Beach
	Forty Baskets Pool
	Little Manly Cove
	Manly Cove
Pittwater	Barrenjoey Beach
	Paradise Beach Baths
	Clareville Beach
	Bayview Baths
	North Scotland Island
	South Scotland Island
	Elvina Bay
	The Basin
	Great Mackerel Beach
	Taylors Point Baths**

* monitoring discontinued
** added from late 2010

Table A- 9: List of analytes, Recreational Water Quality Program

Water quality variable	Detection limit	Unit of measurements	Method/Reference	Place of measurement
Conductivity**	-	µS/cm	Yeo-Kal Meter or WTW	Laboratory
Faecal coliforms*		cfu/100mL	APHA (2005) 9222D	Laboratory
Enterococci	0	cfu/100mL	AS/NZS (2007) 4276.9	Laboratory

* applicable to lagoon samples only and to be discontinued from July 2011
** Harbourwatch Pittwater samples will be analysed from July 2011

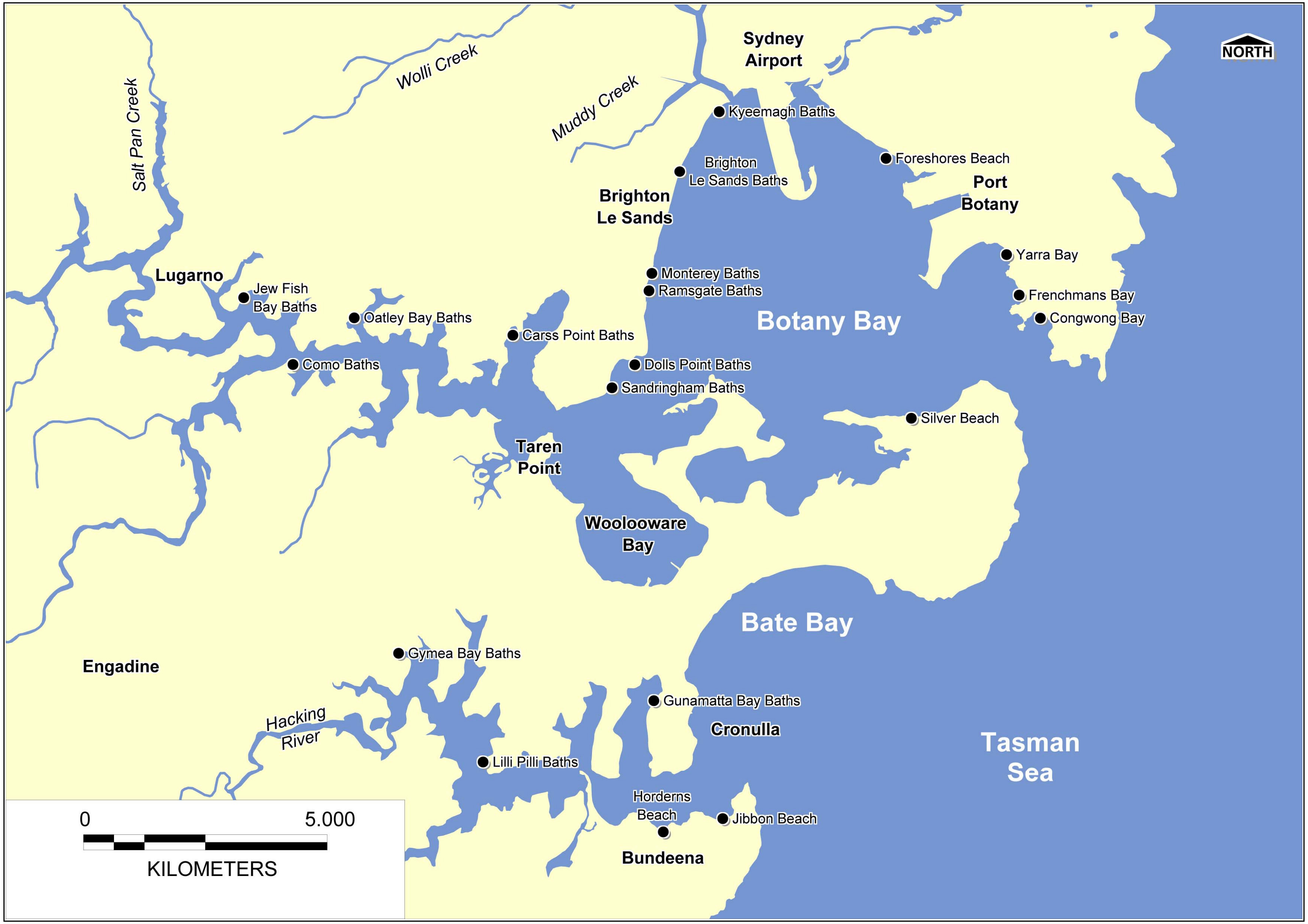

Figure A-5: Harbourwatch monitoring sites (Botany Bay, Georges River and Port Hacking)

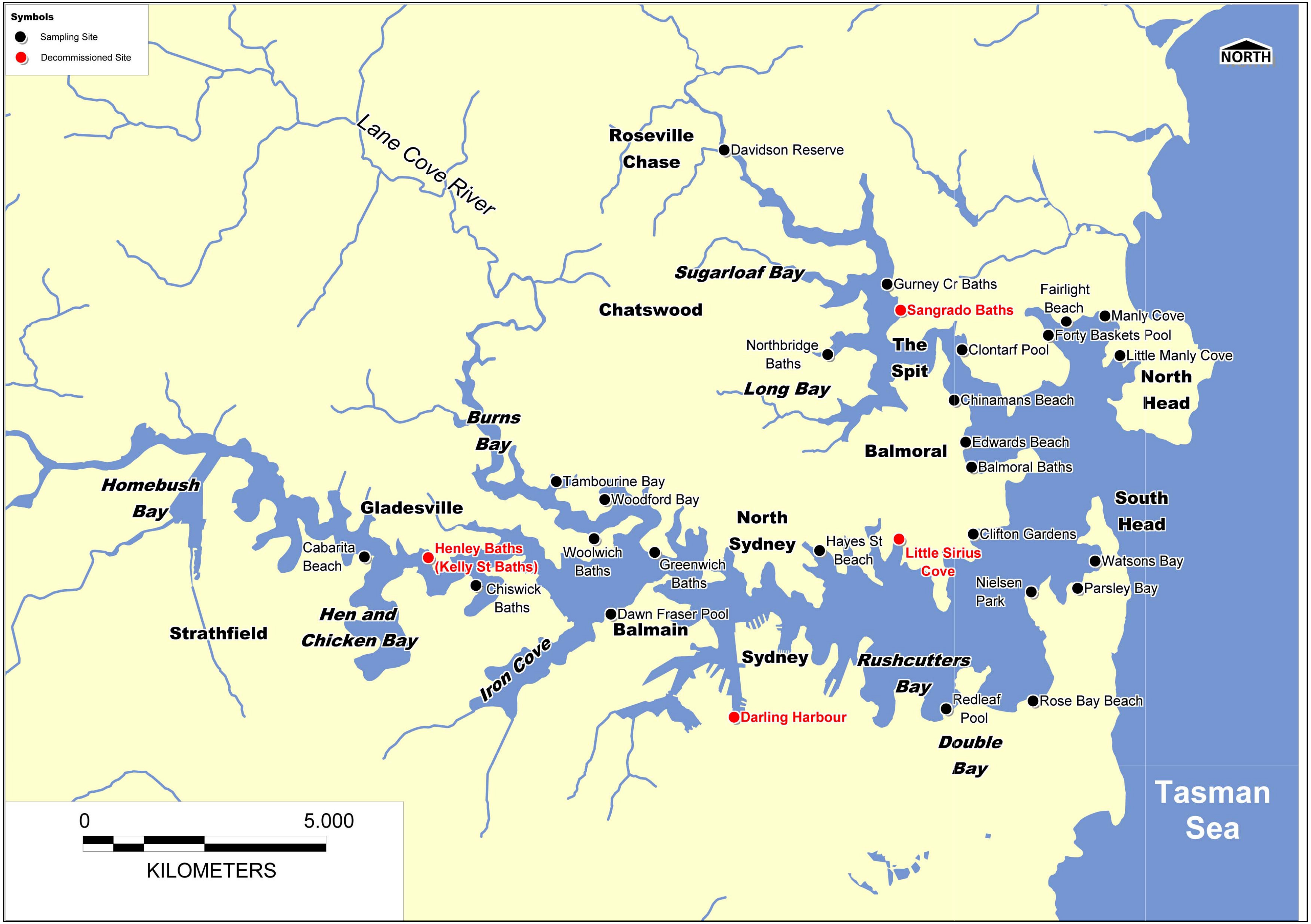

Figure A-6: Harbourwatch monitoring sites (Middle Harbour and Port Jackson)

Figure A- 7: ***Harbourwatch monitoring sites (Pittwater)***

Ecosystem Health- Eutrophication

Table A- 10: List of eutrophication monitoring sites, estuaries

Estuary	;ite code	;ite description	Sample collection by
Port Jackson	PJCB1	Chinamans Beach	DECCW*
	PJSB**	Sangrado Baths	DECCW*
	PJTB	Lane Cove River (nr Tambourine Bay)	DECCW*
	PJLC	Lane Cove River Weir	Sydney Water
	PJDFP	Dawn Fraser Pool	DECCW*
	PJCB2	Cabarita Beach	DECCW*
	PJDR	Davidsons Reserve	DECCW*
	PJ015	Parramatta River at Ermington	Sydney Water
	PJPR	Parramatta River Weir	Sydney Water
Botany Bay	GRFB	Frenchman's Bay	DECCW*
	GRRB	Ramsgate Baths	DECCW*
	GROB	Oatley Baths	DECCW*
	GR01	Cooks River (d/stream Muddy Creek)	Sydney Water
	CR04	Alexandria Canal	Sydney Water
	GR19	Upper Georges River, d/s of Harris Creek	Sydney Water
	GR22	Liverpool Weir	Sydney Water
Port Hacking	PHLPB	Lilli Pilli Baths	DECCW*

* Sydney Water is responsible for provision of sampling materials and costs of delivery to Sydney Water laboratories
** monitoring discontinued

Figure A-8: ***Eutrophication monitoring sites, estuaries***

Ecosystem Health- Intertidal Community

Table A- 11: List of intertidal community monitoring sites

Estuary	Site code	Site description	Easting	Northing
Port Jackson	PJ01	Silverwater Bridge/ Wilson Park	319819	6255454
	PJ025	Kissing Point Bay	324900	6254700
	PJ082	Iron Cove/ Hawthorn Canal	328806	6250399
	PJ115	Lavender Bay	334300	625330
	PJ33	Rushcutters Bay	336479	6250330
	PJ13	Little Sirius Cove	336697	6253828
	PJ28	Quakers Hat Bay	336725	6256743
	PJ05	Lane Cove River/ Woolwich Baths	330487	6254069
	PJ295	Sugarloaf Bay/Castlecrag, reference	335746	6259307
	PJ315	Bantry Bay, reference site	336059	6260863
	PJ245	Balmoral	338200	6255900
Botany Bay	CR04	Alexandra Canal at Canal Bridge Road	316450	6245007
	CR06	Wolli Creek	328447	6244209
	GR01	Cooks River (d/stream Muddy Creek)	330522	6241939
	GR085	Quibray Bay/ Kurnell	332842	6235169
	GR175	Georges River (Edith Bay)	319200	6236900
	GR115	Georges River (Kyle Bay)	324700	6237000
	GR15	Woronora River/Como	320357	6235491
	GR18	Salt Pan Creek d/s road bridge	319400	6239570
Port Hacking	PH04	Gunnamatta Bay	329078	6229754
	PH05	Maianbar	327020	6227276
	PH10**	Wants Beach Port Hacking River	320800	6228300
	Phe05	Southwest Arm	323991	6226345
Pitt Water	PW10	McCarrs Creek, reference site	341341	6278079
	PW12	The Basin, reference site	341500	6280000
Hawkesbury and Berowra	N06**	Marlo Bay Hawkesbury River	329300	6295100
	NB115**	Kimmerikong Bay Hawkesbury River	328800	6286300

** monitoring started from 2009-10

Figure A-9: Intertidal community monitoring sites, estuaries

Coastal Lagoons

Public Health: Recreational Water Quality

Ecosystem Health: Eutrophication

Table A- 12: List of lagoons sampling sites

Site code	Site description	Longitude	Latitude
ML01	Manly Lagoon, upstream Queenscliff Beach Bridge	151.2864	33.7853
ML03	Manly Lagoon at footbridge in Nolan Reserve	151.2719	33.7795
CC01	Curl Curl Lagoon, entrance at North Curl Curl	151.2968	33.7650
DW01	Dee Why Lagoon, entrance at Long Reef	151.3023	33.7461
NL01	Narrabeen Lagoon, Canal entrance u/s of Ocean Bridge	151.3019	33.7029
NL06	Narrabeen Lagoon, 150m Nth of confluence of South Creek	151.2717	33.7196
No code*	Narrabeen Lagoon at Birdwood Park	151.304955	33.703876
WL83	Wattamolla Lagoon	151.11544	34.1375

* monitored by DECCW

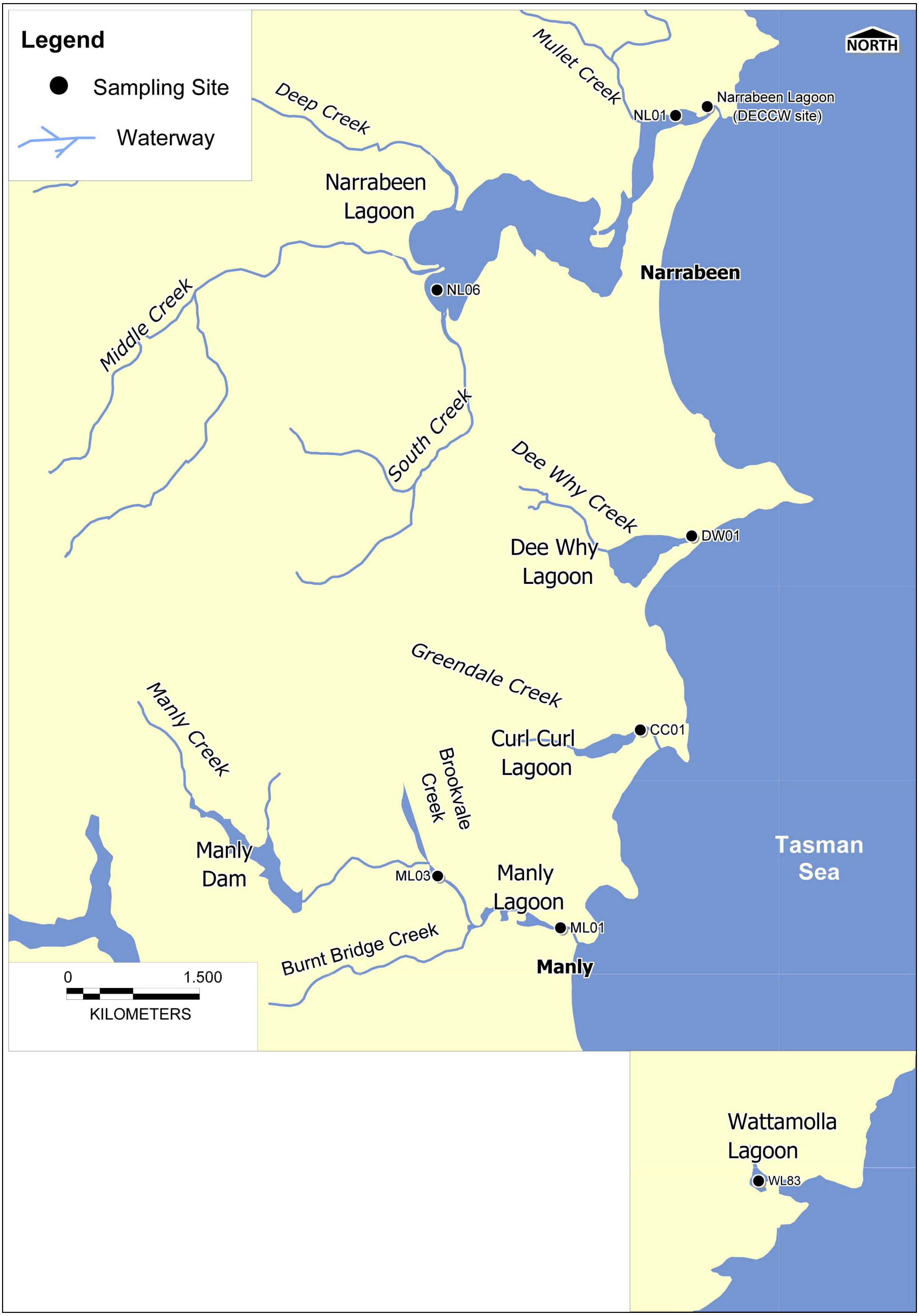

Figure A-10: Lagoon monitoring sites

Ocean and Beaches

Ocean Sewage Treatment Plants: Effluent Quantity, Quality and Toxicity

Table A- 13: Summary of ocean and Illawarra STP/SSTP/STRWP monitoring requirements

STP or SSTP or STRWP	Analytes/ Variables	Frequency of monitoring
Bellambi, Bombo, Bondi, Cronulla, Malabar, North Head, Port Kembla, Shellharbour, Warriewood and Wollongong	Effluent volume, bypass etc.	In-situ monitoring (on-line)
	CBOD, Oil and Grease, and suspended solids	Every 6 days
	Faecal coliforms (Bombo, Shellharbour and Warriewood only)	Every 6 days
	Residual chlorine (Shellharbour, Wollongong and Warriewood)	Following a Bypass or failure of disinfection process until results are below the detection limits..
	Toxicity testing by Sea urchin 1hr fertilisation	Every month
	A range of heavy metals and organics.	Twice a month

Public Health: Recreational Water Quality

Table A- 14: List of recreational water quality sites, Beachwatch Program, Sydney Beaches (DECCW)

Catchment	Monitoring site
Northern Sydney	Palm Beach
	Whale Beach
	Avalon Beach
	Bilgola Beach
	Newport Beach
	Bungan Beach
	Mona Vale Beach
	Warriewood Beach
	Turimetta Beach
	North Narrabeen Beach
	Collaroy Beach
	Long Reef Beach
	Dee Why Beach
	North Curl Curl Beach
	South Curl Curl Beach
	Freshwater Beach
	Queenscliff beach
	North Steyne Beach
	South Steyne Beach
	Shelly Beach (Manly)
Central Sydney	Bondi Beach
	Tamarama Beach
	Bronte Beach
	Clovelly Beach

	Coogee Beach
	Maroubra Beach
	Malabar Beach
	Little Bay
Southern Sydney	Boat Harbour
	Greenhills
	Wanda Beach
	Elouera Beach
	North Cronulla Beach
	South Cronulla Beach
	Shelly Beach (Sutherland)
	Oak Park

Table A- 15: List of recreational water quality sites, Illawarra Beachwatch program

Catchment	Monitoring site
Bombo	Boyd's Beach
	Bombo Beach
	Werri Beach
Shellharbour	Kiama Beach
	Warilla Beach
	Shellharbour Beach
	Lake Illawarra Beach
Wollongong	Wollongong Beach
	Coniston Beach
	North Wollongong Beach
	Bellambi Beach
	Bulli Beach
	Wonoona Beach
	Corrimal Beach
	Austinmer Beach
	Thirroul Beach
	Fisherman's Beach
	Port Kembla Beach

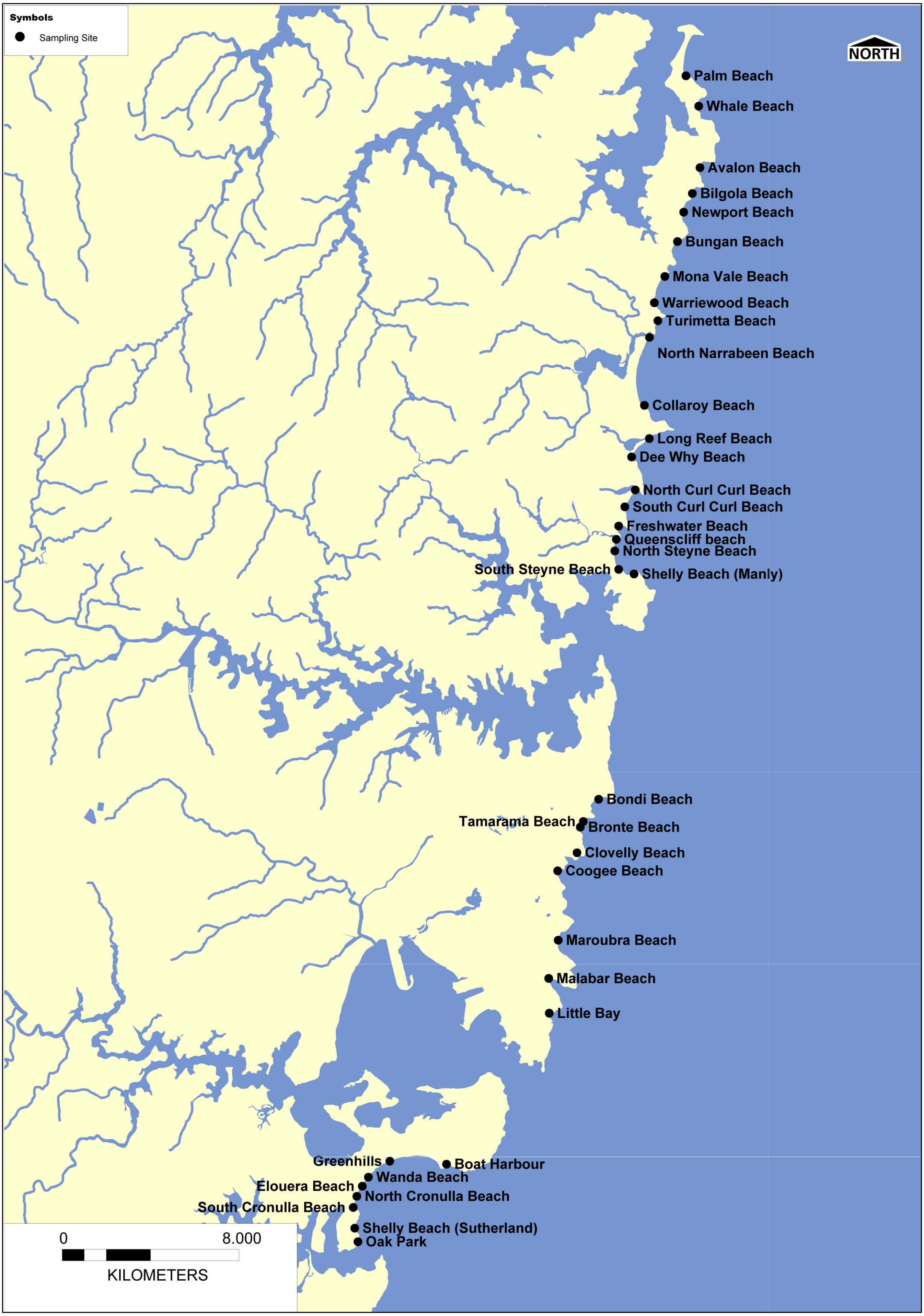

Figure A- 11: Beachwatch monitoring sites, Sydney Beaches (DECCW)

Figure A-12: Illawarra Beachwatch monitoring sites

Ocean Receiving Water

Since 1990, Sydney Water has collected oceanographic data from a monitoring mooring designated the Ocean Reference Station (ORS). The ORS is located in waters 65m deep, approximately 3km east of Bondi. Various changes to the system have been made in recent years and it now operates in non-real time as a stand-alone system.

The ORS measures current speed and direction throughout the water column and a series of temperature sensors throughout the water column estimate the water density profile. Wind speed and direction and wave height and period are obtained from systems owned and operated by the Bureau of Meteorology and Department of Commerce (Manly Hydraulics Laboratory), respectively.

Data are used (a) to assess the oceanographic processes that affect the advection and dispersion of Sydney Water discharges to the marine environment, and (b) as input data for a suite of numerical models to estimate the location and dilution of the effluent plumes.

The system comprises a bottom-mounted Acoustic Doppler Current Profiler (ADCP) and a bottom-mounted thermistor string. Wind and wave data are obtained from remote stations. The location of the ORS is marked using an old wave rider buoy.

The ORS is serviced monthly. This includes an inspection of the mooring system and the download of data. Wind data are obtained from the Bureau of Meteorology's weather station located at Sydney Airport (as well as several back-up locations), which are supplied weekly to Sydney Water. Wave height, period and direction data are obtained monthly from the Department of Commerce's wave rider located near Long Reef. STP effluent flow is obtained from gauging stations at the North Head, Bondi and Malabar STPs from Sydney Water's Hydstra database.

Transfer functions have been developed to ensure continuity between data collected from earlier configurations of the ORS and the (wind and wave) data now collected from remote stations.

All data are quality checked prior to storage (both locally and in the Data Warehouse) and transmission to DECCW, within approximately two weeks of servicing of the system.

Provisions for data loss

Based on experience with similar non-real-time systems, Sydney Water expects to achieve a data recovery rate in excess of 90%. Small data gaps (approximately 2 hours in duration) occur each month due to the servicing and data download processes. These data gaps can be patched using standard oceanographic techniques such as splines, spectral methods or neural networks.

Equipment failure

Most oceanographic equipment presently available is highly reliable and equipment failure is unlikely. The most likely fault will be battery failure, although the use of lithium batteries will reduce this risk. Such a failure is normally not recognized until the system is serviced. For such a scenario, up to one month of data may be lost. With monthly servicing, the loss of an entire month of data still provides 92% data recovery, well in excess of the 85% recovery criteria proposed by DECCW. The present system has been operating for more than 4 years with no major data loss.

Implications for the modelling if data are lost

This depends on the volume of data lost. Data losses for short periods (e.g. a few hours during servicing) have virtually no implication for modelling. If an entire month of data is lost a number of options are available. Sydney Water could build up a statistical picture for each month (based on historical data) and insert this into the data set, with appropriate warnings. Alternative data substitutions are to use neural network techniques to patch large data gaps. Wind data could be used to estimate currents in the upper layer of the water column, although the validity of such an approach may depend on the time of year.

Modelling pollutant dispersion from Deep Ocean Outfalls

Predictive models are used to determine the location and dilution of the deepwater outfall plumes using data from the ORS. As more than 90% of the dispersion of the effluent from the deepwater outfalls occurs in the near-field, near-field models are used.

The near-field model (PLUME) was developed specifically for Sydney's deepwater outfalls and has been appropriately calibrated and validated. The model has been used to estimate the behaviour of the three deepwater ocean outfalls (North Head, Bondi and Malabar) since 1991.

The near-field model is run annually, undertaking simulations every hour. Output from the near-field model include (a) the distance to the boundary of the initial dilution zone, (b) the 3D trajectory of the effluent plume and (c) the dilution of the effluent plumes. These data are combined with data on the concentrations of a range of contaminants in the effluent resulting in the concentration of contaminants at the boundary of the initial dilution zone. Direct comparisons are made with the ANZECC (2000) water quality guidelines to assess the environmental performance of the deepwater ocean outfalls. This information allows Sydney Water to assess the environmental performance of the deepwater outfalls.

Ecosystem Health: Shoreline Outfall Program

Table A- 16: STP shoreline outfall monitoring sites

Monitoring site	Effluent quality	Longitude	Latitude
Warriewood (STP)[2]	Secondary		
Cronulla (STP)[2]	Tertiary		
Bombo (STP)[2]	Secondary		
Diamond Bay (Vaucluse STP) [2]	Primary		
Shellharbour (STP) at Barrack Point	Secondary	150.8736	34.5638
Reference location 1: Northern side of Shellharbour Headland	No discharge	150.8758	34.5796
Reference location 2: Eastern side of Shellharbour Headland	No discharge	150.8772	34.5800

2 included for completeness but it is verified that OHS risk prevents monitoring of this outfall.

Figure A- 13: Shoreline outfall monitoring sites

Ecosystem Health: Marine Benthic and Sediment Quality

Table A- 17: Ocean Sediment Program sampling sites.

Site code	Site description	Easting (grid centre)	Northing (grid centre)
T-1C*	Terrigal 1, 60m	364288.53	6292802.11
T-2C*	Terrigal 2, 60m	365981.63	6298198.85
LR-1C	Long Reef 1, 60m	349791.41	6266903.05
LR-2C	Long Reef 2, 60m	349315.23	6264892.5
NH-1C	North Head 1, 60m	347436.95	6257934.94
NH-2C	North Head 2, 60m	347463.41	6256056.66
B-1C	Bondi 1, 60m	343415.85	6248226.1
B-2C	Bondi 2, 60m	344024.31	6250792.2
MO-1C	Malabar 0km S 1, 80m	342807.4	6238966.99
MO-2C	Malabar 0km S 2, 80m	343468.76	6239125.72
M3-1C	Malabar 3km S 1, 80m	341378.85	6236506.71
M3-2C	Malabar 3km S 2, 80m	341590.48	6236612.53
M5-1C	Malabar 5km S 1, 80m	340638.12	6234628.44
M5-2C	Malabar 5km S 2, 80m	340902.67	6234469.71
M7-1C	Malabar 7km S 1, 80m	339527.03	6233041.16
M7-2C	Malabar 7km S 2, 80m	339394.75	6232723.7
PH-1C	Port Hacking 1, 80m	336749.29	6228649.7
PH-2C	Port Hacking 2, 80m	336749.29	6228411.6
MB-1C	Marley Beach 1, 80m	331643.55	6221348.22
MB-2C	Marley Beach 2, 80m	331722.92	6221163.04
SB-1C*	Shoalhaven Bight 1, 80m	310030.14	6138174.95
SB-2C*	Shoalhaven Bight 2, 80m	310056.6	6137810.41
SB-3C*	Shoalhaven Bight 3, 80m	310400.51	6137672.32
SB-4C*	Shoalhaven Bight 4, 80m	310532.78	6137360.68

* sampling and analysis discontinued from July 2010

Table A- 18: Ocean sediment program sampling analytical requirements

Site codes	Assessment years (every 3rd year)										Surveillance years							
	No of sites (one sample per site)										No of sites (one sample per site)							
			Analysis										Analysis					
	Collection/ subsampling		TOC and GS		Chem1		Chem2		Benthos counts		Collection/ subsampling		TOC and GS		Chem1and 2		Benthos counts	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
T-1C*	10		5		5		0		5		10		5		0		0	
T-2C*	10		5		5		0		5		10		5		0		0	
LR-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
LR-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
NH-1C	10	5	5	5	5	5	5	5	5	5	10	5	5	5	0	0	0	0
NH-2C	10	5	5	5	5	5	5	5	5	5	10	5	5	5	0	0	0	0
B-1C	10	5	5	5	5	5	0	0	5	5	10	5	5	5	0	0	0	0
B-2C	10	5	5	5	5	5	0	0	5	5	10	5	5	5	0	0	0	0
MO-1C	10	10	5	5	5	5	5	5	10	10	10	10	**5**	**5**	0	0	10	10
MO-2C	10	10	5	5	5	5	5	5	10	10	10	10	5	5	0	0	10	10
M3-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
M3-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
M5-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
M5-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
M7-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
M7-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
PH-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
PH-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
MB-1C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
MB-2C	10	5	5	5	5	5	0	0	5	5	10		5		0		0	
SB-1C*	10		5		5		0		5		10		5		0		0	
SB-2C*	10		5		5		0		5		10		5		0		0	
SB-3C*	10		5		5		0		5		10		5		0		0	
SB-4C*	10		5		5		0		5		10		5		0		0	

Notes:

A = Pre June 2010
B = July 2010 onwards
Shading = areas where changes are implemented from July 2010
Bold = analysis used to see if TOC trigger has gone off
TOC = Total organic carbon
GS = grain size (%gravel; %sand: % mud)
0 = Samples are collected and archived but not analysed
Chem1 = metals/metaloids; naphthlene; m-cresol;
Chem 2 = PAHs; o-cresol; 2-chlorophenol; organochlorine pesticides; PCBs; total Kjeldahl nitrogen; phosphorus

Figure A-14: ***Ocean Sediment Program sampling sites***

Special Investigations:

SCAMPS Dry Weather Sewage Leakage Detection Monitoring Program

Table A- 19: Dry Weather Leakage Detection Program monitoring sites

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
Blue Mountains	BHBLH1	Blackheath	1712	Popes Glen Creek	7 J2 (BM)	56249662	6275793
	MVMVC1	Mount Victoria	1716	Fairy Dell Ck	2 H1 BM	56245242	6280897
	PREMP1	Emu Plains	1409	Lapstone Ck	162 H3	56282686	6264490
	PRGLB1	Glenbrook	1409	Glenbrook Lagoon Outlet	161 N12	56280279	6262207
	PRGNP1	Glenmore Park	1409	School House Ck	182 M4	56283798	6260266
	PRJMT1	Jamisontown	1409	Peach Tree Ck	163 B13	56284885	6262052
	PRMPL1	Mount Pleasant	1409	No-Name Ck	143 K8	56286723	6267237
	PRPNR1	Penrith	1409	No-Name Ck	163 D8	56285505	6263302
	WGWAR1/ WLWAL1	Wallacia	12235	Meggaritys Ck	241 H1	56279001	6249062
	WLWAL2**	Wallacia	12235	Scotcheys Creek	241 N11	56280122	6246621
	WMHAZ1	Hazelbrook	1963	No-name Ck	23 H11 (BM)	56264132	6266761
	WMNKT1*	North Katoomba	1963	Katoomba Ck	19 P6 (BM)	56250590	6267950
	WMSKT1	South Katoomba	1963	Katoomba Cascades	29 N2 (BM)	56250426	6265050
	WMWIN1	Winmalee	1963	Springwood Ck	BM F12 (BM)	56273597	6268727
	WMWWF1	Wentworth Falls	1963	Valley of Waters Ck	20 Q13 (BM)	56254192	6266100
Winmalee	WMNKT2**	North Katoomba	1963	Katoomba Ck	19 Q6 (BM)	56250753	6267665
BOOS	BNBNB1	Bondi Beach	1688	Bondi Beach inflow	257 P5	56340312	6248242
	BNBNJ1	Bondi Junction	1688	No-name Ck	257 B8	56337313	6247300
	BNCMD1	Camperdown	1688	Johnstons Ck	235 H14	56331350	6249807
	BNEDG1	Edgecliff	1688	Rushcutters Bay	236 M13	56336185	6250019
	BNROZ1	Rozelle	1688	No-Name Ck	235 L3	56332165	6252434
	BNRSB1	Rose Bay	1688	Rose Bay channel	237 K12	56339357	6250240

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
BOOS	BNSYE1	Sydney East	1688	Woolloomooloo Bay	236 H10	56335250	6250714
	BNSYW2	Sydney West	1688	Cockle Bay	15 G1	56334069	6248895
	BNVAU1	Vaucluse	1688	No-Name Ck	237 N3	56340227	6252681
COOS	CRBAG1	Bangor	1728	Still Creek	311 J7	56316821	6235431
	CRCRN1	Cronulla	1728	No-Name Ck	334 N12	56329027	6230408
	CRCRS1	Caringbah South	1728	No-Name Ck	334 F15	56327246	6229508
	CRENG1	Engadine	1728	Forbes Ck	332 D4	56318984	6232394
	CRGYM1*	Gymea	1728	Alcheringa Gully	333 J8	56324208	6231229
	CRGYM2**	Gymea	1728	Coonong CK	333 G10	56323675	6230645
	CRJAN1	Jannali	1728	Carina Ck	312 J6	56321850	6235282
	CRLOF1	Loftus	1728	Loftus Ck	332 C6	56319070	6231791
	CRMEN1	Menai	1728	No-Name Ck	291 L16	56317402	6237393
	CRMIR1	Miranda	1728	No-name Ck	313 B12	56324649	6233869
	CRSUT1	Sutherland	1728	No-Name Ck	313 B12	56322346	6234147
	CRWOL1	Woolooware	1728	No-name Ck	333 Q7	56325744	6231550
Illawarra	BOKIA1	Kiama	2269	No-Name Ck	65 Q3 (W)	56303172	6160410
	SHALP1	Albion Park	211	No-Name Ck	52 C3 (W)	56296354	6172251
	SHLIL1	Lake Illawarra	211	Bensons Creek	50 C11 (W)	56303857	6174480
	SHSLH1	Shellharbour	211	Oak Park Ck	49 F15 (W)	56300938	6173589
	WOBSV1	Brownsville	218	Brooks Ck	44 L4 (W)	56298374	6180272
	WOBUL1	Bulli	218	Bellambi Ck	26 F6 (W)	56308322	6195630
	WOCOR1	Corrimal	218	Towradgi Ck	26 B15 (W)	56306477	6193640
	WODAP1	Dapto	218	Mullet Ck (Illawarra)	39 H11 (W)	56297767	6182431
	WOFGT1	Figtree	218	Branch Ck	34 M8 (W)	56302600	6187446
	WOFMW1	Fairy Meadow	218	Cabbage Tree Ck	29 N7 (W)	56306588	6191678
	WOGWY1	Gwynneville	218	No-Name Ck	29 L15 (W)	56305966	6189639
	WOPKB1	Port Kembla	218	Minnegang Ck	41 F16 (W)	56304736	6181298
	WOTHI1	Thirroul	218	Hewitts Ck	22 H5 (W)	56308975	6200012

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
Illawarra	WOUNA1	Unanderra	218	Allans Ck	34 L16 (W)	56302151	6185263
	WOWOL1	Wollongong	218	No-name Ck	35 N8 (W)	56306304	6187325
NSOOS	NHAUB1	Auburn	378	No-Name Ck	231 J6	56316398	6251226
	NHBAH1	Baulkham Hills	378	Toongabbie Ck	170 D10	56311568	6262829
	NHBCT1	Beecroft	378	Trib of Devlins Creek	172 K12	56320703	6262370
	NHBGH1	Balgowlah Heights	378	No-Name Ck	197 J11	56339591	6258629
	NHBLR1	Belrose	378	Frenchs Ck	156 C14	56334079	6265850
	NHBLV1	Bella Vista	378	Lalor Ck	169 J16	56309357	6261443
	NHBRK1	Brookvale	378	Brookvale Ck	177 L16	56339644	6261878
	NHCCL1	Curl Curl	378	Greendale Ck	177 P12	56340648	6262435
	NHCHW1	Chatswood	378	Scotts Ck	195 Q5	56333164	6260288
	NHCLR1	Collaroy	378	No-Name Ck	178 D2	56341720	6264732
	NHCMR1	Cromer	378	South Creek	157 N13	56340343	6266147
	NHCRM1	Cremorne	378	No-Name Ck	216 N11	56336427	6254598
	NHCSH1	Castle Hill	378	Darling Mills Ck	171 E13	56315644	6262124
	NHDUN1	Dundas	378	Subiaco Ck	211 N1	56318045	6257469
	NHDVY1	Dundas Valley	378	Vineyard Ck	191 M16	56317771	6257943
	NHEAS1	Eastwood	378	Terrys Ck	173 K11	56323501	6261557
	NHEBL1	East Blacktown	378	Blacktown Ck	189 H1	56308825	6261096
	NHEPP1	Epping	378	Devlin Ck	173 B13	56322407	6262203
	NHFRV1	Forestville	378	Carroll Ck	176 D7	56334089	6263659
	NHGIW1	Girraween	378	Girraween Ck	189 P5	56310430	6259966
	NHGLF1	Guildford	378	Duck Creek	211 G12	56315919	6254057
	NHGRW1	Greenwich	378	No-Name Ck	215 A7	56329703	6255580
	NHHOL1	Holroyd	378	A'Becketts Ck	211 F8	56315854	6255208
	NHHOR1	Hornsby	378	Cockle Ck	153 Q2	56325680	6268757
	NHHUN1	Hunters Hill	378	Tarban Ck	214 G12	56327403	6254533
	NHKIL1	Killara	378	Rocky Ck	175 E6	56330633	6263881

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
NSOOS	NHKLH1	Killarney Heights	378	Bates Ck	176 J13	56335544	6261935
	NHLID1	Lidcombe	378	Haslams Ck	232 B7	56318881	6251640
	NHLNC1	Lane Cove	378	Stringybark Ck	195 B15	56329994	6257495
	NHLIN1**	Lindfield	378	Gordon Creek	175 G13	56331184	6261908
	NHMNY1*	Manly	378	No-Name Ck	198 D2	56341780	6260960
	NHMNY2**	Manly	378	No-Name Ck	198 C13	56341402	6258977
	NHMOS1	Mosman	378	No-name Ck	217 E7	56338221	6255634
	NHMQP1	Macquarie Park	378	Shrimptons Ck	194 A1	56326068	6261044
	NHNEP1	North Epping	378	No-Name Ck	173 B6	56322607	6263809
	NHNPR1	North Parramatta	378	Hunts Ck	191 K4	56317244	6260248
	NHNRB1	Naremburn	378	No-Name Ck	216 A1	56333111	6257216
	NHNRD1	North Ryde	378	No-Name Ck	194 J12	56327521	6257552
	NHNSY1	North Sydney	378	No-Name Ck	215 Q13	56333271	6253820
	NHPAR1	Parramatta	378	No-name Ck	211 D2	56315550	6256910
	NHPNH1	Pendle Hill	378	Pendle Ck	189 Q6	56310688	6259844
	NHPYM1*	Pymble	378	Blackbutt Ck	174 J14	56327918	6261685
	NHRSH1	Rosehill	378	No-Name Ck	211K3	56316808	6256266
	NHRSV1	Roseville	378	Moores Ck	175 N13	56322630	6261505
	NHRYD1	Ryde	378	Strangers Ck	214 G2	56326762	6257073
	NHRYL1	Rydalmere	378	No-Name Ck	212 C4	56318662	6256371
	NHSEA1	Seaforth	378	Burnt Bridge Ck	197 K5	56339493	6260071
	NHSIL1	Silverwater	378	No-name Ck	232 F2	56319767	6252783
	NHSVH1	Seven Hills	378	No-Name Ck	189 J3	56309101	6260479
	NHSWT1	South Wentworthville	378	Finlaysons Ck	190 J14	56312843	6257797
	NHTUR1	Turramurra	378	No-Name Ck	154 N3	56328861	6268812
	NHWAH1	Wahroonga	378	Lovers Jump Ck	154 H1	56327937	6268731
	NHWIL1	Willoughby	378	Sugarloaf Ck	196 E10	56334340	6258742
	NHWLI1**	West Lindfield	378	Little Blue Gum	194P7	56329083	6259909

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
NSOOS	NHWMN1	Westmead North	378	Quarry Branch Ck	190 M5	56313874	6259984
	NHWMS1	Westmead South	378	Twin Creeks	210 P1	56314114	6256981
	NHWPH1	West Pennant Hills	378	Darling Mills Ck	171 H11	56316440	6262625
	NHWRY1	West Ryde	378	Charity Ck	213 D2	56323149	6256788
	NHWTH1	Winston Hills	378	No-name Ck	190 F5	56312311	6259995
	NHWTU1	West Turramurra	378	No-Name Ck	173 Q7	56325785	6263039
	NHWWA1	West Wahroonga	378	Coups Ck	153 E14	56323291	6265790
	NHWWV1	Wentworthville	378	Coopers Ck	190 G12	56312515	6258314
	NHYAG1*	Yagoona	378	Duck River	231 H8	56316404	6251237
	NHYAG2**	Yagoona	378	Duck River	251 H3	56316443	6248479
SWOOS	MAACT1	Ashcroft	372	Cabramatta Ck	268 G4	56304896	6244372
	MAALX1	Alexandria	372	No-name Ck	255 P11	56333022	6246627
	MAARN1	Arncliffe	372	No-Name Ck	274 Q6	56329480	6243724
	MAASF1	Ashfield	372	Iron Cove Ck	234 D12	56326721	6250144
	MAAVL1	Ambarvale	372	Mansfield Ck	366 H8	56297671	6223317
	MABEX1	Bexley	372	Muddy Ck	294 M1	56327318	6240156
	MABKH1	Blakehurst	372	No-Name Ck	294 C14	56326185	6237975
	MABKN1	Bankstown	372	Salt Pan Ck	272 A7	56318426	6243431
	MABKS1	Banksia	372	No-name Ck	274 N12	56328931	6242354
	MABLM1	Belmore	372	No-Name Ck	253 G10	56323759	6246674
	MABLS1	Belmore South	372	Cup and Saucer Ck	254 B16	56321310	6245466
	MABOT1	Botany	372	No-name Ck	276 A15	56333207	6242069
	MABRG1	Bonnyrigg	372	Clear Paddock Ck	228 Q15	56306958	6249622
	MABRT1	Brighton	372	Muddy Ck	294 M1	56328401	6240832
	MABSP1	Bossley Park	372	Orphan School Ck	228 Q11	56305807	6250732
	MABVH1	Beverly Hills	372	Wolli Ck	273F12	56323510	6242372
	MACAB1	Cabramatta	372	No-Name Ck	249M3	56309935	6248631
	MACAS1	Casula	372	Brickmakers Ck	249 G14	56308634	6245817

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
SWOOS	MACBT1	Campbelltown	372	Bow Bowing Ck	326 M16	56298786	6229346
	MACDP1	Condell Park	372	No-name Ck	270 J7	56313286	6243731
	MACGE1	Coogee	372	No-name Ck	257 H15	56339034	6245478
	MACHF1*	Chifley	372	Yarra Bay	296 N11	56336457	6238514
	MACHF2**	Chifley	372	Gully pit	297 E2	56338249	6240793
	MACMP1	Campsie	372	No-name Ck	253 J10	56324287	6246824
	MACNE1	Concord East	372	No-Name Ck	233 M5	56324900	6252076
	MACNW1	Concord West	372	No-name Ck	213F14	56323485	6253839
	MACPN1	Chipping Norton	372	Drain to Amaroo Wetland	250L12	56313451	6246194
	MACTB1	Canterbury	372	No-Name Ck	253 L8	56324655	6247231
	MADRU1	Drummoyne	372	No-name Ck	234 J2	56327805	6252716
	MADUL1	Dulwich Hill	372	No-name Ck	254 H13	56327924	6246295
	MAEAR1	Earlwood	372	No-name Ck	254 G15	56327223	6245325
	MAEGV1	Eagle Vale	372	Thompson Ck	307 D16	56300398	6233436
	MAFAR1	Fairfield	372	No-Name Ck	229 Q15	56310708	6249455
	MAFVD1	Five Dock	372	No-name Ck	234 A8	56326018	6250853
	MAGNF1	Glenfield	372	Macquarie Ck	288 J15	56305572	6237471
	MAGRA1	Greenacre	372	Cooks River	253 C7	56322706	6247590
	MAHOM1	Homebush	372	No-Name Ck	233 A4	56322152	6252015
	MAHOX1	Hoxton Park	372	Maxwells Ck	268 L5	56305776	6244023
	MAHUR1	Hurstville	372	Bardwell Ck	274 G7	56329390	6243370
	MAING1	Ingelburn	372	Redfern Ck	288 D15	56304257	6237621
	MAKEN1	Kensington	372	No-Name Ck	276 J2	56335519	6244734
	MAKGB1	Kogarah Bay	372	No-Name Ck	294 J16	56327947	6237353
	MAKOG1	Kogarah	372	No-Name Ck	294 F11	56327232	6238917
	MAKSG1	Kingsgrove	372	Wolli Ck	274 D5	56326794	6243921
	MALAK1	Lakemba	372	Coxs Ck	253 A8	56322346	6247335
	MALCH1	Leichhardt	372	Whites Ck	235 D15	56330504	6249620

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
SWOOS	MALEU1	Leumeah	372	Leumeah Ck	326 Q15	56299474	6229541
	MALIV1	Liverpool	372	No-Name Ck	269 K1	56309402	6245167
	MALNV1	Lansvale	372	Long Ck	250 B4	56311149	6248683
	MALUG1	Lugarno	372	Boggywell Ck	292 G12	56319873	6238327
	MAMAR1	Maroubra	372	No-Name Ck	296J3	56335879	6240789
	MAMAS1	Mascot	372	No-Name Ck	275 Q9	56333766	6243327
	MAMIN1	Minto	372	No-name Ck	307 G14	56301223	6233869
	MAMOB1	Moorebank	372	Anzac Ck	269 L6	56309696	6243757
	MAMPR1	Mount Pritchard	372	Green Valley Ck	229 D15	56308095	6249437
	MAMRB1	Maroubra Beach	372	No-name Ck	277 K9	56339569	6243055
	MAMRV2	Marrickville	372	No-name Ck	254Q16	56329266	6245061
	MAPAD1	Padstow	372	No-name Ck	272 A13	56319055	6243543
	MAPAN1	Panania	372	Kelso Ck	271 A14	56314819	6241830
	MAPHS1	Penshurst	372	Poulton Ck	293 H14	56324199	6237957
	MAPKH1	Peakhurst	372	No-name Ck	292 P9	56321717	6239124
	MARAN1	Randwick	372	stormwater drain	276 L4	56335847	6244258
	MARBY1	Raby	372	Bunbury Curran Ck	307 C9	56300322	6235076
	MAREV1	Revesby	372	Little Salt Pan Ck	291 L4	56317198	6240936
	MARUS1	Ruse	372	Smiths Ck	327 A13	56299888	6230443
	MARVW1	Riverwood	372	No-Name Ck	272 F9	56319651	6242756
	MASMF1	Smithfield	372	Prospect Ck	230 A8	56311084	6251440
	MASSY1	South Sydney	372	Sheas Ck	256 A9	56333488	6247035
	MASTR1	Strathfield	372	Powells Ck	233 D7	56322989	6251469
	MASUM1	Summer Hill	372	Hawthorne Canal	254 L4	56322954	6251457
	MASYD1	Sydenham	372	No-Name Ck	274 Q2	56329562	6245240
	MAVIL1	Villawood	372	No-name Ck	230 D14	56311584	6249716
	MAWAK1	Wakeley	372	No-Name Ck	229 A14	56307305	6249782
	MAWOD1	Woodbine	372	No-name Ck	327 A6	56299819	6231897

System	Site codes	SCAMP	EPL	Waterway	UBD Map Ref.	Easting	Northing
SWOOS	MAWPK1	Wetherill Park	372	Orphan School Ck	228 Q11	56306934	6250579
	MAYEN1	Yennora	372	No-name Ck	230 C12	56311453	6250342
Warriewood	WWAVA1	Avalon	1784	Careel Creek	119 C2	56345319	6277813
	WWELH1	Elanora Heights	1784	Mullet Ck	138 A10	56341220	6270451
	WWNEW1	Newport	1784	McMahons Ck	118 M11	56343821	6274449
West Camden	WCCMD1	Camden	1675	No-Name Ck	343 M10	56287855	6226889
	WCMAN1	Mount Annan	1675	Kenny Ck	325H9	56294075	6231167
	WCOKD1	Oakdale	1675	Back Creek	339 N11	56272770	6226604
	WCNRL1	Narellan	1675	Narellan Ck	323 H4	56290185	6232341
Western Sydney	CHCHS1	Castle Hill STS	1725	No-Name Ck	150 L2	56313167	6267907
	HHHHT1	Hornsby Heights	750	Walls Gully/Calna Ck	133 H2	56323806	6272636
	NRNRC1	North Richmond	190	Redbank Ck	64 E10	56289291	6282697
	PRMRV1	Mount Riverview	1409	No-name Creek	162 F4	56282372	6265087
	QHBLT1	Blacktown	1724	Breakfast Ck	168 H7	56305246	6263445
	QHDON1	Doonside	1724	Eastern Creek	167 J9	56301685	6263039
	QHOKH1	Oakhurst	1724	Bells Ck	147 D14	56300576	6267127
	QHQHL1	Quakers Hill	1724	Breakfast Ck	168 B4	56303866	6264367
	RHRHL1	Rouse Hill	4965	Smalls Ck	129 K11	56309420	6270564
	RMRIC1	Richmond	1726	Cooley Ck	66 E16	56296978	6281289
	RSRVS1	Riverstone	1796	No-Name Ck	127 G7	56301182	6272093
	SMBCT1	Blackett	1729	No-Name Ck	146 A11	56296079	6266419
	SMMDR1	Mount Druit	1729	Ropes Ck	165 L4	56294710	6264353
	SMSMY1	St Marys	1729	Byrnes Ck	185 E1	56293197	6261135
	SMWER1	Werrington	1729	Werrington Ck	165 A8	56292199	6263323
	WHCHB1	Cherrybrook	1695	Pyes Ck	152 E2	56319583	6268929
	WHTHO1	Thornleigh	1695	Waitara Ck	153 A1	56322177	6269161

* not currently monitored

** new site

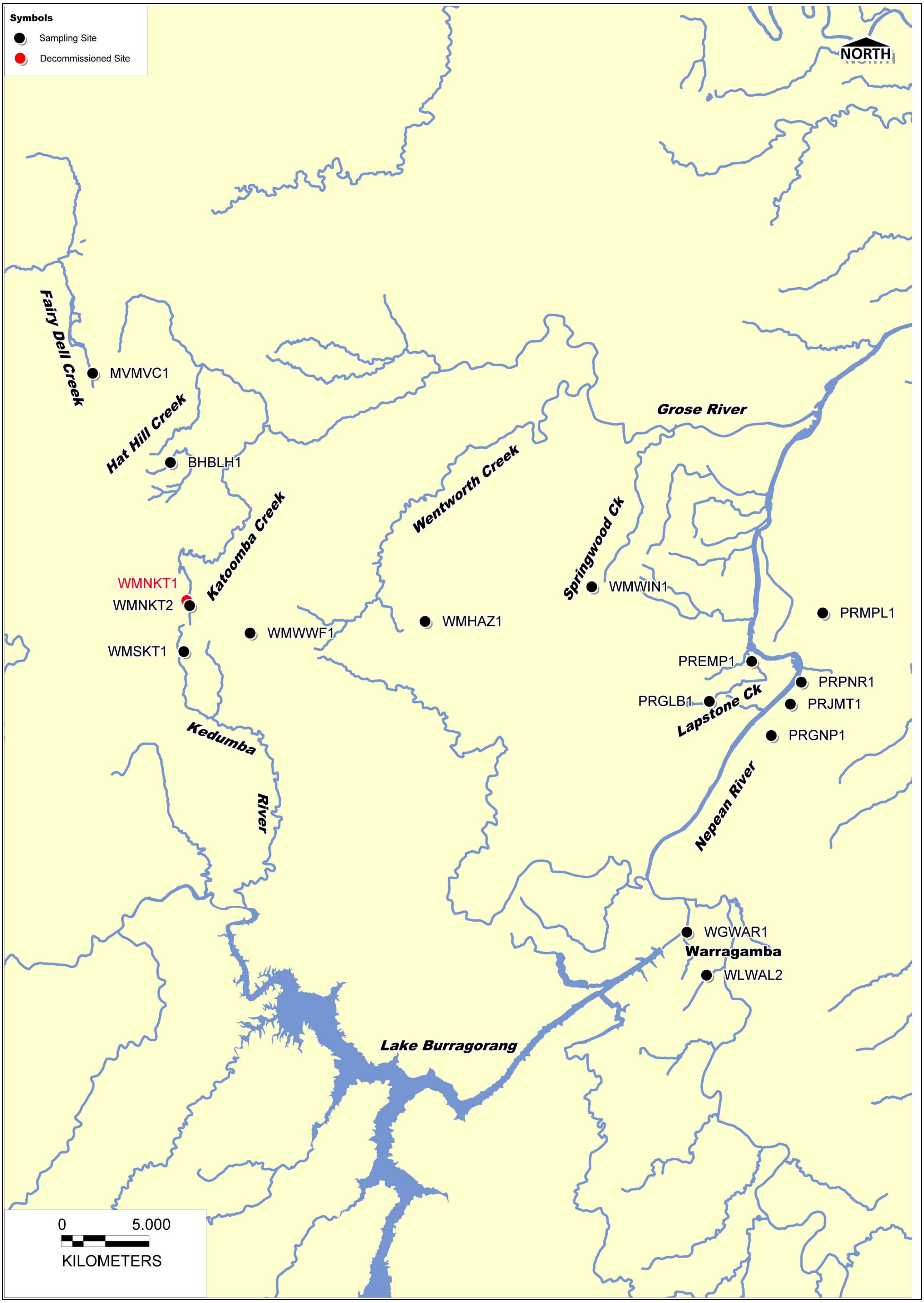

Figure A-15: SCAMPS dry weather leakage detection monitoring sites: Blue Mountains and Winmalee.

Figure A-16: SCAMPS dry weather leakage detection monitoring sites: BOOS and COOS

Figure A-17: SCAMPS dry weather leakage detection monitoring sites: Illawarra

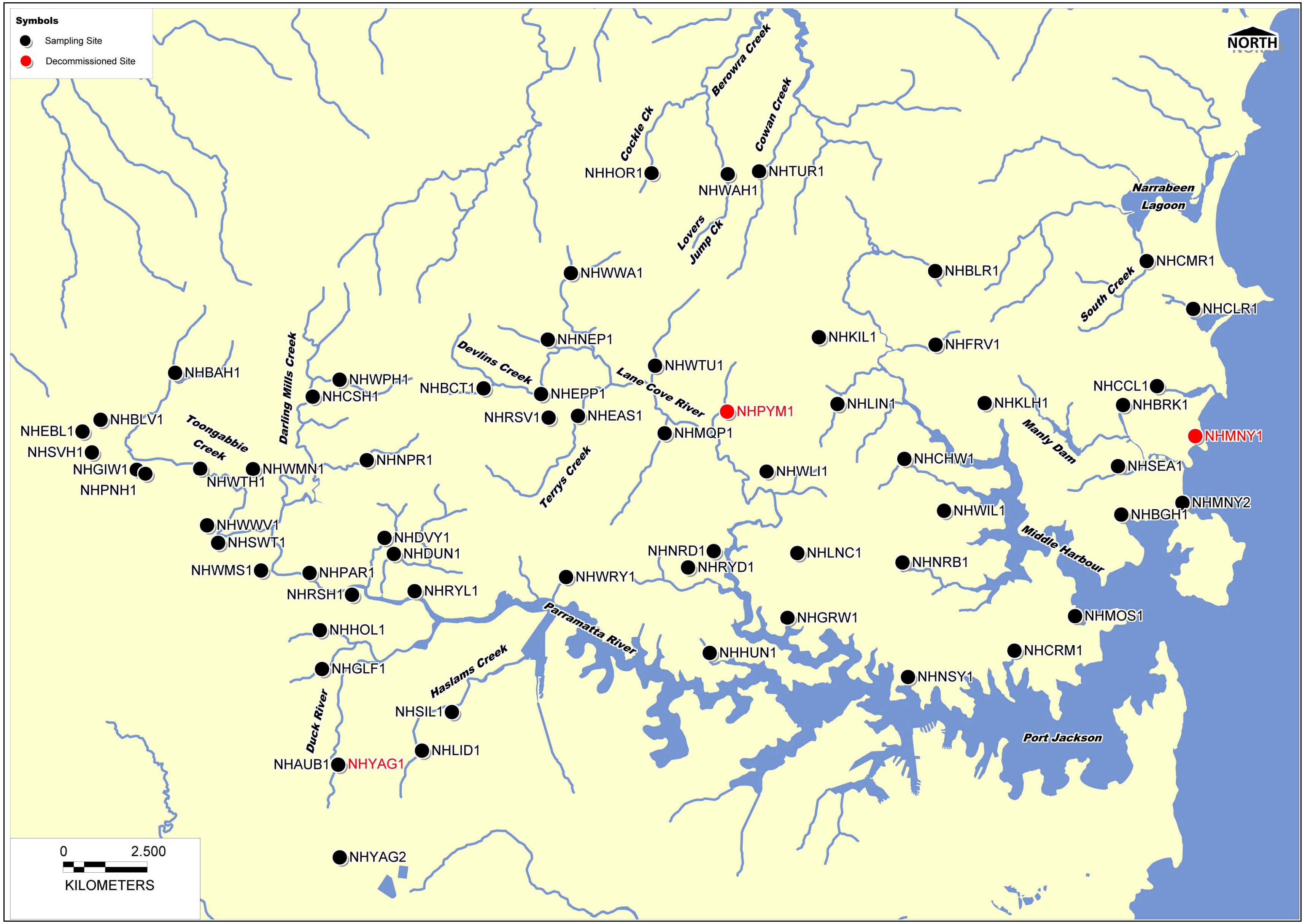

Figure A-18: SCAMPS dry weather leakage detection monitoring sites: NSOOS

Figure A-19: SCAMPS dry weather leakage detection monitoring sites: SWOOS

Figure A-20: SCAMPS dry weather leakage detection monitoring sites: Warriewood

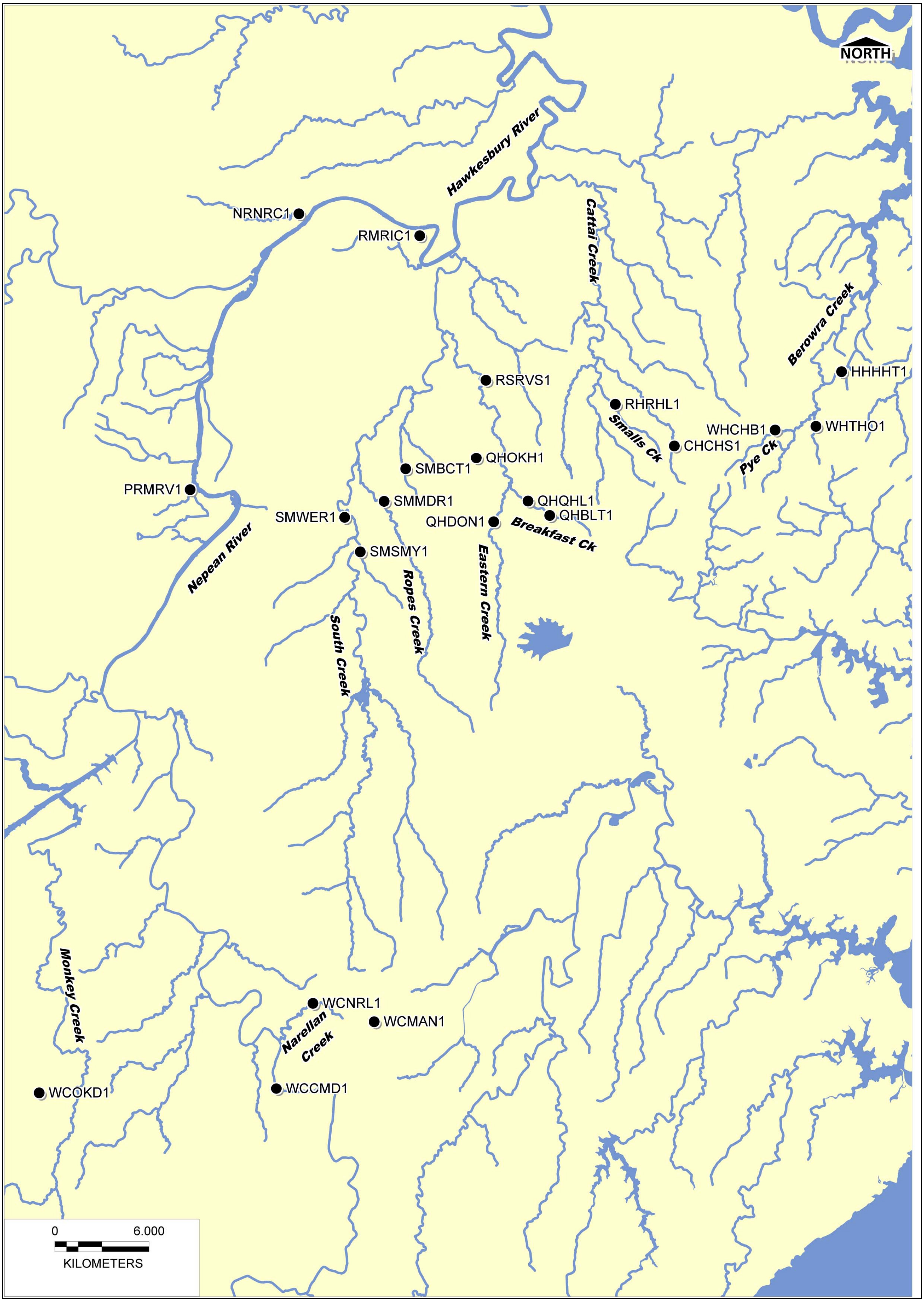

Figure A-21: SCAMPS dry weather leakage detection monitoring sites: Western Sydney and West Camden

Table A- 20: List of analytes, SCAMPS Dry Weather Leakage Detection Program

Water quality variable	Detection limit	Unit	Method/Reference	Place of measurement
Conductivity	-	µS/cm	Yeo-Kal Meter	Field
Faecal coliforms	0	cfu/100mL	APHA (2005) 4500-NH_3 H	Laboratory
Ammonia	0.01	mg/L	APHA (2005) 9230C	Laboratory

Macroinvertebrate Pilot Study

Table A- 21: Sampling sites for the macroinvertebrate pilot study.

Catchment	Site code or Reference	SCAMP catchment
Avondale Ck	LC2002 LC2001	West Turramurra
Blackbutt Ck	LC1602 LC1601	Pymble and West Lindfield
Dundas Valley (The Ponds CK)	PRDS2 PRDS1	North Head
*Devlins Ck unnamed tributary	LC2822 LC2821	Beecroft
*Vineyard Creek	PR02 PR01	Dundas

Of the original five sewer overflow sites selected two were found to be unsuitable for sample collection, being Blue Gum and Swaines creeks. *Hence another two sites have been adopted for this pilot study.

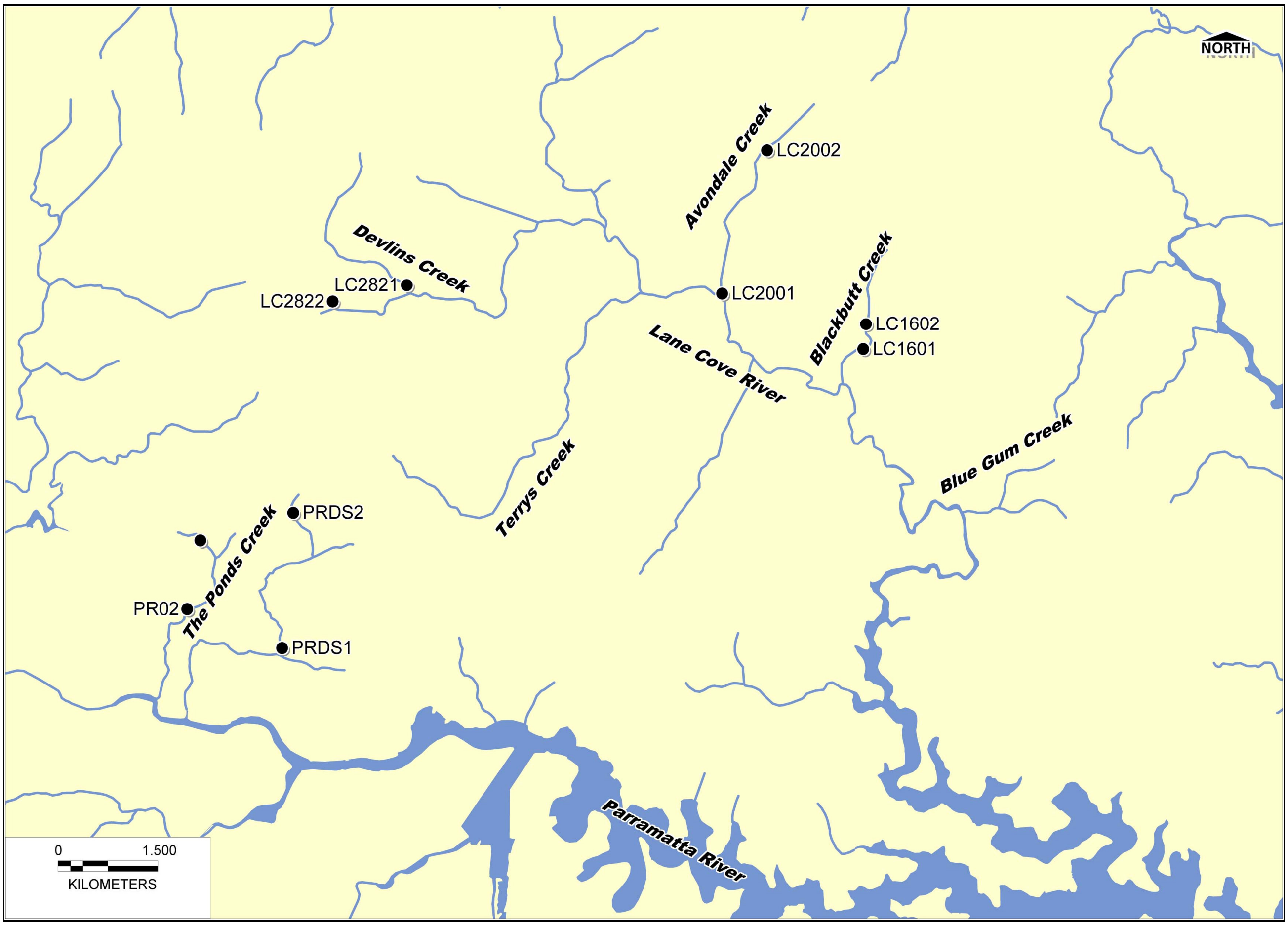

Figure A-22: Sites of macroinvertebrate pilot study

Appendix 3: Quality Control

Sampling Quality Control

The sampling quality control procedures routinely applied to field collection activities are:

- appropriate sample container type and pre-preparation
- field decontamination procedures
- field validation sample collection
- suitable sample preservation
- sample handling and storage procedures
- chain of custody procedures.

The following descriptions provide further detail for each of the above procedures.

Sample containers, pre-preparation and preservation

The container types required for each sample matrix were identified in work specifications. Containers are chosen to limit the potential for contamination. Sample containers, pre-preparation and preservation measures are consistent with Australian Standards, APHA or USEPA standards.

Field decontamination

Decontamination procedures are applied to all equipment used in the field that comes into direct contact with any sample to be chemically analysed. The use of surfactants, acid and acetone is kept to a minimum. Decontamination is undertaken at the conclusion of sampling and prior to the sampling at the next site. Prior to water sample collection the sample containers is rinsed once with local water at the sample site.

Sample handling and storage

All sample handling and storage follows appropriate methods described in APHA and the USEPA guidelines. Contracted analytical laboratories generally commence analysis within 24 hours of sample collection.

Chain of custody

Every sample collected in the field is labelled with a unique identifier code. At the end of each day of sampling, a chain of custody form is prepared to document the number, date, and type of samples collected. The chain of custody form accompanies the sample and documented acceptance and handling from the time they are collected to their registration into the appropriate analytical laboratories. These forms trace the possession and handling of samples by all parties. Chain of custody forms are signed and copies retained by each party involved in sample transfer.

Analytical Quality Control

Chemical analysis of samples are undertaken by contracted laboratory with each required to analyse a range of quality control samples. The number, type and frequency of inclusion of these samples varies depending on the size and range of chemical analyses required.

The types of quality control samples used are described below:

Method blank

Method blanks are used to detect laboratory contamination. Method blanks contain all reagents and undergo all procedural steps used for analysis. If the equipment used for sampling is dedicated equipment, ie, not reused to obtain other samples, no method blank is necessary.

Field duplicate

Field duplicates are collected by field sampling teams and analysed by the contracted laboratory to verify the precision of laboratory and/or sampling methodology. The samples are labelled so the laboratory cannot discern these quality control samples from environmental samples.

Field blank

In order to identify contamination introduced during field activities field blanks are collected during field sampling operations. A field blank consisted of ultra pure water (17-18.4 megohm resistivity) decanted into appropriate sample containers at a nominated sample collection site. The samples are labelled so the laboratory cannot discern these quality control samples from environmental samples.

Trip blank

Trip blanks are used to identify contamination that may occur during sample transportation or from the containers themselves. The trip blanks consist of a prepared water sampling container filled with ultra pure water (17-18.4 megohm resistivity) prior to commencement of field collection operations. These samples are transported together with all other sampling containers to the sampling site. The trip blanks remain unopened for the duration of the sampling event and are transported under the same conditions as environmental samples to the contracted laboratory for analysis. The samples are labelled so the laboratory cannot discern these quality control samples from environmental samples

Laboratory duplicate

A laboratory duplicate is an environmental sample that is split into two separate samples by the contracted laboratory and analysed as separate samples. They are used to verify that the per cent difference between the each separate result is within acceptable control limits. Per cent differences exceeding the specified limits signal the need for procedure evaluation, provided that the excessive difference between the samples is not matrix-related.

Certified reference material (CRM)

A material containing known quantities of target analytes in solution or in a homogeneous matrix. CRMs are used to document the bias of the analytical process.

Matrix spike and matrix spike duplicate

A matrix spike is an environmental sample to which known quantities of selected compounds have been added. Matrix spikes are processed as part of the analytical batch, and used to verify method accuracy. Analysed in duplicate, matrix spikes verify both method accuracy and precision. If recovery values for the added compounds fall within specified limits, the analytical process is considered in control. Recovery values not within the specified limits signal the need for procedure evaluation, provided that unacceptable recoveries are not related to the sample matrix.

Blank spike

A blank spike is an aliquot of water or solid matrix to which selected compounds are added in known quantities. The blank spike is processed as part of the analytical batch, and is used to determine method efficiency. If recovery values for the added compounds fall within specified limits, the analytical process is considered in control. Recovery values not within the specified limits signal the need for procedure evaluation.

Surrogate

Surrogate compounds are virtually identical to the analytes of interest but do not occur in nature and are added to samples prior to extraction in a known amount to document analytical performance.

Calibration

Calibration of analytical instruments followed the requirements specified by the appropriate method and National Association of Testing Authorities (NATA) and/or Australian Standards. For all analyses, initial calibration is conducted at the beginning of each analytical sequence or, as necessary, if the continuing calibration acceptance criteria are not met.