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Lower Hawkesbury-Nepean River nutrient management strategy

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Foreword

It is my pleasure to present this Strategy for managing nutrients in the Lower Hawkesbury-Nepean River, prepared by the NSW Department of Environment, Climate Change and Water, with contributions from a range of stakeholders, including local councils, NSW Government agencies, conservation groups and members of the public.

The *Lower Hawkesbury-Nepean River Nutrient Management Strategy* aims to tackle nutrients in one of Sydney's most important environmental assets. The Hawkesbury-Nepean river system not only supplies drinking water but is also critical to the continued supply of agricultural and fisheries produce. It is also an important ecological asset, adjoining the World Heritage-listed Blue Mountains, and is enjoyed by many recreational users and tourists.

Healthy waterways help make our cities and regional centres attractive places to live but algal blooms and excessive aquatic weed growth in the river have hampered its recreational and commercial use and affected aquatic life. The Strategy strives to address these and other nutrient management issues by setting out actions that will be taken to improve the river's health by building on the important work to date.

By adopting this Strategy, we are confident that we can significantly reduce nutrient loads from a range of sources in the catchment including urban stormwater, agriculture, sewage systems and degraded land. However it will take a coordinated effort from a range of stakeholders and the NSW Government will continue its commitment to building strong partnerships to ensure the actions of the Strategy are achieved.

I thank all those involved in contributing both to the report and to the programs that protect this important waterway and its catchment.

Frank Sartor
Minister for Climate Change and the Environment

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Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CAP	Catchment Action Plan
CMA	Catchment Management Authority
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change and Water
DLG	Department of Local Government
DoP	Department of Planning
DSWP Strategy	Diffuse Source Water Pollution Strategy
EP&A Act	*Environmental Planning and Assessment Act 1979*
GCC	Growth Centres Commission
HNCMA	Hawkesbury-Nepean Catchment Management Authority
HRC	Healthy Rivers Commission
I&I NSW	Industry and Investment NSW
MACROC	Macarthur Regional Organisation of Councils
MER	Monitoring, evaluation and reporting
OHN	Office of the Hawkesbury-Nepean
POEO Act	*Protection of the Environment Operations Act 1997*
SCA	Sydney Catchment Authority
STP	Sewage treatment plant
SWC	Sydney Water Corporation
WSROC	Western Sydney Regional Organisation of Councils
WSUD	Water sensitive urban design

Executive summary

Need for a nutrient management strategy for the lower Hawkesbury-Nepean

The demands on the Hawkesbury-Nepean River to supply water to Sydney and its farmlands, and the pressures from land-use change for urban development, mean there are significant stresses on the lower Hawkesbury-Nepean River, downstream of Sydney's major dams. Elevated nutrient levels and reduced river flows are the two major factors contributing to algal blooms and excessive aquatic weed growth, which hamper recreation and commercial uses of the river and affect aquatic life.

While long-term environmental monitoring data indicates some improvements in water quality, these are improvements from what has been very poor water quality in a number of areas. There is still significant improvement required; aquatic weeds have become more abundant in recent years, and there is a continuing history of algal blooms in the river.

A range of programs and initiatives have been in place to reduce and manage elevated nutrient loads, and a number of these have been very successful. However, to date there has not been an integrated catchment-wide framework to prioritise and coordinate action across different nutrient sources as well as involve the key state and local government bodies, industry and community stakeholders.

Strategy objectives

This Strategy has been developed to help address these challenges by providing a clear direction and overarching framework for current and future nutrient management initiatives, aimed at reducing nutrient loads from existing sources and limiting the growth in nutrient loads from changing land uses.

Scope and context

The Strategy is one component of a package of initiatives underway to improve the health of the Hawkesbury-Nepean River, including the implementation of environmental flows from dams and major weirs and the development and implementation of a water sharing plan to manage river extractions and protect environmental flows.

The Strategy has been identified as an action in the 2006 Metropolitan Water Plan (NSW Government 2006) and its delivery will be assisted by the Australian Government's $77.4 million funding of the *Hawkesbury-Nepean River Recovery Project*.

The scope of the Strategy does not extend above the major water storages as the Sydney Catchment Authority already administers a significant strategic framework to manage water quality in the drinking water catchments.

Priority nutrient sources

Priority nutrient sources have been identified through consultation with stakeholders and recent studies and data on river health, including environmental monitoring data and land-use mapping data. The Strategy targets both diffuse sources, such as urban and agricultural runoff, and point sources, such as sewage treatment plant discharges.

- **Diffuse sources** overall contribute the majority of the nutrient load to the river, particularly during large storm events. Urban land uses, grazing and intensive horticulture have been estimated to represent over two-thirds of the diffuse source nutrient load. On-site sewage systems and degraded land and riparian vegetation have also been identified as important contributors to diffuse nutrient loads. The sub-catchments of South Nepean, South Creek and the Colo River contribute the highest diffuse nutrient loads.
- **Point sources** contribute most of the load during dry weather conditions as they tend to deliver a constant discharge to the river. Sewage treatment plant nutrient loads have been significantly reduced over the past 10 to 15 years through substantial investment. Upgrades of treatment plants, work to address sewage overflows, along with substantial wastewater recycling schemes currently underway are anticipated to reduce nutrient loads further in the coming years.

Nutrient management actions

This Strategy highlights the many initiatives that are already underway to reduce nutrient loads in the lower Hawkesbury-Nepean catchment including educational and compliance activities, extension programs, investment in capital projects, on-ground works, and partnership programs.

It also identifies **strategic priorities** and **new actions** that will build on the work to date and reduce nutrient loads from identified priority sources, including:

- urban stormwater
- agricultural practices
- on-site sewage management systems
- sewage treatment systems
- degraded land and riparian vegetation.

Significant actions proposed under the Hawkesbury-Nepean River Recovery Project are a key component of this Strategy, with estimated nutrient load reductions of at least 48.5 tonnes per year. Other actions include development of tools to assist in decision-making about nutrient management activities, and a review of licensing arrangements for sewage treatment systems that discharge into the lower Hawkesbury-Nepean.

To ensure that actions are implemented and the strategy remains relevant, responsibilities and agreed timeframes have been incorporated into specific actions. A monitoring, reporting and review process has also been developed that includes reporting on progress towards achieving the Strategy's objectives and will allow the Strategy to be updated over time to reflect emerging issues. Most importantly, improved collaboration and coordination is proposed to build on the significant effort that is already being invested by stakeholders that have a role in nutrient management in the lower Hawkesbury-Nepean, and the new Office of the Hawkesbury-Nepean will have an important role in this area.

1. Introduction

1.1 Need for nutrient management in the lower Hawkesbury-Nepean

The Hawkesbury-Nepean River and its catchment provide drinking water, recreational opportunities, agricultural and fisheries produce, as well as tourism and mining resources for the Sydney Metropolitan area. It is also an important ecological asset adjoining the World Heritage-listed Blue Mountains.

The demand for water and the increased pressure from land-use change mean that there are significant stresses on the river downstream of Sydney's major dams. There are a number of factors contributing to the current health of this part of the river, the lower Hawkesbury-Nepean, but reduced river flows and elevated nutrient levels are the two major drivers.

The impact of increased levels of nutrients – predominantly nitrogen and phosphorus – is most evident in the excessive growth of algae and aquatic weeds which can severely constrain recreation and commercial uses of the river, and affect aquatic life. Long-term environmental monitoring data (DECC 2009a) indicates that:

- Generally water quality in the Hawkesbury-Nepean has improved significantly from very poor water quality evident in the 1980s–90s, but there is still considerable improvement needed to meet water quality objectives.
- Nutrient levels are often high. As a result of considerable investment in upgrades of sewage treatment plants the phosphorus levels have markedly improved throughout most of the river system, although levels remain elevated at some sites. Nitrogen levels have also improved at many sites, but at some sites nitrogen levels appear to be increasing.
- Algal blooms have been common in the past, making the river at times unsuitable for swimming, water skiing, boating and irrigation. Chlorophyll-a levels (an indicator of algae) have mostly declined but blue-green algal counts have largely remained stable. Toxic blue-green algae are being replaced by non-toxic species in the river, although the exact reasons for this shift are not clear.
- Aquatic weeds occur extensively throughout the river system and have become more abundant, particularly *Egeria densa* in the reach around Richmond and Windsor. Aquatic weeds have been known to interfere with recreation and navigation, damage irrigation pumps and boat motors, and hamper trawling operations.

Nutrients are naturally present in the soil and waterways of the lower Hawkesbury-Nepean, however elevated loads of nutrients can enter the river through diffuse sources such as agricultural runoff and urban stormwater, and point source discharges from sewage treatment plants. To date, nutrients have been reduced and managed through a range of programs and initiatives however much of the river remains stressed. Unless well managed, nutrient sources could continue and intensify in the future, with potential increases associated with population growth and further urbanisation within the catchment.

1.2 Objectives and purpose of the Strategy

The objectives of the Strategy are to:

- reduce nutrient loads from existing sources
- limit the growth in nutrient loads from changing land uses.

In this way, the Strategy will contribute to meeting the Government's objective to manage nutrient inputs so that agreed environmental values, such as water quality suitable for aquatic ecosystems and recreation, can be achieved over time. Water quality objectives were established for the catchment through the Healthy Rivers Commission process in the late 1990s and the subsequent Statement of Joint Intent by NSW Government agencies and local councils as discussed further in Appendix 1.

The Strategy's purpose is to:

- provide a clear direction and overarching framework for current and future initiatives to improve management of nutrients from both point and diffuse sources
- increase awareness of existing initiatives and opportunities for local councils and State Government agencies to work collaboratively with community and industry stakeholders
- provide strategic guidance for stakeholders with a role in nutrient management by identifying priority nutrient sources, and opportunities for improvement and actions that complement and integrate with existing programs
- encourage natural resource managers to consider nutrient management objectives and priorities in strategic planning and investment decisions
- improve coordination of nutrient management in the catchment
- provide support and guidance to decision-makers and grant applicants seeking funding for initiatives that can improve nutrient management.

1.3 Scope of the Strategy

The geographical scope of the Strategy is shown in Map 1 and focuses on the Hawkesbury-Nepean River, its tributaries and sub-catchments downstream of Sydney's major dams, to the estuary. It includes the local government areas of Wollondilly, Camden, Campbelltown, Penrith, Blacktown, Hawkesbury, Baulkham Hills, Hornsby and in part, Liverpool, Fairfield, Blue Mountains, Lithgow, Cessnock, Gosford, Ku-ring-gai, Pittwater, Singleton and Warringah. The Strategy does not cover the operational areas of the Sydney Catchment Authority as it administers a significant program to manage water quality in the drinking water catchments.

The Strategy addresses nutrient loads from both point and diffuse sources and provides a mechanism to prioritise nutrient reductions across all sources. River flows, which also influence in-stream nutrient levels and growth of algae and aquatic weeds, are being addressed by other plans and actions such as the 2006 Metropolitan Water Plan (NSW Government 2006). This Strategy focuses on nutrient inputs to surface waters, but impacts on groundwater can be considered in future updates if needed.

There are a number of pollutants that have an impact on the health of the Hawkesbury-Nepean, including pathogens. The focus of this Strategy is on nutrient management. Information on other pollutants is available from a number of sources including the final technical report of the Hawkesbury-Nepean River Environmental Monitoring Program and the Sydney Water Environmental Indicators Monitoring Program, which is available at www.sydneywater.com.au/Publications/Reports/SewerageTreatmentSystemImpactMonitoringProgram_2008-2011.pdf

Map 1: Area covered by the Strategy – lower Hawkesbury-Nepean catchment

1.4 Context of the Strategy

The Strategy builds on the extensive work that has already been undertaken to improve the health of the Hawkesbury-Nepean River and integrates with the range of existing plans and strategies at local, State and Federal levels as summarised in Appendix 2. The Strategy will contribute towards meeting the natural resource management targets identified in the **NSW State Plan** by improving riverine and estuarine ecosystems. In addition, the state-wide ***NSW Diffuse Source Water Pollution Strategy*** identifies this Strategy as a specific approach being undertaken to address diffuse source nutrient pollution in the lower Hawkesbury-Nepean (DECC 2009b).

The Strategy fulfils the commitment made in the NSW Government's ***2006 Metropolitan Water Plan*** to develop a strategy for managing nutrient inputs to the lower Hawkesbury-Nepean River from wastewater, stormwater and agricultural runoff (NSW Government 2006). The Strategy is one component of a number of initiatives underway to improve the health of the Hawkesbury-Nepean River, including the implementation of new environmental flow regimes, the development of a water sharing plan to manage river extractions and protect environmental flows, and a commitment to increase the total volume of recycled water in Sydney to 70 billion litres per year by 2015. Reducing nutrients entering waterways is identified as a need in the ***Hawkesbury-Nepean Catchment Action Plan*** and ***River Health Strategy***, which provide a catchment-wide approach for Hawkesbury-Nepean Catchment Management Authority (HNCMA) actions to improve river health.

The Australian Government's funding of $77.4 million under the Water Smart Australia Program to implement the ***Hawkesbury-Nepean River Recovery Project*** will assist the delivery of the Strategy. A package of projects will be implemented over the next three years to improve river health below the major water supply dams by increasing the water available for environmental flows and by reducing nutrient loads to the river. Significant new actions to manage nutrients form a key component of the Strategy and will help address the nutrient management priorities, as detailed further in Section 3. It has been estimated that implementation of this project will prevent at least 48.5 tonnes per year of nutrients entering the lower Hawkesbury-Nepean River system.

1.5 Consultation and development of the Strategy

This Strategy was developed by DECCW with the assistance of an interagency working group that included the Office of the Hawkesbury Nepean, Sydney Water, Industry and Investment NSW and the Hawkesbury-Nepean Catchment Management Authority.

A Discussion Paper which provided background information on the nutrient management challenges in the catchment was provided to stakeholders and a series of workshops held to seek feedback on existing nutrient management initiatives and identify gaps that may be able to be filled from existing resources or with support. A draft Strategy was then released for comment and finalised using feedback from stakeholders.

2. Priority nutrient sources in the lower Hawkesbury-Nepean catchment

2.1 Identification of priority nutrient sources

The following nutrient sources have been identified as a priority for nutrient reduction in the lower Hawkesbury-Nepean catchment by considering the outcomes of consultation with stakeholders and recent studies and data on river health:

- **Priority diffuse sources of nutrients:**
  - urban stormwater
  - agricultural practices
  - on-site sewage management systems
  - degraded land and riparian vegetation
- **Priority point sources of nutrients:**
  - sewage treatment plants
  - sewage overflows

The Strategy focuses on current priorities and does not seek to address every potential source of nutrients. It is recognised that there are a range of other nutrient sources. Some of these have programs in place to manage them: for example, pump-out facilities are provided for recreational vessels and regulations are in place to avoid discharges from commercial vessels.

Nutrient loads from point sources (such as sewage treatment plants) are generally monitored and their predicted impacts have been assessed and documented at various times when upgrades that require planning approval are carried out. The most recent example of this is the assessment carried out for the Western Sydney Replacement Flows Project (SWC 2006).

Nutrient loads from diffuse sources are not as readily understood or quantified as those from point sources. As a first step DECCW has conducted an assessment to provide an understanding of contemporary 'broad-scale' diffuse nutrient load patterns. This assessment, detailed further in Section 2.3.1 and Appendix 4, helped inform the setting of strategic directions and priorities for the Strategy.

Participants in consultation workshops for the development of this Strategy verified the proposed nutrient source priorities. Priority nutrient sources were also consistently identified by participants at a previous Hawkesbury-Nepean workshop for the state-wide Diffuse Source Water Pollution Strategy.

2.2 Factors affecting the importance of nutrient sources

A range of factors has been considered in determining the relative importance of nutrient sources in the lower Hawkesbury-Nepean, based on recent scientific information (Davis & Koop 2006), as detailed further in Appendix 3:

- **Diffuse and point sources:** The relative importance is complex but is related to timing, size and location of nutrient inputs as well as river flow conditions.
- **Nitrogen and phosphorus:** Both nitrogen and phosphorus, rather than just one nutrient, need to be considered when developing nutrient management strategies.
- **Bioavailability:** Nutrients from human activities tend to be in forms that are more readily 'bioavailable' than nutrients from bushland or natural areas.

- **River flows and residence time:** The location, scale and type of response to nutrients is influenced by river flows and residence time.
- **River sediments:** Nutrients accumulated in river sediments are also a potential influence on the health of the river, although their significance is not well understood at this time.
- **Climate change:** The consequences of climate change on nutrient levels will depend on what range of hydrological change is realised as well as the influence of water infrastructure management.
- **Management opportunities:** The effectiveness and ability to implement various management measures to reduce nutrients depends on environmental conditions as well as a range of social and economic factors.

Nitrogen and phosphorus loads from human activities, particularly diffuse sources, are priorities for the focus of efforts to reduce nutrient loads to the river. The Strategy also prioritises nutrient sources that produce large loads and/or generate high amounts of nutrients, as well as nutrient sources located close to waterways. Sub-catchment locations of nutrient sources have been prioritised taking into account the cumulative effect of upstream impacts. An adaptive approach will be applied to account for uncertainties and climate change.

2.3 Priority diffuse sources of nutrients

2.3.1 Overview of contributions of various diffuse source nutrients

Diffuse sources contribute the majority of the total nutrient load to the lower Hawkesbury-Nepean River, particularly during large storm events. Studies have estimated that diffuse sources contributed approximately 70–80% of the total nitrogen and total phosphorus loads in the urbanised catchment of the Hawkesbury-Nepean (Davis *et al.* 1998). An overview of the results of a 'broad-scale' assessment of land uses and sub-catchment locations contributing diffuse sources of nutrients is outlined below.

The assessment undertaken for the Strategy compiled the latest comprehensive land-use mapping for the lower Hawkesbury-Nepean catchment and assigned 'typical' rates of nutrient exports to derive a rapid estimate of the potential nutrient load contribution for the following major land-use categories (area shown in brackets):

- **grazing** (136,000 ha) – livestock grazing of modified pastures and natural vegetation, such as cattle, sheep, horses and alpacas
- **intensive horticulture** (7100 ha) – intensive cropping practices such as flower, vegetable and fruit tree market gardens
- **urban environment** (50,000 ha) – urban built environment such as houses, parks, roads, car parks, utilities, commercial and industrial facilities
- **rural residential** (44,000 ha) – rural residential and associated uses such as small acre farms
- **other diffuse sources** (40,000 ha) – including mining, waste treatment and disposal and a range of facilities
- **intensive animal production** (6400 ha) – farms with high intensity animal practices such as poultry, dairy and piggeries
- **non-intensive agriculture/cropping** (5500 ha) – non-intensive agriculture and cropping such as turf, silage and hay production.

Appendix 4 provides further detail on the assessment methodology, including the limitations associated with estimating nutrient loads from diffuse sources. Land-use mapping is currently limited and does not cover the full extent of the Hawkesbury-Nepean catchment. There are also differences between the reported land uses in some studies due to the different methodologies used when studies have been carried out for different purposes. The nutrient export rates used to calculate nutrient loads from various land uses represent an 'estimate' of long-term average conditions. Actual nutrient loads exported from the land to waterways vary between different properties, management practices and catchment locations due to factors such as the distance to a receiving water body, soil types, climatic conditions, intensity of land use, and mitigation measures. DECCW is working to update the nutrient export rates used in this assessment. The information provided below gives a broad-scale overview of the nutrient loads associated with various land uses and sub-catchments for comparative purposes. Further detailed modelling and monitoring exercises may need to be considered for local decision-making.

Figure 1 provides the estimated percentage contribution to total nitrogen and phosphorus diffuse source loads from major land-use categories. As can be seen, urban land uses, grazing and intensive horticulture are estimated to represent over two-thirds of the diffuse source nutrient load. These results are discussed further in sections 0 to 0.

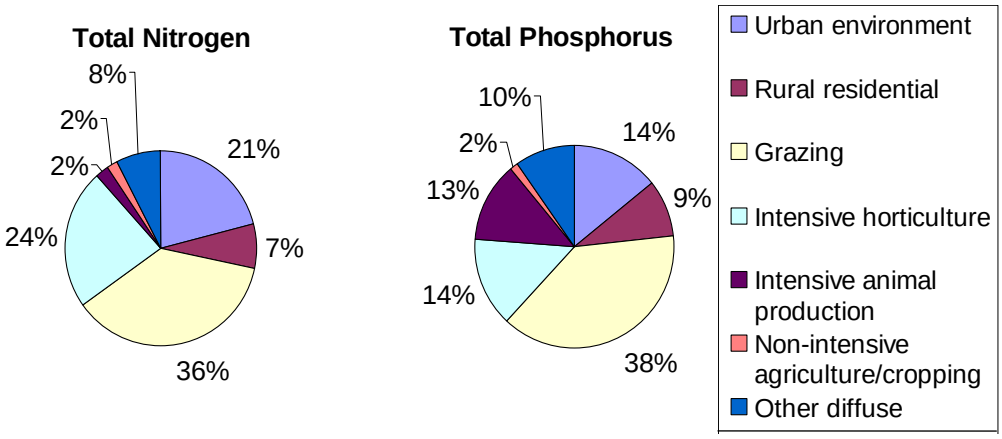
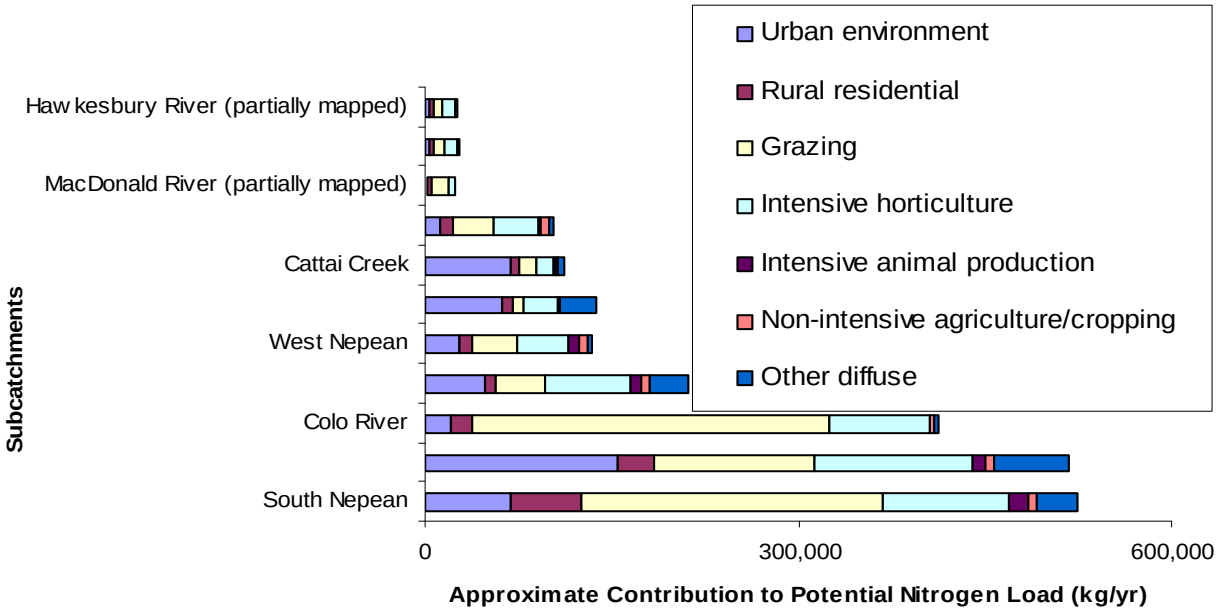


Figure 1: Estimated percentage contribution to total nitrogen and phosphorus loads from diffuse, human sources in the lower Hawkesbury-Nepean catchment

Note on accuracy: Figures based on broad-scale assessment of 'potential' nutrient loads – site-specific management practices and environmental conditions will determine the actual load exported to waterways. Land-use areas are based on available DECCW comprehensive land-use mapping.

Diffuse sources of nutrients are distributed widely across the lower Hawkesbury-Nepean catchment. Figure 2 presents a sub-catchment breakdown of estimated annual total nitrogen and total phosphorus export loads associated with the major land-use categories. As can be seen, the sub-catchments of South Nepean, South Creek and the Colo River are estimated to contribute the highest diffuse nutrient loads.



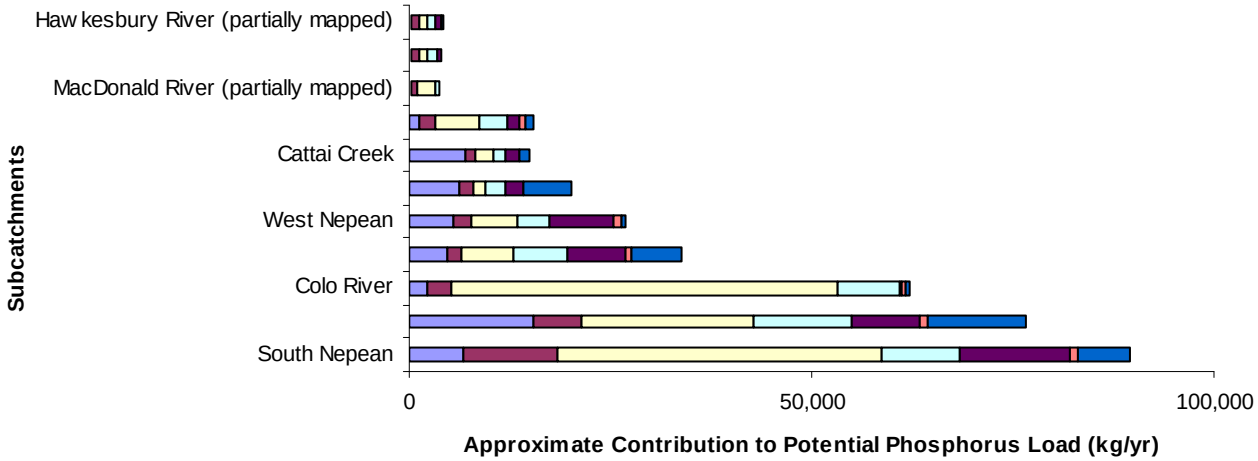
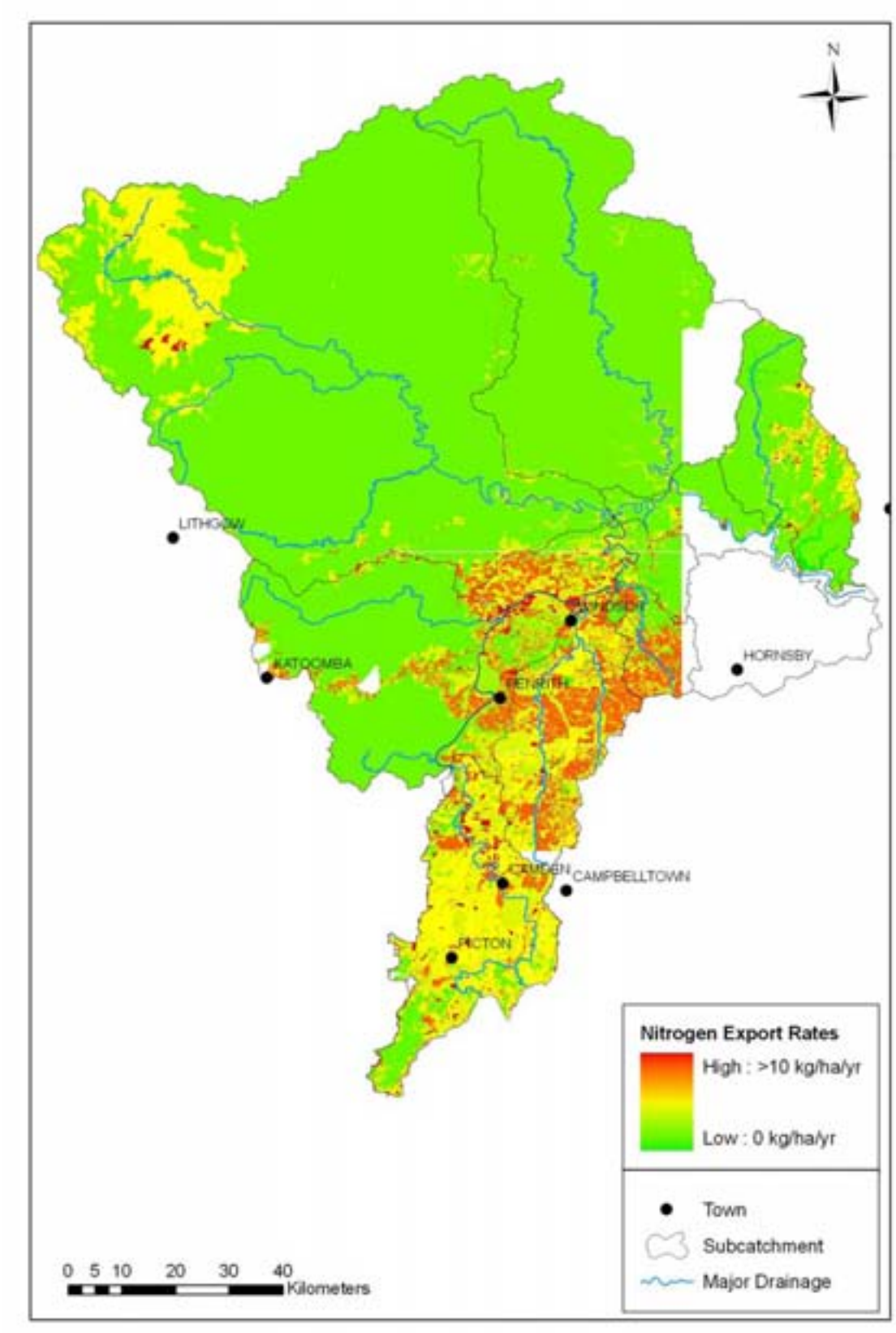


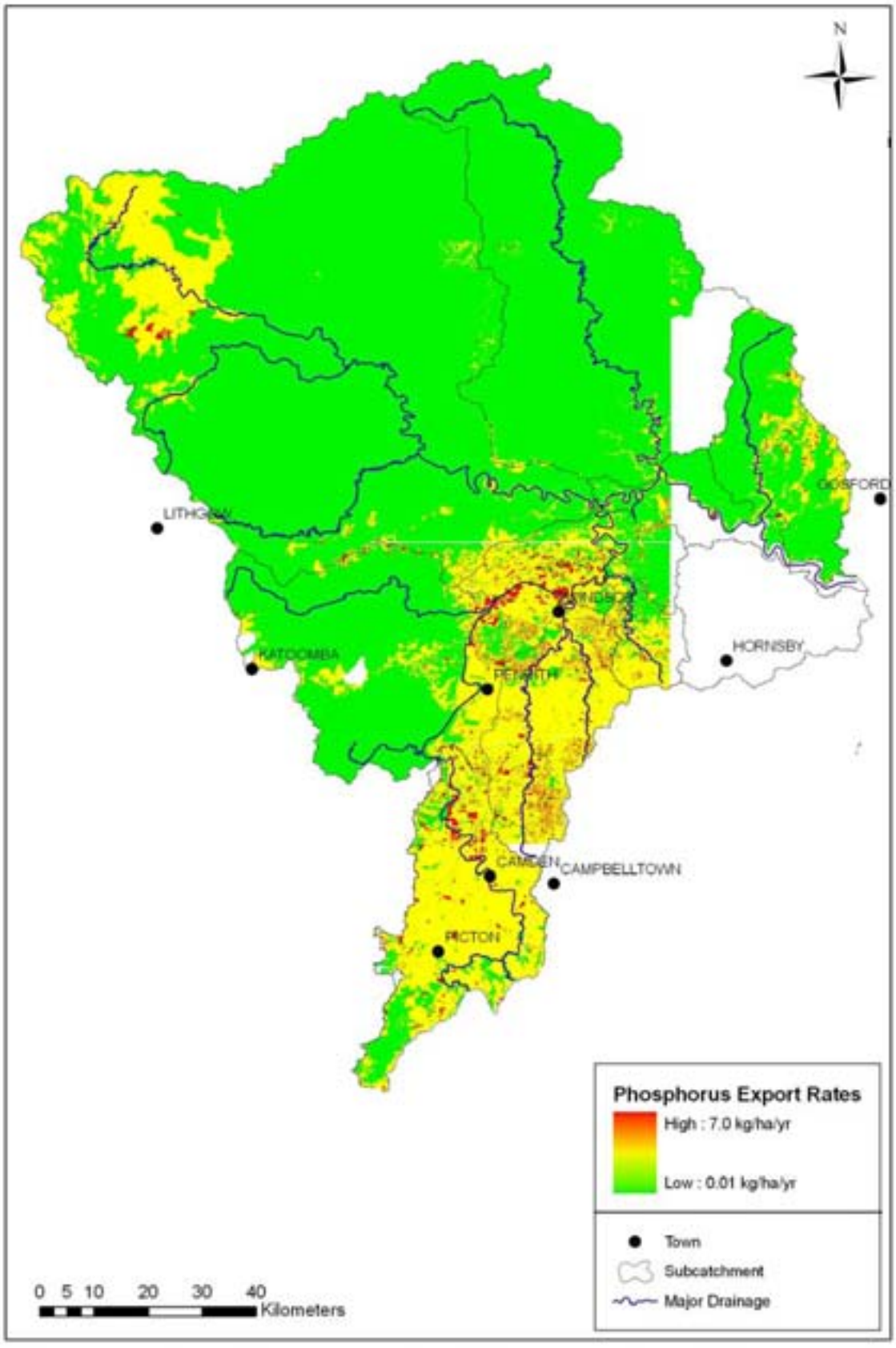
Figure 2: Estimated nitrogen and phosphorus loads from human activities in all sub-catchments of the lower Hawkesbury-Nepean

Note on accuracy: Figures based on broad-scale assessment of 'potential' nutrient loads – site-specific management practices and environmental conditions will determine the actual load exported to waterways. Land-use areas are based on available DECCW comprehensive land-use mapping.

Locations of higher estimated nutrient contribution are shown spatially in Map 2 and Map 3. As shown, higher nutrient-generating land uses are located along the river from the sub-catchments of South Nepean to Hawkesbury and including South Creek and Cattai Creek. Most of the areas of low nutrient generation to the north and west of the catchment are bushland areas such as national parks, wetlands and water bodies, as well as a relatively small proportion of managed forests. These nutrient loads are not included in the land-use figures as they represent essentially natural sources of nutrients which tend to be less bioavailable. However processes such as erosion from access roads can add to nutrient loads.



Map 2: Estimated annual nitrogen export from diffuse, human sources in the lower Hawkesbury-Nepean catchment



Map 3: Estimated annual phosphorus export from diffuse, human sources in the lower Hawkesbury-Nepean catchment

2.3.2 Urban stormwater

Almost one million people currently live in the Hawkesbury-Nepean catchment, with most in the lower catchment, and the population is expected to increase significantly in the future (HNCMA 2008). As shown in Figure 2, stormwater runoff from the urban environment is estimated to contribute around 14% and 21% of the diffuse source nutrient loads from phosphorus and nitrogen respectively, from human activities in the lower Hawkesbury-Nepean. An additional and important nutrient contribution occurs during land clearing and construction of new urban areas, but this is not accounted for in the estimate in Figure 1, due to limited data.

Important sources of nutrients in urban stormwater in the lower Hawkesbury-Nepean catchment include: animal wastes; fertilisers used on gardens, public open spaces and golf courses; detergents such as those used in car washing and from landfill leachate; and soil erosion from construction sites. This untreated water is carried in stormwater channels and discharged directly into creeks and rivers. Runoff is mainly generated during rain events, but can also come from dry weather activities such as garden watering and irrigation. Stormwater quality can also be affected by overflows or leaks from sewage treatment systems or on-site sewage management systems (refer to Sections 2.3.4. and 2.4.2).

As can be seen from Maps 2 and 3, the urban environment is currently a major contributor to total nitrogen and phosphorus loads for the South Creek and Cattai Creek sub-catchments, with extensive urbanisation in the suburbs of Penrith, Blacktown, Liverpool and Baulkham Hills. These sub-catchments also contain most of the area covered by the North West and South West Growth Centres, identified in the Sydney Metropolitan Strategy as the main land release areas for future urban development, with 181,000 new homes planned over the next 30 years (GCC 2008). Other parts of the lower Hawkesbury-Nepean catchment are also experiencing significant urban growth pressures as the demand for rural-residential lifestyle increases.

One method to reduce the impact of nutrients in stormwater is to harvest and reuse stormwater. In urban areas, runoff rates are significantly increased above natural levels, which can have impacts on stream stability and ecology and result in poor waterway health. Stormwater harvesting can reduce the amount of nutrients entering waterways, move towards more natural flow patterns and provide an alternative source of water. However, if too much water is harvested the amount of water available for irrigators and the environment can be seriously reduced.

2.3.3 Agricultural practices

Agricultural production in the Hawkesbury-Nepean catchment is valuable to the economy and community and provides much of the fresh produce (including vegetables, flowers, fruits, eggs and poultry) for Sydney and surrounding regions. Horse-breeding and turf industries are among a range of other economically significant industries. There are approximately 1000 vegetable farms in the Sydney Basin and at least 50% of the growers are from language backgrounds other than English (B Yiasoumi, Department of Primary Industries, pers. comm., 24 February 2009).

As can be seen from Figure 1, a significant proportion of diffuse nutrient loads from human activities in the lower Hawkesbury-Nepean are contributed from various forms of agriculture. These sources are concentrated along the productive floodplains of the river up to the dams, and the sub-catchments of South Creek and Cattai Creek, as shown in Maps 3 and 4. While nutrients are required to maintain agricultural productivity, high levels of surplus nutrients and disturbed soils can be exported into downstream waterways. As well as the financial cost of the loss of nutrients, water quality is important to a large number of irrigated farms in the region.

The following agricultural sources of nutrients will be a focus for the Strategy:

- Nutrient exports from **intensive horticulture**, such as market gardens, are generally recognised as a significant contributor to diffuse source nutrient pollution in the Hawkesbury-Nepean catchment on a per hectare basis (Chan *et al*. 2007). As shown in Figure 1, this activity accounts for an estimated 14% and 24% of the diffuse load of phosphorus and nitrogen respectively, despite only occupying roughly 7100 ha.

  Supplying fresh vegetables and fruit for Sydney, as well as flower growing and plant nurseries, intensive horticulture contributes nutrient loads in most sub-catchments. The nutrient export rates attributed to this activity reflect the level of fertiliser use and harvesting and irrigation which can lead to soil erosion and nutrient transport. These factors vary depending on the practices at individual properties.

- While **grazing** such as for cattle, sheep and horses contributes lower rates of nutrients in runoff, this land use is still a major contributor to nutrient loads because of the large areas of pasture in the catchment (136,000 ha). Grazing represents the highest diffuse nutrient source from human activities, accounting for over one third of the estimated load as shown in Figure 1, mostly from the South Nepean and the upper reaches of the Colo River sub-catchment (Capertee and Wolgan Valleys). Grazing in these areas is largely on modified pastures and nutrient sources include land clearing, fertiliser application and poor ground cover. Where stock is not excluded from stream banks, riparian vegetation is generally degraded.

- **Intensive animal production**, including dairies, poultry and egg production and other livestock processing facilities, makes a relatively large contribution to diffuse phosphorus loads, estimated at 13% in Figure 1. Nutrient-rich manure and effluent can create nutrient hot spots if not contained properly.

- Although a smaller contributor to nutrient loads overall, the proximity to the river of **non-intensive agriculture/cropping** activities such as turf farms makes the management of fertiliser use, harvesting and irrigation practices important.

- The region is also experiencing increased **rural residential** development, often including horse-keeping or other, small animals with potential to degrade soil surfaces and introduce manure, particularly where stocking rates are high. Due to numerous small farms in the catchment, rural residential land use contributes about 7% and 9% of estimated diffuse nitrogen and phosphorus loads respectively (see Figure 1).

2.3.4 On-site sewage management systems

There are approximately 50,000 on-site sewage management systems such as septic tanks operating in the lower Hawkesbury-Nepean catchment and there are approximately 1500 applications for new systems each year. These systems are typically located in areas where a centralised sewerage service is not available and contribute to the nutrient loads from rural residential land shown in Figure 1.

When site-specific requirements are taken into account and the system is operated and maintained appropriately, on-site sewage management systems can provide a cost-effective and reliable means of managing wastewater. However, statistics from the NSW Government's Septic Safe program show that existing on-site systems are failing to meet requirements for environment and public health protection in many places (DLG 2005). Many systems are performing poorly due to inappropriate system selection, siting or design; physical damage; hydraulic or organic overload; or inadequate long-term maintenance. These systems contribute nutrient loads to local waterways through overland flow or via groundwater. As a result, runoff from unsewered areas generally contains higher nutrient concentrations than runoff from sewered areas.

2.3.5 Degraded land and riparian vegetation

Groundcover and riparian vegetation provides a buffer that filters nutrients and sediment in surface runoff from adjacent lands and protects soils and river banks from erosion. However in many areas of the lower Hawkesbury-Nepean catchment, vegetation has been greatly reduced and soils degraded, since European settlement. The Hawkesbury-Nepean River Health Strategy has assessed the condition of riparian lands along 255 river reaches and prioritised 3600 km of waterways for restoration works and management (HNCMA 2007).

Riparian vegetation has been found to reduce sediment and nutrient loads into surface water and groundwater in urban and rural areas by acting as a filter for catchment runoff. However, in urban areas the benefit provided by vegetation is limited, as stormwater is typically discharged directly into waterways.

2.4 Priority point sources of nutrients

2.4.1 Sewage treatment plants

Point sources contribute a lower proportion of the total nutrient loads to the Hawkesbury-Nepean River and tributaries than diffuse sources. However, during dry weather conditions, point sources contribute the majority of nutrient loads as they tend to deliver a constant discharge all year round.

Discharges from sewage treatment plants (STPs) are the only point sources of nutrients in dry weather in the lower Hawkesbury-Nepean catchment which are licensed by DECCW. Sydney Water Corporation presently operates 15 STPs that are licensed to discharge to the lower Hawkesbury-Nepean catchment, and Hawkesbury City Council has two licensed STPs at McGraths Hill and South Windsor. Map 4 illustrates the location of these plants. There are also some small privately owned and operated sewage treatment package systems with relatively small licensed discharge volumes.

Map 4: Location of the main sewage treatment plants operating in the lower Hawkesbury-Nepean catchment (note: Blackheath STP closed in 2008)

As a result of negotiation, direct regulation and the use of economic instruments, such as the South Creek 'bubble' licence, over the past 10 to 15 years phosphorus and nitrogen loads discharged from Sydney Water Corporation's STPs in the Hawkesbury-Nepean have been significantly reduced, despite rapid population growth in western Sydney. Figure 3 shows reductions of 45% in total nitrogen loads and 75% in total phosphorus loads discharged to waterways from Sydney Water's inland STPs between 1995 and 2008. Reductions have been achieved through investment by Sydney Water in upgrading existing plants to treat effluent to a higher standard, wastewater recycling, as well as decommissioning and transferring flows from poorly performing plants.

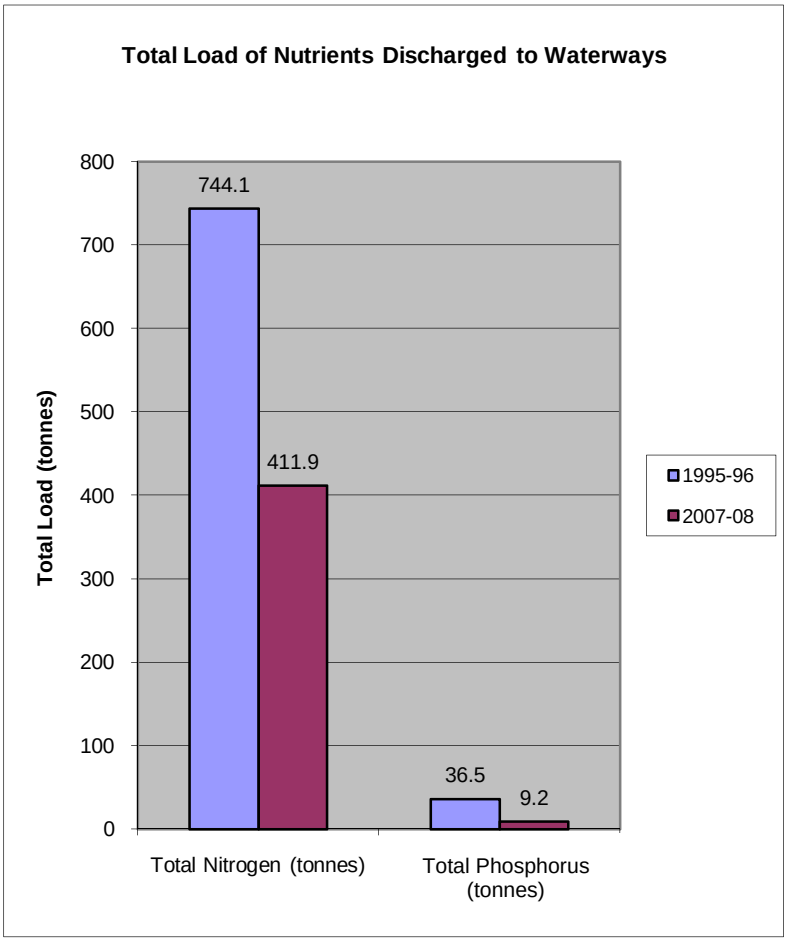
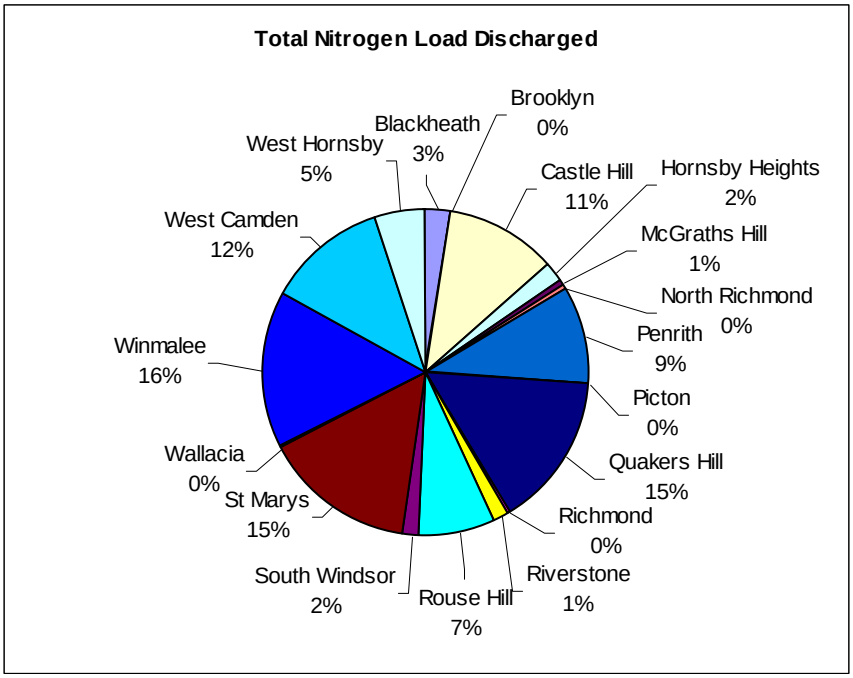


Figure 3: Reductions in nutrient loads between 1995 and 2008 from Sydney Water Corporation's Hawkesbury-Nepean STPs (SWC 2007 & 2008a)

The relative proportion of nutrient loads in effluent discharged to waterways from each STP in the region during 2007–08 is shown in Figure 4. From Sydney Water and Hawkesbury City Council plants in 2007–08 the total nitrogen load was approximately 425 tonnes and the total phosphorus load was approximately 9.9 tonnes. Significant upgrades of STPs currently underway are anticipated to reduce nutrient loads further in the coming years.



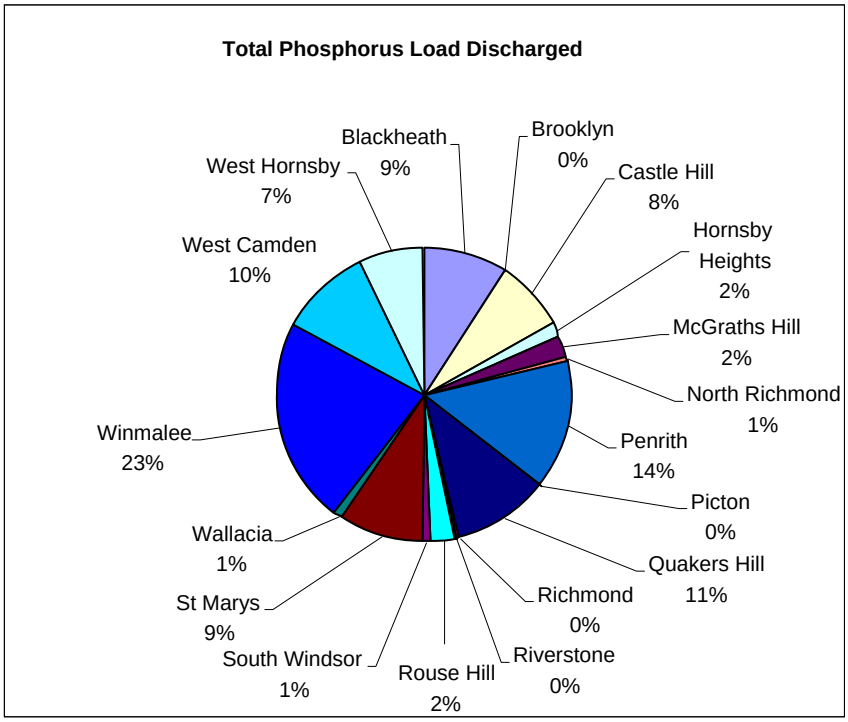


Figure 4: Percentage of total nitrogen and phosphorus discharged from STPs in 2007–08 (SWC 2008b)

In 2007–08, Winmalee, Penrith and West Camden STPs provided the greatest contribution of point source nutrient loads entering the lower Nepean River between Warragamba and South Creek. Downstream of Windsor to Sackville, the STPs at St Marys, Quakers Hill, Rouse Hill and Castle Hill were the predominant point sources of nutrient inputs to the river system through South Creek and Cattai Creek. Nutrients remaining after treatment at West Hornsby STP and Hornsby Heights STP discharge into the upper catchment of Berowra Creek, entering the estuarine reaches of the river.

All the Sydney Water STPs provide tertiary treatment, the final stage of sewage treatment that helps to achieve higher water quality with most removing phosphorus and nitrogen to very low levels (median phosphorus concentrations of 0.1 milligram a litre or less and median nitrogen concentrations of less than 10 milligrams a litre). Existing residential dual reticulation and agricultural effluent recycling and reuse schemes use large proportions of the effluent from Picton, Rouse Hill and Richmond STPs. McGraths Hill STP discharges to a wetland system and irrigation reuse. Various schemes with golf courses, sports fields and within STPs contribute to reductions in nutrient discharges from other STPs.

2.4.2 Sewage overflows

Environment protection licences also encompass the management of nutrients from the sewerage systems in the lower Hawkesbury-Nepean and include specific overflow targets to reduce the number of sewage overflows. Overflows of sewage can occur during dry weather, for instance, when there is a blockage in a sewerage pipe caused by tree roots or other material, or if a pump fails at a pumping station. In wet weather, rainwater can enter the sewerage system through cracks in pipes, faulty joints or illegal stormwater connections. This can overload the sewerage system causing it to overflow from designed overflow points and maintenance holes. Property owners are responsible for maintaining the sewer pipes and downpipes on their property to ensure plant roots and stormwater do not enter the sewerage system.

Most of the Hawkesbury-Nepean sewerage systems are currently meeting long-term wet weather overflow targets or have planned works to prevent overflows in wet weather. Anticipated population growth and increased pipe age are significant challenges that could lead to increases in sewage overflows if not carefully managed.

3. Actions to manage nutrients in the lower Hawkesbury-Nepean catchment

3.1 Identification and implementation of actions

3.1.1 Action priorities

Consultation with stakeholders and the review of priority nutrient sources (outlined in Section 2) have identified further opportunities to improve coordination of actions, integrate planning and investment decisions, reinvigorate successful programs and conduct targeted actions to address knowledge gaps and support on-ground works.

Under the following categories, Sections 3.2 to 3.7 outline progress to date and identify **strategic priorities** and **actions**:

- General nutrient management actions
- Urban stormwater nutrient actions
- Agricultural practices nutrient actions
- On-site sewage management system nutrient actions
- Sewage treatment system nutrient actions
- Degraded land and riparian vegetation nutrient actions.

A prioritisation approach has been used to determine actions to be included in the Strategy. This involved assessing actions against criteria such as risk, effectiveness (the likely nutrient reduction benefits of the actions), efficiency (ease of implementation and maximisation of existing resources) and sustainability. Other considerations included engagement of relevant stakeholders, alignment with existing initiatives and ability to progress the action in the near future.

To ensure that actions are successfully carried out, an implementation framework has been developed, and responsibilities as well as agreed time frames have been incorporated into specific actions.

3.1.2 Implementation partners

Partnerships will play a crucial role in improving the long-term health of the Hawkesbury-Nepean river system, and the Government will be working with interested parties including local governments, landholders and the community to help deliver the strategic priorities and nutrient management actions.

To better coordinate management of the river system and reduce complexity in decision-making, the Government has established the Office of the Hawkesbury-Nepean (OHN). This ‘one-stop shop’ is a positive initiative to assist in coordination and collaboration on a range of river programs. The OHN will provide advice on river health, coordinate weed management in the river and streamline the process for applications for in-stream developments. It will establish a stakeholder committee to provide advice on the functions and activities of the OHN.

DECCW will coordinate implementation of the Strategy in partnership with relevant organisations, including:

- Office of the Hawkesbury-Nepean
- Industry and Investment NSW (I&I NSW)
- Sydney Water Corporation (SWC)
- Hawkesbury-Nepean Catchment Management Authority (HNCMA)
- Sydney Catchment Authority (SCA)

- Department of Planning (DoP)
- local councils
- Western Sydney Regional Organisation of Councils (WSROC)
- Macarthur Regional Organisation of Councils (MACROC).

3.1.3 Funding opportunities

Various grant programs may provide the opportunity to fund actions that support the Strategy by community groups, landholders, councils and other organisations. These could include the Australian Government's Caring for Our Country fund, NSW Government's Climate Change Fund, Environmental Trust Grant Programs and HNCMA's incentive programs. It is also expected that the Strategy will be used to guide investment and service delivery funding programs of local councils, utilities and State Government agencies.

The Hawkesbury-Nepean River Recovery Project funded by the Australian Government will provide funding for projects that will support implementation of this Strategy. Some of the projects will provide opportunities for councils, landholders and other organisations to access funds for work that will reduce nutrient loads to the river. As detailed in Sections 3.2 to 3.6, the project components include:

- Nutrient Export Rate Monitoring Program (Action 1.3)
- Irrigation and Landscape Efficiency Program (Action 2.2)
- NutrientSmart Farms Project (Action 3.1)
- WaterSmart Farms Project (Action 3.2)
- South Windsor Effluent Reuse Scheme (Action 5.1).

3.1.4 Regulatory framework

The NSW regulatory framework will play an important role in ensuring that objectives for nutrient management are an important consideration in decisions about land-use planning and natural resource management.

New or expanding developments and activities generally require an environmental impact assessment through regulatory tools under the *Environmental Planning and Assessment Act 1979* (EP&A Act), such as development control plans, Local Environmental Plans, and State Environmental Planning Policies. This assessment may be done by a local council, the Department of Planning, another State agency or a planning panel.

There is a general ban on polluting water without permission, under the *Protection of the Environment Operations Act 1997* (POEO Act). Landholders are encouraged to conduct activities on their properties to minimise any risk of water pollution. Legislation enables DECCW to reduce nutrient loads to waterways through licensing of activities including sewage systems and intensive livestock processing. Local councils can regulate non-scheduled activities through notice and enforcement powers under the POEO Act.

A number of other regulatory and planning controls are in place to manage diffuse sources of nutrients and prevent land degradation. For example, councils regulate on-site sewage management systems under the *Local Government Act 1993*. Other relevant legislation includes the *Native Vegetation Act 2003, Noxious Weeds Act 1993*, *Fisheries Management Act 1994* and the *Water Management Act 2000*.

The *Water Management Act 2000* plays an important role in relation to water quality through water sharing plans. Water sharing plans can include requirements for the provision of water for the environment and rules to protect this environmental water. Environmental water supports fundamental ecosystem function and can make a positive contribution to improving or maintaining water quality. This Act also controls activities in or near waterways to protect riparian corridors.

3.1.5 Strategy monitoring, reporting and review

The following monitoring, reporting and review process will measure progress towards achieving the Strategy's objectives, and reflect emerging issues.

- **Monitoring progress:** The progress in delivering actions will be monitored using information from organisations that have committed to deliver project actions. Specific monitoring of certain project outcomes and the use of simple models to extrapolate changes in nutrient loads may be undertaken where appropriate.
- **State-wide and catchment scale environmental monitoring:** The State-wide Monitoring Evaluation and Reporting (MER) Strategy and the Hawkesbury-Nepean River Environmental Monitoring Program will inform the review of progress towards achieving agreed environmental values for the river. The MER Strategy measures the natural resource management targets of the NSW State Plan and is reported upon in NSW State of the Environment reports. Relevant targets include:
  - By 2015 there is a reduction in the impact of invasive species.
  - By 2015 there is an improvement in the condition of riverine ecosystems.
  - By 2015 there is an improvement in the condition of estuaries and coastal lake ecosystems.
- **Reporting:** DECCW will track progress on the implementation of the Strategy on a webpage with annual updates. Information on any additional or new actions to implement the Strategy's strategic priorities will be incorporated.
- **Evaluation and review:** DECCW will lead a four-yearly evaluation and review to allow the Strategy to be updated over time to reflect new actions, meet changing priorities for improvement opportunities, and consider stakeholder needs and scientific understanding. The Strategy will be evaluated for effectiveness against its objectives. Information from both program and catchment monitoring will be used in the assessment and review process and to identify new priority sources of nutrients and strategic priorities.

  The timing of the review will aim to allow the Strategy to link with the Metropolitan Water Plan review, the Hawkesbury-Nepean River Environmental Monitoring Program and CMA investment programs.

3.2 General nutrient management actions

Progress to date

Progress to date to improve coordination and general nutrient management activities

- The **Hawkesbury-Nepean River Environmental Monitoring Program** (www.environment.nsw.gov.au/water/hnremp.htm) has been developed to collate and analyse historical monitoring data in a comprehensive study of broad-scale trends in river water quality. This program provides information on trends in river water quality (including nutrients, turbidity and conductivity) and stream flow patterns, as well as the biological patterns of the river's ecosystem (including invertebrate animals, fish and water plants).

- **Aquatic weeds are being controlled** through periodic weed harvesting, chemical spraying, booms and biological control. Although not a source control method, the physical removal of weeds from the river also serves to reduce some of the load of nutrients once they have entered the river. In recent years, trials have been successfully conducted on composting the harvested weeds to produce a product for use in land rehabilitation and similar activities. Algal blooms are managed through the activities of Regional Algal Coordinating Committees and the State Algal Advisory Group.
- The **Hawkesbury-Nepean Catchment Action Plan 2007–2016** (www.hn.cma.nsw.gov.au/topics/2181.html) was approved in 2008, and, supported by the River Health Strategy, helps guide the delivery of HNCMA programs to improve river health on a catchment basis, thereby coordinating efforts across local government areas and community groups.

Strategic priorities

To contribute to improved coordination and general nutrient management, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- **Improve knowledge and understanding** of lower Hawkesbury-Nepean nutrient sources, effectiveness of management practices and processes impacting on river health (such as nutrient cycling).
- Contribute towards the development and use of **tools to improve coordination, prioritisation and evaluation** of nutrient management decisions and activities.
- **Align water quality and environmental monitoring** with the framework and protocols provided by the Hawkesbury-Nepean Environmental Monitoring Program and work collaboratively with other councils to maximise the value of the data collected and share results.
- **Integrate education on nutrients**, such as fertiliser use in gardens, into community education campaigns to increase awareness and encourage actions to protect river health.
- Participate in opportunities to **share learning and develop partnerships** across existing networks and programs on nutrient management issues.
- Continue to **fund and resource** projects and programs that provide efficient and effective reductions in nutrient loads from priority sources.
- Actively **engage decision-makers and senior management** within organisations about the importance of nutrient management issues and programs.

Next steps

Next steps to improve coordination and general nutrient management activities committed to as part of this Strategy

Action 1.1 DECCW, in collaboration with the Office of the Hawkesbury-Nepean and the HNCMA will assist councils to meet the Strategy's objectives and strategic priorities through the sharing of resources and developing guidance material.

Action 1.2 DECCW will develop a **coastal eutrophication risk assessment tool** to be made available online in 2010. This tool will comprise simple models that allow the user to examine broad-scale management scenarios in the estuarine section of the catchment and the corresponding ecological responses (typically chlorophyll-a) resulting from changes in the nutrient or sediment loads.

Action 1.3 DECCW will continue to implement the **Nutrient Export Rate Monitoring Program** until 2011 as part of the Hawkesbury-Nepean River Recovery Project. This project aims to enhance information available on the quantity of nutrients moving off farms ('nutrient export') before and after the implementation of mitigation measures under local conditions for the catchment. It will assist in evaluating the results of nutrient reduction measures under Actions 3.1 and 3.2, and also support future decisions on locations for investment in on-ground works and rural management practices for the Hawkesbury-Nepean catchment. DECCW is working with I&I NSW in communicating the findings.

Action 1.4 DECCW will continue to **promote communication** on diffuse source water pollution issues through its website and will encourage stakeholders in the lower Hawkesbury-Nepean to nominate projects for inclusion.

Action 1.5 Government agencies will work together to develop a new Water Quality Model for the Hawkesbury-Nepean.

Action 1.6 DECCW will provide further information and analysis on nutrient loads and sources in the Hawkesbury–Nepean catchment as new data becomes available.

3.3 Urban stormwater nutrient actions

Progress to date

Progress to date to reduce nutrient loads from urban stormwater

- **Water sensitive urban design (WSUD) objectives** and **stormwater management targets** have been developed to minimise the impact of urbanisation on waterways within and downstream of the Growth Centres. A number of councils have prepared stormwater and water sensitive urban design Development Control Plans and/or Policies.
- Sydney Metropolitan CMA's **WSUD Program** (www.wsud.org) continues to build council capacity and provides ongoing support for councils through the sharing of information and generating linkages between government, research and industry.
- The **Urban Stormwater Program** awarded 55 grants worth $8.3 million to councils in the lower Hawkesbury-Nepean to help mitigate future urban stormwater problems in rapidly developing areas. The program assisted on-ground works, such as sediment basins and artificial wetlands, community education, and helped improve council officers' urban stormwater management skills. The **Blue Mountains Urban Runoff Control Program** provided an additional $19 million to stormwater management in the Blue Mountains.
- Councils are adopting a **stormwater management service charge**, which is capped at $25 per household annually, to fund new/additional stormwater works and maintenance activities. During 2006–07, councils within (or partially within) the lower Hawkesbury-Nepean catchment raised approximately $3.8 million through the stormwater management service charge. This increased to almost $8.4 million during 2007–08.
- Grants of over $6.5 million have been awarded to local councils under the **Urban Sustainability Program** (www.environment.nsw.gov.au/grants/urbansustainability.htm) from 2006 to 2008 for stormwater and urban water management related projects in the lower Hawkesbury-Nepean.

- The **installation of rainwater tanks** is encouraged through the NSW Government's Rainwater Tank Rebate and the Building Sustainability Index program (BASIX) (www.basix.nsw.gov.au), and by councils. While primarily reducing water demand, reduced runoff also reduces nutrient loads.
- Increasingly, **innovative stormwater treatment** and **stormwater harvesting and reuse projects** are being developed, helping remove nitrogen and phosphorus loads, along with other pollutants, from established and new urban areas. Sydney Water has implemented an extensive stormwater trunk drainage management program in the Rouse Hill Development Area, as part of an integrated water cycle management program.
- Councils are recognising the need for **ongoing maintenance of stormwater devices** and undertaking inspections and cleaning activities after major storm events. Some councils, such as Hornsby Shire Council, also have well established lifecycle asset management planning in place and report on performance.
- Projects are underway to **improve nutrient management on open spaces** such as golf courses, parks and playing fields including improved irrigation efficiencies, soil and fertiliser management, and stormwater harvesting and reuse projects. Some councils are also implementing environmental management systems and training staff.
- Other initiatives that are widely occurring across the region include **water quality monitoring and research**, **street sweeping**, **industrial auditing**, **emergency spill response** and **environmental compliance and management**.
- **Guidance material** is available to improve stormwater management design, construction and implementation practices. This guidance includes resources for use by local councils in the planning and review of erosion and sediment controls on building sites. Material is also available to inform nutrient management on open spaces. This material can be found at www.environment.nsw.gov.au/water/stormwater.htm.
- Programs that support **stormwater capacity building within councils** have been delivered, including the WSUD (water sensitive urban design) in the Sydney Region Program, workshops on Stormwater Guidelines by DECCW and the Sydney Metropolitan CMA, and training of officers in Soil and Water Management by HNCMA.
- **Education programs** have been undertaken to raise community awareness and change behaviour. These include stencilling of gutters, 'pick up after your dog' campaigns and promoting gardening practices that reduce nutrients at community nurseries. Some councils have promoted training programs for builders in partnership with the Housing Industry Association, Master Builders Association or TAFE.

Strategic priorities

To contribute to reduced nutrient loads from urban stormwater, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- Manage urban stormwater to **maximise outcomes for river health**, minimise stormwater flooding risks and optimise its use as an alternative water source where stormwater harvesting improves flow patterns.
- Include all reasonable management actions to **minimise impacts on the downstream environment** when designing stormwater management approaches.

- **Strengthen environmental planning** of new urban development by incorporating water sensitive urban design principles and stormwater targets into Development Control Plans and through the development assessment process.
- **Target retrofitting of stormwater treatment measures** at 'hot spots', where a catchment generates a significant amount of nutrient load.
- Ensure sediment and erosion control is put into practice during the **development and construction** phase of building works, by including conditions in development approvals, and carrying out site inspections, education and compliance activities.
- **Build the capacity of councils** to improve the management of urban stormwater and to implement water sensitive urban design.
- **Promote public support** by focusing stormwater management activities on specific key areas where activities will be able to demonstrate tangible results to the community, and reporting on actions and achievements in council reports.
- Provide for **sustainable financing and planning** to ensure continued maintenance and improvement of existing stormwater devices and programs into the future.
- Pursue **regional cooperative approaches** between councils, government agencies, Sydney Water and other landholders to develop integrated stormwater management projects including stormwater harvesting, reuse and infiltration projects.
- Improve **open spaces nutrient management** including developing plans and projects to improve fertiliser use and irrigation management.

Next steps

Next steps to reduce nutrient loads from urban stormwater committed to as part of this Strategy

Action 2.1 DECCW will continue to liaise with the Department of Planning on ways to include **stormwater management provisions** for new developments in the planning process.

Action 2.2 Sydney Water will continue to implement its **Irrigation and Landscape Efficiency Project** (www.sydneywater.com.au/Water4Life/ILEP/) until 2011 through its Every Drop Counts Business Program, as part of the Hawkesbury-Nepean River Recovery Project. This project offers an Irrigation and Landscape Assessment to councils, schools and golf courses, and supports implementation of on-ground measures to improve the efficiency of potable water use in open space irrigation.

Action 2.3 DECCW and WSROC will continue to encourage councils to **work collaboratively and share information on urban water management** by supporting the Western Sydney Councils urban water management network.

Action 2.4 DECCW will **present information to the urban water management network** on funding opportunities to assist with the preparation of grant applications and facilitate discussion on potential regional collaborative stormwater treatment and reuse projects.

Action 2.5 WSROC and DECCW, in collaboration with MACROC and WSUD for Sydney Region, will consider how a **coordinated review of stormwater and WSUD provisions** in Development Control Plans and Policies could be carried out, to improve consistency and share resources across councils. The applicability of templates developed through the Botany Bay Coastal Catchments Initiative to the lower Hawkesbury-Nepean region will be considered as part of this review.

Action 2.6 DECCW will continue to **provide information on stormwater management** by updating its website in 2010 with new guidance on stormwater management as well as links to other relevant resources that councils may use in stormwater planning and design, the education of builders, developers and council staff.

Action 2.7 WSROC and DECCW, in collaboration with MACROC, will continue to provide support to councils undertaking **education and compliance activities for erosion and sediment control at building sites**.

3.4 Agricultural practices nutrient actions

Progress to date

Progress to date to reduce nutrient loads from agricultural practices

- A range of **best practice management guidance** is available to facilitate the adoption of sustainable practices into farm management. I&I NSW and DECCW are working with producers and land users to implement best practice for nutrient use in agricultural production.
- Various **industry-led programs** are available to support growers, farmers and suppliers in implementing environmental practices including nutrient management. A number of these involve accreditation schemes to support implementation of industry best management practice guidelines.
- I&I NSW is working in partnership with landholders, the HNCMA and other organisations to deliver programs that provide **support for on-ground works and capacity building** and encourage environmental improvements in land management practices. I&I NSW also provides technical advice, training courses and extension activities, and they have various research and demonstration sites. Key programs delivered in the lower Hawkesbury-Nepean have included:
  - **Waterwise on the Farm** – on-farm training by I&I NSW (www.dpi.nsw.gov.au/agriculture/resources/water/quality/publications/farm-water)
  - **Sustainable Grazing Project** – education and training by I&I NSW and HNCMA for landholders to improve grazing practices
  - **Central Coast Plateau Sustainable Farming Project** – demonstration sites and support for on-ground works in Mangrove Mountain catchment by I&I NSW and HNCMA (www.wollombi.nsw.au/news/display/264)
  - **Tide to Table Program** – support for on-ground works to improve aquatic habitat and water quality, an OceanWatch Australia initiative in partnership with I&I NSW, NSW Farmers' Association, NSW Food Authority and HNCMA (www.oceanwatch.org.au/campaignAquatic.htm)
  - **Fish-Friendly Farms Program** – education on fish-friendly land management in the Hawkesbury-Nepean by I&I NSW, NSW Council of Freshwater Anglers and HNCMA (www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/316292/Kondinin-Grp_FFF_CharlieJ-Dec09.pdf)
  - **Rural Land Incentives Program** – workshops and support for rural on-ground works, including water quality management, by Hornsby Shire Council (www.hornsby.nsw.gov.au/environment/index.cfm?NavigationID=1484).
- **Factsheets** and **workshops** that include information on nutrient management practices have been developed to support market gardeners from language backgrounds other than English, by I&I NSW in partnership with Liverpool, Penrith, Blacktown, Fairfield and Hawkesbury councils with assistance from the Environmental Trust.

- A **nutrient offset scheme** (www.environment.nsw.gov.au/greenoffsets/epapilots.htm) has been piloted in the South Creek catchment to trial the use of nutrient offsets to achieve low cost abatement of nutrients from diffuse sources. With funds from Sydney Water and Landcom, nutrient reduction measures at a greenhouse property, grazing property and a number of market gardens have been estimated to have reduced nutrient emissions by over 75%. The pilot scheme is currently being assessed.
- Councils have undertaken **environmental audits** of specific agricultural businesses, such as nurseries, orchards, market gardens and small farms. These audits are conducted with an education focus, with council officers inspecting sites and providing advice on how businesses could comply with environmental legislation requirements by reducing nutrient runoff or sedimentation and erosion.

Strategic priorities

To contribute to reduced nutrient loads from agricultural practices, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- Incorporate nutrient reduction strategies into land management **education, extension and incentive programs** for priority nutrient sources in the catchment.
- More extensively encourage **integrated management** of nutrient application and irrigation of farms to increase productivity, use water efficiently and minimise effects of runoff on river health.
- Continue programs that support landholders in **fencing riparian areas** to control stock access to provide a simple and effective method to reduce nutrients entering waterways.
- Further promote **demonstration sites** that provide practical examples to other landholders on how to implement best management practices for nutrient reduction.
- Continue efforts to **collaborate and coordinate projects and programs** which reduce nutrient loads from agricultural activities.
- Ongoing delivery of educational programs that support farmers from **language backgrounds other than English** to manage nutrients sustainably.
- Investigate opportunities to apply **market-based instruments** or incentives to support nutrient load reductions from agriculture where these are cost-effective and feasible.
- Conduct **educational audits of agricultural sites** in collaboration with other agencies to encourage effective implementation of nutrient control measures.

Next steps

Next steps to reduce nutrient loads from agricultural practices committed to as part of this Strategy

Action 3.1 I&I NSW and the HNCMA will continue to jointly implement the **NutrientSmart Farms Project** (www.dpi.nsw.gov.au/agriculture/resources/smartfarms) until 2011 as part of the Hawkesbury-Nepean River Recovery Project. This project engages agricultural landholders in capacity building / education and on-ground works aimed at improving farm nutrient management and reducing nutrient export from farms. The project focuses on land uses such as grazing, dairy, market gardens, turf farms and small farms.

Action 3.2 I&I NSW will continue to implement the **WaterSmart Farms Project** (www.dpi.nsw.gov.au/agriculture/resources/smartfarms) as part of the Hawkesbury-Nepean River Recovery Project, with additional funding from the NSW Climate Change Fund. This project supports irrigated agricultural landholders in sprinkler retrofitting or irrigation system upgrades and water harvesting/recycling and reuse projects to make water savings through improved irrigation efficiencies and improved nutrient management. The project also includes education/training, the provision of an irrigation scheduling service and establishment of a demonstration site. The project complements Actions 1.3 and 3.1 and focuses initially on irrigated turf farms, field-grown vegetable growers, nurseries and greenhouse operations.

Action 3.3 I&I NSW will develop mechanisms to **facilitate communication and coordination of agricultural related programs**, particularly the NutrientSmart Farms and WaterSmart Farms projects, with HNCMA, councils and other relevant stakeholders.

Action 3.4 I&I NSW will **publish and promote** *Sustainable land management practices for graziers: Best management practices for graziers*.

Action 3.5 I&I NSW will **offer existing PROfarm™ workshops** (www.dpi.nsw.gov.au/agriculture/profarm) to farmers in the lower Hawkesbury-Nepean catchment to assist with their on-farm management of nutrients.

3.5 On-site sewage management systems nutrient actions

Progress to date

Progress to date to reduce nutrient loads from on-site sewage management systems

- The **Septic Safe Program** provides support to councils and landowners in undertaking their sewage management responsibilities. Councils are required to supervise the operation of on-site sewage management systems and they are able to charge a fee, on a cost recovery basis, to carry out these functions. All landowners with on-site sewage management systems are required to obtain an approval to operate from council. They must also maintain and manage their systems in accordance with health and environmental performance standards (e.g. preventing sewage contamination of waterways and groundwater). A survey of NSW councils in 2005 found that the majority have an **on-site sewage management strategy** and an **ongoing program of inspections** (DLG 2005). However, only about half of these councils were found to carry out inspections according to risk-based criteria and less than 50% of councils issued approvals based on risk.
- Councils in the lower Hawkesbury-Nepean participate in the **Hawkesbury-Nepean On-site Wastewater Working Group** to facilitate the sharing of knowledge and experience in helping council officers better manage the installation and operation of on-site sewage management systems.
- Council officers have indicated **maintenance of aerated wastewater treatment systems** and the level of expertise and experience of servicing technicians is an ongoing issue. The Department of Local Government has advised that other regional groups of councils have worked together to develop minimum criteria to determine the acceptability of service agents operating in their areas, such as the Hunter Septic Tank Action Group, which includes representatives from a number of councils in the Hunter region.

- The **Priority Sewerage Program** (www.sydneywater.com.au/majorprojects/Wastewater/PrioritySewerageProgram/index.cfm) provides improved sewerage services to areas nominated in Sydney Water's Operating Licence. The program provides environmental and social benefits including reduced risk to public health and improved water quality in local streams and rivers. Work on Stage One has been completed, making improved sewerage services available to more than 5400 properties in 16 villages in the greater Sydney region. A number of these areas are located in the lower Hawkesbury-Nepean catchment. Sydney Water has also commenced work on the construction of the Glossodia, Freemans Reach and Wilberforce Sewerage Scheme under Stage Two.

Strategic priorities

To contribute to reduced nutrient loads from on-site sewage management systems, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- Continue to **implement the Septic Safe Program** with a particular focus on providing householder education, undertaking yearly inspections of systems in high risk areas, and issuing approvals for new systems based on risk.
- **Record information** in on-site sewage management system registers in a way that assists coordination of catchment-wide initiatives to improve performance and compare information using benchmarking and best practice principles.
- Continue the **Hawkesbury-Nepean On-site Wastewater Working Group** to facilitate the sharing of knowledge and experience in helping council officers better manage the installation and operation of on-site sewage management systems.
- Pursue opportunities to develop **regional criteria** for aerated wastewater treatment system service agents, similar to the program developed by the Hunter Septic Tank Action Group.
- Continue to persuade residents to **connect to existing reticulated sewerage schemes** that have been provided under the Priority Sewerage Program.

Next steps

Next steps to reduce nutrient loads from on-site sewage management systems committed to as part of this Strategy

Action 4.1 DECCW will investigate developing a **Soil and Land Constraint Assessment Tool** for sewage management use, in discussion with the Hawkesbury-Nepean On-site Wastewater Working Group and Sydney Catchment Authority, to help councils identify areas where on-site sewage management systems are likely to pose a high risk to the surrounding environment.

Action 4.2 Councils will liaise through the Hawkesbury-Nepean On-site Wastewater Working Group with the Hunter Septic Tank Action Group to investigate opportunities to further **coordinate management of on-site sewage management systems**.

3.6 Sewage treatment system nutrient actions

Progress to date

Progress to date to reduce nutrient loads from sewage treatment systems

- Legislation enables DECCW to **improve sewage management through regulatory controls**. Under the *Protection of the Environment Operations Act 1997*, DECCW issues environment protection licences to the owners or operators of scheduled sewage treatment systems that discharge to the environment. Licence conditions to reduce the impacts of discharges (pollution reduction programs) and polluter-pays based frameworks (load-based licensing) are driving continuing reductions in nutrient loads in the Hawkesbury-Nepean. Specific targets are in place to reduce the number of sewage overflows.
- The **South Creek 'bubble' licence** (www.environment.nsw.gov.au/licensing/bubble.htm) has reduced the phosphorus and nitrogen loads from Sydney Water sewage treatment plants discharging to South Creek by 35% and 80% respectively since 1995–96.
- The NSW Government's 2006 Metropolitan Water Plan (NSW Government 2006) projects the volume of recycled water to increase from 15 billion litres per year to more than 70 billion litres per year by 2015 and Sydney Water is taking major steps towards this through **water recycling initiatives**, including:
  - The **Rouse Hill recycled water scheme** (www.sydneywater.com.au/Water4Life/RecyclingandReuse/RecyclingAndReuseInAction/RouseHill.cfm) provides recycled water to more than 16,500 homes for toilet flushing and outdoor uses such as watering gardens and washing cars. The amplification works were completed in 2009, enabling the plant to provide 4.7 billion litres of recycled water per year to service 36,000 new homes.
  - The **West Camden STP** is being upgraded to cater for future population growth, reduce nutrient loads and improve water quality. Completed in 2009, the STP is able to treat 23 million litres of wastewater per day. The recycled water pipeline to Elizabeth Macarthur Agricultural Institute has been constructed and when fully operational will provide up to five million litres of recycled water each day.
  - **The Western Sydney Recycled Water Initiative** will recycle up to 27 billion litres of treated wastewater each year by 2015. Construction has begun on the first stage, the **Replacement Flows Project** due for completion in 2010. A new recycled water plant will decrease the current total nitrogen and phosphorus loads discharged from St Marys, Penrith and Quakers Hill STPs. Up to 50 megalitres per day of highly treated recycled water will be released, replacing water currently released from Warragamba Dam to maintain environmental flows. Dual reticulation for recycled water will also be progressively rolled out in urban growth areas as they are developed (www.sydneywater.com.au/MajorProjects/WesternSydney/ReplacementFlowsProject/index.cfm).
- Sydney Water is continuing to make considerable **investment in capital works**. Over the past decade, nutrient loads discharged from Sydney Water's inland STPs have decreased considerably as a result of investment to upgrade existing facilities and close old and poorly performing plants including:
  - The new **Wallacia STP**, which replaced Warragamba STP in 2006, has reduced phosphorus and nitrogen loads discharged by 78% and 65% respectively.
  - Work has recently been completed on a program to connect all remaining Blue Mountains STPs to Winmalee STP, with Blackheath STP ceasing discharge to the Grose River in July 2008.

- Sydney Water is undertaking integrated planning for the provision of potable water, recycled water and wastewater in the North West and South West Growth Centres at the request of the Growth Centres Commission (now Department of Planning). The provision of recycling will significantly reduce the nutrient load from sewage effluent when compared to traditional approaches. Where some unused effluent is discharged, environment protection requirements will limit the load discharged to the river. While Sydney Water has prepared environmental impact assessments for the first release precincts in the Growth Centres, Sydney Water may not be the service provider for all precincts within the Growth Centres due to the introduction of the *Water Industry Competition Act 2006*.
- Sydney Water is implementing programs to reduce sewer overflows. Many sewage pumping stations have been closed or upgraded to prevent sewer overflows in dry weather and there is ongoing action to prevent overflows in wet weather. The implementation of SewerFix (www.sydneywater.com.au/majorprojects/Wastewater/SewerfixProgram.cfm), an extensive program to reduce the number of sewage overflows reaching waterways and protect public health, has also reduced nutrient loads. SewerFix targets three main areas: reducing wet weather overflows, reducing dry weather overflows and rehabilitation of sewers.

Strategic priorities

To contribute to reduced nutrient loads from sewage treatment systems, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- Continue to **reduce nutrient loads** through use of cost-effective technology at STPs.
- Provide **recycled water** as an alternative water source where cost-effective and practicable.
- Incorporate measures to **limit the growth in waste water nutrient loads** from development in the lower Hawkesbury-Nepean in planning for integrated servicing of the Growth Centres.
- Continue to implement cost-effective measures to **reduce sewer overflows**.
- Investigate measures to support, promote and supplement **changes to the operating environment** such as the commissioning of the Replacement Flows Project, urban growth and recent reforms to encourage private sector involvement in wastewater services in Sydney.

Next steps

Next steps to reduce nutrient loads from sewage treatment systems committed to as part of this Strategy

Action 5.1 The Hawkesbury City Council will construct the **South Windsor Effluent Reuse Scheme** (www.hawkesbury.nsw.gov.au/environmental-services/water-and-sewerage/the-hawkesbury-nepean-river-recovery-program) from 2010 to 2011 as part of the Hawkesbury-Nepean River Recovery Project. This scheme involves the construction of a recycled sewage treatment plant and distribution system to supply recycled water for open space irrigation. It aims to reduce total nitrogen loads discharged to the river system and also provide a small reduction in phosphorus.

Action 5.2 DECCW will liaise with Sydney Water to review environment protection licence arrangements for the sewage treatment systems in the lower Hawkesbury-Nepean.

3.7 Degraded land and riparian vegetation nutrient actions

Progress to date

Progress to date to restore, revegetate and manage riparian areas

- The HNCMA, councils and other agencies have extensive **programs to support on-ground works** to restore and rehabilitate vegetation along degraded creeklines, riparian corridors and sensitive swamps. A number of projects to rehabilitate streams and repair land degradation and erosion damage to waterways have also been undertaken. Many of these projects are undertaken with the assistance of bush regeneration contractors and community volunteers.
  - The **River Restoration Project** (www.hn.cma.nsw.gov.au/topics/2106.html) is restoring creek and river banks in key river reaches identified by the Hawkesbury-Nepean River Health Strategy. In 2006–07, $1.15 million was invested by the HNCMA to deliver landholder projects such as fencing creek and river banks to protect riparian zones and providing off-river stock watering systems.
  - **Landcare** activities supported by the HNCMA are restoring riparian vegetation through the removal of weeds such as willows, and planting of native species.
  - The **Capertee and Wolgan Valley Soil Conservation Project** has completed projects to reduce land degradation and soil erosion through a partnership between the HNCMA, Capertee Valley Catchment Group and local communities.
- **Property management programs** including rehabilitation of disturbed sites such as coal mines, bushfire management and noxious weed controls are implemented by major landholders in the region including Land and Property Management Authority and National Parks and Wildlife Service (a part of DECCW).
- A number of **regulatory and planning controls** are in place for conserving and improving riparian vegetation and managing erosion.
- **Improved soil management planning** is supported by an interactive DVD – *Soil and Land Resources of the Hawkesbury-Nepean Catchment* – released in September 2008 (www.environment.nsw.gov.au/publications/slrhnc.htm). The DVD maps degraded areas of soil and land as well as those that are vulnerable to degradation across the entire Hawkesbury-Nepean catchment, providing comprehensive property planning information to land owners and land managers.

Strategic priorities

To contribute to enhanced nutrient buffers by managing and restoring degraded land and riparian vegetation, local councils, State Government agencies and other organisations are encouraged to develop actions that support these strategic priorities.

- Plan works in accordance with the Hawkesbury-Nepean **River Health Strategy management objectives** (maintain the condition of reaches in natural or near natural condition, maintain and improve reaches in good condition, improve the environmental condition in the remaining reaches, achieve the highest environmental and community gain for the resources).
- Discuss new restoration proposals with neighbouring councils and the HNCMA who will **coordinate the various programs** in sub-catchments to ensure priority areas are targeted for funding and on-ground works.
- To **maximise long-term benefits**, address the causes of urban stream erosion and minimise high nutrient loads being released into the aquatic environment prior to stream habitat restoration.

- Councils and the HNCMA to continue to **educate and support** landholders to rehabilitate degraded land, protect and restore creeks and river banks, and continue to support community groups with riparian zone planting and weed removal.
- Include management objectives to reduce nutrient loads in **land and property management plans** by government agencies such as councils, DECCW, and Land and Property Management Authority, for example by improving riparian vegetation and weed control where appropriate.
- In **planning studies** for any major redevelopment sites, address soil and land-use constraints and ensure there is a commitment to long-term riparian corridor management.

Next steps

Next steps to enhance nutrient buffers by managing and restoring degraded land and riparian vegetation that have been committed to as part of this Strategy

Action 6.1 Hawkesbury-Nepean CMA will work with agencies and councils to ensure that the aims and objectives of **Catchment Action Plans** are readily understood and considered in relevant decision-making, planning and reporting processes.

Action 6.2 Hawkesbury-Nepean CMA will work with agencies and councils to implement the **Hawkesbury-Nepean River Health Strategy** (www.hn.cma.nsw.gov.au/topics/2201.html) and other such strategies which promote a coordinated approach to riparian fencing and re-establishment of riparian areas.

Action 6.3 DECCW will investigate benefits of developing a tool to help the HNCMA and land managers identify areas where **gully erosion is likely to pose a high risk** to the surrounding environment.

Action 6.4 DECCW and relevant agencies will continue to work with the Department of Planning on developing model provisions and definitions relating to riparian areas, which assist local councils in developing their local environmental plans.

Appendix 1: Objectives for water quality and guidelines for nutrient levels

The strategic framework for water quality improvement in the Hawkesbury-Nepean is provided by the water quality objectives determined by the NSW Healthy Rivers Commission inquiry into the Hawkesbury-Nepean system in the late 1990s (HRC 1998) and agreed to by the NSW Government through a Statement of Joint Intent in 2001. The water quality objectives recognise the community's 'environmental values' and uses of the waterways and provide goals that help in the selection of the most appropriate management options. Water quality objectives consist of three parts: environmental values, water quality indicators and their guideline levels.

The environmental values that have been identified as applying to all of the lower Hawkesbury-Nepean catchment waterways are:

- protection of aquatic ecosystems
- secondary contact recreation
- visual amenity.

Some sections of the river and its tributaries have also been recognised as providing additional environmental values such as:

- water for irrigation and general use
- livestock drinking
- human consumption of aquatic foods
- raw drinking water
- primary contact recreation.

The Hawkesbury-Nepean River Health Strategy released in 2007 also identifies economic, social and environmental values of 150 river reaches as well as threats to those values as a basis for setting management objectives and actions. A panel process of assessment was used to capture values of importance to the local communities and experts.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000) help to define the in-stream water quality to protect these environmental values. Nutrient concentrations for total phosphorus and total nitrogen and biological indicators such as level of nuisance algae are key water quality indicators for these environmental values.

For nutrients, there are guideline trigger values in ANZECC & ARMCANZ (2000) for aquatic ecosystems varying from 350–500 µg/L total nitrogen and 25–50 µg/L total phosphorus for lowland rivers. Numerical criteria were also identified for nutrient concentrations for various parts of the Hawkesbury-Nepean river system following the Healthy Rivers Commission inquiry in 1998 (HRC 1998), and these are shown in the examples in Table 1. These criteria pre-date the ANZECC/ARMCANZ trigger values. Separate values are available for other areas such as estuaries and marine waters. Water quality guidelines for recreational waters identify that nuisance organisms such as macrophytes, filamentous algal mats and blue-green algae should not be present in excessive amounts. Specific algal cell count levels are provided as guidelines to protect recreational and water supply values.

Water quality indicator	Guideline value
Total nitrogen (mg/L)	< 0.7 (mixed use rural areas) < 0.5 (urban areas – main stream) < 1 (urban areas – tributary stream)
Total phosphorus (mg/L)	< 0.035 (mixed use rural areas) < 0.03 (urban areas – main stream) < 0.05 (urban areas – tributary stream)

Table 1: Hawkesbury-Nepean Healthy Rivers Commission Inquiry nutrient guidelines for water quality objectives[1]

It is important to recognise that these criteria are trigger values to help guide decision-making in achieving environmental values; they are not of themselves limits or targets. In the absence of specific local studies the relevant ANZECC/ARMCANZ trigger values are typically used to guide decision-making. Planning and management decisions need to recognise that activities and decisions made upstream affect water quality downstream. In addition, the effects of other environmental conditions also need to be taken into account, including the flows and volume of water body, mixing, light, turbidity, temperature, suspended solids and nutrient status of sediments.

The Strategy adopts the guiding principles that where the environmental values are already being achieved, they should continue to be protected, and where they are not being achieved, relevant activities and development should work towards their achievement over time. The time frame for achieving these depends on the current condition of the waterway and the practical and economic feasibility of restoring the waterway or reducing impacts on it. It is not acceptable for developments or activities to implement a lesser level of environmental performance, simply because a waterway is currently degraded.

[1] Statement of Joint Intent for the Hawkesbury-Nepean River System, 2001.

Appendix 2: Relationship to other plans and strategies

Name of plan	Relevance to nutrient management
National Water Quality Management Strategy and National Water Initiative	The Strategy is consistent with the national frameworks to manage water resources and water quality as set out in the Australian Government's *National Water Initiative* and *National Water Quality Management Strategy*, including the companion technical reference of the Australian and New Zealand Environment Conservation Council (ANZECC) 2000: *Guidelines for Fresh and Marine Water Quality*.
Water Smart Australia Program	Under the Water Smart Australia Program, the Australian Government is funding $77.4 million for the Hawkesbury-Nepean River Recovery Project. This will support implementation of a package of projects until 2011 to improve river health below the major water supply dams by increasing the water available for environmental flows and by reducing nutrient loads to the river.
NSW State Plan	The Strategy will contribute to delivering against the Natural Resource Management targets in the NSW State Plan to improve riverine and estuarine ecosystems. These targets have been informed by the NSW Water Quality Objectives which are consistent with the national framework. The Natural Resources Commission set the targets and also has a Standard for Quality Natural Resource Management available online at www.nrc.nsw.gov.au.
Diffuse Source Water Pollution Strategy	The Strategy is guided by the priorities and actions identified in the state-wide *NSW Diffuse Source Water Pollution Strategy*. Sediments, pathogens and nutrients are identified as the priority diffuse source pollutants and a priority action plan set out to address these across the state. The implementation website will host links to programs and actions to manage diffuse pollution. Further detail on the Strategy is available at www.environment.nsw.gov.au/water/dswp.htm
Healthy Rivers Commission and Statement of Joint Intent Hawkesbury-Nepean River Management Forum	The Strategy has been developed in the context of past recommendations to improve the sustainable management of the Hawkesbury-Nepean river system from the Healthy Rivers Commission, as endorsed and modified in the NSW Government's *Statement of Joint Intent for the Hawkesbury-Nepean River System* in 2001. Further to this, the Hawkesbury-Nepean River Management Forum made a series of recommendations relating to environmental flow regimes, demand management, effluent reuse and modification of weirs to improve the health of the river without compromising Sydney's water supply (HNRMF 2004). Many of the recommendations were adopted by Government and implemented under the Metropolitan Water Plan. Many initiatives have since been achieved.
Metropolitan Water Plan	The Strategy has been identified as an action towards protecting catchment and river health in the NSW Government's *2006 Metropolitan Water Plan* (NSW Government 2006). The plan sets out how the NSW Government will provide a secure supply of water that can meet the long-term needs of Sydney. Other key components of the plan that particularly relate to the management of nutrients include: • protecting river health through the release of environmental flows from water storages • on-ground catchment actions and monitoring • various initiatives to increase recycling including significant wastewater recycling projects. The *2008 Metropolitan Water Plan Progress Report* shows that implementation of the plan is well on track, and a number of important initiatives are underway to improve the health of the Hawkesbury-Nepean River (NSW Government 2008). Further detail on the plan and progress reports is available at www.waterforlife.nsw.gov.au.

Name of plan	Relevance to nutrient management
Water sharing plan and environmental flows	The implementation of new environmental flow regimes for major dams and weirs in the Hawkesbury-Nepean catchment and a water sharing plan for Sydney will support the Nutrient Management Strategy. Environmental flows from Avon Dam in the upper Hawkesbury-Nepean River catchment began in 2008. The other upper Nepean dams (Cataract, Cordeaux and Nepean) and weirs have also been configured to allow environmental flow releases to be made, and to pass down the river for environmental benefit. Environmental flows from these dams will be implemented when the weirs are capable of passing these flows. This is expected to occur in 2010. Work is also presently underway to identify a final regime for environmental flow releases from Warragamba Dam. The Government is presently finalising a water sharing plan for unregulated rivers of the Sydney Region that will define the rules relating to releases of environmental water from major dams and weirs, as well as the rules relating to licensed extraction of water for Sydney's water supply as well as by irrigators and others.
Hawkesbury-Nepean River Health Strategy and Catchment Action Plan	The Strategy is guided by the values, threats and management strategies identified in the catchment-wide Hawkesbury-Nepean River Health Strategy, released by the Catchment Management Authority in 2007 (HNCMA 2007). Widespread consultation in developing the River Health Strategy identified nutrients and aquatic weed and algae occurrence along river reaches as major threats to the catchment's natural resources. The River Health Strategy nominates the need for management action by other institutions to 'reduce nutrients entering waterways to reduce favourable conditions for aquatic weed growth'. Linked with the River Health Strategy, the Catchment Action Plan released in May 2008 sets directions for the investment and activities of the CMA to improve the catchment (HNCMA 2008). These strategies direct a number of significant and successful programs run by the Hawkesbury-Nepean Catchment Management Authority that work with community and Landcare groups to provide either direct or indirect reductions in nutrient loads.
Other relevant NSW Government strategies	Other strategic documents that relate to the Strategy include the NSW Oyster Industry Sustainable Aquaculture Strategy (DPI 2006) and the Metropolitan Strategy: City of Cities – a Plan for Sydney's Future (NSW Government 2005).
Council environmental management plans and strategies	Local priorities and actions identified by councils as part of various water- and environment-related activities are reflected in Council Management Plans and Investment Plans as well as Environmental Planning Instruments. These activities will be informed by this Strategy, facilitating a greater degree of consistency in the management of nutrients across the catchment.

Appendix 3: Nutrient background information

What are nutrients, and why are they important in the river?

The nutrients nitrogen and phosphorus are basic building blocks of plant life. Algae and aquatic plants require certain amounts of these nutrients to grow. Nitrogen and phosphorus occur naturally in waterways, and where levels of these nutrients in the water are relatively low, algae and aquatic plants tend to be in balance with the rest of the ecosystem. However, where nutrient levels are higher, growth of algae and aquatic weeds can reach nuisance proportions. This can reduce the overall species diversity of the environment and may trigger changes in species' distribution and structure.

The river is a complex system, and the growth of nuisance algae and aquatic weeds is influenced by many factors in addition to nutrients, including light penetration, river flow, residence times, stratification and water temperature; however, nutrients are known to be a key contributing factor.

Is phosphorus more important than nitrogen?

In the past there has been a general belief that phosphorus is the more important nutrient in freshwater systems, with nitrogen being more important in marine and estuarine systems. More recent assessment has found that nitrogen provides as important a contribution as phosphorus to undesirable freshwater riverine responses such as algal blooms and excessive growth of aquatic weeds.

Where do nutrients come from?

Water quality in the Hawkesbury-Nepean is affected by nutrients from diffuse sources such as urban and agricultural runoff and point sources such as sewage treatment plant discharges.

The relative importance of diffuse and point sources is complex but is related to timing, size and location of nutrient inputs as well as river flow conditions. In terms of total loads, diffuse sources contribute most of the nutrient load to the river; however, during drought and dry weather conditions, point sources contribute the majority of the load.

It has been estimated that in urbanised catchments diffuse sources contribute approximately 70–80% of the total nitrogen and total phosphorus loads with point sources contributing the remainder (Davis and Koop 2006). In less populated areas, the diffuse source contribution can be as high as 96–98% of the total load.

Does the source of the nutrients matter?

The nutrients nitrogen and phosphorus are generally found in a range of chemical forms. Some of these chemical forms are more easily used by bacteria, algae and aquatic plants for growth. These forms are considered to be more 'bioavailable'.

In simple terms, bioavailable nutrient inputs tend to increase with population and human activity such as urbanisation and agriculture due to increased erosion, inputs of inorganic fertilisers, manure from livestock, discharge of sewage effluent, stormwater runoff and removal or disturbance of wetlands and riparian zones. Studies have demonstrated that these sources deliver dissolved inorganic forms of nutrients that tend to be more readily bioavailable (Davis & Koop 2006). These are therefore the focus of efforts to reduce nutrient loads to the river.

Nutrients in river sediments

River sediments can become a store for nutrients through natural processes such as sediment deposition and plant decay. Sediments can be deposited during low flows and slower moving waters such as in weir pools. Under conditions where flow is low and stratification has occurred, nitrogen and phosphorus nutrients can be released from sediments under low dissolved oxygen conditions and become available for plant growth. There is also potential for nutrients to be made available when sediments are disturbed by high flows.

Why are river flows and residence time also important?

Changes in the flushing rates of rivers, lakes and estuaries have a major impact on the ecosystems and their water quality. Systems that are highly flushed can be clear and dominated by aquatic macrophytes. Systems with still or slow moving river flows leading to retention of nutrients for a longer time ('long residence') tend to lose native aquatic plants and become dominated by algae and introduced aquatic weeds.

In the Hawkesbury-Nepean River system natural river flows are affected by the dams and weirs. This has increased the areas subject to longer residence times leading to algal and aquatic weed growth due to lower turbidity and the time available for growth. The formation of relatively stable layers of water ('stratification') may also occur under these conditions, resulting in changes to water quality conditions that favour nutrient release from sediments (see above).

Climate change impacts on nutrients

NSW Government agencies and the University of NSW are developing climate change forecasts for the Sydney region (DECC 2008). Interim findings from the project indicate there may be an increase in spring rainfall and a decrease in winter rainfall. An increase in maximum temperatures is projected, with the greatest warming in spring (2–3^{o}C). Higher temperatures and changes to evaporation are likely to create slightly drier conditions in winter and spring. The pattern of the El Niño-Southern Oscillation cycle is projected to continue, but with hotter and drier El Niño events and more frequent storms with heavy downpours during La Niña years.

Overall, these changes will more likely than not lead to a slight increase in average annual runoff. However there may be some redistribution of runoff across the seasons, with likely increases in summer and autumn and decreases in winter and spring. Changes to rainfall are likely to increase sediment shedding from the hinterland, potentially causing changes to stream channels including bank erosion. Agriculture and urban development within floodplains may be affected by sediment deposition, increased flood risk and saltwater inundation.

The consequences of climate change on nutrient levels in the streams and rivers in the Hawkesbury-Nepean catchment will depend on what range of hydrological change is realised as well as the influence of water infrastructure management.

A more detailed study looking specifically at the potential climate change impacts on Sydney's water supply and demand is currently underway. This study is a collaboration between the Department of Environment, Climate Change and Water, Sydney Water Corporation, Sydney Catchment Authority, University of New South Wales, CSIRO and the Commonwealth Department of Climate Change and Energy Efficiency. It will take into account local conditions in Sydney's drinking water catchments, and will project customer demand under climate change scenarios. The final report from this study is expected in 2010.

Aquatic weeds

Native species of large aquatic plants (macrophytes) such as water ribbon (*Vallisneria gigantea*) play an important role in the river in absorbing nutrients, and providing habitat for fish such as bass. However, excessive aquatic weed growth has a range of impacts, such as interfering with recreation and navigation, damaging irrigation pumps and boat motors as well as suppressing native macrophyte growth. Aquatic weeds are known to hamper trawlers operating in the river as far downstream as Wisemans Ferry. Aquatic weeds moving downstream during higher flow events also have the potential to damage infrastructure such as ferry cables. While excessive growth of macrophytes has impacts, this may limit the likelihood of the river becoming algal dominated.

Some of the commonly occurring aquatic weeds in the Hawkesbury-Nepean River include submerged weeds, egeria (*Egeria densa)* and elodea *(Elodea canadensis)*, and floating weeds, alligator weed (*Alternanthera philoxxeroides*), salvinia (*Salvinia molesta)* and water hyacinth *(Eichhornia crassipes).* For example, during the summer of 2003–04 the lower Nepean and Hawkesbury Rivers experienced a significant outbreak of *Salvinia molesta*, resulting in large floating mats of weeds. NSW Maritime and I&I NSW are working together to control the spread of salvinia and other nuisance aquatic weeds in the lower Hawkesbury-Nepean River.

There are also a large number of emerging weeds that, although not yet strongly established, could pose a serious threat in the future. It can be difficult to determine which plant may become a nuisance in any one year. There are many factors which can influence a species becoming dominant, including competition from other species, river flow conditions and nutrients.

In 2007 DECC commissioned I&I NSW to map the distribution of submerged, emergent and floating freshwater macrophytes, both native and weed species, in the Hawkesbury-Nepean River from Warragamba Dam to Wisemans Ferry. Within the surveyed area general observations included:

- Much of the shoreline from Warragamba Dam to Wisemans Ferry was vegetated with emergent or submerged macrophytes.
- The greatest number of native species and exotic species were located in the Wilberforce to Fairlight Gorge stretch of the river.
- The native water ribbon was present throughout much of the surveyed area.

With regard to aquatic weeds the observations included:

- The aquatic weed egeria was present throughout much of the surveyed area with the abundance of egeria thought to be markedly influenced by minor flooding that occurred in the winter of 2007.
- Floating macrophyte weed species were restricted to the more central section.
- The emergent weeds Senegal tea (*Gymnocoronis spilanthoides)* and sagittaria (*Sagittaria graminea* ssp. *Platyphylla)* are present in limited amounts in the central section.

DPI Fisheries sampling in 2004 and 2007 suggests that egeria may have expanded its distribution, particularly in the reach around Richmond and Windsor.

Algal blooms

Algae are present in waterways at all times, although under certain conditions they grow rapidly and blooms can form, making the river at times unsuitable for swimming, water skiing, boating and irrigation. Algal blooms occur in the weir pools along the Nepean River during low flows and there is a history of algal booms in the reach from just upstream of Yarramundi down to Sackville.

Algal blooms can have a range of impacts depending on the types of algae and area of the river. Blue-green algae can produce toxic compounds which can make water unfit for human or animal consumption or contact, severely restricting use of the river by businesses and the community. Filamentous algae growth (long strands of algae) can hamper recreational use and clog irrigation pumps and boat motors, as well as smothering native aquatic plants. Community concern about algal blooms and water quality may reduce consumer confidence in fishery products such as oysters and prawns.

Algal monitoring in the Hawkesbury-Nepean is well established with records dating back to the early 1970s. The Hawkesbury-Nepean River Environmental Monitoring Program has identified declines in chlorophyll-a levels but little change in blue-green algal counts at many sites. Biological monitoring of the river has also detected significant changes in blue-green algal species composition, with non-toxic species of *Aphanocapsa* largely replacing *Anabaena* and *Microcystis* as the dominant bloom species in the river. The exact reasons for this community shift are unknown but it is of particular interest for predicting future changes.

Appendix 4: Background to diffuse source assessment – Land-use mapping and nutrient loads

Previous nutrient modelling exercises

The Catchment Management Support System (CMSS) was developed to predict the consequence of land use and/or land-use management practice on total phosphorus and total nitrogen loads generated within a catchment. During 1992–93 the then Water Board used CMSS to assess the impact of urban development on water quality in the Hawkesbury-Nepean Basin (Cuddy *et al*. 1994).

As part of this exercise CMSS was run to predict average annual total phosphorus and total nitrogen loads generated from land uses on a catchment and sub-catchment scale. Land uses were mapped at a scale of 1:25,000 and nutrient generation rates derived from published literature, expert knowledge and unpublished data. For the lower Hawkesbury-Nepean the model identified that, following bushland, the land-use categories of fertilised and unfertilised grazing and unsewered peri-urban were the next highest contributors for total phosphorus loads. Total nitrogen loads were dominated by bushland followed by unsewered peri-urban, fertilised grazing and unfertilised grazing.

In 1999 CMSS was used by the NSW Environment Protection Authority (EPA) to estimate total nitrogen and total phosphorus loads by land use on a sub-catchment scale for the Hawkesbury-Nepean catchment. Rates were assigned to each of ten land use categories based on published export rates, monitoring data and local expert opinions. The model assumed that all nutrients generated within a catchment were capable of reaching major waterways. For the lower Hawkesbury-Nepean, this exercise identified, after bushland, the next highest contributors to total nitrogen loads as unsewered peri-urban, followed by fertilised and unfertilised grazing. Total phosphorus loads were dominated by the land uses fertilised grazing, unsewered peri-urban, unfertilised grazing, urban, and then intensive vegetable and turf growing.

The NSW EPA also undertook a GIS-based project in 2000 to help identify diffuse sources of pollution and determine quantities of nutrients which may be contributed to waterways at different spatial and temporal scales in the South Creek catchment. Results from this modelling exercise suggested that market gardens potentially contributed the highest total nitrogen and total phosphorus loads to waterways followed by pasture (improved and unimproved) and urban and industrial/commercial land uses.

As can be seen, results vary among the modelling exercises. This may be due to different land-use area estimates and which land uses are assigned to various land-use categories. In particular, the rates assigned to nutrient exports from various land uses have varied over time as more research and local knowledge have refined estimates.

More recently the Sydney Catchment Authority has developed the Catchment Decision Support System (CDSS) to rank and prioritise pollution sources in the catchments. The CDSS is a risk-based spatial analysis tool which maps and ranks the sources' four priority pollutants (pathogens, total phosphorus, total nitrogen and suspended solids) across 14 pollution source modules including grazing, sewage treatment plants and urban storm water. When combined with water quality risk assessment results for raw water supply and a range of other considerations, it greatly assists the SCA to prioritise catchment management responses as part of its catchment planning and delivery process.

Methodology to estimate diffuse source nutrient contributions

The following methodology was used to estimate current nutrient loads from diffuse sources in the lower Hawkesbury-Nepean for the purposes of the Strategy.

Land-use mapping

DECCW recently completed a comprehensive land-use mapping exercise for NSW that generated over 500 detailed land-use classes at spatial scales as small as individual lots through to national parks (land-use mapping does not cover the full extent of the Hawkesbury-Nepean catchment as seen in Map 2 and Map 3).

The land-use layer represents a data set of land use between June 2000 and June 2007 for NSW. The land-use mapping was undertaken using satellite imagery, aerial photography, existing data sets, local knowledge and field verification as the main data sources. Officers independent of DECCW, with more than 20 years experience in land-use classification techniques, validated the original mapping and classification of polygons. The overall accuracy of the mapping ranges from 92–99%.

Each land-use class includes a detailed description of characteristics that define it. Assigned to each detailed land-use class is a land-use category based on the Australian Land Use and Management (ALUM) classification system. This system provides a nationally consistent method to collect and present land-use information across Australia. (For more information regarding the ALUM classification system refer to the Australian Government Bureau of Rural Sciences website: adl.brs.gov.au/mapserv/landuse/index.cfm?fa=classification.class&tab=class.)

For the purposes of the Strategy, each ALUM category was assigned to one of seven major land-use categories as presented in Table 2. The seven categories effectively capture the major land-use groups in the catchment and represent a combination of categories used in previous modelling exercises, available nutrient export rates, and discussions of the Working Group.

Nutrient exports

A ‘typical’ rate of nutrient exports for total nitrogen and total phosphorus was assigned to each of the eight major land-use categories, based on a combination of:

- rates used in DECCW’s Diffuse Source Water Pollution Estimator (www.environment.nsw.gov.au/dwpe/index.htm). These rates integrate a range of published studies and expert knowledge
- current published literature
- expert opinion gained through Working Group discussions.

There is considerable variability among published rates of nutrient exports for each land-use category. This variability can be attributed to a range of factors, including the scale of assessment and the inherent site-specific physical and climatic conditions particular to a location, such as soil type, erosion hazard, slope, aspect, rainfall, past management practices, distance to receiving waters, etc. Furthermore, current practices at specific locations, such as fertiliser application and mitigation techniques, will also contribute to variation in rates.

The rates used in the Strategy therefore represent an ‘estimate’ of long-term average conditions which may be encountered in the catchment and are subject to considerable variation and uncertainty.

Nutrient load calculation

The total area occupied by each land-use category for each sub-catchment was multiplied by the estimated nutrient export rate to determine the total nutrient load for each land-use category.

Due to the variability of nutrient export rates, the calculated nutrient loads provide a broad-scale picture of the nutrient load contribution from various land uses and sub-catchments. For this reason the ‘relative’ nutrient loads have been used to compare contributions among land uses on a sub-catchment basis, rather than absolute loads.

At present, the calculated nutrient loads cannot be used to identify nutrient hot spots at a local scale or to accurately predict loads from changes in land use or adoption of best management practices. The analysis simply provides an overview of relative diffuse source loads for comparative purposes.

A comparison of the results across a range of different rates for nutrient exports was conducted based on a review of published rates, particularly studies for the Hawkesbury-Nepean catchment (Baginska *et al*. 1998, McNamara & Cornish 2001, Hollinger *et al.* 2001 and Dougherty 2008). This found that the different land-use categories remain relatively consistent in rank in terms of the nutrient loads exported, but there may be some shifts in percentage contributions within a catchment.

GIS maps

GIS land-use maps were also produced to help identify broad-scale geographic trends in nutrient load distribution to assist in the identification of regions where nutrient abatement efforts may be directed.

Table 2: Land-use categories

Major land-use category	Description	Examples of assigned ALUM categories
Urban environment	Urban residential and built environment, including commercial, industrial and roads and car parks	o Transport and communication o Utilities o Residential o Manufacturing and industrial
Rural residential	Rural residential land and associated uses	o Rural o Intensive uses
Grazing	Livestock grazing of modified pastures and natural vegetation	o Grazing modified pastures o Grazing natural vegetation
Intensive horticulture	Intensive cropping practices	o Intensive horticulture o Irrigated perennial horticulture o Irrigated seasonal horticulture o Seasonal horticulture o Production from dryland agriculture and plantations
Intensive animal production	Farms with high intensity animal practices, e.g. poultry and dairy farms	o Intensive animal production
Non-intensive agriculture/cropping	Non-intensive agriculture and cropping	o Cropping o Irrigated cropping o Irrigated modified pastures o Perennial horticulture o Irrigated land in transition
Other diffuse	A number of categories of human land-use activities not covered elsewhere	o Mining o Waste treatment and disposal o Services

Note: Natural bushland, forests and waterways categories are not included in this assessment.

Appendix 5: Further reading and resources

Stormwater and water sensitive urban design (WSUD)

Department of Environment, Climate Change and Water resources

The following are available at: www.environment.nsw.gov.au/stormwater

DECC (2008) *Managing Urban Stormwater: Soils and Construction - Volume 2A: Installation of Services, Volume 2B: Waste Landfills, Volume 2C: Unsealed Roads, Volume 2D: Main Road Construction, Volume 2E: Mines and Quarries*

DECC (2007) *A Resource Guide for Local Councils: Environmental Management of Council Operations*

DECC (2006) *A Resource Guide for Local Councils: Erosion and Sediment Control*

DECC (2006) *Managing Urban Stormwater: Harvesting and Reuse*

DECC (2007) *Improving the Environmental Management of New South Wales Golf Courses*, Australian Golf Course Superintendents Association

Environment Protection Authority (EPA) (2002) *Site Guide: Environmental Planning for Landscaping Works and Model EMP: Environmental Management Plan for Landscaping Works*

Landcom resources

The following are available at www.landcom.com.au

Landcom (2004) *Managing Urban Stormwater: Soils and Construction Volume 1*, 4th Edition, commonly known as the 'Blue Book'

Landcom (2004) *The Hip Pocket Handbook*, 1st Edition

Landcom (2004c) *Planning for Erosion and Sediment Control on Single Residential Allotments*, 1st Edition

Landcom (2008) *Open Space Design Guidelines*

Water Sensitive Urban Design (WSUD) in the Sydney Region resources

The following are available at www.wsud.org

Water Sensitive Urban Design in the Sydney Region (WSUD Sydney) (2003) *Water Sensitive Planning Guide for the Sydney Region and a series of Practice Notes*

Upper Parramatta River Catchment Trust (UPRCT) (2004) *Water Sensitive Urban Design Technical Guidelines for Western Sydney*

The WSUD Sydney website also includes a Tools & Resources section (www.wsud.org/tools-resources) with technical information and guidance, enabling the translation of best practice WSUD into strategies, policies, plans, practices and on-ground works. It also contains a Planning & Policy section (www.wsud.org/planning-policy) with an overview of WSUD legislative and policy tools at the federal, state and local level, and details an 'ideal' local council with WSUD integrated throughout the organisation and within development located in its local government area.

Other WSUD resources

Southern Sydney Regional Organisation of Councils (undated) *Do it Right on Site Fact Sheets*

For more information visit www.ssroc.nsw.gov.au/publications.aspx

Other material, including training videos and trade-specific leaflets, is available from the HNCMA or www.cityofsydney.nsw.gov.au/Environment/Water/WhatYouCanDo.asp

Sydney Metropolitan CMA (2008) *Incorporating Appropriate Stormwater Management / WSUD Requirements in Local Environment Plans*, Botany Bay Coastal Catchments Initiative

For more information visit www.sydney.cma.nsw.gov.au/bbcci/WaterSensDesign.html

Agriculture

Department of Primary Industries (2007) *Best Practice Guidelines for Using Poultry Litter on Pastures*

Department of Primary Industries (2006) *Deep Litter Housing for Pigs*

For more information visit www.dpi.nsw.gov.au/agriculture. Various agnote fact sheets are also available on issues such as *Sustainable horticulture*, *Fertiliser calculations*, *Managing blue-green algae in farm dams*, *Agricultural land classification* and *Managing wastewater from intensive horticulture*.

DECC and DPI (2006) *Guidelines for Using Compost in Land Rehabilitation and Catchment Management*

DECC (2008) *South Creek Agricultural Education Partnership Program*, Factsheet, NSW Environmental Trust

DECC (2008) *Soil and Land Resources of the Hawkesbury-Nepean Catchment: Interactive DVD*

DECC (2004) *Environmental Management on the Urban Fringe: Horse Properties on the Rural Urban Fringe, Property Management Plan, Environmental Assessment, Economic Incentives for Environmental Management*

For more information visit www.environment.nsw.gov.au

Malcolm, P & Fahd, R (2009) *Ground Truthing of the Sydney Vegetable Industry in 2008*, Horticulture Australia Limited and NSW Department of Primary Industries.

Drinking water

Scott, B & Knights, P (2008) 'A Decision Support System for Rectification Action Planning in the Sydney Drinking Water Catchments', in Lambert, M, Daniell, T, and Leonard, M (eds), *Proceedings of Water Down Under 2008*, 14–17 April 2008, Adelaide.

For more information visit www.sydneywater.com.au

On-site wastewater systems

Department of Local Government (1998) *Environment & Health Protection Guidelines On-site Sewage Management for Single Households*

Department of Local Government (2000) *The Easy Septic Guide*

For more information visit www.dlg.nsw.gov.au. Also available are circulars, questions and answers and links to related Department of Health documents.

Degraded land and riparian vegetation

Department of Water and Energy (2008) *Guidelines for Controlled Activities*: various, including Riparian corridors; Vegetation Management Plans among others

For more information visit www.hn.cma.nsw.gov.au. Also available are various case studies and details on HNCMA and Landcare programs.

Examples of Environment Trust projects underway

Achieving Sustainable Sporting Fields (Penrith City Council with partners Auburn Council and Camden Council)

Implement Ropes and South Creek Regional Open Space Management Plan (Penrith City Council and partner Blacktown City Council)

Water in the Landscape Regional Community Engagement for Water Management (WSROC with partners: Auburn Council, Bankstown City Council, Baulkham Hills Shire Council, Liverpool City Council, Hawkesbury City Council, Holroyd City Council, Parramatta City Council, Penrith City Council)

Werrington Creek Rehabilitation and Community Engagement Project (Penrith City Council)

Urban Waterway Management Framework for Wollondilly LGA (Wollondilly Shire Council)

Erosion and Sediment Control – Eliminating Excuses in the Bush (Master Builders Association of NSW)

New Estates Sustainable Living Education Program (Landcom)

For more information on Urban Sustainability and other Environment Trust program grants visit www.environment.nsw.gov.au/grants/Summary.htm

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DECC—*see* Department of Environment and Climate Change NSW

Department of Environment and Climate Change NSW (2008) *NSW Climate Change Action Plan: Summary of Climate Change Impacts Sydney Region*, Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change NSW (2009a) *Hawkesbury-Nepean River Environmental Monitoring Program – Final Technical Report*, Department of Environment and Climate Change, Sydney.

Department of Environment and Climate Change NSW (2009b) *NSW Diffuse Source Water Pollution Strategy*, Department of Environment and Climate Change, Sydney.

Department of Local Government (2005) *Onsite Wastewater Management Survey of NSW Councils*, Department of Local Government, Nowra.

Department of Primary Industries (2006) *Oyster Industry Sustainable Aquaculture Strategy*, Department of Primary Industries, Fisheries Conservation and Aquaculture Branch.

DLG—*see* Department of Local Government

DoP & SCA—*see* Department of Planning and Sydney Catchment Authority

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DPI—*see* Department of Primary Industries

GCC—*see* Growth Centres Commission

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Hawkesbury-Nepean River Management Forum (2004) *Water and Sydney's Future, Balancing the Values of our Rivers and Economy*, Final report of the Hawkesbury-Nepean River Management Forum, NSW Department of Infrastructure, Planning and Natural Resources, Sydney.

Healthy Rivers Commission (1998) *Independent Inquiry into the Hawkesbury-Nepean River System*, Healthy Rivers Commission of NSW, Sydney.

HNCMA—*see* Hawkesbury-Nepean Catchment Management Authority

HNRMF—*see* Hawkesbury-Nepean River Management Forum

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HRC—*see* Healthy Rivers Commission

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SWC—*see* Sydney Water Corporation