Development of Catchment Health – indicators for the drinking water catchments

Sydney, the Illawarra, Blue Mountains, Southern Highlands and Shoalhaven
The NSW Office of Water is a separate entity within the Department of Environment, Climate Change and Water. The Office manages the policy and regulatory frameworks for the State’s surface water and groundwater resources to provide a secure and sustainable water supply for all users. The Office also supports water utilities in the provision of water and sewerage services throughout New South Wales.

**Development of Catchment Health: indicators for the drinking water catchments – Sydney, the Illawarra, Blue Mountains, Southern Highlands and Shoalhaven**

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1. Introduction

The *Sydney Water Catchment Management Act 1998* (the Act) established the Sydney Catchment Authority (SCA) and confers and imposes upon it, amongst other things, certain functions with respect to the protection and management of catchment areas, and for the protection of the environment. Section 42A of the Act specifies that the catchment area is subject to periodic catchment audits by an auditor appointed by the Minister. The catchment audits must assess the state of the catchment area having regard to catchment health indicators approved under Section 42 of the Act, as in force at the time of the assessment.

Previous audits of the drinking water catchments for Sydney, the Illawarra, Blue Mountains, Southern Highlands and Shoalhaven ("the Catchments") were undertaken in 1999 and 2002 by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and in 2003, 2005 and 2007 by the Department of Environment and Climate Change (DECC) and its predecessors (Environment Protection Authority (EPA) and Department of Environment and Conservation (DEC)).

These auditors had no predetermined list of indicators against which to report, and used instead those that they considered most appropriate at the time for the task. A key focus of the 2003 audit undertaken by the EPA/DEC was the development of a set of core indicators that would provide effective information to guide management of the Catchments. These auditors utilised a minimum set of indicators developed to provide a coherent understanding of the condition of the Catchments based on protecting water quality and protecting ecosystem health (DEC 2003). The same indicators were used in the subsequent two audits in 2005 and 2007.

As a result of amendments to the Act which commenced in February 2008, catchment audits are to be undertaken at three yearly intervals and with specific reference to a formal set of catchment health indicators. The amended Act requires that the Minister responsible for the SCA to appoint a public authority or other person to develop and approve catchment health indicators of the catchment health of the catchment area, and to publish the approved catchment health indicators in the *NSW Government Gazette* before 1st January 2009. The Minister appointed the then Department of Water and Energy (DWE) (now the NSW Office of Water NOW) to this task and the NOW has, accordingly, developed, approved and published a list of selected indicators which are likely to be used for the purposes of the next catchment audit.

This Technical Report has been prepared in addition to the then DWE’s notice of the indicators published in the *NSW Government Gazette* (19th December 2008), for the following purposes:

- To describe how the indicators were selected, including a summary of the outcomes of stakeholder consultation;
- To provide a summary of the recommended methods for the collection of data for each indicator; and
- To identify which agencies are likely to be responsible for collecting those data.

2. Definitions

The Catchments cover over 16,000 square kilometres and extends over parts of the hydrologic catchments of the Hawkesbury-Nepean, Shoalhaven and Woronora catchments (Figure 1). In particular, it covers the entire catchment area upstream of Warragamba Dam, including the Coxs,
SCA’s drinking water catchments

Figure 1  SCA’s Area of Operations
Kowmung, Nattai, Wollondilly and Wingecarribee River subcatchments and their tributaries. It also covers the upper Nepean catchment upstream of the Nepean Dam and upstream of the Pheasants Nest and Broughtons Pass Weirs, and the small catchments of the Greaves Creek, Cascade and Woodford Dams in the Blue Mountains. Outside of the Hawkesbury-Nepean Basin, the Catchments include the catchment of the Woronora River upstream of Woronora Dam, and the catchments of the Shoalhaven and Kangaroo Rivers upstream of Tallowa Dam.

The Act (s3) formally defines catchment health as follows:

“catchment health, in relation to the catchment area, means the condition of ecosystems and systems of management (such as sewerage and stormwater systems) in that catchment that protect water quality”.

The ecosystems include both the aquatic and terrestrial ecosystems found within the catchment area.

3. Catchment health indicators and catchment audits

The OECD (2003) states that catchment health indicators are used to inform on key aspects of catchment health. They are physical, chemical, biological or socio-economic measures which provide information about and describe the state of a phenomenon, environment or area, and have a significance extending beyond that directly associated with the measurement value. Data are collected for the attributes that best represent the key elements of complex ecosystems or environmental issues, and are then used to evaluate and report on the state of the environment, the measurement of environmental performance, and progress towards sustainable development.

To date, audits of the catchment have been used to provide information to stakeholders about the state of the catchment over a defined period of time. The Act stipulates that catchment audits must assess the state of the catchment area having regard to the approved set of catchment health indicators in force at the time of the assessment.

Information on the indicators can be used to assess the pressures on and the state of the catchment, and through identifying trends in selected indicators inform about changes in the state of the catchment over time (DECC 2007). This information can then be used to guide land managers and the community to make decisions about the management of the catchment. The Act stipulates that the next catchment audit is to be completed no more than three years after the date of presentation to the Minister of the 2007 audit, that is by 30 November 2010.

4. Methods

4.1 Pressure State response

Previous catchment audits (DEC 2003, 2005; DECC 2007) have been undertaken using the “Pressure-State-Response” (PSR) model. Environmental pressures describe the pressures from human activities exerted upon the environment, including natural resources, whereas environmental conditions relate to the quality of the environment and the quality and quantity of natural resources. Societal responses show the extent to which society responds to environmental concerns, including the mitigation of human-inflicted negative effects, halting or reversing environmental damage caused, and preserving and conserving nature and natural resources (OECD 2003). In doing so, the PSR model highlights cause and effect relationships, provides an easy framework for understanding otherwise complex relationships in an ecosystem, and can be easily adjusted to take account of specific circumstances of features.
Indicators can be developed for each of the three components of the PSR model. Indicators of environmental pressures often show production or consumption patterns, reflecting emission and resource use intensities, and related trends and changes over time. Indicators of environmental conditions (state) provide overviews of the current situation of the environment and its development over time. Finally, societal response indicators show the extent to which society responds to environmental concerns (OECD 2003). Development of the catchment health indicators attempted to include at least some indicators from each of the three components of the PSR model.

4.1.1 Indicator development

DWE’s selection of the catchment health indicators began with a review of relevant literature. This review provided a list of catchment health indicators that are used in similar situations elsewhere within New South Wales, in other Australian states and territories, by the Commonwealth for their environmental reporting requirements, and those used in several countries overseas. These were indicators that could potentially also be used for catchment audits. Included in the listing were indicators used in past catchment audits by DECC (and its predecessor departments) and by CSIRO. It also included the Environmental and Ecologically Sustainable Development (ESD) Indicators currently used by the SCA (SCA 2001) and the Catchment and Environmental Performance Indicators that the SCA is required to report on annually under its Operating Licence (IPART 2006).

The review resulted in indicators that could be summarised along the following themes:

- Inland water, which included indicators of hydrology, water quality, aquatic ecology and groundwater condition;
- Land use and terrestrial biodiversity, which included indicators of changing land use, soil erosion, dryland salinity and native vegetation; and
- Socio-economic and cultural heritage, which included population and settlement patterns, water and energy use, community attitudes, economic attributes, and natural, historic and indigenous heritage.

Consultation is recommended in the CSIRO’s (1998) best practice guidelines for environmental indicator development. Examples where stakeholder input has been sought when developing environmental health indicators are provided by the Commissioner for Environmental Sustainability, Victoria (2005) and the Ministry for the Environment, New Zealand (2008). The former NSW EPA also sought stakeholder input when developing the indicators used in the 2003, 2005 and 2007 catchment audits (DEC, 2003).

Targeted consultation with key NSW and local government stakeholders on proposed indicators provided an opportunity for others to critique the indicators, and provided an opportunity for other agencies which are similarly responsible for the collecting data which can be used to report on the chosen indicators to have input on a matter which may directly affect their operations.

The stakeholders invited to provide input to the process of catchment health indicator development and selection can be found in Appendix A.

Stakeholder organisations were identified on the following bases:

- those which have responded to past catchment audits;
- those which have responsibility for implementing processes which relate either to the condition of ecosystems within the catchment and/or the systems of management (such as sewerage and stormwater systems) in the catchment that protect water quality;
- those with related regulatory responsibilities or interests.

A number of publications (for example Fairweather and Napier, 1998; Hamblin, 1998; Saunders et al., 1998; ANZECC, 2000; OECD, 2003) list criteria that require consideration when developing
environmental health indicators. Stakeholders were requested to consider the following criteria when providing input into the selection process for the catchment health indicators:

- Relevance to the catchment and the formal definition of catchment health under the Act;
- Has an agreed scientifically or socio-economically sound meaning;
- Representative of environmental conditions within the Catchments, pressures on the environment, or society’s responses;
- Measurable;
- Ease of interpretation and ability to show trends over time;
- Responsive to environmental changes and related human activity;
- Assists management decision making and policy development; and
- Aligns with state-wide environmental reporting requirements (for example, State of Environment reporting, NSW Monitoring Evaluation and Reporting Strategy, State Plan reporting) and with SCA’s environmental reporting responsibilities (such as reporting required under its Operating Licence).

A workshop of stakeholders was held in November 2008 to consider the lists of potential catchment health indicators summarised from the literature review.

The basis of the review was to consider potential indicators from a “catchment to tap” basis, that is, consider those indicators that were applicable at a broad catchment scale, and work down to those that may be more specific to the quality of raw water leaving the catchment.

The final list of 18 catchment health indicators determined from this stakeholder consultation was approved by the Director General of DWE and subsequently published in the Gazette on Friday 19th December 2008.

The list as published is presented in Table 1. This gazetted list provides a brief description of the indicators, without any details or descriptions of what data would be required to inform each indicator, and the likely sources from where future auditors may access this information. The recommended means of informing each indicator and sources of data are discussed in the following section of this report.
Table 1 The 18 approved catchment health indicators, arranged by themes

<table>
<thead>
<tr>
<th>Theme</th>
<th>Approved indicator</th>
<th>Type of Indicator</th>
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<tbody>
<tr>
<td>Land Use and Human Settlements</td>
<td>Land Use</td>
<td>Pressure</td>
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<tr>
<td></td>
<td>Sites of Pollution and Potential Contamination</td>
<td>Pressure</td>
</tr>
<tr>
<td></td>
<td>Soil Erosion</td>
<td>State</td>
</tr>
<tr>
<td></td>
<td>Population Settlements and Patterns</td>
<td>Pressure</td>
</tr>
<tr>
<td></td>
<td>Community Attitudes, Aspirations and Engagement</td>
<td>Response</td>
</tr>
<tr>
<td>Biodiversity and Habitats</td>
<td>Macroinvertebrates</td>
<td>State</td>
</tr>
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<td></td>
<td>Fish</td>
<td>State</td>
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<tr>
<td></td>
<td>Riparian Vegetation</td>
<td>State</td>
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<td></td>
<td>Native Vegetation</td>
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<td></td>
<td>Fire</td>
<td>Pressure</td>
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<td></td>
<td>Wetlands</td>
<td>State</td>
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<td></td>
<td>Physical Form</td>
<td>State</td>
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<tr>
<td>Water Availability</td>
<td>Surface Water Flow</td>
<td>Pressure and State</td>
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<td></td>
<td>Environmental Flows</td>
<td>Pressure and Response</td>
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<td></td>
<td>Groundwater Availability</td>
<td>Pressure</td>
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<tr>
<td>Water Quality</td>
<td>Ecosystem and Raw Water Quality</td>
<td>State</td>
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<tr>
<td></td>
<td>Nutrient Load</td>
<td>Pressure</td>
</tr>
<tr>
<td></td>
<td>Cyanobacterial Blooms</td>
<td>State</td>
</tr>
</tbody>
</table>

5. Measurement and data sources

5.1 Theme – Land use and human settlements

The following five indicators are included under this theme.

5.1.1 Land use

Understanding the use of land within the catchment, and the changes in land use that are occurring over time is important in order to gain an understanding of the possible sources of pollution and the potential risks to catchment water quality arising from them.

Land uses previously identified in the catchment (DECC 2007) include abandoned and degraded land, conservation or natural areas, cultivation or intensive agriculture, forestry, grazing or improved pasture, mining, natural water and wetlands, special purpose, transport and utilities, urban and rural residential.

The recommended measure is:

- Type and extent of land use.

Land use data is a pivotal dataset for all types of catchment and water quality analyses. The SCA maintains a dataset that can be used to derive this information.
The recent past audits (DEC 2003, 2005; DECC 2007) used the number and type of development applications (DAs) submitted to the SCA for concurrence as a surrogate measure of short term land use change. However, this did not consider all DAs in the catchment, as not all DAs in the catchments are referred to the SCA by councils. The number, type and spatial distribution of development applications will give an idea of the location of development pressures and changes in land use. These data are available from councils and should be considered when discussing land use and changes in land use.

### 5.1.2 Sites of pollution and potential contamination

Sites of pollution and potential contamination can have a direct impact on catchment water quality through the export of a range of pollutants into surface and ground waters.

This indicator is a modification of that utilised in former audits (DEC 2003, 2005; DECC 2007). The recommended measure for future audits is:

- Sites and areas of potential pollution impact.

Due to the high variability of datasets used in past catchment audits, this indicator is confined to sites holding Environmental Protection Licences under the *Protection of Environment Operations Act 1997*, and sites listed on contaminated site registers in accordance with the *Contaminated Land Management Act 1997*. Other possible or potential diffuse pollution sources will be picked up under the land use indicator.

Data to inform this indicator are available from DECC and from Councils.

### 5.1.3 Soil erosion

Soil erosion can impact on catchment water quality and aquatic ecosystems due to the mobilisation of sediments and associated nutrients from land into water bodies, and by increasing the turbidity of the water body.

The focus of this indicator is on gully erosion, as this is the most prominent form of soil erosion within the Catchments, and is readily observable and measurable. Sheet and rill erosion are less apparent, and have been estimated only in past audits (DECC 2007) using the Revised Universal Soil Loss Equation. The recommended measure for this indicator therefore is:

- Estimates of the total area of the catchment with observed gully erosion.

Gully erosion in the catchment has been comprehensively mapped by the SCA, using a combination of satellite imagery, aerial photography, modelling and field work. This work provides a robust data set and good baseline data for future comparative analysis.

Other sources of data include DECC and the Catchment Management Authorities.

### 5.1.4 Population settlements and patterns

This is an indicator not used in previous catchment audits. The number of people living within the catchment and their distribution patterns across the catchment can have potential implications on water quality, especially in subcatchments where population density is greatest. Increasing populations will only increase pressure on the catchment and its water resources.

The recommended measure for this indicator is:

- Population and distributions across the catchment.

Data to inform this indicator are available from the Australian Bureau of Statistics population censuses, from Councils, and the Department of Planning.
5.1.5 Community attitudes, aspirations and engagement

This is a new indicator that aims to gauge the attitudes of the community living within the Catchments towards maintaining and improving catchment health, and the level of engagement within the community to bring this about. In doing so, it should therefore provide some measure of the community’s ability to provide input into the management of the catchment. Knowledge of how the community can participate in catchment management will assist in setting catchment health objectives and appropriate management actions to achieve them.

Two measures are recommended to inform this indicator:

- The number of community natural resource management organisations within the catchment; and
- The number of landholders engaged in improvement works.

Data for these measures are available from the Catchment Management Authorities (CMAs).

5.2 Theme – biodiversity and habitats

Seven indicators are recommended under the Biodiversity and Habitats theme.

5.2.1 Macroinvertebrates

The measurement of macroinvertebrate community structure and abundance is a widely used technique to determine aquatic ecosystem health and has been used in past catchment audits.

Macroinvertebrates are usually abundant and diverse when water quality is good, but they are sensitive to deteriorating water quality and habitat condition, and to changes in flow regimes. Other factors in their usefulness as aquatic environmental indicators include their ease of collection, a good taxonomic literature is available for their identification, and that they provide an integrated measure of the environmental conditions that have occurred within a water body over a period of time. Actual measured macroinvertebrate assemblages are compared against those expected to be present in an unimpacted system. The greater the difference between observed and expected, the more impacted the system may be.

The recommended measure for this indicator is:

- AusRivAS scores, plus more recent additional data collected for the Sustainable Rivers Audit (as extended to coastal NSW).

The SCA has an annual macroinvertebrate monitoring program, and samples are collected from sites in each sub-catchment. DECC also collects macroinvertebrate data.

5.2.2 Fish

Native fish species are a highly relevant measure of ecosystem health because they interact on many trophic levels and they are also sensitive to many kinds of human disturbance within a catchment area, including barriers, cold water pollution, competition from exotic fish species, harvesting, degraded habitat and poor water quality (DECC 2007). They can be highly mobile and long lived, factors also useful for environmental assessments.

Fish have been used as a catchment health indicator in past catchment audits, and will continue to be used as an indicator in future audits. The recommended measurement for this indicator is:

- Numbers and proportions of native fish and exotic species present within each sampled water body.

Data to inform this indicator is collected by the DPI.
5.2.3 Riparian vegetation

The use of riparian vegetation as an indicator of catchment health is ongoing from previous audits. Riparian zones alongside rivers and streams provide many benefits to aquatic ecosystem health, including the stabilisation of stream banks and a reduction in erosion; providing shelter, food and other habitat benefits to both terrestrial and aquatic animals, and providing some flood mitigation effects. The greater the extent and the better the condition of native riparian vegetation, the better the health of the aquatic systems.

The measure for this indicator is:

- The extent and condition of riparian vegetation within the catchment.

Data for this indicator are collected by the CMAs. The SCA has also developed a vegetation condition index that may inform this indicator.

5.2.4 Native vegetation

Native vegetation has been considered in previous catchment audits. Maintaining native terrestrial vegetation is an important aspect of ensuring a healthy catchment. Native vegetation within a catchment provide major ecosystem services to the natural habitat and to the community, including reducing soil and nutrient loss from the catchment to the waterways, reducing soil and groundwater salinity and acidity, retaining rainfall and reducing the risk of excess runoff and flash flooding, providing habitat to native fauna, maintaining biodiversity, and providing resources such as food and building materials.

The recommended measure to inform the native vegetation indicator in future audits is:

- The area and condition of native vegetation

Data on native vegetation area and condition are available from DECC, the SCA and from CMAs. The SCA’s datasets are mainly limited to Special Areas. Assessment of native vegetation should not be limited to national parks and forestry reserves, but should be inclusive of the entire catchment.

5.2.5 Fire

This is a new indicator recommended for use in future catchment audits. Bushfires can have devastating effects on catchment health, destroying native vegetation, farmland and infrastructure. Areas burnt by bushfires are prone to accelerated soil erosion, resulting in enhanced sediment and nutrient export to the surface water bodies downstream. Removal of vegetation by fire also reduces the ability of catchment areas to retain rainfall and can lead to altered hydrological conditions in streams until the vegetation becomes re-established.

The following measure should be used to report the impacts of fire on catchment health in future audits:

- Area and location burnt by bushfires and hazard reduction burns.

Data on fires within the Catchments are available from DECC, DPI, Councils and the Rural Fire Service.

5.2.6 Wetlands

Wetlands are important ecosystems within catchments, providing important ecosystem services and adding substantially to catchment health. They provide sinks for sediments, nutrients and other pollutants mobilised from within the catchment area; they provide habitats and food for a variety of fauna and flora and connectivity for biodiversity. In addition they store runoff during periods of heavy rainfall and thus providing a measure of flood mitigation. They also enhance recreational and aesthetic values for people living within the catchment.
The locations, types, sizes and condition of wetlands within the Catchments has not been reported in previous catchment audits. The recommended measure for reporting on wetlands in future audits is:

- Size, type, location and condition of wetlands.

Information on wetlands to inform this indicator is available from DECC, SCA and Councils. Data on wetland condition may not be consistently available across the catchment area, but should be recorded for those wetlands where they are available.

5.2.7 Physical form

Physical form is a new indicator for use in future catchment audits. Stream geomorphic complexity is an important measure of stream health, because highly structured habitats contain more native aquatic taxa than simple structured habitats. Physical form also provides a measure of the recovery potential of degraded streams. The established method used to undertake biophysical assessments and measurements in NSW is the River Styles® Framework (Brierley and Fryirs, 2005), with a field manual on determining geomorphic reference reaches also having been published by DWE (Young and Outhet, 2006). The measure for informing this indicator is:

- River Styles Stage 2 (Condition)

Extensive data on the River Styles within the Catchments are available from the CMAs and DWE.

5.3 Theme – water availability

There are three indicators to be used in future catchment audits to describe the availability of water.

5.3.1 Surface water flow

The quantity of water within the streams of the Catchments and the temporal variability of its delivery are fundamental attributes determining the ecosystem health of the rivers and streams of the catchment. Therefore it has been recommended that describing the actual availability of surface water within the catchment would be the most appropriate measure of catchment health in regards to catchment hydrology.

Past audits (e.g. DEC 2003, 2005; DECC 2007) have considered various measurements of pressures on water availability within the catchment, in particular the maximum permissible annual volume of water that can be extracted under water access licences, and the number of farm dams that may intercept runoff before it enters catchment streams. Stakeholders considered that continuation of at least the measure of water that can be extracted was essential, to enable a description of outputs from the catchment. Therefore one new measure to describe surface water availability within the catchment, and one former measure to describe maximum potential water usage are to be used in future audits. These measures are:

- Level and variability of streamflow; and
- Maximum permissible annual volume of surface water that can be extracted under water access licences in each subcatchment.

The SCA operates a network of river gauging stations that measure the level and variability of streamflow. Data on water access licences are available from DWE.

5.3.2 Environmental flows

An indicator describing environmental flows has been used in recent audits (DEC 2003, 2005; DECC 2007), and continued use of this indicator is recommended.

The term “environmental flows” is usually used to describe water released from reservoirs to the downstream river to maintain ecosystem function and mimic natural flow variability, and to describe
water that is protected from extraction by rules and extraction limits. Under its Water Management Licence, the SCA is required to release environmental flows from its storages to the Hawkesbury-Nepean, Shoalhaven and Woronora Rivers.

As well as the main dams and weirs at the downstream ends of the catchment, there are also other barriers to flow within the catchment. In past audits in-stream barriers have been considered as part of the discussion of the Fish indicator. However, the impact of in-stream barriers relates more to the issues surrounding environmental flows. Two measurements therefore inform this indicator:

- Total volume of water by type released from SCA storages.
- Number of dams, weirs and other barriers to flow in the catchment, including the number remediated.

Data for the first measure, the volume of water by type released from SCA storages, are available from the SCA. Further information is available from DPI and DWE.

5.3.3 Groundwater availability

Groundwater is a significant resource in most catchments, for both environmental and anthropogenic use. As well as being extracted for town supply, stock and domestic use, and irrigation and industrial use, groundwater is a major contributor to base flow in rivers and streams in dry periods, and in maintaining wetlands and other groundwater dependant ecosystems. Excessive extraction for human use can decrease the amount of groundwater available for maintaining surface aquatic ecosystems, and can also lead to salinisation of the resource.

Groundwater is an important resource that contributes to the maintenance of catchment health. The recommended measure of groundwater availability for use in catchment audits is:

- Extraction entitlement relative to the sustainable yield (long term average extraction limit) at a Groundwater Management Area or water source scale.

Data to inform this indicator are available from DWE.

5.4 Theme – water quality

Three indicators are included under this theme.

5.4.1 Ecosystem water quality

The presence of high quality water in rivers, streams and reservoirs is a particularly relevant indicator of a healthy catchment. Maintaining good water quality is essential to ensure the health of the natural aquatic ecosystems that occur within the catchment, and to provide high quality water for treatment and supply.

A range of water quality attributes can be measured that will indicate whether human activities within the catchment are impacting on water quality. Ecosystem water quality has been used as a catchment health indicator in past audits (DEC 2003, 2005; DECC 2007) who assessed 12 water quality attributes against the relevant guidelines for the protection of aquatic ecosystems in upland rivers (> 150 metres in altitude) and in reservoirs published jointly by the Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ 2000).

Past audits (DEC 2003, 2005; DECC 2007) assessed catchment water quality data against the default trigger values provided by ANZECC and ARMCANZ (2000) which suggest further investigations are required if exceeded, and are not threshold values indicating unhealthy ecosystem conditions if exceeded. Exceptions were for turbidity, where the auditors used a locally derived guideline, and for total iron, which was based on a Canadian guideline value (DECC 2007). It is recommended that this
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indicator and the means of assessing it be continued in future audits using the same methods as applied previously (DEC 2003, 2005; DECC 2007).

The measurements to inform this catchment health indicator are:

- Turbidity, pH, electrical conductivity (EC), total aluminium, total iron, total nitrogen (TN), total phosphorus (TP), oxidised nitrogen (NO₃), ammoniacal nitrogen (NH₄), filterable reactive phosphorus (FRP), chlorophyll-a and dissolved oxygen (DO), assessed against the ANZECC and ARMCANZ (2000) guidelines.

The SCA collects data on these analytes in catchment streams, storages and at offtakes to water filtration plants as part of its water monitoring program.

5.4.2 Nutrient load

Eutrophication of rivers and reservoirs generally enhances algal and aquatic macrophyte growth, which in turn can result in a reduction in water quality and the health of the aquatic ecosystem. The increased algal and plant growth leads to increased organic material which in turn increases biological oxygen demand and reduction in dissolved oxygen concentrations, and the subsequent mobilisation of metals and other noxious gases and chemicals. Increased algal and plant growth, plus the changes that they cause to the water quality, can have considerable adverse impacts on the other flora and fauna sharing the aquatic ecosystem.

Nutrient inputs arise from both diffuse sources and point sources within the catchment. Diffuse nutrient inputs originate from the broader area of the catchment, and include natural inputs from the geology and soils of the catchment, as well as inputs delivered by runoff from agricultural and urban land. Poor land use and urbanisation can lead to enhanced nutrient loads from these areas. Point sources originate in particular at locations where effluent from sewage treatment plants and industry is discharged into surface waters.

Nutrient load is a measure of the quantity of a various nutrient, usually phosphorus or nitrogen, that has entered a water body over a particular unit of time, and has been an indicator used in past audits (DEC 2003, 2005; DECC 2007). Both diffuse source and point source nutrient loads have been considered in these audits. While point source loads are reasonably easy to measure, input from diffuse sources are much more difficult to determine empirically, requiring detailed monitoring of both flow and nutrient concentrations at a number of locations around the catchment over time.

Because of the difficulties of using empirical measures, past audits have used modelling to estimate nutrient loads from diffuse areas using assumed export rates per hectare for various types of land use, and the total area of that land use per subcatchment. The models can also be calibrated to flow and water quality data. However now that the diffuse nutrient loads from these subcatchments have been modelled previously, further modelling is unlikely to provide much new additional information, unless land use or climatic conditions change markedly. Such land use changes would be noted under the Land Use indicator, above. Further, the use of assumptions not reflective of local conditions or management practices will only reflect major land use changes and not the critical changes in management practices which are the primary focus of catchment interventions.

The measure to inform this nutrient load indicator is:

- Level of compliance of sites of point source nutrient input with Environment Protection Licences and/or Pollution Reduction Programs during the audit period.

Data can be obtained from DECC, and Councils may also have data.
5.4.3 Cyanobacterial blooms

Cyanobacterial blooms may have water quality and environmental impacts when they occur in reservoirs and slow-moving or ponded sections of rivers. This is because a number of cyanobacterial species can produce potent toxins that can pose a threat to water users unless the water is appropriately treated.

In the context of catchment health, recreational guidelines are used rather than drinking water guidelines to assess cyanobacterial bloom occurrence within the Catchments. Therefore the recommended indicator is:

- Compliance with the NHMRC (2008) recreational water quality guidelines for cyanobacteria in freshwater.

Data on cyanobacterial presence in rivers and reservoirs across the catchment are available from the SCA, DWE and from Councils.

6. Conclusions

Selection of catchment health indicators for the next catchment audit took place following an extensive review of potential indicators used in State of the Environment reporting elsewhere in New South Wales, interstate and to a limited extent overseas. Stakeholders were then consulted and the lists of potential indicators reduced to those considered most relevant to the Catchments and for which data would be readily available to inform the audit.

The outcome was that 18 catchment health indicators were selected for use in the next catchment audit, some of which have been used before in previous catchment audits, some of which are modifications of previous indicators, and some of which are new. These 18 indicators were approved by the Director General of DWE and published in the *NSW Government Gazette* on Friday 19th December 2008.

Nine of the recommended indicators describe the state of the catchment, these being the indicators for soil erosion, macroinvertebrates, fish, riparian vegetation, native vegetation, wetlands, physical form, ecosystem and raw water quality, and cyanobacterial blooms. Six indicators – land use, sites of pollution and potential contamination, population settlements and patterns, fire, groundwater availability and nutrient loads – describe various pressures on the catchment; while the indicator of community attitudes, aspirations and engagement is an indicator of societal response. The surface water flows indicator has two components, one that describes a pressure on river health and the other the hydrological state of catchment streams; while the environmental flows indicator has one component that is a response indicator and a second that describes a pressure on river health.
7. References


National Health and Medical Research Council (2008) *Guidelines for Managing Risks in Recreational Water*. (NHMRC, Canberra)

Appendix A

The following stakeholders, including 15 local councils whose areas wholly or partially fall inside the catchment, were invited to contribute to the catchment health indicator process:

1. Department of Environment and Climate Change
2. Department of Health
3. Department of Planning
4. Department of Primary Industries
5. Hawkesbury-Nepean Catchment Management Authority
6. Independent Pricing and Regulatory Tribunal of NSW
7. Southern Rivers Catchment Management Authority
8. Sydney Catchment Authority
9. Sydney Water Corporation
10. Blue Mountains Council
11. Campbelltown Council
12. Cooma-Monaro Shire Council
13. Eurobodalla Council
14. Goulburn Mulwaree Council
15. Kiama Council
16. Lithgow Council
17. Oberon Council
18. Palerang Council
19. Shoalhaven Council
20. Sutherland Council
21. Upper Lachlan Council
22. Wingecarribee Council
23. Wollondilly Council
24. Wollongong Council