



Australian Government

National Land & Water Resources Audit

An initiative of the Australian Government

ESTUARINE, COASTAL AND MARINE HABITAT INTEGRITY

INDICATOR HEADING

Estuarine, coastal and marine habitat condition

INDICATOR GUIDELINE

Nutrient concentration in the water column and/or sediments

Recommended by the Audit for further consideration

This version of the guideline has been developed through the National Land and Water Resources Audit and was informed by expert review and broad consultation on national indicators via national coordination committees and their associates. Version 1 – June 2008 does not yet have the final endorsement of any jurisdiction. The document is for guidance only and is presented to provide a basis for on-going discussion. It may require further consideration by a jurisdictional based reference group before national endorsement.

Nutrient concentration in the water column
and/or sediments

Status of indicator agreement

The National Land & Water Resources Audit (the Audit) coordinates the collation of data to support reporting on natural resource condition required under the National NRM Monitoring and Evaluation Framework (National M&E Framework).

The National M&E Framework identifies three requirements for monitoring natural resource condition:

- a set of resource condition indicators to measure progress toward the agreed national outcomes on a medium and long term basis
- a set of indicators for monitoring community and social processes relevant to or affected by NRM programs, as well as measures of the adoption of sustainable development and production techniques
- contextual data pertinent to the indicator being considered.

The Audit Advisory Council has agreed to a process for achieving a practical set of indicators under the National Monitoring and Evaluation Framework.

This process is to:

- obtain on-going **recommendations** from the relevant **National Coordination Committees** for each thematic area (including “Matters for Target”) on appropriate indicators, protocols and information needs
- seek **endorsement** from the **Audit Advisory Council** that the indicators and protocols can be implemented at the national, state / territory and regional levels
- seek **agreement** from the Natural Resource Policies and Programs Committee (**NRPPC**) (or the Marine and Coastal Committee –**MACC**- for Estuarine, Coastal and Marine) that the indicators will be used and promoted by jurisdictions to underpin evaluations of NRM initiatives.

The NRPPC and MACC report to the Natural Resource Management Ministerial Council (NRMMC).

Introduction

This suite of “indicator guidelines” is relevant to the Estuarine, Coastal and Marine Habitat Integrity Matter for Target.

Two indicator headings are identified:

1. Estuarine, coastal and marine habitat extent and distribution
2. Estuarine, coastal and marine habitat condition.

Initially, 31 potential indicators were developed to measure the effect of the stressors on ecosystem condition (physical/chemical and biological) and habitat extent (Scheltinga et al., 2004). These indicators were reviewed at a national workshop (Souter and McKenzie, 2006) and further refined to 19 nationally agreed indicators (Table 1).

Drawing on a series of state/territory trials and national consultations; the documentation for the indicators has been modified from a “protocol” format that sought to define both measurement standards and reporting (information) products to one that presents “guidelines” for the collection and storage of monitoring data.

These “indicator guidelines” should be used as standards for the collection, collation and storage of data in order to assist NRM service providers and community groups make observations that can potentially be pooled and re-used at a later date.

Ten ECM indicators were prioritised and guidelines have been developed through extensive consultation and reviewed by key experts in the field.

Table 1. Nationally agreed ECM Resource Condition Indicators. Indicators prioritised for documentation and included in this document are shown with an asterisk.

Indicator heading	Indicator
Estuarine, coastal and marine habitat extent and distribution	<ol style="list-style-type: none"> 1. Extent and distribution of key habitat types*
Estuarine, coastal and marine habitat condition	<p>Biological condition</p> <ol style="list-style-type: none"> 2. Algal blooms 3. Animal or plant species abundance* 4. Chlorophyll a* 5. Coral bleaching 6. Mass mortality events 7. Pest species (number, density, distribution)* 8. Targeted pathogen counts 9. Vertebrates impacted by human activities <p>Physical/chemical condition</p> <ol style="list-style-type: none"> 10. Dissolved oxygen* 11. Nutrients* 12. pH 13. Presence / extent of litter (marine debris)* 14. Salinity (EC) 15. Sedimentation/erosion rates* 16. Shoreline position 17. Temperature 18. Toxicants (in water / sediments / biota)* 19. Turbidity / water clarity*

Nutrients

Matter for target:

Estuarine, coastal and marine habitat integrity

Indicator heading:

Estuarine, coastal and marine habitat condition

Indicator name:

Nutrient concentrations in the water column and/or sediments

This document presents the recommended monitoring guidelines for collecting, collating and reporting information on nutrient concentrations in the water column and/or sediments for national, state/territory and regional application.

1. Definition

This indicator documents the levels of total nutrients and soluble nutrients in estuarine, coastal or marine waters and/or sediments.

AIM: To determine the median annual concentrations of nutrients under ambient (ie not during major flood inflows) conditions and to compare with local guidelines.

INDICATOR 1: Concentration of oxidised nitrogen.

INDICATOR 2: Concentration of organic nitrogen.

INDICATOR 3: Concentration of ammonia.

INDICATOR 4: Concentration of total nitrogen.

INDICATOR 5: Concentration of filterable reactive phosphorus.

INDICATOR 6: Concentration of total phosphorus.

2. Rationale

Excerpt from OzCoast and OzEstuaries

(http://www.ozcoasts.org.au/indicators/water_column_nutrients.jsp):

[BT]The nutrients nitrogen (N) and phosphorus (P) are elements, and are essential building blocks for plant and animal growth. Nitrogen is an integral component of organic compounds such as amino acids, proteins, DNA and RNA. Phosphorus is found in nucleic acids and certain fats (phospholipids). Chemical and biological processes transfer nitrogen and phosphorus through the lithosphere, atmosphere, hydrosphere and biosphere. This is called nitrogen and phosphorus cycling. Nitrogen-fixing bacteria convert di-nitrogen gas into organic nitrogen species that can enter the hydrological cycle and food webs. Phosphorus is made biologically available through the weathering of rocks.

Excerpt from the guidelines for State of the Environment reporting (Ward et al., 1998):

[BT]Nitrogen is one of the main plant nutrients, and in marine systems it is most often the limiting nutrient – the one whose concentration governs the viability and growth of plant species. This contrasts with freshwater systems where phosphorus is often the limiting nutrient. Abundant and bioavailable nitrogen, combined with other favourable conditions, can lead to eutrophication of waterways – in extreme situations familiar to most Australians is the graphic choking of coastal lagoons, estuaries and other confined marine systems by excessive growth of algae. In less severe circumstances, excess levels of nitrogen cause initially subtle but eventually chronic changes to marine ecosystem structure. Sediments can often serve as a reservoir for nutrients that regularly recharge overlying waters, and thus serve to trigger a perennial cycle of algal blooms. Hence, this indicator should warn of, or identify the potential for, eutrophication and problem algal blooms in marine waterways.

Nutrients exist both as organic and inorganic species, and in dissolved and particulate forms. Total nutrients is the total amount of a nutrient present in all its forms, eg total nitrogen (TN) is the sum of the nitrogen present in all nitrogen-containing components except N₂. Dissolved nutrients occur as dissolved organic and inorganic forms eg total dissolved nitrogen (TDN) is the sum of the dissolved organic nitrogen (DON) (eg proteins, amino acids, urea) and dissolved inorganic nitrogen (DIN) (eg nitrate, nitrite and ammonia). In general, dissolved nutrients are readily available for plant uptake. Determining the amounts of both total and dissolved nutrients present in the water column and/or sediments will give an indication of the amount of bioavailable nutrients present.

Nutrient concentrations within the water column are important as it is from here that nutrients are taken up by phytoplankton which may then form blooms if sufficient nutrients are present. Nutrients in sediments are important in most shallow water ecosystems.

Information on nutrient loads, concentrations and budgets, nutrient transport, and on what causes nutrient loads and concentrations to change can be found at the OzCoast and OzEstuaries website (http://www.ozcoasts.org.au/indicators/water_column_nutrients.jsp) and the National Eutrophication Management Program website (http://www.rivers.gov.au/Our_Research/National_Eutrophication_Management_Program/index.aspx).

3. Monitoring methodology

3.1 Monitoring locations

Samples for dissolved nutrients should be taken from sites within, the mid estuary and, where possible, also from the upper and lower reaches of an estuary. In estuaries where little or no monitoring has been done before, initial samples should ideally be taken along the length of the estuary at intervals of 10% of the total length (but not closer than every 3 km).

When sampling sediment, stratified random sampling is normally used to account for sediment heterogeneity (ie a location composed of several different habitats is deliberately divided up so that each individual habitat is randomly sampled).

3.2 Monitoring frequency required

The monitoring of dissolved nutrients needs to be conducted on a monthly basis. In estuaries with a tidal range of approximately 2 m or more, sampling should be done on the falling tide at approximately half tidal height to reduce the influence of ‘cleaner’ marine waters. In

estuaries with little or no tidal movement or marine areas sampling can be done at any stage of the tidal cycle. Sampling should occur for at least one year. Sediments can be sampled once per year.

Nutrients in rivers and estuaries can rise dramatically following events such as heavy rain and, where resources allow it, monitoring might be expanded to include short term sampling during/after specific events. The resulting data will be valuable to nutrient budgets and calculating nutrient loads but it should be excluded from monitoring data that investigates changes over time or between water bodies.

Excerpts from the guidelines for State of the Environment reporting (Ward et al., 1998):

Temporal scales: Nutrient levels respond to change on a very broad range of scales, from perhaps minutes as a flash flood sweeps sediments and wastes into an urban stream, to seasonal as a result of cycles of planktonic growth and decay, and out to decadal as changes in land use are reflected in coastal ecosystems (mangroves, reefs, seagrass beds etc.). Therefore, surveys need to be conducted at different scales.

With automated nutrient analysers for field measurement just gaining acceptance, it would be strongly advisable to consider the incorporation of this type of instrument, when proven, into the survey design to give continuous monitoring at one of the five estuarine stations (as described in the Survey strategy for indicators 3.17 chlorophyll concentrations and 6.3 turbidity). Short-term nutrient fluctuations — missed with intermittent sampling — would then be observed.

3.3 Data measurement method

At each site, samples are collected, and analysed for (all or some of) total nitrogen, total phosphorus, oxidised nitrogen, organic nitrogen, ammonia and filterable reactive phosphorus.

Excerpt from OzCoast and OzEstuaries

(http://www.ozcoasts.org.au/indicators/water_column_nutrients.jsp):

[BT]Total nitrogen and total phosphorus are determined by analysing unfiltered water samples. Dissolved nutrients pass through a 0.45µm filter and are reported as: soluble reactive phosphorus (SRP) or filterable reactive phosphorus (FRP) in the case of phosphorus; and total dissolved nitrogen (TDN) in the case of nitrogen. TDN can be further analysed for nitrate, nitrite, ammonium and organic nitrogen. The term 'reactive' implies that [the reaction between (some of) the phosphorus containing compounds in the water and the reagents used in the analytical procedure is rapid].

The widely accepted analytical techniques for quantifying nutrients and producing comparable data, are a set of wet chemical processes used in combination with spectrophotometry (also termed colorimetry). The techniques involve blending precise amounts of sample and wet chemicals. A reaction occurs with the 'reactive' nutrient and the solution develops a specific colour. The depth of the colour is proportional to the concentration of the nutrient, and is measured with a spectrophotometer. Total nutrients are measured the same way except the nutrients being quantified are initially converted to a reactive form through a chemical digestion process. There are different techniques and instrumentation for quantifying select nutrients, such as ion chromatography, fluorescence, probes and inductively coupled plasma. When comparing data from less conventional techniques one should always

confirm [that the same form of the nutrient has been quantified in the different methods].

Water column nutrient sampling

Equipment required:

- Boat
- Sample bucket
 - The sample bucket is a 10 L high-density polyethylene (HDPE) plastic bucket with a handle and polypropylene (PP) lid. Each bucket is purchased new so that the history of its use is known. The sample bucket and lid is adequately labelled, “WATER SAMPLE COLLECTION ONLY” to eliminate improper use. If sampling is done with the bucket attached to a rope then do not store the rope in the bucket.
- Sample containers
 - A 250 mL bottle for total nutrients and a 125 mL bottle for filtered nutrients. The bottles are polypropylene (PP) with a high density polyethylene (HDPE) screw on lid. The lids do not contain inserts which are potential sources of contamination.
- Bottle labels
 - Polypropylene 38 mm x 82 mm fade- and acid-resistant labels. A Zebra Technologies Stripe S-500 brand thermal label printer is used to produce the bottle labels.
- Syringe
 - A 60 cc/ml lock tip plastic syringe is used to transfer water from the sample bucket to the 250 mL and 125 mL sample bottles (Wruck and Ferris 1997).
- Glass fibre filter
 - A 0.45 µm filter is used in conjunction with the syringe to deliver filtered water into the 125 mL sample bottle (Wruck and Ferris 1997).
- Glass fibre pre-filter
 - In waters with high suspended solid content a pre-filter is used between the syringe and 0.45 µm filter to improve the filter’s efficiency.
- Ice box
 - All nutrient samples are placed in an ice slurry immediately after collection (Wruck and Ferris 1997).
- Freezer
 - Samples are frozen until ready for analysis by an accredited laboratory.

Site procedures (middle of estuary, from boat):

1. Locate the site using a Global Positioning System.
2. While in a slow forward motion, cut the engine, if safe to do so, to prevent fouling.
3. Ensure bucket and lid have been cleaned prior to survey with water blaster, and at least once per month with 2% DECON 90.
4. Remove the lid from the sample bucket, taking care not to touch the inside of the lid or bucket.
5. Clear any floating matter or surface scum using the underside of the bucket.
6. Invert the bucket and place it under the water surface to approximately 0.2 m depth. Turn the bucket right-side up and fill..
7. Vigorously swirl the water and discard.. Repeat three times and retain the final sample for total and dissolved nutrients measurement.

Total nutrient sample procedure:

1. Swirl the bucket to re-suspend particulate matter.
2. Pour enough sample water in to fill half the 250 mL container (this is the rinse).
3. Replace lid and vigorously shake the container for 5 seconds.
4. Swirl the bucket to re-suspend particulates.
5. Pour sample water directly into the bottle leaving an air space of approximately 3 cm from the top.
6. Screw the lid onto the container as tightly as possible.
7. Place the sample immediately on ice.

Dissolved nutrient sample procedures:

1. Remove a new syringe from its packaging. Without touching the body of the syringe, insert into the bucket of collected sample and withdraw to full extent.
2. Discard and repeat three times.
3. Using the filter packaging as a guide and without touching the body of the filter, screw the filter to the tip of the syringe.
4. For extremely turbid water, screw a pre-filter between the filter and syringe.
5. Empty 20 mL of filtered sample into the 125 mL container. Replace lid and vigorously shake. Discard water.
6. Empty the remaining sample into the container.

7. Screw the lid onto the container as tightly as possible.
8. Place the sample immediately on ice.

NOTE: Container lids must be tightly secured. As the ice cools the bottle, it contracts, potentially drawing in water and contaminating the sample. Samples should be promptly cooled and stored in the dark during the field trip and rapidly frozen as soon as possible on return.

Post sampling:

1. Once all the samples are collected and transported, the nutrient containers are packed into a dedicated freezer holding only nutrient containers.
2. At the end of the month remove all samples in order and transport in ice boxes to an accredited laboratory for analysis.

Potential problems:

- Contamination
 - Tobacco smoke, sweat, suncream, insect repellent and dirt from collector's hands and surrounding work environment
 - Poor cleaning, handling and rinsing techniques of grab buckets, filters, sample containers and syringes
 - Emissions from outboard engines and nearby traffic
 - Dead fauna at or near collection point
 - Collection of sample with surface scums and/or bottom sediments.

Great care needs to be taken when sampling for ammonia as samples are particularly prone to contamination.

- Storage and handling
 - Settling of water in the sample bucket prior to sampling, potentially underestimating nutrient concentrations
 - Thawing of the samples prior to analysis.
- Incorrect labelling of sample containers

Sediment nutrient sampling

Excerpt from OzCoast and OzEstuaries

(http://www.ozcoasts.org.au/indicators/sediment_org_matter.jsp):

[BT]Sediment carbon and nitrogen are best measured by high temperature oxidation methods (eg CHN analyser) (Craft *et al.*, 1991), while total phosphorus content is determined by wet chemical oxidation (Nicholls, 1975). Appropriate standard reference materials should be analysed to check recovery.

Nutrient mass accumulation rates in sediment (nutrient $\text{cm}^{-2} \text{ year}^{-1}$) are probably more indicative of nutrient loads than sediment nutrient concentrations because the latter are subject to dilution effects caused by the co-deposition of mineral sediment (Radke, 2002). Calculation of nutrient mass accumulation rates requires that sedimentation rates and bulk density be determined in addition to carbon and nutrient concentrations.

Excerpt from the Water Quality Sampling Manual (EPA, 1999):

Sediment samples are typically more heterogeneous than water and wastewater samples. Furthermore, with a water body or a wastewater flow, any heterogeneity can usually be detected more readily because the water moves easily and is comparatively more transparent than a mass of deposited sediment. This means special care is needed in removing sediment samples from the stream bed. It also means that a composite sample is more likely to be appropriate than a single sample.

For detailed advice on sediment sampling, refer to AS/NZS 5667.12:1999 'Guidance on the Sampling of Bottom Sediments'.

Where practicable, collect sediment samples in the container to be used for sample transport. As this is often impracticable, your next choice should be a clean, wide-mouthed jar, which you should first wash in clean water from the sampling site; transfer the sample promptly from the sampling jar to the prepared sample container for transport.

If use of a jar is impracticable, use a suitable mechanical device such as a grab, dredge, or corer, washed in waters at the sample site.

Before any samples are taken, the laboratory who will perform the analysis must be contacted and the monitoring methodology discussed.

3.4 Data collation / calculation method

Data for a specific site should be collated over the study period and the median value calculated and compared against the relevant guidelines.

3.5 Data storage and management

Data should be stored by state/territory agencies and by the collectors (if different) of the data. If possible, the public should have access to the data (and report summaries) through a website hosted by state/territory government.

3.6 Data analysis and interpretation

Data from at least one year should be used in the analysis. Median concentrations of nutrients should initially be compared with the relevant guidelines. 'National' default trigger values for total phosphorus (TP), filterable reactive phosphorus (FRP), total nitrogen (TN), total oxidised nitrogen ($\text{NO}_x = \text{NO}_3^- + \text{NO}_2^-$) and ammonia have been listed in the 'Water Quality Guidelines' on a bioregional basis (ANZECC/ARMCANZ, 2000a); these trigger values are superseded in Queensland by the 'Queensland Water Quality Guidelines' (EPA, 2006). Local guidelines (which supersede both national and state/territory ones) may be available for some estuaries.

Excerpts from OzCoast and OzEstuaries

(http://www.ozcoasts.org.au/indicators/water_column_nutrients.jsp):

[BT]Nutrient loads alone cannot dictate whether a waterway will have a nuisance plant problem (ANZECC/ARMCANZ, 2000a). Nutrient impacts on coastal waterways vary as a function of both the loads and bioavailability of the nutrients, and the extent to which hydrodynamic features (eg water volumes, residence times and extent of mixing) and turbidity levels modulate the stimulatory effects of nutrients on plants and algae (ANZECC/ARMCANZ, 2000a; Harris, 2001).

Chlorophyll-a is probably a better 'instantaneous' indicator of trophic status than nutrient concentrations. This is because nutrient concentrations are affected by biological uptake, which in turn are influenced by uptake capabilities, interaction with grazers, temperature, turbulence and turbidity levels (Hinga *et al.*, 1995). Concentrations of N (or P) taken from water column samples can also underestimate nutrient availability in a system because large pools of nutrients can be found in sediment (see sediment nutrients).

The effect of nutrient load on environmental conditions (including chlorophyll a concentrations) of different types of waterways can be examined using the Simple Estuarine Response Model II (SERM II) (<http://www.per.marine.csiro.au/serm2/index.htm>).

Information on the significance of excessive nutrient loads can be found at the OzCoast and OzEstuaries website (http://www.ozcoasts.org.au/indicators/water_column_nutrients.jsp).

The Department of the Environment and Heritage (Australian Government) provides water quality targets online (<http://www.environment.gov.au/water/publications/quality/targets-online/index.php>) for TN, oxides of nitrogen, TP and filterable reactive phosphorus.

3.7 Reliability, validity and quality assurance

Quality assurance and control measures are important to minimise avoidable errors in the data and thus give more confidence in the data collected and conclusions made. Individuals collecting the data must have adequate training in sample collection. Instrument calibration and/or laboratory quality assurance should be regularly examined and recorded.

3.8 Metadata

Metadata documentation should be completed for all datasets (see Appendix A). The metadata statement should be consistent with current ANZLIC standards, which now complies with ISO 19115.

See the following web site for the Metadata Profile:

http://www.osdm.gov.au/ANZLIC_MetadataProfile_v1-1.pdf?ID=303

For the Metadata Guidelines see:

http://www.osdm.gov.au/ANZLIC_MetadataProfileGuidelines_v1-0.pdf?ID=397

4. Reporting / information products

4.1 Audiences

Regional natural resource managers will be the main audience for information on specific estuaries and coastal waters. State and federal managers will be more interested in the collation of information into regional summaries/reports.

4.2 Products

At the smallest reporting level (ie at the site scale) nutrient concentrations are probably most easily represented in tables, graphs or box plots showing the median and 20th and 80th percentiles for the location. Box plots are an easy way to visually compare the data with reference data/guidelines. Once sufficient information on nutrient concentrations is available for a location, it will be possible to produce graphs and annotated tables on the maps showing trends/change and their statistical significance. These trends can then be reported as an estimate of change. The number of times nutrient concentrations exceed appropriate guidelines should be reported.

When reporting at an estuary or larger scale then the number of zones/sites in which annual median nutrient concentrations exceed the relevant guidelines should be reported (see Table 1 for scoring categories).

Table 1. Scoring categories and indicator values for nitrogen or phosphorus as an indicator of estuarine condition.

<i>Condition indicator: nitrogen or phosphorus</i>	
Condition score	Indicator value
Excellent	0% of sites exceed guidelines
Good	1-19% of sites exceed guidelines
Fair	20-50% of sites exceed guidelines
Poor	51-99% of sites exceed guidelines
Very Poor	100% of sites exceed guidelines

4.3 Confidentiality

Data confidentiality is the responsibility of the data custodian.

4.4 Data collation/calculation method

The development of regional summaries/reports for state and national managers will require the collation of local datasets. Scoring categories provided for local scoring (Table 1) can also be used for scoring at a regional level.

4.5 Data analysis, integration and interpretation information

Any national/regional level information products (ie interpreted products) need to be linked to the regional/local information that was used to create it (ie to the relevant state/territory and regional databases/information systems). Any specific methodologies, assumptions, additional data and changes in confidence in the interpreted products need to be stated.

4.6 Data access and storage

National level products should be developed with the needs of the various stakeholders in mind. Data access and storage for national level products should be through a nationally known and recognised web site such as 'OzCoast and OzEstuaries'. Links should then be made to state/territory and regional web sites to access the underlying products/datasets.

4.7 Product definition statement

Each product should have a product definition statement. The product definition statement follows the same general format as the metadata statement referred to in 3.8.

5. Current national activities

There are no national activities related to nutrient monitoring.

6. Future development

More relevant (ie at least state/territory) nutrient guidelines need to be developed.

7. Links to other indicators

Chlorophyll a (indicator)

Nutrients in aquatic environments (matters for targets)

8. Further information

ANZECC/ARMCANZ. 2000a, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality

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Ocean Office, Silver Spring, MD, 36 pp.

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http://www.rivers.gov.au/Our_Research/National_Eutrophication_Management_Program/index.aspx

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Rochford D.J. 1980. *Nutrient status of the oceans around Australia*. Division of Fisheries and Oceanography Report, 1977–1979. CSIRO. pp 9–20.

Ward, T., Butler, E. and Hill, B. 1998. *Environmental indicators for national state of the environment reporting – Estuaries and the sea*. Australia: State of the Environment (Environmental Indicator Reports). 81 pp. Department of the Environment; Canberra. Website: <http://www.environment.gov.au/soe/publications/indicators/pubs/estuaries.pdf>

Waterwatch Australia Steering Committee. 2002. *Waterwatch Australia National Technical Manual. Module 4 – physical and chemical parameters*. Environment Australia, Canberra.

Wruck, D.J. and Ferris, J. 1997. Collection and storage of water samples for nutrient analysis. Workshop on Sampling Nutrients in Aquatic Ecosystems: Collecting Valid and Representative Samples. University of Canberra, 21-22 April 1997.

9. Glossary

Ambient – prevailing (normal or typical) conditions.

Ammonia – A colourless gas (NH₃) which is present in solution in animal waste product and is released during the decay of dead animals and plant material.

Benthic – On the bottom of a body of water or in the bottom sediments.

Eutrophication – The process of enrichment of water with nutrients that increase plant growth and the subsequent depletion of dissolved oxygen; a natural process that can be caused/enhanced by an increase in nutrient loads or decreased flushing rates resulting from human activity.

FRP – Filterable reactive phosphorus; an estimate of phosphate concentrations available for biological uptake.

Grazers – Animals which feed (graze) on small organic particles, plants and algae.

Organic nitrogen – The nitrogen combined in organic molecules such as proteins, urea, amines and amino acids.

Oxidised nitrogen – Oxidised ions of nitrogen (eg nitrate, nitrite); the form in which nitrogen can be used directly by plants.

Temporal – Pertaining to time.

Appendix A: Metadata statement

Monitoring program	The name of the monitoring program
Custodian of data/Contact	The business name and address/contact details of the custodial organisation or responsible party
Summary of program	A brief narrative summary of the program
Geographic extent	The ordinary name(s) of the locations where the data was collected (ie study area)
Indicators monitored	List of all indicators monitored
Method of data collection	Summary of the methods used to collect the data
Past/future sampling	Description of when sampling started, how often it occurred, when it will finish
Quality assurance	Description of the quality control/assurance procedures used
Data access	1) Location: Where and how the data is stored. If it can be accessed remotely (ie from a website) 2) Format in which dataset is stored and available 3) Any restriction or legal prerequisites that may apply to access and use of the data
Other comments	Any other comments
Information source(s)	Where information on the program can be found (eg reports, literature, websites)
Date metadata created	Date when the metadata record was created