

Chapter 3 Explanation of Outcomes and Targets

Part 1 Long term outcomes for the environment, society and economic prosperity

Division 1 Environmental outcomes - Healthy, productive and diverse water dependent ecosystems

Many of the rivers and floodplains of NSW have been modified and used to provide a range of important social and economic benefits. The water is diverted for town water, manufacturing and irrigation, the fertile floodplains are farmed and, in turn, support numerous towns and transport routes. Similarly aquifers and the ecosystems which depend on them have been impacted by water extractions, mining, and by the infiltration of pollutants.

As rivers are increasingly modified, not only is their ecological character changed but the basic health of the river becomes compromised. Generally the more developed the river, the less natural it becomes and the less healthy it is. This is because the changes we impose on the river and its environment affect the basic ecological functions and values (or services) that a natural river would provide such as: the provision of clean water, energy production, nutrient cycling, and sustaining river and coastal fisheries and water bird habitats and populations.

A useful concept is that of a “healthy working river” (CRC for Freshwater Ecology in Watershed, February 2002; Hillman *et al.*, 2000). This concept accepts that most rivers must continue to be worked to provide economic and social benefits. But it cautions that the impacts must be limited and managed to appropriate levels in order to indefinitely sustain a reasonable level of health and ecological functioning.

This is also the basis of the *Water Management Act 2000*. A principle of the Act is to maximise the social and economic benefits to the community. However, other principles emphasise the importance of protecting and restoring water sources and floodplains, and the habitats, animals and plants that depend on them. Specifically, the Act requires that in sharing water, the highest priority is to protect the water source and its dependent ecosystems.

Many rivers and aquifers are now being used at a level that is likely to result in ongoing deterioration in environmental health. This decline in health, when fully realised, is likely to be unacceptable to this generation and potentially disastrous to future generations. It is critically important to minimise existing impacts and in many cases actively attempt to reinstate key ecological processes and biodiversity.

- (1) Primary ecological production maintained or improved including:**
- (a) carbon cycling,**
 - (b) production to respiration ratios, and**
 - (c) carbon and food fluxes between rivers, floodplains, estuaries and coastal waters**

Relevant Policies: NSW Biodiversity Strategy (1999), *Fisheries Management Act 1994*, State Rivers and Estuaries Policy (1993), Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (1999), Draft NSW Groundwater Dependent Ecosystems Policy (2001), NSW Interim Environmental Objectives (1999), NSW Wetland Management Policy (1996), NSW Coastal Policy (1997).

The development of our water sources, including floodplains, estuaries and coastal waters has resulted in significant damage to the natural ecology of these areas and declines in the diversity of both habitats and species.

The strategic goal of the NSW Biodiversity Strategy is to “Protect the native diversity of NSW and maintain ecological processes and systems”. Healthy functioning ecosystems are fundamental to the continuing survival of plant and animal species and to the human communities and economies that depend upon them. The movement of water, the transported sediments and nutrients, and the wetting and drying cycles profoundly affect the ecology and productivity of an aquatic or semi-aquatic system. Water movement affects how energy (mainly in the form of organic carbon) flows through the system, the nature of interactions between organisms in the food web, and the ecology and life strategies of those organisms.

Flow regimes, fluctuating water levels and intermittent floodplain inundation all play critical roles in:

- determining habitat availability and condition,
- connecting aquatic and floodplain ecosystems,
- food production (eg biofilm - bacteria and algal communities living on rocks and logs, plankton – microscopic plants and animal succession),
- carbon cycling,
- the ratio of production to respiration,
- stony bed scouring, and
- species dominance and competition.

Structural damage to rivers, riparian zones and floodplains, as well as the proliferation of barriers to flow and to the movement of aquatic fauna, and the construction of drains are all potentially detrimental activities. They can reduce the diversity and quality of available habitat, interfere with the hydraulic connection between habitats and disrupt food chains. Water extraction from rivers and aquifers has also had an impact by changing the patterns and frequency of wetland inundation, reducing wetland productivity and altering the frequency of food and energy exchanges between wetlands and rivers.

Water pollution, in particular high acid discharges, high salinity and low oxygen levels, can also impact on ecological processes and threaten individual aquatic species.

All of the above factors need to be addressed in an effective water management regime if the health and productivity of water dependent ecosystems are to be maintained and/or improved.

In recent years increased scientific effort has been focused on understanding the basis of ecological primary production and on developing predictive flow response models. The “Integrated Monitoring of Environmental Flows” (IMEF) program covers a number of such indicators, for example, carbon cycling, biofilm production and stony bed scouring. There is a need to continue and expand this effort to help us understand the long term trends in the basic functioning of aquatic ecosystems.

(2) Degraded wetlands rehabilitated and listed wetlands of national or international significance protected or restored

Relevant Policies: NSW Wetlands Policy (1996), Ramsar Convention, JAMBA & CAMBA Agreements, NSW Biodiversity Strategy (1999), *Fisheries Management Act 1994*, *National Parks and Wildlife Act 1974*, *Threatened Species Conservation Act 1995*, NSW Interim Environmental

Objectives (1999), NSW State Groundwater Dependent Ecosystems Policy (2001), NSW Coastal Policy (1997).

In NSW there are about 4.6 million hectares of wetlands ranging in type from mangroves, saltmarshes, seagrasses and coastal brackish wetlands, to inland freshwater and floodplain wetlands, backswamps, billabongs, large terminal wetlands, ephemeral claypans and salt lakes. Many wetlands depend on river flows for their water supply. Of the 6.3 million hectares of wetlands estimated to occur in the whole Murray-Darling Basin, over 90% are floodplain wetlands. Some of these wetlands are dependent on groundwater levels to create and/or maintain wetted areas.

Wetlands are vitally important to the environmental health of rivers and estuaries by providing unique habitats for a diverse range of plant and animal species; making important contributions to biodiversity; providing nursery and breeding grounds for many aquatic and semi-aquatic species; improving water quality; providing essential sources for biological productivity and nutrient recycling; mitigating floods; protecting foreshores, and increasing groundwater recharge.

Wetlands are often important cultural sites for Aboriginal people. This importance is due not only to a spiritual connection to these places, but also to their ongoing value as places of cultural learning and resource use.

Unfortunately many wetlands have been substantially degraded by a range of activities, many of which are related to water use and development such as:

- reduction in the frequency, extent and duration of inundation,
- reduction in the hydraulic connection between wetlands and the river or other water sources through construction of physical barriers,
- poor land management practices,
- artificial drainage,
- tidal barrages,
- filling of wetland depressions for urban or agricultural development, and
- modification into permanent water storages.

The NSW Wetlands Policy was released in 1996 and seeks, through its associated wetland action plans, to provide clear guidance on the protection, rehabilitation and wise use of wetlands. While it has supported a range of wetland initiatives through associated educative programs and financial grants, there is still substantial effort required to generally restore wetland functions and rehabilitate key wetlands.

Water management needs to specifically address the rehabilitation of at least a proportion of the degraded wetlands in each water management area. This may require:

- identification of wetlands in the management area,
- restoration of conditions known to favour native plant species in wetlands,
- reconnection of wetland with the relevant water source through removal, modification or periodic opening of floodplain barriers and flood gates,
- improvement in the frequency and duration of inundation - which may involve better groundwater level management, increased flow frequency in the relevant high flow range, and reduced impact from unseasonal regulated supply flows,
- improvement or reduction in the rate of decline in water quality – particularly nutrients and salt in freshwater water sources, and
- improved land management practices.

Some wetlands in NSW have been recognised as having particular national or international significance because they are relatively rare or are good representatives of their type, or they may

provide important habitat for nationally or internationally recognised or endangered animal and plant species or communities. Examples of these significant wetlands are those:

- listed under the Ramsar Convention,
- listed in the Directory of Australian Wetlands, and
- providing significant habitats for migratory waterbirds listed under the Convention on Migratory Species, and the JAMBA and CAMBA Agreements.

NSW has a particular responsibility to ensure that these wetlands are, as far as possible, restored and protected from further damage. There is a range of mechanisms available to help achieve this including voluntary conservation agreements with landholders; plans of management under the *Environmental Protection and Biodiversity Act 1999* for Ramsar wetlands; general environmental flow provisions; and flows targeted specifically at the listed wetland.

A number of monitoring programs have been established which can help inform the assessment of wetland status. These programs include the IMEF program and the NPWS wetland mapping program. There have been detailed surveys of some freshwater and coastal wetlands including seagrasses, mangroves and saltmarshes but there has been no comprehensive monitoring across NSW.

(3) The diversity and abundance of native aquatic plants and animals protected and restored by addressing the cumulative impacts of water resource management on their habitats and lifecycles. The status of aquatic communities to be informed through, but not limited to, the following indicators:

- (a) abundance and diversity of invertebrate populations improved,**
- (b) native fish populations increased within their natural range, and the ratio of alien to native fish species reduced,**
- (c) increased colonial waterbird breeding opportunities and abundance and diversity of other water-dependent vertebrate species,**
- (d) estuarine prawn populations improved, and**
- (e) the status of threatened species, populations and ecological communities improved**

Relevant Acts and Policies: NSW Biodiversity Strategy (1999), *Threatened Species Conservation Act 1995*, *Fisheries Management Act 1994*, *Environment Protection and Biodiversity Conservation Act 1999*, National Objectives and Targets for Biodiversity Conservation 2001-2005 (2001), Draft MDBC Native Fish Management Strategy, NSW Wetlands Management Policy (1996), *National Parks and Wildlife Act 1974*, NSW Interim Environmental Objectives (1999), State Environmental Planning Policy 14, State Environmental Planning Policy 46, Ramsar Convention, NSW State Groundwater Dependent Ecosystems Policy (2001).

The continuing loss of biodiversity is an issue of state and national concern and has been identified as perhaps our most serious environmental problem. Despite many advances in understanding and awareness, and increased efforts to conserve biodiversity in recent decades, ecosystems continue to be degraded. There is now a growing recognition that we have been under-investing in biodiversity conservation and we have failed to effectively manage activities that threaten biodiversity. Without further investment in biodiversity conservation, serious long-term ecological and economic consequences may result.

Biodiversity has many values. At the most fundamental level, biodiversity is the basis for healthy, functioning ecosystems. Biodiversity is also essential to allow adaptation to changing environmental

circumstances such as climate changes. In addition, biodiversity is essential to maintain the habitats and food webs that support many of the species on which we (and other animals) depend. Put simply, biodiversity provides all the critical processes that make life possible. We gain enormous benefits from these processes, but they are often grossly undervalued.

Aquatic biodiversity provides many direct economic and social benefits. Economic benefits include the provision of valuable food (fish and shellfish), industrial materials, and the means to control some pest species and diseases. Some examples of these economic benefits are:

- a significant contribution to the gross value of Australian commercial fisheries production (in 1999-2000 this was \$2.32 billion - ABARE 2001). Invertebrate species such as prawns, lobsters and pearl oysters accounted for two-thirds (\$1.56 billion) of this total,
- recreational fishing and tourism on inland waterways are a mainstay of the economy of many small towns. An estimated 20 percent of the population, representing over 1 million people, go fishing each year in NSW,
- it has been estimated that the average hectare of mangrove habitat could be worth \$8,000 annually in fish production, and
- the tourism value of large wetland areas such as the Macquarie Marshes and the Gwydir wetlands is growing rapidly.

The conservation of biodiversity also has social benefits. Aboriginal people have depended upon aquatic and water dependent species not only traditional and contemporary food and medicine resources but also as the basis of broader cultural association through totem species, ceremonies and dreaming stories.

In addition to the biological resources we already use, aquatic biodiversity represents a pool of untapped opportunities, a 'storehouse' of genetic and chemical material that could provide the future foundation for new technologies in the pharmaceutical and other industries.

There is also growing community recognition of the intrinsic value of biodiversity, acknowledging the inherent right of all species to exist, regardless of their value to humans. Australia's aquatic biodiversity is valued not only by Australians but also internationally for its richness and uniqueness.

Objective 4.7 of the NSW Biodiversity Strategy requires the “effective management of water resources to conserve biodiversity and meet environmental, economic, social and community needs”.

In order to protect or improve aquatic biodiversity, it is important to ensure that, as far as possible, water management addresses the full spectrum of habitats and the differing requirements of all species within an ecological community but which must coexist in order to ensure the health and survival of the whole. For practical purposes, the status and diversity of an ecological community may be reasonably informed through a number of indicator or key species. This SWMOP therefore adopts four key indicator groups (a-d) together with any listed threatened water- dependent species, populations or communities.

(a) abundance and diversity of invertebrate populations improved

Aquatic invertebrates are animals without backbones, which live at least part of their life within the water column or substrate of an aquatic environment.

Invertebrates play a very important role in aquatic ecosystems, by breaking down organic matter, transforming nutrients, and feeding on fungi and algae to provide a major food source for higher order animals such as fish and waterbirds. A healthy aquatic ecosystem often supports a wide range of invertebrate species, reflecting a diversity of food sources and a diversity of habitat types. Abundant populations of invertebrates will ultimately be reflected in the abundance of the fish, reptiles and waterbirds that feed upon them.

Aquatic invertebrate communities can be impacted by changes in both water flow and quality. In upper and mid sections of rivers, the reduction in the frequency of freshes and floods reduce the frequency of bed disturbance and so the “resetting” of benthic (ie bottom-dwelling) invertebrate populations is less frequent. This is likely to lead to a less diverse fauna, with the biomass dominated by a small number of species. Reduced flushing will lead to clogging of coarse riffle substrates, with fine sediments and organic matter reducing the amount and quality of the benthic habitat.

The changes in the invertebrate communities in lowland rivers are largely due to habitat alteration rather than direct flow effects on the organisms. Reduced flow variability, reduced habitat diversity due to snag removal, bank slumping and loss of littoral vegetation, changes in substrate, changes in water temperature and the predominance of slow turbid flows in weir pools etc have all contributed to changes in invertebrate diversity and abundance.

Invertebrates are considered so fundamental to ecosystem health and production that a national effort, the Australian River Assessment System (AusRivAS) is underway to monitor river health using measurements of aquatic macroinvertebrate communities. This program uses the environmental attributes of a river reach to predict the kinds of macroinvertebrates that would be present in the reach if the river was “healthy”. The difference between the predicted species and those actually collected from the reach over time provide an index of river health.

(b) native fish populations increased within their natural range, and the ratio of alien to native fish species reduced

Over the last 100 years the abundance and distribution of native fish including many commercial and recreational species (eg Murray cod, golden perch, silver perch, catfish, and Macquarie perch) have declined markedly in many of the State’s surface water sources. Eleven fish species and two endangered populations are currently listed as threatened under the *Fisheries Management Act 1994*.

These declines have been attributed to a range of factors including:

- general habitat degradation,
- altered river flows,
- introduction of alien fish and diseases,
- interrupted migration pathways,
- reduced water quality and pollution,
- overfishing, and
- changed energy fluxes.

A lack of detailed information on the habitat associations and requirements of most native fish and on the impacts of alien fish species means the relative significance of these factors is unknown. Furthermore their relative influence will almost certainly vary substantially from water source to water source. Nevertheless, altered flow and sediment regimes have had a dramatic impact on fish populations including removal of spawning and migration cues, reduced dispersal and recruitment, reductions in aquatic vegetation and habitat connectivity, increases in siltation, reduction in water quality and reductions in habitat diversity. The imposition of barriers to fish passage has also been a major factor in the decline in fish in many water sources.

A large-scale systematic survey of riverine fish in the New South Wales part of the Murray-Darling Basin was undertaken in 1996/97 (Gehrke *et al.* 1995). Samples were taken at 80 sites on four occasions over two years. Of the 25 native freshwater species expected to occur only 18 were recorded overall. 15 of these were rated as either rare (7 species), having restricted distribution (2 species), or were absent (6 species). The Murray, Murrumbidgee and Lachlan water sources were found to be in the worst condition.

More recently, the draft Murray-Darling Basin Native Fish Management Strategy documented that:

- only 10 percent of pre-European native fish populations remain in the Murray-Darling Basin, and
- native fish make up only 4 percent of the total catch in the Murray.

Native fish are also a reasonably good long term indicator of the general health of rivers as they are sensitive to the loss of a wide range of instream and wetland habitats. They are also highly dependent on food supplies from both instream and floodplain sources. Many native species require periodic floodplain or wetland inundation to trigger spawning and ensure the successful recruitment of juveniles. For many marine species the trigger is the amount of fresh water that moves offshore to the adult populations. Many species migrate or disperse over reasonable distances, often between rivers and estuaries, and are therefore sensitive to barriers and flow conditions.

Habitat structure and diversity, which is a function of hydrology and hydraulics, as well as of geomorphic elements such as riffles, runs and pools, sediment types and snags, is a major factor determining the species composition and abundance of fish communities.

There are in excess of 12 alien fish species present in rivers across the State, mostly as a result of deliberate introductions dating from the mid-1800s. Of these carp, goldfish, gambusia and redfin perch are the most widespread, and carp is the species that has caused the most ecological damage.

Rivers whose flow regimes have been significantly modified commonly exhibit both a decreased native species diversity and a proliferation of alien species. There is substantial evidence to show that river regulation has favoured carp at the expense of native species. Because native fish have reasonably specific flow requirements for reproduction and the successful recruitment of juveniles, reductions in flow variability reduces the abundance of those species. Carp, on the other hand, have less specific flow requirements, as reproduction is not cued by seasonal flow conditions, and successful recruitment is less dependent on specific flow conditions. Although the levels of scientific evidence vary substantially, declining native fish populations, blue-green algal blooms, increased turbidity and lost aquatic vegetation have all been attributed to some degree to the proliferation of carp.

The ratio of alien to native species in the rivers has been found to be a useful index of the health of a river as it reflects the relative advantage that changes in river condition and particularly flow gives to alien over native fish species. It also provides an indicator of the degree of pressure that alien fish species themselves place on the system.

(c) increased colonial waterbird breeding opportunities and abundance and diversity of other water-dependent vertebrate species

Colonially breeding waterbirds (ibis, egrets, herons, spoonbills and cormorants) breed in large colonies on a relatively few wetlands supplied by rivers in New South Wales (eg Macquarie Marshes, Gwydir wetlands, Barmah Millewa Forest, Booligal wetlands). The strongholds of remaining breeding areas in Australia are primarily concentrated in the surface water sources in New South Wales. For example, the Macquarie Marshes is the most important site (in terms of the numbers of breeding birds and/or the frequency of breeding and range of species) for colonially breeding waterbirds in Australia. The breeding of colonial waterbirds is closely linked to the flooding of inland surface water sources. The area available for breeding waterbirds to forage appears to be a critical factor for breeding. Breeding success is also closely linked to the size of floods with much greater reproductive success during larger floods than smaller floods. The regulation of rivers with dams and extraction upstream of major wetlands has severely affected the breeding of colonial waterbirds. It has been calculated that extraction of water from the Macquarie River reduced breeding by 100,000 pairs in the Macquarie Marshes every 11 years.

There has been inadequate attention to the importance of aquatic habitats for other vertebrate groups such as amphibians, snakes, lizards and mammals. The abundance and diversity of these groups must be considered explicitly in management decisions.

(d) estuarine prawn populations improved

River discharge and estuarine productivity are closely linked. Fluctuations in salinity, turbidity, and nutrients can affect the extent of available habitat and the productivity of the estuary. Lonergan and Bunn (1999) and previous work by Glaister (1978), and others have confirmed that high river discharges can have a strong positive effect on the production of commercial and recreational coastal fisheries, especially on prawns.

Catches of school prawns in the Hunter River and Clarence River showed that each year following major rainfall, productivity increased (Ruello 1973; Glaister 1978). These increases are thought to be linked to secondary effects of rainfall such as reduced salinity and turbulence which stimulates the migration of juvenile prawns from nursery habitats in estuaries and rivers.

Lonergan and Bunn (1999) have also observed similar results in longer-lived species such as mud crabs and flathead. The catches of prawns are likely to be related to increased juvenile productivity, as the time delay between when the rainfall event occurs and when the juveniles enter the fishery is in the order of only six months. Therefore, while the influences on increased productivity of these species require further investigation, prawn productivity is a useful short-term biological indicator of the linkage between river flow and estuarine productivity.

(e) the status of threatened species, populations and ecological communities improved

The State's rivers, lakes, estuaries and wetlands form complex biological systems that support a rich diversity of plant and animal communities. However, some of these animals and plants are facing threat of extinction as the State's aquatic systems undergo dramatic changes due to factors such as reduced or modified flow regimes, loss of riparian vegetation and habitat diversity, and declining water quality. The number of threatened animals and plants is continuing to grow.

Objective 2.4 of the NSW Biodiversity Strategy requires the State to "Implement mechanisms for the identification, recovery, and rehabilitation of threatened species, populations and ecological communities and protection of critical habitats".

The *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994* aim to stop the decline in biological diversity by promoting recovery of species, populations and ecological communities and eliminating or managing threatening processes.

Both Acts provide for the listing of animal and plant species according to their status. Once listed a recovery plan must be prepared within 3 to 5 years, depending on the listing. These plans will be comprehensive documents that outline future management actions to encourage the recovery of species. Primary recovery actions generally aim at stabilising population numbers and halting habitat deterioration. Further actions may aim at rebuilding populations and conserving further habitat. Complementary to the recovery planning process is the management of key threatening processes through a process of threat abatement planning.

The on-going management of aquatic systems must seek to reduce the decline in biological diversity by ensuring activities and management plans are consistent with the objectives and recommendations of recovery plans and threat abatement plans. Additionally, high conservation values and areas that possess special requirements for threatened species or communities, should be maintained or improved for conservation purposes.

Recovery and threat abatement planning for many species, populations and ecological communities, and key threatening processes are still in the initial stages. In the absence of such plans and identified conservation values and areas, effort should be focused on preserving or restoring ecological processes and on maintaining and restoring the known flow or habitat requirements of better known key species. Since these species are sensitive to change, their conservation becomes a benchmark for other species about which less is known.

For all threatened species, populations and ecological communities, the paucity of information and the need for more research on life history, habitat requirements, distribution and threatening processes directs a need to adopt a precautionary approach to water management.

The NSW Government is responsible for ensuring that the requirements of threatened species, populations and ecological communities, critical habitats, key threatening processes and their associated plans are addressed in the development of all plans and individual resource management decisions.

Division 2 Social outcomes - The community's basic needs and values sustained

NSW society and its local communities will be the ultimate beneficiaries of more sustainable water management. Improved environmental outcomes will ensure that current and future generations will be able to enjoy the benefits of our natural heritage and the essential services that the water-related ecosystems provide. Improved economic certainty, water use and investment efficiency, and water trading and dealing opportunities will ensure more productive water use and improved economic returns. In addition to these, water source planning and management must ensure that the basic needs of the community continue to be met. This includes the right to essential domestic and stock water supplies whether within a town or rural setting, which are not compromised by other economic demands, and reasonable opportunities to enjoy the recreational, aesthetic, cultural and spiritual values provided by water sources and their associated environments.

(1) Water supplies necessary to maintain or improve the health and wellbeing of rural and urban communities assured

Relevant Policies: NSW Interim Environmental Objectives (1999).

An owner or occupier of a landholding is entitled under the *Water Management Act 2000*, without the need for an access licence, water supply work approval (for works excluding instream dams or weirs) or water use approval, to take water from any river, estuary or lake, to which the land has frontage or from any aquifer underlying the land. This basic rights provision is to meet normal domestic requirements and non-intensive stock watering.

The *Water Management Act 2000* requires that these basic rights be protected from the impact of other extractions. It also specifies that town water supply (local water utilities) must have priority to water from rivers and aquifers over other licensed uses.

Human and stock drinking water is also being increasingly threatened by water quality problems which, at worst, can impact on the health of stock or the people dependent on the contaminated water source and, at best, can substantially increase the costs associated with water treatment or alternate supplies for rural land-holders and communities.

Many indigenous communities, in particular, rely on bores, local dams and river pumps for their water supplies. Significant resources are spent on setting up and maintaining this infrastructure and yet, in spite of this, both the quality and quantity of the water supplied to many communities remain inadequate. This is contributing to the poor health and living standards of those communities.

Salinity is now recognised as one of the greatest threats to water supplies for rural communities within the Murray-Darling Basin. At Dubbo, on the Macquarie River, the water currently exceeds the World Health Organisation (WHO) guidelines for the acceptable taste of drinking water (800 EC) 6 percent of the time. This is predicted to increase to over 80 percent of the time by 2100, unless the trend can be managed.

(2) Aboriginal traditional and contemporary dependencies on, and cultural associations with water protected and improved. In particular:

- (a) economic access to water increased,**
- (b) cultural and customary associations with water protected,**
- (c) opportunities for learning and information exchange improved, and**
- (d) capacity for Aboriginal people's involvement in water management increased.**

Relevant Policies: Statement of Commitment to Aboriginal People, *National Parks and Wildlife Act 1974*.

For over 50,000 years, Aboriginal people have been living in and around Australia's rivers, floodplains, billabongs, marshes, swamps, lakes and mud flats and depending upon these water sources for basic survival. These water sources also have cultural relevance. Food was obtained from rivers (fish, crustaceans, oysters etc.), the floodplain (grasses, tubers, fruits etc.) and associated wetlands (kangaroo, emu, birds, snakes etc). Vegetables, fruits and traditional medicinal plants are most often sourced from or near waterways.

Major waterways, and most other water sources, in NSW continue to have cultural relevance to Aboriginal people and are often associated with dreaming stories and cultural learning that are still passed on. Cultural learning through dreaming stories teaches Aboriginal people who they are and where they belong. Many ceremonial rites are linked with water and impart knowledge of how to continue a respectful partnership with water and all the creatures that use it. For these reasons, an object of the *Water Management Act 2000* is to recognise and foster the benefits that result from the sustainable and efficient use of water, including the benefits to Aboriginal people in relation to their spiritual, social, customary and economic use of land and water.

Aboriginal people are concerned about declines in population of many species due to changes in the natural ecosystem, eg, the Murray cod. This totem species was actively managed using traditional knowledge accumulated and passed down the generations over thousands of years. Aboriginal people feel that degrading its ecological status also degrades the cultural integrity of the people who must maintain that totem.

Aboriginal 'relics' and declared places are protected under the provisions of the *National Parks and Wildlife Act 1974*. Any action that may damage, deface or destroy such items or places requires the consent of the Director-General of the National Parks and Wildlife Service. As part of water management planning, the intimate and unique relationship of Aboriginal people to water sources and their dependent ecosystems should be acknowledged and the cultural values of waterways and water-dependent species need to be accounted for and protected.

But the Aboriginal dependencies on water go well beyond their cultural or spiritual associations. Traditionally, their communities derived much of their food, shelter and the goods for trade from the rivers and water-dependent ecosystems. In the 21st century these traditional forms of access to the

water are no longer available to these communities due to the increasing alienation of traditional hunting grounds, and the decline of habitats and important animal and plant species. Alternate forms of economic access appropriate to contemporary Aboriginal life are now needed. Future water planning and management must provide opportunities for Aboriginal people to restore their economic as well as cultural benefits from water.

Such access does not have to come at the expense of other water users but could be achieved through access to unassigned water and the water market.

The key to ensuring these benefits accrue to Aboriginal people will be effective communication with, and involvement of the relevant Aboriginal communities who can speak for the areas for which management planning and decision-making are taking place. This may occur through the Aboriginal representatives on management committees but may need to include a broader investigation of cultural and contemporary issues and needs.

To ensure that individuals and the communities they represent can be most effective in the water management process, it is critical that the means are provided for training, information access and knowledge exchange.

(3) Incidents of problem algal blooms affecting essential water supplies and recreational values reduced

Relevant Policies: NSW Interim Environmental Objectives (1999), National Water Quality Management Strategy (2000), Algal Management Strategy for the Murray-Darling Basin (1994).

Algal blooms generally, and blue green algae (*Cynobacteria*) in particular, are a natural part of the freshwater environment. However human induced changes to river and estuarine water sources have resulted in conditions which favour these algae and periodically encourage rapid rates of growth which can lead to algal blooms. These blooms can affect the community in a variety of ways including:

- toxins produced by some algae can cause liver damage, stomach problems and damage to the human nervous system,
- stock deaths and poisoning of wildlife and domestic pets,
- undesirable tastes and odours, discolouration and scums,
- decaying algae can reduce oxygen levels and cause stress and death to other aquatic organisms,
- water supplies can be disrupted when filters and other equipment is blocked,
- costs of water supply increases when algae/toxins need to be removed, and
- recreation and tourism is disrupted.

The growing concern about the amount of nutrients entering rivers and estuaries as a result of effluent discharges, agricultural and urban runoff is primarily because of the risk this brings of nuisance algal blooms. Reductions in the incidence of problem algal blooms can generally be achieved by one or more of the following:

- improving flow regimes, increasing turbulence and flow velocity and variability, and aiding the destratification of pools,
- reducing the potential for stagnation and stratification of water in weir pools,
- restoring the riverine riparian zone to intercept nutrient-rich storm runoff and to reduce the amount of sunlight on the water which stimulates algal growth, and

- reducing the input of nutrients from point and diffuse sources.

Division 3 Economic outcomes - Economic value of water improved

Many water sources in NSW are approaching or have exceeded the limits of their capacity to support the growing consumptive demand for water without unacceptable impact on the environment or the rights of other water users. This means that a new focus is required to increase the economic return from the use of the available water and to support new development opportunities.

The introduction or expansion of demand management, water reuse and water market opportunities can result in significant reductions in the volumes of water required to support existing uses. This will free up water within extraction limits to support additional production. At the same time, the water market will encourage water to move to higher value uses, and therefore also contribute to an increase in the economic return per megalitre of water extracted. An effective water market will also increase the value of water licences, thereby offsetting any reduction in the gross volume of water which can be extracted as a result of environmental water provisions.

Sound water management is crucial to regional economic development. The water related aspects of state and regionally significant development would be accommodated within overall regional planning through the PlanFirst initiatives. This will help ensure the effective linking between water management and landuse planning to achieve sustainable regional development and the best economic, environmental and social use of regional water sources.

- (1) Productive capability of land and water maintained, with particular reference to:**
- (a) rate of land degradation associated with irrigation activities reduced, and**
 - (b) rate of increase in river salinity levels reduced**

Relevant Policies: NSW Water Conservation Strategy (2000), Policy for Sustainable Agriculture (1998), NSW Salinity Strategy (2000), NSW Interim Environmental Objectives (1999), National Water Quality Management Strategy (2000).

The use of water for irrigation in NSW provides a significant economic contribution to the community. The value of irrigated agriculture in the Murray-Darling Basin is \$3 billion per year, rising to \$9 billion after value adding.

Most of the water extracted from rivers and aquifers is used for irrigated agriculture. The economic efficiency of these irrigation industries is dependent not only on continued access to adequate quantities of water but also to the ongoing productive capability of that water and the lands to which it is applied.

Water quality, and in particular, rising salinity levels is the main threat to the productive capability of water. Land degradation in its many forms can threaten the productive capability of irrigated lands. Both problems can cause significant reductions in the yield per megalitre of water.

(a) rate of land degradation associated with irrigation activities reduced

The extent of some forms of land degradation continues to increase in many areas of NSW. In some areas this increase is associated with irrigation activities and in many instances, it can be attributed to poor irrigation practices. There are numerous opportunities to maintain or improve the productive value of land for current and future generations and at the same time, minimise external economic and environmental effects.

This outcome reflects the principles of the *Water Management Act 2000*, with respect to water use, drainage management, floodplain management, controlled activities and aquifer interference. These principles encompass the need to avoid or minimise soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline in native vegetation and salinity; and, where possible, seek to rehabilitate affected lands.

The processes involved in degradation of irrigated land vary substantially. However, external impacts from the process of irrigation are primarily a result of deep drainage or surface run-off. Of the forms of land degradation described in the *Water Management Act 2000*, soil erosion, contamination, waterlogging, salinisation, decline in native vegetation, geomorphic instability and oxidisation of potentially acid sulfate soils can all have external effects. While compaction and soil acidification tend to have relatively little off-site impacts, they can significantly reduce the long term productivity of the land itself, with obvious inter-generational implications.

The effect of land degradation on the productive value of land is substantial, affecting the natural resource base within NSW. However, recently, there has been recognition of the specific measures that need to be employed to reduce many of these problems. This is evident in the NSW Water Conservation Strategy, the Policy for Sustainable Agriculture and the NSW Salinity Strategy. It is also evident in best management practices and codes of practice developed for dryland farming and by sectors of the irrigation industry.

Land degradation needs to be considered with respect to irrigation enterprises if the productive capability of these lands are to be maintained.

For example, waterlogging and salinisation can give rise to loss of production and subsequent scalding of land. As identified in the NSW Salinity Strategy, drainage schemes have not proven entirely effective in managing this problem. Risks to productive capacity increase substantially where watertables have risen to within 2 metres of the surface of the land. Waterlogging can occur from surface run-off or deep drainage, especially where hydraulic loading from irrigation is substantial. Like salinisation, it is exacerbated where clearing occurs for an irrigation enterprise. Salinisation occurs due to changes in water balance. Irrigation salinity is a function of the volume, rate, timing and location of water applied, its quality, whether leaching fractions are calculated accurately, and changes to vegetation cover that arise from a different water use pattern.

(b) rate of increase in salinity levels reduced

The implications of rising salinity are probably the greatest threat to the future productive capability of the State's water sources. The yields of some crops, such as rice and horticulture, are affected by saline water at levels as low as 700 EC. Current predictions, in the absence of effective mitigating action, indicate that most major western flowing rivers will exceed 700 EC by the year 2020. Many irrigation enterprises will be at risk. Water of low salinity is also an important requirement of the manufacturing and food processing industries. Continuation or expansion of these industries in regional locations is at risk from rising salinity levels.

Salt underlies much of the NSW landscape and has been mobilised across all the inland catchments. While salinity can develop naturally, where human intervention has disturbed the natural ecosystems and changed the hydrology of the landscape, the movement of salts into rivers and onto the land surface has accelerated.

Increasing salinity can be due to agricultural, industrial or urban activities including:

- clearing of native vegetation,
- native vegetation replacement with crops and pastures with different water use characteristics,
- the introduction of irrigation practices, and
- the use of inappropriate drainage and watering systems.

If current activities and practices are not modified, salinity will rise to levels that will threaten agricultural production, water supplies and ecosystems within decades. Additional inappropriate development would accelerate these trends.

In late March 2000, the NSW Government hosted a Salinity Summit to develop a cooperative effort to manage the growing salinity problem. The NSW Salinity Strategy was subsequently released in August 2000 and leads the way to setting salinity targets and management responses including:

- protecting and managing native vegetation,
- land uses and practices which reduce the amount of water going into the watertable,
- more effective and efficient water use,
- engineering solutions,
- alternative use of land affected by salt, and
- focus on priority salinity hazard landscapes.

Water management can assist in limiting future increases in salinity by, for example:

- limiting saline drainage from irrigation and urban areas,
- setting a limit on water extractions in all affected water sources,
- affording greater protection to flows/discharges from rivers and aquifers with low salt loads (by setting more stringent extraction limits in these areas if possible), and
- ensuring, through future water use approvals, that irrigation developments and practices are not undertaken at unacceptable rates or in high salinity hazard areas.

(2) Water use efficiency increased

Relevant Policies: COAG Water Reform Policy (1994), NSW Water Conservation Strategy (2000).

As the demand for water increases, recognition that water is a valuable and scarce resource increases. The increased value that people place on water provides a direct incentive for water to be used more efficiently. At the same time, efficient use reduces on-site effects and external impacts that result from applying an additional volume of water at a location where it does not naturally occur. Measures that encourage the efficient use of water are supported by the NSW Water Conservation Strategy. This outcome of the SWMOP refers to efficiency in the irrigation, urban and industrial sectors.

If the irrigation industry does not use water efficiently, the losses associated with deep drainage and surface runoff can degrade water resources and affect the productive capacity of the land. Efficiency in the irrigation sector can be measured in terms of crop water use efficiency (yield/megalitre), irrigation efficiency (megalitre per hectare applied relative to the theoretical irrigation demand per hectare) and economic efficiency (dollar value/megalitre). Catchment-scale system efficiency can also be increased by better managing the delivery of water.

Efficiencies in the urban water sector would reduce the demand for water that could otherwise be applied to environmental uses or reallocated to other consumptive use. Efficiency gains also reduce the capital investment requirements for drainage and water treatment infrastructure. Efficiencies in the industrial sector, likewise, reduce costs to industry and to the environment.

The actions taken to reduce the forms of land degradation, in many instances, will also improve the efficiency with which water is used, by minimising deep drainage and surface runoff.

Efficiency gains can be achieved through:

- improving irrigation infrastructure and technology, and ensuring that crop type and system choice match soil type,
- improving irrigation scheduling ie applying the right volume of water at the right site, at the right rate, at the right time to meet the demands of a crop or to refill a soil moisture deficit,
- application of minimum leaching fractions,
- industry benchmarking,
- urban and industrial demand management,
- community education,
- incentives provided by effective and transparent water trading markets,
- pricing mechanisms which separate fixed and usage charges (and account for external impacts),
- improving water reuse, and
- research and technological development.

The costs associated with improved efficiency are substantial and further incentives may be required to encourage adoption in the short term. However, economic and environmental benefits in the long term are substantial. Implications are likely to be more substantial in industry sectors with the least access to capital and those that have developed dependent on less efficient technology.

(3) The economic efficiency of investment in water industries improved

Relevant Policies COAG Third Meeting Communique – Water Resource Policy (1994), National Approach to Water Trading (2002), NSW Policy Advice (No 2) on Supplementary Water Access (2001).

New water developments require significant investment in order to secure:

- the necessary access rights to the water,
- an efficient water use system including for example, laser levelling, and efficient water reticulation, drainage and recycling systems, and
- water storage, where this is necessary, to improve the reliability of supply.

Existing water industries, on the other hand, must make choices about:

- investment in ongoing maintenance of infrastructure,
- investment in new infrastructure to improve water use efficiency, allow a change in crops, or reduce maintenance costs,

- purchasing additional access rights to enable an increase in cropping or improvement in water supply reliability,
- divestment of access rights where they may be excess to need or yielding a poor rate of return relative to their market value.

To ensure an economically efficient water industry it is essential that investment decisions by both existing and potential water users be properly informed with respect to:

- the true nature of the access rights such that:
 - the licence reflects the expected long term reliability of access to water,
 - the conditions of access are clearly specified, and
 - the rights are reasonably stable over a realistic investment horizon,
- water pricing policy,
- effective market options and valuations, and
- flexibility in the type of rights available and in the associated accounting rules which allow enterprises to establish the appropriate mix of maximum water access, water use, water access licence dealings and carryover to ensure optimal economic efficiency.

Understanding the nature of a water access licence is a critical factor driving future investment. As embargos on new access licenses are applied to more water sources the water licence has become an increasingly important and valuable asset. However, ill-defined licences with respect to the volumes they represent, the security of supply and their tenure, make it difficult to properly assess the long term supply potential that the licence represents. This can lead to inefficient and unwise investment decisions.

In the past water licence holders have assumed a higher level of long term supply reliability than could be expected given the amount of licensed entitlement which currently exists relative to the amount of water that is available in many years. This was because:

- in many water sources limits had not been set on extractions so that increases in water usage could be met from the river flows (albeit from higher less frequent flows), or by mining of the groundwater (albeit requiring progressively deeper bores),
- the real nature of the licensed access right was not made explicit and licence holders were left to wrongly assume that they had an absolute right to access their full licensed volume if it was physically available. However, the reality was that most water sources could not reliably supply all of the licensed volume once it was active,
- water licenses have failed to clarify the difference between the licensed volume and the access right, the end product of which is the water allocations made available under the water sharing processes established at the time,
- under-use by some water users was reassigned to active users by administrative process or rostering arrangements,
- access to supplementary (previously called off allocation) water was based on local operational decisions that were not defined in licence conditions or policy, and
- the individual's storage capacity relative to that of other water users was constantly changing.

Separation of different categories of access licences and their components, establishment of extraction limits, and specification of individual share components for all licence holders, including those who are currently inactive, will give greater certainty to both current and new investors, and will increase the value of the right. It will also facilitate better informed and more efficient investment decisions.

PART 2 Five year water management targets

Division 1 Limits on extractions

- Target 1** Limits on the total volume of water that can be extracted established, such that:
- Target 1a** Extractions in Murray-Darling Basin's regulated rivers limited to the level of the long term average annual extraction below the Murray-Darling Basin Ministerial Council (MDBMC) Cap which results from the long term impact of the environmental water rules
- Target 1b** Extractions in Murray-Darling Basin's unregulated rivers limited to the MDBMC Cap level
- Target 1c** Long term average annual extraction limits which are ecologically sustainable, and which minimise downstream impacts, established in all coastal water sources
- Target 1d** Floodplain water harvesting extractions licensed and capped at 1993/94 levels in the Murray-Darling Basin, and at levels consistent with the long term average annual extraction limit in other water sources
- Target 1e** The long term average annual extractions for groundwater limited (or being phased down) to an ecologically sustainable level (the Sustainable Yield) as determined by detailed assessment of each groundwater source and consultation with the relevant management committee. In the absence of such an assessment, the following to apply:
- 100 percent of average annual recharge for a groundwater source where there is no significant ecosystem dependency
 - 70percent of average annual recharge where there is significant ecosystem dependency
- Target 1f** Rules for adjustments to future available water determinations, in the event that the extraction limits are exceeded, clearly prescribed in consultation with the relevant management committee, and acted upon

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Since the 1950s, and as a result of government policy to encourage irrigation development, there has been continued growth in the amount of water extracted from the surface and groundwater sources of the State. Among other things, the levels of water extracted has significantly reduced river flows, with the median annual flow at the end of several western regulated rivers now only 30 percent to 40 percent of that which would have occurred prior to development. This reduction has most notably affected the frequency of small to medium sized freshes, with many of these events being completely eliminated. Such changes to the flow regime have had a significant impact on river health. There has been a contraction in wetland communities, native fish have declined, algal blooms have increased in frequency and intensity, and salt water has been able to move further upstream from coastal estuaries

with consequent impacts on freshwater species. Groundwater levels have also declined in many aquifers as a result of extraction, with consequent impacts to the baseflow contributions to rivers and to the health of dependent ecosystems.

Long term average annual extraction limits set an upper bound on the amount of water that can be taken from a surface or ground water source in any year, or group of years. Extraction, for this purpose, includes both the water pumped directly from the river or aquifer as well as those volumes extracted from the rivers via irrigation or other channels measured at the offtake point, and therefore includes the transmission losses associated with those extractions.

In the past there was a reluctance to set limits on extraction because there was a belief that:

- the environmental damage resulting from increased extraction was the inevitable and acceptable cost for economic development,
- future demand for water could be met from high flows with minimal environmental impact,
- an extraction limit would unacceptably impact on the economic return from continued water resource development, and
- an extraction limit would mean that future activation of undeveloped entitlement would be at a cost to the water supply reliability of active water users.

There is, however, increasing acceptance of the need to place overall limits on extraction, typically defined as long term average annual extraction limits, in order to halt the environmental decline that is becoming evident in many water sources. High flows in an up-river management area, for example, will often translate to lower flows so that additional extraction will compromise the security of supply to downstream users. Clear specification of the limits to extraction are essential for the clarification of access rights, the effective operation of a water market, informed business planning and efficient investment decisions.

Extraction limits protect the security of supply of existing licence holders by limiting the granting of new licences in a 'fully allocated' water source. In the absence of an extraction limit, over-use can arise or be exacerbated, causing conflict within a community, devaluing individual entitlements and encouraging inefficient investment.

A recent "Review of the Operations of the Cap – Social and Economic Impacts" by Marsden Jacobs and Associates 2000, observed that: "The prime benefit of the Cap is the guaranteeing of security on a valley-by-valley basis. In the absence of the Cap there would be substantial erosion of security of entitlements across the Basin. The Cap provides a better and more certain climate for investment and jobs growth."

In the absence of constraints to extraction there are generally few motivations for efficient water use and the marginal value of water will generally remain low.

While it is difficult to define exactly what level of extraction is "sustainable" as it would involve a complex measure of biophysical interactions and social and economic demands, a number of State and inter-Government policies establish appropriate limits.

Evidence of significant environmental damage and the continuing erosion of supply reliability to downstream users led the Murray-Darling Basin Ministerial Council (MDBMC) to place a cap on water extractions in the Basin at 1993/94 development levels (the MDBMC Cap).

However, there is scientific evidence to suggest that water extractions at the Cap level may be responsible for unacceptable degree of environmental damage in parts of the Basin and a lower extraction limit may be required to rehabilitate these water sources and ensure the effectiveness of the environmental water rules. The extraction limit target for the NSW regulated rivers of the Murray-Darling Basin is therefore set at a level of extraction below the MDBMC Cap, which results from the impact of the prevailing environmental water rules.

This lower extraction limit is necessary to ensure that river flows not specifically targeted or restored by environmental water rules cannot be further diminished by extractions. Because the extraction limit is below the Cap it ensures that this external obligation is also met.

Floodplain harvesting is the collection, extraction or impoundment of water flowing across floodplains. These floodplain flows can originate from local runoff that has not yet entered the main channel of a river, or from water that has overflowed from the main channel of a river during a flood.

To date, floodplain harvesting has not been subject to any licensing or control processes. If this were allowed to continue, further growth in extractions would occur which would threaten river and wetland health and the water supply to other water users. The increase in flood harvesting extractions would have to be offset by a reduction in other forms of water extraction. Leaving floodplain harvesting as a freely available source of additional water supply is no longer acceptable. The MDBMC Cap applies to all water extracted from inland NSW rivers, and so floodplain harvesting clearly falls into those activities that are required to be licensed under the *Water Management Act 2000*. So long as floodplain harvesting remained freely available it also undermined the water market and reduced the incentive for water use efficiencies.

Issuing access licences and approvals for floodplain harvesting and clarifying the rights of those involved in it will assist future investment and business decisions. This should initially focus on controlling the works via approvals, but should move towards specifying access licence share and extraction components.

In inland water sources, the MDBMC Cap is based on the use of water associated with the level of development that was in place in 1994, and therefore this must form the basis for the future limits on floodplain harvesting extractions. Works in place in 1994 will be identified using aerial photography and Landsat imagery from that time and from this estimates will be made of the extent of activity then compared to what is currently in place. While there has been growth in floodplain harvesting works and extractions since 1994 in many water sources, it is expected that the licensing and approval process will result in some modifications of existing works or will identify works in place in 1994 that are now no longer operational. This may offset some of the post-1994 development. If not, restrictions will need to be imposed on the use of the licensed works in order to return extraction to Cap levels. By preventing the construction or enlargement of structures, the opportunity for further growth in floodplain harvesting extraction will be minimised.

The NSW Groundwater Quantity Policy requires that access to groundwater be managed within the Sustainable Yield of an aquifer so that the resource is sustained for future generations and dependent ecosystems remain viable. This is also consistent with the “National Framework for Improved Groundwater Management in Australia” ARMCANZ (1996) which states that “The groundwater extraction regime, measured over a specified planning timeframe, should not allow unacceptable levels of stress and protects the higher value uses that have a dependency on the water”.

To ensure that water levels recover over the longer term, total groundwater extractions should not exceed average annual recharge. However this criteria alone would allow extractions to draw water levels significantly below natural bounds over shorter timeframes when recharge may be below average. Therefore annual extraction rates (the Sustainable Yield) should be set at levels below the average annual recharge to reduce the extent of drawdown wherever this could threaten dependent ecosystems or surface water sources. Where detailed information on the environmental dependencies is not available, this volume should be equivalent to 30 percent of the average annual recharge. In aquifers where few significant groundwater dependent ecosystems can be identified, this volume may be reduced.

An overall limit on extractions is also required in coastal river water sources. Many coastal rivers are already stressed and without defined extraction limits there will be a continued risk of overdevelopment, with consequent damage to both the freshwater and estuarine ecosystems and coastal fisheries. It is also important that such limits are specified now to ensure that water users are aware of their future options. What the annual extraction limit should be in each case will depend on

the evidence of environmental damage from current extraction levels, the degree of environmental vulnerability and the degree to which the water source is contributing to downstream water supplies. In the absence of clear evidence, a precautionary approach is required by the Act. In unregulated rivers the extraction limit will need to take into account the supply reliability which results from flow variability and the impact of daily flow extraction limits. Setting daily extraction limits without an appropriate annual limit could increase the frequency or duration of stress by increasing the number of days which are subject to the maximum extraction rates, particularly in already stressed water sources. It is important that the limits are made explicit so that business decisions are properly informed.

Growth in water extractions can occur through activation of current sleeper (unused) licences through business expansion or through the water market (transfers or dealings), increases in water use infrastructure and changes in water users' management decisions. This growth can be rapid, and could easily lead to extractions significantly exceeding established limits within just a few years, even where no new water licences are being issued.

The only viable response if extractions start to exceed the agreed limits is to adjust the water management rules in ways that reduce water usage and discourage further unsustainable growth. Experience demonstrates that each time a management adjustment is required there is debate and conflict regarding the form and degree of the adjustment that should be applied. This leads to lengthy delays in determination and application of adjustments, with the result that extractions continue to exceed limits for long periods of time with consequent impacts on environmental water and users in downstream water sources. The lack of clear and decisive action and forewarning of the type of action that will be taken also leads to investment uncertainty and inefficiency.

The specification of clear rules over the determination and timing of management adjustments made in response to growth in water extractions beyond extraction limits will help ensure that environmental objectives are met. It will also mean that those who would be affected by any such adjustments are aware of this potential and can manage their businesses and investment decisions accordingly.

The most direct and effective way to achieve an overall reduction in water extractions is to reduce the maximum amount of water that is made available for extraction. This reduces water extractions in high water use years, and discourages further expansion of works to capture more water.

Water sharing plans must clearly prescribe what the management response should be, when and how it is to be applied to offset any growth in water use beyond the extraction limits established by the plans and, for inland surface water sources, the MDBMC Cap. These responses must include reference to the audit processes, the triggers for adjustment, the mechanisms for adjustment including the licence categories to be affected and the process for calculation of the degree of adjustment to be imposed.

Division 2 Environmental management

Target 2 All management plans incorporating mechanisms to protect and restore aquatic habitats and the diversity and abundance of native animals and plants, with particular reference to threatened species, populations and communities and key threatening processes

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

It is important to ensure that management plans are consistent with sections 5(2)(b), 5(2)(e), 5(2)(f) and 5(3) of the *Water Management Act*, which aim to optimise environmental outcomes, especially in regard to biodiversity and the recovery of threatened species.

Furthermore, the loss of habitat as the result of the destruction or degradation of water sources and associated ecosystems has a direct, and scientifically established, impact on the health and wellbeing of Aboriginal people. It further impacts upon the observance of traditional laws and customs as well as on the contemporary and recreational activities of Aboriginal people. Therefore an improvement in the condition of ecological habitats and their dependent species is one essential element in improving the social and cultural life of Aboriginal people. It is also important to actively and effectively engage Aboriginal people in the water planning process to ensure that these interests are properly recognised and addressed.

While recognising that definitive information on water and habitat requirements and sensitivities for many plant and animal species and communities may not be available, it is important that management plans have thoroughly considered all the available information, sought field or modelling verification (wherever practicable) and have reflected this.

Where possible the approach should be to develop a plan hypothesis setting out how the plan is expected to contribute to a long term improvement in ecological health and in the abundance and diversity of communities and species. This would require the following steps:

- identify elements of the flow regime and/or other physical factors that are likely to have a significant influence on the habitat condition, ecological functions and or life cycle responses of ecological communities or species. Models or relationships between the ecological, community or species response and the physical aspect which is being managed can be obtained from the scientific literature or derived from monitoring and assessment programs,
- design actions or management rules that will maintain or improve the relevant aspects of the flow regime or other physical parameters. The requirements of any relevant threatened species recovery or threat abatement plans would need to be given priority in this process, and
- assess whether the flow or physical changes resulting from the plan are large enough to have a positive impact on the ecology.

There are a wide range of mechanisms available which can help to improve biodiversity such as:

- establishing annual extraction limits for water sources,
- environmental releases from storages which can improve flow frequency, connectivity and the duration of critical events for bird or fish breeding etc.,
- removal or modification of barriers,
- rehabilitation of eroded channel or riffles,
- reinstatement of flood paths and inundation areas,
- re-flooding of drained wetlands and creeks,
- mitigation of flow-related water quality problems,
- reduction in cold water pollution,
- restoration of riparian zones, and
- weed management.

Target 3 A network of aquatic reference sites based on biogeographical regions identified, and the monitoring and management implications assessed

While this target may ultimately have implications for management plans under the *Water Management Act 2000*, it will need to be initially addressed independently of such plans.

A wide range of water and broader catchment management initiatives are being put in place to improve or rehabilitate aquatic habitats and the abundance and diversity of their dependent plant and animal communities. The ongoing monitoring and assessment of these habitats, ecological processes and communities is essential to inform the future review and adaptation of the various management provisions. Unfortunately such performance monitoring is made extremely difficult by the large number of confounding and dynamic factors that can impact on aquatic systems. It has been proposed therefore that a network of sites, encompassing a range of river styles, and river flow and ecological characteristics, where the degree of future change is likely to be minimal, could provide an invaluable reference against which the management outcomes of other water sources may be compared and judged. Such sites would also have educational and research value, provide a means to raise community awareness of river health issues and would help to manage and conserve examples of aquatic ecosystems.

The selection and extent of such sites, how representative they are of larger water sources and what would be involved in adequately managing and monitoring them, will be critical factors in determining whether such an approach is likely to be practical and useful.

The focus of this target is therefore on:

- determining the number and type of reference sites which would be necessary to provide a meaningful representative system,
- designing a cost effective monitoring and assessment program to provide a meaningful benchmark,
- identifying the management and development implications associated with maintaining a stable system of benchmarks, and
- assessing the potential costs associated with the establishment and maintenance of such a network, both in terms of any development opportunity foregone and in the cost of monitoring.

Site selection should be based on a biogeographical regionalisation of water sources across NSW. As a matter of practicality and to keep potential impacts minimal, representative sites on water sources which fall within existing terrestrial reserves should be given priority.

Target 4 Environmental water rules and extraction limits established in regulated and unregulated rivers subject to gazetted water sharing plans, such that:

Target 4a Wherever the frequency of “end of system” daily flows would be less than 60 percent of the predevelopment level without environmental water rules or extraction limits, the flows increased to 60 percent of the predevelopment level or increased by at least 10 percent of the pre-development frequency

Target 4b Frequency of “end of system” daily very low flows (as defined by local field investigation) protected or restored to predevelopment levels to maintain or restore their critical ecological functions, drought refuges and habitat connectivity. In the absence of such local assessments, protection extended up to at least the pre-development 95th percentile

Target 4c The channel capacity of all lower river and effluent creek systems used for the delivery of regulated water determined. Subject to reasonable socio-economic impacts, limits on daily supply

volumes established for identified effluent systems such that they do not exceed 80 percent of the channel capacity for more than 10 percent of days in each month of each year. Where daily supply volumes are currently substantially less than channel capacity, alternative limits established to reduce the impacts of unseasonal flows arising from future access licence dealings.

Target 4d A proportion of the natural drying phases reinstated in the core areas of terminal wetlands

This target is relevant to management plans under Part 3 the *Water Management Act 2000* dealing with: Division 2 - Water sharing. (Note: Target 4d maybe addressed in the implementation program rather than the water sharing plan where this may affect water supply operations rather than the bulk access regime).

While annual extraction limits are an essential tool for slowing or limiting environmental degradation, they cannot address the more localised impacts of extraction on the pattern and frequency of high, moderate, low and seasonal flows.

The Interim Environmental Objectives released in 1999 identified low flow protection (RFO 2), the restoration of high flows (RFO 3), and flow variability (RFO 6), as three of the most critical aspects of the flow regime.

There is increasing evidence that variable flow regimes across the full range of flows are critical to water dependent ecosystems and targeting just one element of the flow will not be effective in correcting the general environmental decline resulting from a loss of flow variability.

Low flows generally:

- moderate the rate of decline in water quality,
- moderate water temperature increases particularly in unshaded rivers , and
- maintain refuge areas in pools and wet gravel beds,

While the ecological stresses imposed by drought are a natural and important phenomenon, if these conditions occur too frequently or for too long they will reduce the capacity of the ecosystem to recover when conditions improve and may cause the local extinction of more sensitive species. For example, if flows into natural pools are reduced for extended periods, turbulence is reduced and oxygen exchange also declines. Stratification of the pool may eventuate and the oxygen depletion accelerated. Dissolved oxygen, which varies naturally with temperature and flow, is critical to many ecological processes and the survival of aquatic species. Low oxygen levels can reduce threaten local populations of sensitive species, reduce biodiversity and favour a few low oxygen tolerant species.

High flows encompass:

i) Pulses or freshes that remain within-channel and typically wet the top half of the channel cross-section. These within-channel pulses have been found to:

- maintain the channel,
- trigger fish breeding and dispersal events (as many native fish do not rely on floodplain inundation for spawning),
- wash carbon from in-channel benches and bars,
- increase turbulence and therefore oxygenation,
- suppress thermal and chemical destratification of pools,
- suppress algae growth,

- scour stony beds,
- reset biofilm succession on rocks and snags,
- trigger macroinvertebrate reproduction,
- reduce salt concentrations, and
- suppress alien species.

ii) Flood pulses which break out of the channel and:

- inundate and rejuvenate wetlands and floodplain woodlands,
- stimulate food production and breeding of a diverse range of aquatic and semi-aquatic species,
- temporarily connect floodplain and instream habitats for the exchange of carbon and invertebrates,
- stimulate native fish breeding and migration and enable distribution of juveniles, and
- stimulate waterbird breeding.

Because of the importance of flow variability and the complex relationship between habitats and ecological process and flow, this target seeks an improvement across the full flow range. For practical purposes, however, it is expected that this target would be primarily evaluated against the following flow levels: 95th percentile (the flow which is equalled or exceeded on 95 percent of days), 80th percentile, 50th percentile, 30th percentile, 15th percentile and 5th percentile. Of course, other thresholds eg the commence-to-inflow levels for wetlands may also be targeted for the design of local environmental water rules.

Daily extraction limits and/or environmental water rules governing releases from storages are required to protect or improve critical regimes and to clearly define the access rights of individual licence holders:

- the extraction components of the access licence would need to identify water level or flow thresholds which would trigger a specified reduction in extraction, and
- environmental water rules would apply to in-river dams that impact on the flow regime by capturing some or all of flow events. Some of these events can be restored by releasing some or all of the inflow (often termed "translucent dam rules"), or by storing environmental water in the dam for later release according to down-river flow or environmental conditions.

The greatest impact of water extraction is typically at the end of a river due to the cumulative demands of upstream dams and pumps. The recommended flow targets therefore apply to the end of each river or, in the case of those water sources that terminate in a wetland or estuary, the estimated inflows to that wetland or estuary. In the case of unregulated rivers, the end of river is the downstream point of each nominated management unit.

The target seeks to protect or reinstate flows to at least the level equivalent to 60 percent of their natural frequency. This is based on the assumption that a river maintaining 60 percent of its natural flow has a high probability of sustaining a healthy ecology over the long term. This assumption is supported by the NSW Stressed Rivers Assessment which was undertaken in 1998 and found that when greater than 60 percent of the flow remains other indicators of environmental stress were unusual. It is also consistent with the view of an expert panel of scientists from the CRC for Freshwater Ecology, the CRC for Catchment Hydrology and the National Parks and Wildlife Service reported in Watershed, February 2002, stating "There is substantial risk that a working river will not be in a healthy state when the key attributes of its flow regime are reduced to below two thirds of their natural level."

The regulated rivers of NSW and the Barwon-Darling support important ecosystems and populations of aquatic species particularly in their mid to lower sections. River regulation and associated water

extractions have substantially reduced the flows with consequent declines in ecological processes and species abundance and diversity. Given the degree of impact on flow frequency in their lower reaches experienced by most regulated rivers and the increasing evidence of decline in the ecology of these rivers, a target requiring a 10 percent improvement where flows have been reduced by greater than 40 percent is established.

In 1998, river management committees for the regulated rivers of NSW recommended an interim set of environmental flow rules. These rules were designed to address the significant features of the flow regime that had been impacted by river regulation and water extractions. These rules were reviewed for water sharing plans in terms of meeting environmental targets, and the rules modified as appropriate.

Because this target seeks to maintain or improve flow frequencies throughout the year it should therefore be primarily judged using the whole of year daily flow statistics. However, regulated rivers can impact on flows differently in different months due to the pattern of irrigation demands and the seasonal effects of dams and their operations. Therefore the seasonal or monthly impacts of different water supply and flow rules should also be assessed. It is quite likely, for example, that environmental water rules which seek to improve spring flows for bird breeding or fish spawning purposes may unintentionally worsen flow frequency in the remaining months of the year when other ecological processes may be important.

The following table shows the flow frequency as a percentage of the pre-development level, with and without the interim (1999/2000) environmental flow rules (EFR).

River	High Flows (10 th percentile)		Medium Flows (50 th percentile)		Very Low Flows (95 th percentile)	
	No EFR	Interim EFR	No EFR	Interim EFR	No EFR	Interim EFR
Murrumbidgee (Balranald)	50%	49%	19%	30%	30%	52%
Lachlan (Booligal)	71%	82%	61%	44%	100+%	0 flow
Macquarie (Marebone - d/s extractions)	87	90%	34%	47%	100%	100+%
Namoi (Mollee -d/s extractions)	58%	61%	51%	48%	29%	14%
Gwydir (Yarraman + Mehi inflow - d/s extractions)	48%	50%	55%	66%	81%	100%

(Note: Best available figures at the time of preparation of this SWMOP).

The shaded boxes indicate where the 1999/2000 interim environmental flow rules (pre initial water sharing plan) would not have fully met the target.

A Stressed Rivers Assessment was undertaken in 1998 for the unregulated rivers of the State. It assessed the hydrologic stress as the proportion of the daily low to medium flow that would be extracted by licence holders during peak irrigation periods. It also considered the level of stress exhibited by a range of other environmental indicators. The analysis suggested that subcatchments (management units) which had a significant proportion of their low to median flows extracted during the irrigation season were typically likely to exhibit other evidence of environmental stress. Of the total number of unregulated subcatchments across the State (>700), approximately 25 percent were assessed as having their flows reduced to less than 40 percent of natural (high stress category), and another 10 percent as having their flows reduced to less than 60 percent of natural (moderate stress category) at these times. About 30 percent of subcatchments were not assessed due to inadequate river flow data.

This target is therefore consistent with the stressed rivers' assessment. However, because the impact of water extractions in unregulated rivers is generally concentrated in a few critical months when flows are typically low, and there is no buffering effect of a major dam as there is in regulated rivers, the target should be assessed in relation to the flow statistics for the critical months instead of/or in addition to the whole of year statistics. The critical month is the month of highest irrigation demand relative to flow.

In regulated rivers a large portion of the water made available for extraction is delivered down-river from the headwater storages during the irrigation season when river flows would have been naturally low for much of the time. This means that long distances of the main stem of these rivers, as well as some regulated anabranches and effluent creeks, are carrying unseasonably high flows for long periods of time. In many cases these flows are held at or close to bankfull, saturating the riparian banks and/or inundating adjacent wetlands/billabongs for unnatural periods.

These flows typically eliminate natural water level variations and flow pulses that would otherwise trigger important ecological processes and influence species competition and succession. At worst they will kill riparian and wetland plants, and cause local extinction of animal species which cannot tolerate long periods of inundation or stable water levels, and at the very least they will reduce the food supplies, lower ecological productivity, reduce native fish numbers and advantage alien species. The damage often increases the higher the supply flows are relative to channel capacity. For example, river flows typically break out into adjacent wetlands and start to saturate riparian root zones when the flow level is in the top 10 to 20 percent of the channel. Seeking to keep supply flows below this level should help to reduce the damage.

The upper sections of regulated rivers are often run closest to channel capacity for the longest length of time. This is because the total supply volume necessary to satisfy the full irrigation and other demands must be supplied through these reaches. In some water sources, such as the Murray (at the Barmah Choke) and the Murrumbidgee (at Gundagai), the problem is exacerbated by natural or artificial restrictions in the channel. So, while, the flow impact is often greatest in these reaches, there is little capacity to make a significant difference without major impacts on the whole irrigation industry. These reaches do not form part of this target.

At the same time, there are significant reaches of the lower river and its effluent creeks that are carrying increasing volumes of regulated supplies as a result of expanding irrigation and water transfers and dealings into these areas.

Many of these lower reaches also have significant and diverse ecological communities such as billabongs and ephemeral stream habitats that have evolved as a result of the naturally diminishing flows in these areas. The relatively constant supply levels can therefore cause substantial damage in these sensitive areas. At the same time, because such water sources are typically only supplying a small proportion of the irrigation demand, there is more capacity to modify the rates of supply to reduce or minimise the problem. Where the irrigation demand has already developed and the reaches are already run at full capacity for significant periods, reducing the peak supply rates to 80 percent of channel capacity should provide some

significant improvements. In river reaches still relatively undeveloped lower limits should be determined to reduce the potential problems.

The following table indicates what constitutes the lower river and effluent creeks of regulated rivers, and which sections are currently supplying water at rates greater than 80 percent of the channel capacity for significant periods. It also shows the channel capacity and an estimate of the installed pump capacity under access licences.

Some of the reaches of lower river and effluent creeks may be constrained by inter-Government obligations which may preclude them from fully meeting the target, but opportunities to address the problems associated with this seasonal reversal of flows should be explored within these constraints.

Peak supply rates do not currently exceed 80 percent of the channel capacity in the Border Rivers, Hunter River, Murray, Lower Darling, Namoi and the Lachlan rivers.

Determining Target 4c will involve an assessment of current practice, environmental features, options to progress to the target, socio-economic impacts and the timeframe to achieve the target.

For those river reaches and effluents where supply delivery is currently less than 80 percent channel capacity, an assessment will be completed to set appropriate upper channel capacity limits to avoid seasonal flow reversal from occurring in these areas. This will also provide guidance on sustainability limits for future water transfer and dealing decisions in these reaches.

Regulated river water source	Definition of lower river	Known area of concern	Supply constraint (megalitres/day)	Estimated installed pump capacity (megalitres/day)
Murray River	Murray River downstream of Torrumbarry Weir Edward River downstream of Moulamein	None		
Murrumbidgee River	Downstream of Narrandera	Yanco Creek	1,400	10,715
Lachlan River	Downstream of Forbes	*		
Macquarie River	Downstream of Warren	Bulgeragar Creek	500	735
Namoi River	Downstream of Narrabri	* Pian Ck	2000	2085
Gwydir River	Downstream of Pallamallawa	Carole Creek, Moomin Creek	2,500 2,200	4740 6,000
Border Rivers	Downstream of Goondiwindi	None		
Lower Darling	Downstream of Menindee	None		

*Note: The issue of concern in these water sources relates to getting water into the effluent system through the regulator, not the capacity of the effluent itself.

Parts of the central core of major terminal wetlands of the Gwydir, Macquarie and Lachlan water sources have been receiving unnatural flows during dry periods due to one or more of the following:

- excess regulated supplies up-river which are not extracted due to local rainfall or over-ordering, and
- continuous stock and domestic supplies into the lower river reaches.

These more or less continuous, albeit low volume, flows keep the central areas of the wetland unnaturally wet and prevent the natural drying cycle which determines plant species composition and allows the aerobic decomposition phase critical to wetland productivity. More stringent management of regulated water and pulsing or piping of stock and domestic supplies can enable drying phases to be restored in these core wetland areas.

Division 3 Clear and legal entitlements

Target 5 Access rights for water access licensees clearly and legally specified in terms of shares and extraction components

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Most holders of water licences have held these licences for many years and many have made significant investment in the irrigation or other enterprises that are dependent on continued access to water. Other licences have changed hands through land or water transfers and significant sums have been paid to obtain the water licence. Despite this, there has been growing uncertainty about what assurances, if any, these licences provide the holders in respect to their continuing access to water. These concerns typically relate to:

- the erosion of water availability due to increased environmental provisions,
- the potential for changes to licence conditions and the imposition of extraction limitations during the term of the licence,
- the erosion of water availability due to the development of inactive (sleeper) licences, particularly as a consequence of water transfers and dealings, and
- the lack of an effective water market in unregulated and groundwater water sources.

A water access right exists when the community supports and protects for a certain period of time the exclusive use and enjoyment of the access right and allows it to be traded or passed to others. An access right is therefore only of value whilst systems of regulation limit others from enjoying the benefits associated with this exclusivity. At the same time, the exclusivity can only be realised if it is subject to controls in the way it is exercised and if the effective value of it can be modified through the application of regulations.

As a general rule, the establishment of an effective market-based system of access rights in water requires these to be:

- in demand, ie they need to be limited in extent or availability. Most water sources are now embargoed and total extractions capped which means that access rights in water can now be established,
- well specified in the long term so that the market can interpret and depend on what the access rights mean. This allows for transparent “book-keeping” and enables the holder to better assess their likely water availability and reliability so that they can make better informed business decisions. This does not mean that the rights will have any absolute value but rather they will be a capped share of the water, as it becomes available in the variable climatic cycles. The specification of a volume or a share on an access licence therefore has two purposes - it sets an upper limit on the value of the right, and it provides the means for calculating the relative share of the available resource,

- exclusive such that the benefits and costs associated with the access rights are attributed to the holders of the access licence. Water allocation systems in the past have failed in this respect because the under-use of fully or partially inactive licence holders have typically been administratively redistributed to large users from year to year,
- enforceable and enforced through regulations and systems. A proper system of access rights depends on an effective and transparent system of regulations, and
- transferable and divisible. This can only exist where the rights are clearly specified in volumetric or share terms, and extractions are carefully monitored.

Such access rights to water must still be able to be attenuated or diminished by the conditions that are applied to their existence so as to enable the rights of the broader community to be safeguarded and sustainability ensured, as required by the *Water Management Act 2000*. The conditions and processes by which this may happen should however be made clear and transparent in water sharing plans.

Target 6 The total volume of share components specified on access licences to be more closely matched over the term of a water sharing plan to the extraction limit of the plan, such that:

Target 6a For groundwater sources, the total volume of water specified on access licences reduced over the term of a water sharing plan to no more than 125 percent of the Sustainable Yield

Target 6b For surface water sources, a pathway for reducing the share components to 200 percent of the long term average annual extraction limit to be established not later than the end of the term of the SWMOP

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

In most water sources, it is reasonable for the sum of the share components specified on access licences to exceed the extraction limit. This is because the extraction limit is generally specified as a long term average annual volume while the licence share components are related to the maximum volume that a licence holder can extract in any individual year.

The maximum volume extracted will generally be larger than the average volume extracted because of the effect that climatic variability has on water availability and on water demand. This effect will vary greatly between surface water sources and groundwater sources, and more particularly between different rivers depending on the regularity of their flow.

Furthermore, many access licence holders treat much of the share components specified on their licence as a buffer against drought and reduced water availability. In some years water users may also suppress their planting or irrigation in response to low commodity demands or prices. In combination, these factors will mean that water extractions will be considerably less than the total share components specified on water licences in many years.

Conversely, if the total licensed share component is significantly greater than the long term average annual extraction limit for the water source, individual licence holders, particularly new entrants, may assume unrealistic expectations about the long term water volume that they can expect to receive and may over-develop their enterprise. The result will be inefficient investment and the over-valuation of licences in the market.

Such unrealistic expectations can also act as a catalyst for growth in water use in a water source, which will subsequently require reductions in water availability to all users to ensure that the

extraction limit is met. This will contribute to greater management and industry uncertainty, especially in water sources where use may already be in excess of extraction limits.

The degree of difference which can be tolerated between the total share component specified on licences and the long term average extraction limit without creating false expectations and other adverse effects is less in water sources where there is less variation in the available water. For this reason the Groundwater Quantity Policy proposes that total groundwater entitlements should not exceed 125 percent of the Sustainable Yield.

In surface water sources, on the other hand, 200 percent is considered more appropriate given the high variability of flows and water use. Nevertheless assessments should be carried out over the next 5 years to determine whether further reductions should be applied in the future.

The following indicates the current status of licensed share components (in 2002) relative to the MDBMC Cap (although it will ultimately need to be judged against the extraction limits for regulated water sources).

Surface Water Sources

Total share component 200 –300 percent of extraction limit:

- Lachlan Regulated River
- Peel Regulated River
- Barwon-Darling Unregulated River

Total share component 300-400 percent of extraction limit:

- Lower Gwydir Unregulated Rivers
- Castlereagh Unregulated Rivers

Total share component over 400 percent of extraction limit:

- Belubula Regulated River
- Far West Intersecting Unregulated Rivers

Priority Groundwater Sources

Total share component 125-200 percent of Sustainable Yield:

- Great Artesian Basin
- Lower Murrumbidgee
- Lower Lachlan

Total share component 200-300 percent of Sustainable Yield:

- Lower Namoi
- Upper Namoi
- Gwydir

Total share component over 300 percent of Sustainable Yield:

- Lower Murray
- Lower Macquarie

Note: Another nine groundwater sources not on the current priority list for the development of water sharing plans are also likely to have a total share component that exceeds 125 percent of Sustainable Yield.

The above is indicative only, and final numbers will depend on the determination of the extraction limit in each water sharing plan. It is nevertheless likely that the target will affect about 10 percent of surface water extraction management areas across the State. Of these, three will need to have their total share component reduced by up to 25 percent to meet the target, and another two by between 25 percent and 50 percent to meet the target, and two by over 50 percent.

These issues have not been addressed in the initial round of surface water sharing plans. For these plans, the Minister will ensure that a pathway for reducing the share components to the 200 percent for surface water sources will be determined by the end of this SWMOP.

Nine priority groundwater sources will be affected. However, the initial water sharing plans are addressing this issue.

All future water sharing plans, prepared after the initial priority plans, will take this target into account from the outset.

The short term economic impact of any reductions in share components specified on licences will depend on the degree of adjustment required. Also, the economic impact will largely be limited to the fully active water users and can be phased in over the first few years to give these water users time to adjust.

Where total extraction is currently within the extraction limit, any reductions in the share components specified on water access licences would be likely to lead to a short term reduction in overall water use and consequent short term loss of economic productivity. This can be avoided by increasing the upper limit on available water determinations to above 100 percent, to offset the licence share component reductions. In future years, as total water use increases as a result of water trading, and licence activation occurs, this maximum available water determination percentage would be reduced.

While there may be some short term economic impacts as a result of the reductions in share components these should not be large and can be mitigated through appropriate management of announced available water determinations and carryover provisions.

If the licensed share components, on the other hand, are left at unrealistically high levels compared to the expected long term availability of water, the cost will be continuing inappropriate investment, ongoing cutbacks in available water determinations with consequent impacts on the economic development resulting from this investment, and uncertainty in the operation of the water market.

Target 7 Mechanisms in place to enable Aboriginal communities to gain an increased share of the benefits of the water economy

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Access to water and its dependent ecosystems for hunting, fishing, medicines and trading has been pivotal to the survival of Aboriginal communities and to the exercise and enjoyment of Aboriginal customs and traditions. Much of these traditional benefits have been lost or eroded through the increasing alienation of hunting grounds, loss of habitats and other forms of environmental degradation.

Facilitating greater opportunity to enjoy economic access to water will be an important factor in addressing issues of social justice and socio-economic disadvantage, and for improving the economic prosperity of Aboriginal people. This is consistent with Section 3 (iv) of the *Water Management Act 2000* that recognises “benefits to Aboriginal people in relation to their spiritual, social, customary and economic use of land and water”.

Greater access to water could provide Aboriginal communities with the means to:

- help restore, maintain and protect the customs and beliefs of Aboriginal people and natural resources which sustain them,
- help maintain and restore traditional sources of animal, fish and plant life necessary for hunting, medicine and to practice other traditions, and
- develop contemporary industries to support the future economic independence of Aboriginal communities.

It is not intended that this target be achieved at the expense of existing water users but rather by providing Aboriginal communities with greater opportunity to access, for example:

- any unallocated water (only likely to be available in some groundwater and coastal surface water sources), and
- the water market.

Target 8 Daily extraction components specified and tradeable, subject to metering, reporting and compliance, for at least 50 percent of unregulated river access licences and for 80 percent of stressed unregulated rivers

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Access to water from unregulated rivers depends on the flow regime and this is typically highly variable. Setting limits on daily extraction for low, median and high flows respectively is essential to ensure that basic rights and fundamental river and estuarine health is protected. It is also a necessary prerequisite for an effective water market.

Once bulk daily flow extraction limits have been determined they must then be shared amongst the licence holders in each water source including those within tidal pool and estuarine sections. This will make it clear what individual licence holders may extract on any day without impacting on others or on environmental water.

Ultimately the value of access rights and therefore the water market depends on the:

- individual rights to the available flow in each water source, or management unit within it, being known, and
- the daily flow extraction component of the access licence being transferable.

These daily extraction components will provide an objective and transparent basis for approval of various dealings associated with the licences. For example, new entrants will only be allowed into a water source or management unit if there are excess daily flow shares available (ie the daily flow extraction limit is not fully allocated) or if they purchase extraction components from existing licence-holders in fully allocated water sources.

Ultimately it is expected that all unregulated river water sources will be subject to daily flow extraction limits, however these may not be assigned initially as extraction components of access licences in low demand rivers without established river flow gauges. This target therefore seeks to ensure that at least 50 percent of unregulated water access licences (over 5000 licences) incorporate daily extraction components within five years. It is expected that these licences would tend to cluster together where there is more favourable topographic, soil and river flow characteristics. This concentration of demand is also a primary reason for the development of hydrologically stressed water sources (as identified in the 1991 Stressed Rivers Report). It is therefore expected that a high proportion (80 percent) of the (S1) stressed water sources can be dealt with through this target.

Target 9 Supplementary water for regulated rivers clearly specified and volumetrically licensed such that:

Target 9a Flow thresholds for declaration of supplementary water access, which take into account environmental needs, clearly specified

Target 9b Annual limits on supplementary water extractions, consistent with the long term average annual extraction limits, established in all regulated river water sources

Target 9c Rules for sharing between supplementary water access licence holders made explicit

Target 9d Supplementary access licence dealings made possible in regulated river water sources subject to extraction limits, environmental assessment, and Aboriginal spiritual and cultural constraints

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Supplementary water access (previously known as off-allocation water) may be granted to licence holders on regulated rivers at times when inflows from the catchment below the headwater dams, or flows arising from dam overflows, are in excess of environmental water provisions and the immediate water needs of higher priority water users. Any water extracted at these times is not debited against the licence holder's regulated river water account and therefore supplements their normal supplies. Historically this supplementary water was a significant source of supply, especially in the State's northern cotton valleys, and the way it has been managed has had major environmental consequences.

These uncontrolled flows, are generally all that remains of the natural high flow variability in these highly regulated rivers, and they provide for a range of environmental needs. They are important for maintaining general river health and providing water for wetlands. Because they are naturally occurring high flows they also provide environmental triggers for a range of ecosystem processes such as the spawning and migration of fish and the resetting of biofilm succession. This importance is reflected in the fact that the environmental water rules for the northern river water sources are primarily focused on protecting a greater proportion of these events. At the same time the establishment of clear and transparent rules for sharing the extraction component of this source of water is becoming critical.

In the past, the declaration of periods of supplementary access and decisions about who could take it were at the discretion of the Ministerial Corporation (ie Department of Land and Water Conservation under delegation from the Minister). This meant that, subject to the size of their water access share component, those licence holders who had the biggest pumps and on-farm storages were generally able to take the a larger share of the supplementary water. This encouraged continued investment in infrastructure even after the limits on total extractions were applied in all inland regulated water sources. This meant that the only benefit of continued investment in on-farm infrastructure was to enable the individual water user to compete against other licence holders for this now limited source of water. However at the regional level, such investment is not efficient or productive, as each additional megalitre of water an individual licence holder can take reduces the water available to those with existing infrastructure. This process inevitably erodes the returns on sunken capital and reduces the overall productive value of the water extracted.

The *Water Management Act 2000* provides for licensing of such access and for the conditions of access to be set out in the supplementary access licences and water sharing plans.

The specification of rules governing the declaration of these periods, available water determinations and how the access will be shared between licence holders in water sharing plans should:

- better protect environmental flows generally and the effectiveness of specific environmental water rules,
- ensure that future availability of supplementary water is consistent with maintaining overall extraction limits,
- ensure that the management of supplementary access is consistent with other forms of licensed water access and protects higher priority rights as established in the Act,

- ensure equitable and predictable sharing of available water,
- reduce the potential for unproductive and excessive investment in on-farm infrastructure, and
- enable the activation of supplementary water access licences in the water market that would bring economic and water use efficiency benefits, although the establishment of a supplementary access water market might be deferred to allow water users to adjust to the new water sharing arrangements.

Division 4 Groundwater dependencies

Target 10 Degree of connectivity between aquifers and rivers assessed, and zones of high connectivity mapped to enable baseflows to the river to be maintained or improved

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

(Note: The mapping and assessment required will have to be undertaken as a prerequisite of planning and therefore this target may not be fully addressed in the initial round of water sharing plans).

Highly connected river and ground water sources mostly occur within unregulated rivers where the associated alluvium is shallow, and the sediments are dominated by sand and gravel, and the water table is in direct connection with the river. In these water sources, the alluvial sediments are highly permeable, and water moves freely between the surface and the ground water source and vice versa. Similar conditions would also occur in parts of some regulated rivers and also in coastal sand bed groundwater sources that are dissected by rivers.

Although the hydraulic connection has long been recognised, the integration of surface and ground water management has been slow to develop, partly because of the complexity in the nature of the connection between different surface and ground water sources and the difficulties in measuring and modelling these interactions.

Three of the NSW Government's Interim Environmental Objectives for River Flow (1997) are relevant to the management of 'highly' connected surface water and ground water sources. These are:

- protect natural water levels in river pools and wetlands during periods of no flow (RFO 1),
- protect natural low flows (RFO 2), and
- maintain groundwater within natural levels and variability, critical to surface flows and ecosystems (RFO 8).

Rivers interact with groundwater in all types of landscapes. The interaction takes place in three basic ways:

- rivers gain water from inflow of groundwater through the riverbed (termed a gaining or effluent source);
- they lose water to groundwater by outflow through the riverbed (termed a losing or influent source); or
- they do both, gaining in some reaches and losing in others.

In some environments, river flow gain or loss can persist in one direction while in other environments flow direction can vary a great deal along a river, with some reaches gaining and others losing water. In NSW very little work has been carried out to determine the influent or effluent status of our rivers.

Withdrawing groundwater from shallow aquifers that are directly connected to surface water bodies can diminish the available surface water by capturing some of the groundwater flow that otherwise would have discharged into the river. Alternatively groundwater pumping can induce the reversal flow from the river into the surrounding aquifer. In the long term, for highly connected rivers, the

quantity of groundwater withdrawn is approximately equal to the reduction in river flow (specifically in baseflows). The further the bores are from the river and the lower the transmissivity (the rate that the water moves through the aquifer) of the geology, the longer it will take for the impact on the surface water to be felt. In many alluvial source of moderate to high transmissivity, bores as far away as 1000 metres or more from the river can have a significant and relatively short term impact on river flow (ie a ratio of bore pumping to river losses greater than 80 percent within 2 to 3 years).

As well as maintaining low flows in many rivers, the actual point of interface between the groundwater and surface water within river channels is ecologically significant. This interface is called the hyporheic zone and it plays an important ecological function in respect to both the river and the aquifer, and must be protected to maintain ecological biodiversity.

The extraction limits for highly connected groundwater sources should ensure that flow regimes protected by the surface water extraction limit are not further compromised by continued growth in groundwater extractions.

It may also be necessary to limit local groundwater extraction rates in areas adjacent to the river, particularly during low flow periods. Reductions in groundwater extractions during these times can be achieved by either applying groundwater level triggers for lowering extraction rates or by adopting similar daily flow limits to those being applied to river access licence holders based on adjacent river flows. This might be appropriate where there is little groundwater storage, transmissivity is high and bores are close to the river.

The first step in protecting or restoring low flows from the impact of groundwater extractions is to map the highly connected zones and assess the transmissivity and potential for impact on adjacent river flows and the hyporheic zone. Then, depending on the degree and nature of this connection, extraction criteria need to be developed and the Sustainable Yields and local extraction rates reviewed and revised accordingly.

Target 11 Groundwater dependent ecosystems identified and mapped for all priority aquifers, and the ecological water requirements assessed to enable local groundwater extraction rates and/or Sustainable Yields to be reviewed

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing. (Note: The mapping and assessment required will have to be undertaken as a prerequisite of planning and therefore this target may not be fully addressed in initial round of water sharing plans).

There are many native animal and plant species that rely on groundwater for at least part of their life cycle. These include plants that depend on groundwater where it emerges at the surface as springs and wetlands, and other plants whose roots tap into the water table at some depth below the surface, and animal species that live within these wetlands or within the interstitial spaces of the bed and banks of rivers or cave systems which are kept moist for long periods by groundwater seepage. This means that if groundwater levels are artificially drawn down, then there will be impacts on these dependent species and ecosystems.

Objective 8 of the NSW Interim Environmental (River Flow) Objectives identifies the need to maintain groundwaters within natural levels, and variability, as this is often critical to maintaining surface flow and dependent ecosystems.

Dependent ecosystems are sensitive to changes in both the frequency and amplitude of water level variations which can impact on the water available within the root zone of many native shrubs and trees, on the wetting and drying cycles of wetlands and the hyporheic zone (typically the gravel beds) of rivers. They may also be adversely impacted by changes in the groundwater quality. Priority ecosystems and habitats which are dependent on groundwater should be identified and mapped, and

the nature of their dependency determined (eg seasonal or temporary lakes or wetlands, roots extending into the saturated zone), and the groundwater requirements assessed. This information will be an important input into future water management review and planning processes that will need to:

- review the Sustainable Yield estimates for the aquifer to ensure that total extraction will not result in unacceptable impacts on the ecosystem,
- establish an adjacent protection zone and limit local groundwater extraction rates or establish cease-to-pump triggers to protect the ecosystem, and
- apply planning controls through environment protection plans, or limits on approvals for controlled activities and aquifer interference to limit other detrimental impacts.

Division 5 Basic and cultural needs

Target 12 Measures in place in all water sources subject to a gazetted water sharing plan, to protect domestic and stock rights from the impact of other water access and use

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Water extractions by access licence holders, particularly during dry periods can impact on the basic domestic and stock rights if appropriate provisions or extraction limits are not put in place. In unregulated rivers “cease-to-pump” levels and daily flow extraction limits must be set at levels adequate to protect the flows to support these rights throughout a catchment. In regulated rivers, storage reserves are set aside to keep the river running to supply these rights through drought years. In groundwater sources, extraction limits and distances between high yielding and domestic and stock bores may be needed to protect the water levels.

The domestic and stock requirements need to be assessed for each water management area and water extraction limits and reserve rules (how much water is held in the major storages) set accordingly.

Target 13 The knowledge-sharing, training and resources necessary to ensure that Aboriginal people have the capacity to be effectively involved in water management identified and addressed

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

Aboriginal people have an active interest in all aspects of water management and river health as it has a direct impact on the lives and wellbeing of present and future generations of Aboriginal peoples. It is therefore critical that Aboriginal peoples are effectively engaged in the planning and management processes that will govern the future management of water sources. This will require capacity building for Aboriginal representatives and assistance to the Aboriginal communities in providing input to and interpreting the complex range of assessment and planning information available. Equally it should also involve the development of means to enable the knowledge and understanding of the value and nurture of these natural resources held by Aboriginal peoples to be shared by resource managers, water users and the broader community.

Including Aboriginal representatives on management committees is an important step, but over the next few years it is critical that training, information, and other resources and support systems are established to improve the effectiveness of Aboriginal participation. This target therefore anticipates the development of a comprehensive capacity building program and a clear commitment to resources

to effectively implement it. It should be said that much of this work is already underway in consultation with the NSW Aboriginal Land Council and local Aboriginal representatives.

Wherever possible, local Aboriginal people should also be involved in on-the-ground management and works. In this way these communities can apply their local knowledge and understanding of water sources in practical ways and can ensure that such work and management is undertaken in ways that preserve the cultural and spiritual values of these places.

On 5 and 6 March 2002 in Canberra the NSW Aboriginal Land Council and the Department of Land and Water Conservation jointly sponsored the Boomanulla Conference for Country. This was attended by some 55 natural resource representatives from Aboriginal communities in NSW. It was designed to develop a statement about Aboriginal peoples expectations of the water, catchments and native vegetation planning processes of the NSW government. In particular the aim was to develop a strategy for improving Aboriginal involvement in these planning processes and greater recognition of Aboriginal views and values.

Target 14 Water sources, ecosystems and sites of cultural or traditional importance to Aboriginal peoples identified, plans of management prepared and measures put in place to protect and improve them

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

The key method for identifying traditional and contemporary Aboriginal cultural associations with water can only be achieved by consulting with the relevant Aboriginal community. This will ensure, as far as possible, that culturally significant places and species are identified and guidance obtained on how they can best be protected.

Steps that can be taken to address key values where they have been identified include:

- assess appropriate river flow and water quality objectives, to protect areas of particular economic and cultural value from degradation,
- promote the conservation and management of Aboriginal cultural heritage and places and issues of significance (eg, particular wetlands, riparian vegetation, threatened species etc.),
- identify areas of local cultural significance and where water extractions etc could be limited to maintain important sites,
- identify and provide for long-term monitoring of areas that are protected under the *National Parks and Wildlife Act 1974* and that are dependant upon water flows,
- specify appropriate site, species-specific or habitat management prescriptions for cultural significant areas and species, and
- ensure appropriate environmental impact assessment is undertaken for activities proposed in areas of cultural significance.

Division 6 Water use efficiencies

Target 15 At least 90 percent of approved water management works for the extraction of surface or ground waters (excepting domestic and stock bores) metered and reported in each water source subject to a gazetted water sharing plan

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use.

Monitoring and reporting on how much and when water is extracted from rivers and groundwater is essential for the following reasons:

- ensuring that extractions are in accordance with the terms of the water sharing plan and the conditions of individual access licences and use approvals means that the rights of licence holders can be better protected from people taking more water than they are allowed or from people taking water when they should not, and
- accurate information on water extractions means that management decisions are sound and licence holders are properly informed about the efficiency of their practices and about the value of water.

About 80 percent of water pumps are currently metered in regulated rivers and most groundwater extractions (except domestic and stock bores) - but only a small minority of pumps on unregulated river are currently metered or have water use monitored. A strategy for monitoring water extraction is being developed which will guide the progressive installation of new meters and monitoring procedures, and replacement of defective meters on most licensed pumps and bores over the next 5 to 10 years. In the long term all pumps and bores with works approvals (excepting domestic and stock bores) should be properly monitored and recorded in all water sources.

In the short term it is critical that all pumps and bores within all water sources are monitored and reported in accordance with a gazetted water sharing plan.

Target 16 Improved and extended water markets through:

Target 16a All share components of access licences tradeable

Target 16b Separation of existing water licences (excepting domestic and stock bores) under the *Water Act 1912* into water use approvals and water access licences completed for:

- 100 percent of licences in water sources subject to the initial round of gazetted water sharing plans
- 50 percent of licences across the remainder of the State

Target 16c Conversion factors and protocols established to facilitate trading and dealings between water sources, whilst also protecting existing access and environmental water

Target 16d Reduced conversion factors only applied when necessary to offset increased losses associated with water supply delivery

Target 16e Any unassigned access rights identified and clear mechanisms established for their future assignment

Target 16f Zones established where necessary for environmental protection and limits/constraints on water dealings in them made explicit

Target 16g Full public disclosure of access licence dealings and market prices

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Market competition improves water valuations and encourages the development of appropriate water uses over wasteful or poor-value uses. An effective water market will:

- redistribute water access rights amongst licence-holders,
- encourage higher productive value for the water used,
- allow water users to adjust to any reductions in historical water availability,
- reduce the net economic impact of any reductions in licensed access rights,
- reduce waste and limit the amount of water locked up in unused or inappropriate applications,
- allow new investors to acquire water without jeopardising a sustainable environment,
- provide a mechanism that allows for the redistribution of economic opportunity eg. enable Aboriginal people to gain a greater share of the benefits of water economy, and
- provide a mechanism to encourage water to move away from unsuitable and unproductive land.

The water market has expanded rapidly in NSW regulated rivers and is delivering major economic benefits by stimulating regional development and moving water to higher value uses. However, the development of the market has been uneven across water sources. Major impediments to efficient use and market opportunity remain, particularly in unregulated river and groundwater sources.

A paper on a "National approach to water trading" was released in January 2001 that builds on the outcomes of the COAG Strategic Water Reform Framework. The paper promotes a set of principles for water trading which include:

- distinctive and clearly specified tradeable rights which must be volumetric and constitute a clear and defined share of the extractable resource,
- explicit extraction limits,
- removal of unnecessary market distortions such as inappropriate conversion factors,
- separation of water access rights from land,
- market information,
- appropriate transfer and dealing protocols, and
- appropriate third party and environmental protection.

NSW must address all these factors to ensure that an effective water market can operate in all water sources as agreed extraction limits are reached and the highest productive value of water is realised. Action has already commenced to improve water market opportunities including:

- licensed share components in unregulated river and groundwater sources are being progressively converted to volumes and, in the case of many unregulated river licences, extraction components are being established as shares of daily extractive volumes. As these are incorporated into access licences, they will become tradeable,
- opportunities for water transfers and dealings between water sources are being identified and trialed. Suitable "exchange rates" must be established between water sources with different extraction limits and supply reliability so as to ensure that transfers or dealings do not impact on other water users or the environment, and
- unnecessary market distortions or disincentives are being removed. For example, in the past a deduction was sometimes made against the licensed volume or account water when it was traded ("transfer reduction factor"). In some cases this was to overcome the increased transmission losses in delivering the supply to its new location. In others cases the deductions were applied in order to achieve a "clawback" of environmental water. This latter practice is no longer acceptable as environmental water is now being addressed in the water sharing plans.

Target 17 In determining the best environmental and health outcomes for an effluent management scheme, decisions to have considered all practicable options to replace high value water used for urban and industrial purposes with treated effluent

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 7 - Environmental protection.

To date, sustainable reuse options for town and industrial sewage effluent have been based principally on land application in the form of pasture irrigation. However, there are a number of other effluent management options that better value the water.

Urban and industrial applications represent a high value use of water which is estimated to be worth \$600-\$800 per megalitre. Other high value agricultural uses include viticulture and horticulture. The urban and industrial applications will reduce the annual demand for a water supply scheme and reduce extractions from surface or groundwater sources. For local water utilities the surplus water in the account can be temporarily traded during the water year or used to meet future growth in demands.

It is proposed that greater emphasis be placed on reusing treated effluent for high value urban, industrial and agricultural uses. It is likely, however, that the opportunities and local circumstance will vary widely across the State with reuse potential varying on a case by case basis.

Target 18 High quality return flows credited against town (local water utility) water access licences all environmental requirements for a credit are met

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 7 - Environmental protection.

The NSW Government has a policy of allowing return flows to be credited against the annual water entitlement of a local water utility consistent with the new approach to integrated water cycle management. Although treating an effluent discharge to a higher standard will result in increased costs, this cost will be offset by the increased economic value of the discharged water. Therefore, allowing for the credit of any high quality discharges returned to rivers provides an economic incentive for improving the quality of discharges.

Also underlying this target is acknowledgment of the value of the discharged water and the potential for any water returned to the river to relieve pressure on stressed water sources. The water's value can be realised via the following mechanisms:

- to meet any increased water demands generated by the body that generates the effluent discharge,
- to be traded through the water market and therefore moved to other high value uses, and
- to offset any restrictions in access resulting from the application of environmental protection measures.

The rules for effluent credits (including environmental requirements) will be established by a Regulation that will be made under the *Water Management Act 2000* in 2003. The draft sewage effluent management and recycling policy will provide a context for the Regulation. These processes will set out clear guidance on selecting the best sewage management option or mix of options.

Target 19 Country town (local water utility) water consumption to decline by greater than 5 percent per head of population on average Statewide, excluding Sydney Water Corporation and Hunter Water Corporation whose demand management targets are set in their operating licences

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use.

Many country towns in NSW have already achieved demand management and water supply system improvements. The introduction of water efficiencies to towns throughout NSW has the potential to reduce water use by up to 20 percent. Reduced water use is also likely to result in a commensurate reduction in wastewater volumes. Reduced water demand and wastewater generation can create potential savings in the delivery of bulk water supply and the costs associated with the collection, treatment and disposal of sewage effluent.

Use of alternative (waste) water sources such as sewage and stormwater, particularly where existing bulk supply uses are replaced, can also produce reductions in bulk water usage. On a Statewide basis, it is expected that a 5 percent reduction in bulk water demand can more than offset any increase in water requirements due to population growth over the next 10 years.

It is expected that the proposed reduction of 5 percent per head of population can be derived from the following areas:

- implementation of demand management strategies,
- use of alternative (waste) water sources such as sewage and stormwater to meet existing demands, and
- improved infrastructure delivery and reduction in water losses via leakage.

These are all elements of the Integrated Water Cycle Management Plans currently being developed for NSW country towns.

Hunter Water Corporation has a strong record of achievement in demand management since the early 1980s when pay-for-use pricing was introduced. Residential consumption per household is the lowest of the 19 major Australian metropolitan agencies and around 10 percent of the Corporation's average dry weather sewer flows are reused by industry in the Lower Hunter region. In line with its new operating licence, which came into effect from July 2002, the Corporation is preparing an Integrated Water Resource Management Plan which explicitly evaluates both demand and supply options for assuring the security of water supply to the community.

Sydney Water Corporation's first operating licence established in 1992, sought a 25 percent reduction in demand. A moderate reduction was achieved between 1991 and 1997. In 1999, with per capita demand again on the rise, Sydney Water revised its demand management strategy to include 12 key demand management activities including pricing reforms, residential audit and retrofit, education and rebate programs, a focus on outdoor water use, leakage reduction and water recycling. Despite some success from these programs, total water demand continued to rise in 2000 and 2001. The current operating licence, whose conditions were set by the Independent Pricing and Regulatory Tribunal (IPART) in 1999, sets a target of 364 litres per capita per day for June 2005 and 329 litres per capita per day for June 2011. Current demand is 411 litres per capita per day. IPART has reviewed the demand management strategy as part of the mid-term operating licence review, and recommended more detailed reporting of demand management and consumption.

Target 20 Nil or minimal increase in basic domestic and stock rights resulting from rural subdivisions in sensitive or stressed water sources

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 7 - Environmental protection.

The *Water Management Act 2000* requires that access to water by holders of access licences must not prejudice access by basic rights holders and this requirement is recognised in Target 12. However, in some water sources there is a significant potential for rural subdivision. The increased water consumption associated with those lots would place considerable stress on existing water sharing arrangements and on environmental health, particularly during dry periods. This potential is of particular concern in sensitive and or already stressed water sources. To ensure that environmental requirements and existing basic and licensed access are managed sustainably, this target seeks to ensure that actions are taken, most probably through the environment protection provisions of the *Water Management Act 2000*, to ensure that subdivisions of properties that front stressed rivers or overlay stressed aquifers do not increase the impact of basic landholder rights on the health of the water source and on other holders of basic rights.

Target 21 At least 60 high flowing bores (>5 litres per second) in the NSW section of Great Artesian Basin capped and piped

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management.

The Cap and Pipe the Bores Program is a jointly funded initiative of the NSW and Commonwealth Governments to achieve sustainable land and water management in the Great Artesian Basin (GAB). The program has been running in NSW for several years and with additional funds provided through the combined GAB Sustainability Initiative (GABSI), \$20 million will be available in NSW over the five years from 1999 to 2004. The current phase of the Cap and Pipe the Bores Program will run until 2004, at which time continued Commonwealth funding will be re-negotiated.

Implementation of the Program will reduce water wastage, address artesian pressure decline, improve water use efficiency, reduce salinity, conserve biodiversity, control feral animals and encourage sustainable land and stock management practices.

At this stage the Program is targeting bores flowing in excess of 5 litres per second. This involves approximately 180 bores in NSW with a combined annual outflow of 80,000 megalitres. Over the next 5 years the Program aims to deal with at least 60 (over 30 percent) of these high flowing bores, deleting in excess of 2,000 km of bore drains. The majority of the water saved will be held in the system to assist in pressure recovery and to help rejuvenate ailing groundwater-dependent ecosystems, such as mound springs.

Division 7 Cost recovery

Target 22 The NSW Government to seek full cost recovery in all practicable cases excepting where capital infrastructure cannot reasonably be funded by small numbers of water access licence holders. Water access licence holders to face water charges as determined by IPART

Public as well as private investment plays a critical role in the development and management of the State's water. It is becoming increasingly important that the true cost of water supply and management is factored into future investment decisions. In 1992 the National Strategy for Ecologically Sustainable Development was released. Its objective in relation to pricing was "to

develop, improve and enhance the effective use of pricing and economic instruments as a means for achieving better management of Australia's natural resources."

The Strategic Framework for the Reform of the Australian Water Industry was subsequently developed and endorsed by the Council of Australian Governments in 1994 to be implemented over a five to seven year period.

One of the major elements of the Framework was pricing reform. In particular, States were to adopt consumption-based, full cost recovery pricing and to remove (or make transparent) any cross-subsidies between groups of water users. Suppliers were to achieve real rates of return on assets and this was to be included in costs.

Pricing reform is a long term process. NSW has an independent pricing regulator - the Independent Pricing and Regulatory Tribunal (IPART) has determined bulk water prices since 1996. In its 1996 Interim Report, IPART found that price had played a minimal role in the allocation of scarce bulk water resources. While a great deal of pricing reform has already occurred in NSW, the process is not yet complete. Pricing reform remains important at both State and local levels, to address both the relative scarcity of water and the need to use it efficiently.

NSW is committed to full cost recovery in the pricing of water to bulk rural, non-metropolitan urban, and metropolitan urban water users. However, full cost recovery is a management outcome that may not be achieved in all areas during the life of this SWMOP, because the NSW Government recognises that there are socio-economic impacts of large and frequent increases in price and these are important considerations in IPART's pricing process.

It also recognises that in a very small number of situations, full cost recovery may not be achievable at all due to previous decisions on capital infrastructure. It is not practical to expect a small number of water users to pay for the costs of a substantial dam or other infrastructure. Rather, it would be disclosed as a transparent subsidy to those access licence holders.

Division 8 – Artificial barriers and openings

Target 23 Review of all licensed weirs on 3rd order and larger rivers completed, a review of unlicensed structures on these rivers substantially progressed, a priority listing prepared, and action taken to:

Target 23a Ensure that there is no net increase in the number or total capacity of weirs in each water management area

Target 23b Remove at least 10 and structurally modify 15 of the priority weirs recommended for action across the State (eg install fishways)

Target 23c Establish improved operational protocols for priority operable weirs that will reduce their environmental impacts

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 6 - Controlled activities and aquifer interference activities.

Objective 9 of the NSW Interim Environmental (River flow) Objectives is to minimise the impact of in-river structures.

The NSW Weirs Policy was released in 1997. "Weirs" defined under the Policy include dams (less than 10 metres high), locks, regulators, barrages, causeways or floodgates across a defined watercourse that will pond water, restrict flow or hinder the movement of fish along natural flow paths

in normal flow conditions. The Policy recognises that the continued proliferation of weirs across the State is having a severe impact on the riverine environment by:

- creating barriers to fish movement,
- changing fast flowing river reaches to slow flowing reaches with consequent change in species,
- drowning adjacent riparian and wetland vegetation, and
- increasing the probability of stratification, causing dissolved oxygen to be depleted in the lower layers of the water column. This stimulates the release of nutrients from the sediments, which is one factor contributing to blue green algal bloom development.

The Government initiated a comprehensive review of weirs to identify:

- weirs which no longer serve a useful purpose and could be removed,
- weirs which could be structurally modified to reduce their impact (eg a fishway constructed), and
- weirs whose impact could be mitigated by improved operational management.

Some 1400 licensed structures Statewide have undergone a preliminary review and the following recommendations have been made:

- 88 for possible removal, and
- 135 for possible fishway construction.

There are 638 licensed weirs on named watercourses and 852 on unnamed watercourses still to be reviewed. It is also estimated that there could be up to 4000 unlicensed weirs Statewide (excluding causeways). Completion of these reviews will be an important outcome for the next five years.

Action on the recommended weirs is essential for improving river health, restoring native fish populations and in particular, for the recovery of threatened fish species. Substantial progress on the recommended program of work needs to be made over the next five years. More detailed assessments and designs will be required before any action can be taken. Nevertheless it is expected that over 10 percent of the weirs recommended for action can be targeted for completion by 2006, ie:

- removal of 10 weirs at approx. \$100,000 per weir, and
- fishways constructed on 15 fishways at approx \$300,000 per weir.

This will require a capital investment in the order of \$5 million (ie approximately \$1 million per year).

Target 24 Review of all existing tidal barriers completed, and action taken to remove, or partially, or periodically open at least 100 tidal barriers/gates

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

The NSW Interim Environmental Objectives released in 1999 identified minimising the effects of weirs and other structures (RFO 9), and rehabilitating estuarine processes and habitats (RFO 12) as two important elements to achieve good flow regimes and protect water-dependent ecosystems.

Many flood and tidal barriers have been constructed on coastal rivers in an attempt to increase and protect the area of productive farmland. Floodgates traditionally operate passively as “one way” structures that drain water from land on the upstream side and exclude tidal ingress from downstream.

The negative impact of floodgates has, however, been increasingly recognised by landholders, local councils, industry groups and resource management agencies. Such problems can include acid water discharges, loss of estuarine wetlands, reduced agricultural production, and declining fish populations.

A report by Williams *et al.* released in 1996 documented an inventory of all coastal barriers restricting fish passage and tidal inundation in NSW. They found 1035 floodgates with some potential for rehabilitation. Over half of these (784) occurred on the north coast of NSW.

Active floodgate management is the controlled opening of a floodgate during non-flood periods for the purposes of allowing tidal water to enter the affected waterway. The benefits of active floodgate management can include:

- improved water quality and overall waterway health,
- improved fish passage,
- improved soil and pasture, through better watertable management,
- neutralisation of acid discharges,
- reduced weed infestation in waterways,
- enhancement of native, water-tolerant pasture vegetation, and
- rehabilitation of aquatic habitats.

A program of audit and prioritisation of floodgates has commenced. Nearly 800 floodgates have been inspected on the Richmond, Tweed, Clarence and Macleay floodplains. The audit should be completed for the rest of the NSW coast over the next five years.

At the same time, detailed investigations of the priority floodgates and drainage systems will be carried out. These investigations will determine the best possible strategies for actively managing the floodgate and drain network. Active management of the floodgates requires funding to assist with the development of a management plan, construction of sluice gates or winch mechanisms to allow the opening of the gates, and labour to manage and operate the structures during non-flood periods. It is estimated that each structure will cost in the order of \$30,000.

It is therefore proposed to target 100 floodgates (or approximately 10 percent of the total) to be removed, or partially, or periodically opened over the next five years which should cost in the order of \$3 million. Action has already commenced on 28 of these.

Target 25 Action taken to (re)connect at least 60 percent of the natural 1 in 5 year flooded area to the river for 11 key rural floodplains by ensuring:

Target 25a The major flood paths and flood dependent ecosystems are mapped

Target 25b The significant barriers to flooding are identified, and action to deal with the major barriers commenced

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities.

RFO 4 of the NSW Interim Environmental (River Flow) Objectives is maintain or restore the natural patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems.

The floodplain is an important feature of the middle and lower reaches of a river. During periods of low flow, aquatic habitats are restricted to billabongs and the main river. Increased flows connect the river to backwaters and billabongs, wet previously dry areas, reorder the plant community and stimulate the growth of micro-invertebrate populations. The river overflows its banks, inundates the floodplain, deposits suspended material over previously dry areas, and picks up nutrients and organic matter from these same areas. Finally as water levels subside, organic material, including bacteria and other microbes, invertebrates and dissolved nutrients are carried back into the river with the returning water. Temporary wetlands are left on the floodplain, contributing to the aquatic diversity, which in turn supports the diversity of other species such as birds.

This temporary connection between the river and floodplain is critical in the energy and nutrient dynamics of rivers, and in the reproduction and maintenance of populations of many species of aquatic plants and animals. Floodplain inundation leads to an abundance of food for fish larvae. Similarly, the breeding success of waterbirds and frogs in floodplain wetlands is enhanced by the increase in productivity following flooding.

The effectiveness of river-floodplain exchanges is reduced by floodplain development, and by floodplain fragmentation and isolation which occurs mainly as a result of levee construction. Such floodplain development can totally isolate floodplain wetlands from a river so that they no longer receive their periodic flooding. The plant and animal species that depend on temporary inundation ultimately die out or abandon these areas.

This target provides for action on the following 11 key rural floodplains (encompassing 30,000 square kilometres in total):

- Namoi River Floodplain (Narrabri to Wee Waa),
- Namoi River Floodplain (Carroll to Boggabri),
- Gwydir River Floodplain (Moomin Creek Effluent),
- Gwydir River Floodplain (Biniguy to Moree),
- Liverpool Plains,
- Macquarie River Floodplain (Narromine to Macquarie Marshes),
- Lachlan River Floodplain (Gooloogong to Jemalong),
- Lachlan River Floodplain (Jemalong to Condobolin),
- Lachlan River Floodplain (Lake Brewster Weir to Whealbah),
- Central Murray Floodplain, and
- Billabong Creek Floodplain (Walbundrie to Jerilderie).

While this target addresses the whole floodplain, it focuses, in particular, on those areas of the floodplain which would probably have naturally been inundated more frequently (eg a flood event having a 1 in 5 year return period). This is not intended to detract from the importance of wetlands and floodplain ecology beyond this 1 in 5 year flooded area, but to provide a significant and practical start to the process of rehabilitating areas currently isolated from the river.

The 1 in 5 year flooded area has been selected as the initial target for the following reasons:

- most wetland plant species that require inundation require flood frequencies in excess of once in 5 years (eg river redgum typically requires flooding about 6 to 8 years in every 10; black box are generally healthy if they are flooded every 2 to 5 years; lignum in the south-west requires flooding every 3 years on average; lignum in the north west requires flooding every 2 to 10 years, spiny mudgrass requires flooding 3 years out of 4; water couch requires annual flooding; common reed may survive up to 10 years without flooding, but generally would be in lower areas of the floodplain),
- the majority of remnant floodplain wetlands are found in the 1 in 5 year flooded area,
- the higher risk of flooding in the 1 in 5 year flooded area has generally discouraged substantial investment in its development and the cost of action is likely to be less, and
- the identification and action on levees and banks affecting the 1 in 5 year flooded area is more feasible in the short term than attempting to address the broader floodplain.

Action has already been initiated on 30,000 square kilometres of floodplain in western NSW to prepare strategic floodplain management plans with a view to identifying those levees that must be modified or removed in order to restore more natural flooding regimes to wetlands and floodplain ecosystems.

This target is therefore to complete, for 11 floodplains, the assessment and mapping of the distribution of different sized floods across each floodplain, and identification of those structures impeding natural flooding of wetlands and floodplain ecosystems with particular emphasis on the area naturally flooded once in 5 years on average. Options to reduce the impact of those structures must then be identified and negotiated with landowners.

Target 26 Dams responsible for cold water pollution identified, a priority listing prepared, and action initiated to ensure that the temperature regime below these dams is kept within the 20th to 80th natural percentile range for each month (or within bounds determined by site specific investigations), by ensuring:

Target 26a Structural modification of at least 2 priority dams

Target 26b Improved operational protocols established for priority dams with existing temperature management infrastructure

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing (Note: This target may be addressed in the implementation program rather than the water sharing plan where this may affect water supply operations rather than licensed access to water), Division 6 - Controlled activities and aquifer interference activities.

Human induced change in river water temperature poses a significant threat to aquatic ecosystems. Disturbance to the thermal regimes of natural rivers can be a serious side effect of flow regulation using dams and weirs. Water released from the bottom layer of a thermally stratified reservoir is typically much colder than the natural inflow to the storage in summer. The release of large volumes of this cold water during the summer irrigation period can depress river temperatures for long distances downstream, with deleterious impacts on fish and other biota (Lugg 1999).

The potential for storages to adversely impact on river temperatures is recognised in RFO 10 of the NSW Interim Environmental (River Flow) Objectives which sets out to minimise the downstream water quality impacts of storage releases.

It has been estimated that serious cold water pollution occurs downstream of 17 major impoundments in NSW affecting an estimated 3,000 km of riverine habitat. Temperature suppression of up to 15 degrees Celsius below natural has been observed although more usually, suppression is around 8 to 12 degrees. However, the situation is more complex than a simple suppression of the temperature. For example, variation from natural temperature occurs year round, the summer peak temperature is typically delayed by up to 3 weeks, the rapid temperature rise in spring is eliminated, and the difference between annual maximum and minimum temperatures is severely reduced.

Changes in water temperature can have a substantial effect on aquatic ecosystems such as:

- influences on the physiology of the biota (eg growth and metabolism, reproduction timing and success, mobility and migration patterns and production may all be altered by changes to the ambient temperature regime), and
- influences on ecosystem functioning (eg through changes in the rate of microbial processes and altered oxygen solubility).

Available evidence in Australia suggests that temperature suppression has a profound adverse impact upon native warm water fish communities via:

- in some cases certain native fish species have been eliminated below a dam and replaced with alien species,
- silver perch may die or virtually cease growing as a result of cold water releases, and
- breeding opportunities for key native species may have been eliminated because water temperatures consistently fail to reach critical thresholds during the breeding season.

To address this issue it is necessary to estimate the natural range of temperatures that would have been experienced below each major storages in each month. Action should then be taken to keep temperatures within these bounds.

The ANZECC (2000) Water Quality Guidelines recommend that, where appropriate reference systems are available, and there are sufficient resources to collect the necessary information for the reference systems, the median temperature of cold water discharges should not be permitted to fall below the 20 percentile temperature value obtained from the seasonal distribution of temperature data from the reference ecosystem. For highly disturbed ecosystems and those in very poor condition, ANZECC recommends that appropriate site-specific scientific studies be undertaken, and the information from these studies be used together with professional judgement and other relevant information, to derive the trigger values. Where there is a lack of either information or resources to undertake the necessary site-specific studies, it is best to use the default trigger using the 20 percentile value and professional judgement.

Options for mitigating detrimental thermal effects associated with some storages include:

- construction of an off-take structure with multiple inlets which enable water to be drawn from depths other than the deepest and coldest layer. Estimated costs of upgrades vary with each storage but are generally in the range of \$0.5M to \$30M per upgrade,
- fitting of surface mounted impellers to push a plume of surface water down to the low level outlet (cost in the range of \$0.75 to \$1.5 million),
- withdrawal of warmer surface water using a submerged curtain around the low-level outlet (\$3m per upgrade),
- trunions, which are hinged pipes mounted on the low level outlet, are only suitable for smaller dams (cost about \$0.8 million),
- destratification (but this is generally unsuitable for larger storages and can cause other water quality problems), and
- improved operation of storages with existing multi-level inlet structures, including Pindari, Glenbawn and Glennies Creek dams.

Work is currently underway to assess the impacts of major storages throughout the State, identify the priorities for action and the most cost-effective solutions.

The major storages where this is a significant issue are generally owned and operated by rural or urban water supply authorities such as State Water (an arm of the Department of Land and Water Conservation), Sydney Catchment Authority, and Hunter Water Corporation.

Smaller storages, owned by state, local government and private organisations may cause local temperature problems and should be upgraded using the cheaper solutions where feasible.

Upgrades of at least 2 major storages should be achieved over the next 5 years to bring their temperature impacts during the key native fish reproductive period to within the 20th to 80th natural percentile range. This will cost between \$6 and \$30 million depending on the solution adopted.

A number of these major storages are already capable of releasing warmer water, however the operational protocols need to be reviewed or developed to ensure that the temperature targets are successfully met most of the time.

Target 27 Frequency of artificial manipulations of coastal lagoon entrances reduced, and management strategies to improve natural flow dynamics recognising their consequences on ecosystems and social assets

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

There are approximately 135 major estuaries along the NSW coastline and of these 60 (45 percent) have intermittently opening entrances and are known as intermittently opening coastal lagoons. They often the focus of recreational activity such as swimming, fishing and canoeing.

They become separated from the ocean when sediments in the entrance are moved and redistributed by wind, wave and tidal forces and form a barrier. Formation and breakdown of the barrier may occur frequently (eg. 5 to 6 times per year for Dee Why lagoon) or infrequently (2 to 3 times per century for Lake Conjola). Around half of these lakes have their entrances artificially breached from time to time (West *et al.* 1985).

Intermittently-opening coastal lagoons tend to have differing aquatic vegetation and fish populations that have adapted to the variation in salinity and freshwater inputs, and the natural closing regime of the lagoon. Under natural conditions, the frequency and duration of closure of these lagoons is influenced by factors such as the morphology of the entrance site, exposure to 'longshore drift', the size of the catchment, the tidal prism and prevailing climatic conditions. However, where urban and rural development has occurred around the fringes of the lagoon, other factors such as flooding of properties, water quality changes, and odour can result in calls from the community to artificially breach the closed entrance. When a lagoon closes, tidal flushing is eliminated and water and pollutants (eg septic and stormwater discharges, nutrient enrichment and algal blooms) from the catchment concentrate within the lagoon. This can impact on the visual and social amenity of the lagoon.

On the other hand, artificial opening of lagoons can alter the aquatic biodiversity and ecological processes of these estuarine water sources, moving them towards becoming a more permanently open estuary. If the ecological features and processes exhibited by intermittently-opening coastal lagoons are to be conserved, interference with the hydrological processes must be minimised as much as possible.

Appropriate planning for entrance management is required but is currently undertaken in an ad hoc manner by local government, state agencies and the community. The management of intermittently opening coastal lagoons is currently a focus of the Government's response to a Healthy Rivers Commission Inquiry. Decisions need to recognise the inherent differences between the impacts of opening lagoon entrances on ecosystems and the impacts on social assets.

Division 9 River channel rehabilitation

Target 28 Percentage cover of native riparian vegetation within waterfront land increased consistent with an approved catchment management plan, or increased by at least 5 percent where it is currently less than 50 percent of natural average on 3rd order or larger rivers

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 4 - Drainage management, Division 7 - Environmental protection.

Riparian land may be defined as that part of the landscape which exerts a direct influence on river channels or lake margins, and on the water and ecosystems contained within them. Waterfront land is precisely defined in the *Water Management Act 2000* and typically encompasses, for the purpose of this target, a 40 metre strip of land parallel to the high banks (or high water mark in tidal sections) and therefore encompasses the riparian zone.

The remnant vegetation contained within this waterfront land provides:

- a specialised habitat and a corridor linking other land components,
- essential functions for riverine ecology including:
 - providing a significant proportion of the food (energy inputs) required by aquatic organisms,
 - providing shelter and breeding and feeding sites for aquatic organisms,
 - influencing water temperature through shading,
- an important buffer and filter strip between land use and watercourses (nutrients, sediments and other contaminants),
- a riverbank stabilising function by nature of the soil-binding ability of roots, and
- cultural, spiritual and aesthetic values.

The assessment of riparian vegetation cover may be undertaken using remote sensing and image analysis technology. Such an analysis was undertaken for the Gwydir, Macintyre and Namoi catchments to determine the percentage cover values of riparian vegetation on each named river within a strip 20 metres wide.

The analysis found on average the following percentage tree cover existed within the 20 metre riparian strip across each catchment:

- Gwydir – 35 percent,
- Macintyre – 30 percent, and
- Namoi – 30 percent.

It is likely that similar percentages will be found in other catchments across the State although this analysis still has to be undertaken in a comprehensive way.

This type of analysis needs to be progressively undertaken on a comprehensive basis covering all 3rd order and larger rivers across the State. Then management strategies can be adopted or extended where necessary to achieve an average 1 percent per annum improvement in the percentage of riparian tree cover in each catchment.

Improvement in riparian vegetation is also a key target in most of the catchment management plans, which typically set targets for a 10 year horizon. In many cases these have proposed a greater rate of riparian revegetation per year than is proposed here. Where there is a riparian revegetation target in the finalised catchment management plan this should prevail. As the Regional Vegetation Management Plans should also be consistent with the catchment management plans this should ensure that objectives for riparian vegetation management are consistent and complementary.

Many initiatives are already underway which will contribute to a net improvement in riparian vegetation including:

- sustainable farm planning and management programs,
- Landcare and Rivercare projects,
- assistance for alternate off-river stock watering points, and

- clearing controls under the *Native Vegetation Conservation Act 1997*.

It is estimated that there is in excess of 60,000 kilometres of 3rd order and above rivers throughout NSW (draft report of River Condition, Norris et al. for the National Land and Water Audit).

This target is seeking action to revegetate up to 5 percent (in the order of 2 to 3,000 kilometres) Statewide.

Target 29 No net decrease in the length of natural river corridors through urban areas

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

Many natural rivers passing through urban areas have been piped and or channelled. This was done for a number of number of reasons such as:

- to reduce local flooding by speeding up the drainage of water away from built up areas,
- to maximise the land available for development,
- to minimise maintenance costs associated with weed infestation, littering etc, and
- to reduce risks to public safety associated with unlit wooded areas.

As a result many have become open drains carrying polluted water, excessive algae and sediment along a narrow strip of disused land.

However, there is a growing awareness of the disbenefits associated with pipes and drains including:

- loss of aquatic habitat and species,
- increased storm runoff and reduced low flows to downstream rivers,
- increased flooding and erosion downstream,
- public safety and liability risks associated with fast flowing drains,
- low aesthetic values which is showing up in lower value of land adjacent to drains compared to land adjacent to more natural watercourses, and
- increased water quality problems as pollutants are rapidly transferred downstream and their natural rate of decay (associated with detention times, the impact of sunlight, and biota in natural streams) is diminished.

The Healthy Rivers Commission inquiries have highlighted the importance of natural river channels and riverside vegetation to river health and to the urban community that live near these streams. The Commission found that riverine corridors provide multiple environmental and human health benefits such as:

- ecological corridors and wildlife habitat,
- erosion control,
- biofiltering of pollutants, and
- landscape and recreational amenity.

For some years now, approvals for the excavation of river channels previously under the *Rivers and Foreshores Improvement Act*, and now the *Water Management Act 2000*, have generally sought to maintain the natural characteristics of these urban rivers wherever practical. Some local councils have been gradually replacing drains and pipes with more natural watercourses, while many local community groups have been active in rehabilitating their local watercourses.

This target therefore seeks to at least ensure that there is no net loss of natural riverine corridors in major urban areas, in particular Sydney, Wollongong and Newcastle. This is consistent with the NSW Government's response to the Healthy Rivers Commission's recommendations for the Georges River-Botany Bay system. It is also consistent with the intent of the State Riverine Corridor Policy being developed as part of the Government's response to the Healthy Rivers Commission's Hawkesbury-Nepean Inquiry.

This target will be achieved through the implementation of the Guidelines for Urban Streams being developed under the State Riverine Corridor Policy. In particular, new urban developments should avoid further channelisation of rivers whether by piping, concrete lining or by conversion to grass swales. Instead they should be required to preserve, to the greatest extent possible, the natural values and characteristics of each watercourse. An essential element of this will be to ensure that sufficient area is protected on either side of the drainage line to maintain the rivers in healthy, albeit modified, condition. In many cases this may be achieved by integrating the provision of open space with the maintenance of riverine corridors. Such corridors must also be protected from the indirect impacts of urban development such as increased nutrients, runoff, weeds and excessive silt loads. In addition, wherever possible, previously piped or channelled watercourses should be rehabilitated as compensation for any unavoidable losses or as part of broader urban renewal and redevelopment programs involving a mix of regulation, incentives and partnership arrangements. In many cases such action could be undertaken in the context of local government stormwater management or flood mitigation programs.

Target 30 Coastal floodplain areas with high water quality risk (eg. acid drainage and/or oxygen depletion) addressed by:

Target 30a Areas of drained natural wetlands identified and mapped

Target 30b 7 pilot remediation projects completed

Target 30c Future program of land rehabilitation developed and commenced

Target 30d No increase in acid drainage resulting from new developments in a mapped acid sulfate hot spot

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

Coastal floodplains and wetlands in NSW are subject to frequent flooding. Governments have sought to mitigate flood impacts through drainage, river redesign, levees and floodgates to allow this land to be used as productive farming and urban areas. This has resulted in the loss or alteration of wetlands, and changed vegetation on floodplains and wetlands from flood-tolerant to flood-intolerant species.

These areas are also underlain by brackish water sediments that contain iron sulfide minerals. When beneath the watertable, these soils are benign. However, if over-drained either during naturally dry conditions or artificial drainage, the sulfides oxidise and form sulfuric acid. These soils, known as acid sulfate soils, can also mobilise aluminium, iron, manganese and other heavy metals, creating a toxic environment for aquatic species, and have been linked to many fish kills in the past.

Changed land management of coastal floodplains has also resulted in the generation of "black water", low in dissolved oxygen, which is very detrimental to aquatic fauna. This was typified by the major fish kills during the 2001 floods in the Macleay, Clarence and Richmond Rivers where rapid drainage of low dissolved oxygen water created from decaying flood-intolerant vegetation on the floodplain, and mobilisation of iron mono-sulfide black sludge in drains where acid sulfate soils were present, caused dissolved oxygen levels to fall rapidly for several weeks.

In 2000 the NSW Government announced the Acid Sulfate Soils Hot Spot Program which seeks to rehabilitate priority hot spots in coastal floodplains. Two million dollars has been allocated for the first two years to target on-ground changes in of seven major hot spots. At the same time it is important that the acid drainage from these hot spots does not increase as a result of new development or activity. The potential for applying an offset scheme to prevent and, if possible, reduce any acid drainage should be investigated. This would need careful consideration to ensure that the intended environmental outcomes are achieved.

At the same time, additional work is required to assist landholders to improve the management of coastal floodplains and minimise the risk of new hot spots developing. Drained wetlands and backswamps must be managed differently to reduce the risk of chronic acid sulfate soil and black water discharges following rainfall events. The first step will involve mapping high-risk drained wetlands and then working with landholders to reduce these risks. This may require modifications to drainage, watertable management, rehabilitation of wetland vegetation and other techniques.

Target 31 The peak volumes of urban stormwater runoff reaching natural watercourses reduced

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 4 - Drainage management, Division 5 - Floodplain management, Division 6 - Controlled activities and aquifer interference activities, Division 7 - Environmental protection.

Urban stormwater is the rainfall runoff from the impervious surfaces and shallow rooted lawns dominating urban areas. The unnaturally high volume and velocity of runoff following rainfall events and the consequent reductions in low and/or baseflows, can pose significant environmental risks to the receiving rivers and estuaries.

Storm runoff can also wash large loads of pollutants from the urban surfaces into urban drains and creeks that find their way into the rivers and estuaries. Urban runoff can be significant source of the phosphorus and nitrogen that contributes to algal blooms, and of harmful pathogens (with their consequent risks to human health).

There are many options for better managing urban stormwater and these are currently being developed and explored through the preparation of plans, and managed through the preparation and implementation of integrated urban water cycle management principles. Such solutions include:

- increased retention time for storm runoff through the replacement of engineered drains and pipes with more natural watercourses,
- retention and infiltration of runoff in selected basins and artificial wetlands,
- collection and reuse, and
- higher quality runoff collected and used for groundwater recharge.

The Urban Stormwater Program was originally established as part of the 1997 Waterways Package. It was evaluated by the Stormwater Trust Board and extended for the 2002/3 financial year. The next phase of the Urban Stormwater program will focus on further enhancing the capacity of local councils to manage urban stormwater in an environmentally responsible manner.

The bulk of the grants in the initial program were to local councils and this partnership arrangement continued into the second stage of the program to ensure delivery of improvements in flow regimes and water quality using local knowledge and resources. This will be done through local government plans relating to stormwater, guided by integrated urban water cycle management guidelines currently being finalised by the NSW Government.

Projects funded under this program have focussed on water quality improvement, although recent projects have also sought to reduce the volume and velocity of runoff in recognition of the environmental significance of the flow regime in urban waterways.

Target 32 The adoption of water efficient and sensitive urban design measures in urban areas/ivers increased

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 4 - Drainage management.

The Planning and Management Guidelines for Water Sensitive Urban Design define water sensitive design as “a new approach based on the premise that as easily available water resources become limited and the capacity of receiving environments to accept more waste decreases, conventional water supply, sewerage disposal and discharge systems cannot be sustained in the long term”. At the same time continuation of significant housing development on the fringe of Sydney and other urban centres places the rivers and estuaries under increasing stress as a result of growing demands for water supplies and increased urban storm runoff.

However, these problems can be reduced through good urban planning and water sensitive urban design including for example:

- effective water demand management including greater use of water efficient devices,
- recycling or reuse of wastewater,
- increased use of on-site storage and reuse of stormwater eg rainwater tanks,
- reductions in the area of impervious surfaces directly connected to drainage systems,
- increased use of absorbent surfaces or infiltration zones in driveways and along roadways etc,
- replacement of lawn areas with low water demand landscapes,
- localised water supplies for irrigation purposes, and
- rehabilitation of natural watercourses to increase their capacity to retain and absorb storm runoff.

While water sensitive design is most effective when implemented early in the land use planning and development process, many elements can be retrofitted into existing urban areas particularly as part of urban renewal projects. Water sensitive design measures do not have to significantly increase the cost of development. A recent case study of an urban development site in Brisbane included a comparative assessment of “conventional” and “water sensitive” design approaches. It found that the water sensitive design could provide:

- the same lot yield at approximately the same capital cost,
- maintenance costs which were only marginally higher than conventional designs,
- equivalent, if not superior, marketable values and return on investments,
- offsite environmental impacts that were significantly less than those for conventional designs, and
- more functional and attractive open space.

This target is consistent with the Integrated Water Cycle Management and Stormwater Management programs being implemented by local councils. In fact, the increased adoption of water sensitive designs should improve the effectiveness of capital expenditure on stormwater management and sewer overflows.

It will also complement a range of urban water management targets (Targets 17, 19, 29 and 31) in helping to reduce the growing impact of urban water demands, effluent and stormwater on the State’s water sources.

Target 33 Zones of high irrigation salinity risk mapped, and irrigation accession rates assessed to enable action to be taken to stabilise or reduce accession rates within these zones

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 4 - Drainage management.

The *Water Management Act 2000* requires land degradation to be taken into account when assessing irrigation developments and water use approvals. Assessment of the risk will be fundamental to the development of management plans dealing with the use of water. The application of water to land can be managed to minimise deep drainage and saline discharge.

Detailed mapping of areas prone to irrigation salinity, to improve the information base on which decisions are formulated, is recommended in the NSW Salinity Strategy, as are activities to reduce accession, through efficient and effective use of water. Without reducing accessions, the risk to the aquatic environment and agricultural production will continue to increase.

This target will contribute to the actions necessary to slow the rate of increase in salinity levels in watercourses (as sought under Target 36). Importantly, it will contribute to maintaining the productive value of irrigated land. This target will be supported by improved water use efficiency.

Despite mapping of depth to watertable in some areas and development of catchment scale salinity predictions in other areas, mapping of zones at risk from irrigation salinity has not progressed far. It is important to establish cause and effect at a sub-catchment level and prioritise actions to reduce accessions to the watertable from irrigation. Accessions are a function of the water applied, weather conditions and crop water uptake. Irrigation salinity occurs where water is not applied efficiently to replace the soil moisture deficit or supply crop requirements, including minimal leaching fractions. Environmental assessment of irrigation developments and their suitability at that location will continue to support this target, especially under Part 5 of the *Environmental Planning and Assessment Act 1979*, a process which is now supported by the use approval process in the *Water Management Act 2000*. The Sustainable Agriculture Policy also supports this target.

The rate of accession can be calculated from volume of water applied (metered extractions as a default), effective rainfall (ie. rainfall minus evaporation), crop type and area of crop grown. Where it is difficult to calculate accession rates, it may be preferable to monitor increases in area of irrigation in areas of high irrigation salinity risk. Calculations of critical accession rates at a catchment scale are likely to be reasonably indicative of the situation. Despite the need to minimise accessions to the watertable, it is important to allow for leaching fractions, which wash salts contained in irrigation water below the root zone. However, there are substantial opportunities for irrigators to consider leaching fractions in more detail, to accurately calculate their requirements and to manage their application.

Mapping of zones of risk can support the development of plans by management committees and guidelines about water use approvals, particularly in relation to decisions about the location and nature of future development. Hazard or risk mapping will inform the future regulation of rates of water application in specific soil types or locations, through the water use approval process and through education programs, such as *WaterWise*. Also, phasing out practices that exacerbate irrigation salinity can also be encouraged through incentives, such as those provided by the structural adjustment programs.

The costs associated with changing practices may be substantial. However, other benefits are derived, such as the opportunity to use water savings for other purposes, increased protection of land resources and savings in remediation costs. The opportunities to reduce accessions are more substantial in areas where the system design needs upgrading; where system design does not match soil type and

characteristics; and where information that informs the decision by irrigators to irrigate could be improved.

Target 34 Major irrigation drains to natural watercourses carrying saline discharges identified, and priority drains monitored to enable action to be taken to ensure no net increase in the load or concentration of the saline discharge (unless agreed to in an applicable management program with approved offset provisions)

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 3 - Water use, Division 4 - Drainage management.

Discharge of saline water from irrigation areas, industries and towns contributes significantly to the decline in water quality. However, despite recognition of the problem, data about the discharge from major drains are limited. The NSW Salinity Strategy 2000 provides the basis for this target by encouraging reductions in salt loads.

Whilst Targets 20 and 22 contribute to the reduction of the load of salt that enters watercourses, this target focuses on a specific issue that singularly contributes substantially to decline in water quality. In some instances, greater environmental effects are caused by the concentration at which salt is released.

Primarily, achievement of this target can be supported by the development of drainage management plans under the *Water Management Act 2000*, stormwater management plans by local government, education programs, and providing funding as an incentive. However, as a first step, monitoring to determine the severity and extent of the problem is critical.

The load and concentration of saline water can be reduced through:

- reductions in catchment salinity and reductions in remobilisation,
- improved water use efficiency to reduce accessions to the watertable,
- reuse of water in irrigation areas,
- engineering works to better manage drainage water,
- direct dilution, and
- staging the time of release, as occurs in the Hunter Salinity Trading Scheme.

The costs of monitoring may not be substantial and should be a condition on the installation and operation of major drains, whether currently licensed or not. The costs associated with engineering works or changes in catchment management to reduce loads may be more substantial. However, some significant gains can be made through minor changes in practice. The opportunities to reduce saline drainage are more substantial in the irrigated areas in the southern part of the State. The savings from activities to reduce drainage will be substantial both in terms of environmental benefit and maintenance of community infrastructure.

Division 11 River and groundwater quality

Target 35 All management plans incorporating water quality objectives that have considered the Government approved Interim Environmental Objectives, the current ANZECC Guidelines and the recommendations of relevant Healthy Rivers Commission Inquiries

This target is relevant management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 7 - Environmental protection.

Water quality is one of the features of all water that is critical to the protection of aquatic ecosystem and human health and can significantly impact on the cost and productivity of many dependent industries.

Many management committees have already endorsed the NSW Interim Environmental (Water Quality) Objectives for their rivers. These objectives were developed in consultation with catchment management bodies and the broader community. They are based on environmental values and identify the water quality necessary to support the ecosystem and human related needs. In many water sources these objectives may be adequate to guide the water management needs and priorities. Where more specific guidance is needed, the current ANZECC Water Quality Guidelines and/or site specific studies may be used.

The ANZECC Water Quality Guidelines (2000) provide new and revised water quality trigger values, which, given the lack of detailed water quality and ecosystem data in many areas provides useful water quality criteria which should be incorporated into the management objectives of all management plans made under the *Water Management Act 2000*. The guideline trigger values are useful to indicate priorities and directions for change, while precise numerical targets only need to be as accurate as the models used to determine what catchment changes can generate the greatest improvements.

Consistent with the recommendations of the Healthy Rivers Commission for several river systems, the ANZECC Water Quality Guidelines should be used as conservative “trigger levels”. Where they are being substantially breached, this may demonstrate the need for more site-specific studies or, where the pollution sources can be identified, specific actions determined to address the source rather than to narrow the ambient water quality target.

However, wherever regulatory mechanisms, specific works or trading schemes are to be applied, more detailed site-specific studies may be appropriate to enable a better assessment of what the aquatic ecosystem is likely to be able to sustain, particularly in respect to nutrient levels.

Target 36 River salinity maintained at levels consistent with the salinity targets specified in approved catchment management plans

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing, Division 3 - Water use, Division 4 - Drainage management, Division 7 - Environmental protection.

The NSW Salinity Strategy establishes interim salinity targets for nine inland rivers of NSW. Catchment management boards have reviewed these and made recommendations to the Government on final targets. The targets will drive a strategic, coordinated approach to managing salinity. The targets will guide investment in actions at both the landscape and property scale.

The baseline for target setting is the estimated salt load and electrical conductivity (EC) levels in the year 2000. The targets are set for 2010, as the ten year timeframe should allow adequate time for change to be achieved and measured.

The NSW Government will conduct a comprehensive review of system performance in meeting the targets in 2006 and will assess whether actions or provisions in management plans have assisted in slowing down the increase in salinity. To assess progress, the NSW Government will continuously monitor salt loads, EC levels and river flow at each target location. The Government will upgrade, and where necessary, install new monitoring equipment and will report publicly on the findings.

Catchment management boards have prepared 10 year catchment management plans, which incorporate, where appropriate catchment and management targets relating to salinity management.

Target 37 Sources of non-saline water contributing significant dilution flows downstream prioritised to enable action to be taken to protect these sources

This target is relevant to management plans under Part 3 of the *Water Management Act 2000* dealing with: Division 2 - Water sharing.

Electrical conductivity (EC) is a measure of salinity concentrations. The EC levels in a river will result from a complex function of:

- volume of flow (degree of dilution), and
- the salt load.

The relationship between flow and salt concentration is complicated and increasing the volume of flow in order to increase the dilution is generally not an effective solution unless the source of the flow is relatively low in salt. A high flow event may provide a large volume of water and theoretically a high dilution factor, however, it is likely that the higher flow is the result of a storm runoff event which may also be carrying a high salt load from the landscape to the river. High runoff events are therefore often characterised by high EC levels.

The quality of a water source is therefore a critical factor in determining the salt concentrations in downstream reaches. It will therefore be important to ensure that the flows contributed from non-saline water sources are not unduly reduced by water extractions. These sources should be identified as a matter of priority so that water extractions and transfers and dealings can be limited accordingly or salt load offsets required elsewhere to mitigate any further reductions in their contributions.

Target 38 Aquifer water quality vulnerability zones mapped and extraction limits reviewed to reduce the risk of lateral intrusion of poor quality water

This target is relevant to management plans under Part 3 the *Water Management Act 2000* dealing with: Division 2 - Water sharing (Note: The mapping and assessment required will have to be undertaken as a prerequisite of planning and therefore this target may not be fully addressed in initial round of water sharing plans).

Sometimes a high quality groundwater source may be flanked by lower quality, often more saline water. Large volumes of extraction may cause the lower quality water to be drawn into the higher quality aquifer, diminishing its value and potentially making it unusable for irrigation, domestic or stock purposes.

Water quality changes resulting from water extractions should not reduce the beneficial uses (environmental values) of an aquifer. Beneficial use categories have been established in the NSW Groundwater Quality Protection Policy, and will be specified for each of the State's aquifers.

Areas or zones where significant groundwater quality changes are a threat (water quality vulnerability zones) should be identified and measures taken to protect against this threat including:

- setting distance limits between high and low quality groundwater interface within which intensive pumping cannot occur, and
- setting groundwater quality criteria at appropriate monitoring bores which when approached, trigger a change in the extraction rate for licensed bores.

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Glossary

- ABARE:** Australian Bureau of Agricultural and Resource Economics
- acid sulfate soils:** Soils containing highly acidic soil horizons or layers resulting from the oxidation of soil materials that are rich in sulfides, primarily pyrite. This oxidation produces acidity in excess of the sediments capacity to neutralise the acidity resulting in soils of pH 4 or less.
- algal bloom:** The rapid excessive growth of algae, generally caused by high nutrient levels, high water temperatures, low flow velocities and other favourable conditions. Can result in deoxygenation of the water body when algae die.
- alluvial:** Transported by water flow processes eg alluvial sediments.
- anabranch:** A secondary channel of a river that usually flows only when the river levels are high.
- ANZECC:** Australian and New Zealand Environment and Conservation Council
- applicable management program:**
A program that may be required as a condition of a licence or approval, eg a land and water management plan
- aquifer:** A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.
- ARMCANZ:** Agriculture and Resource Management Council of Australia and New Zealand`
- available water determination:**
A determination under Section 59 of the *Water Management Act 2000* in relation to a water management area or water source which sets the amount of water available to the holders of water access licences from time to time depending on the status of the resource/storage, the extraction limit and any adjustments made necessary as a result of previous exceedence of the extraction limit as set out in the water sharing plans and associated implementation programs.
- benthic:** Living in the bottom sediments of rivers and lakes etc
- biodiversity:** The variety of life forms, the different plants, animals and micro-organisms, the genes they contain and the communities and ecosystems they form. It is usually considered at three levels; genetic diversity, species diversity and ecosystem diversity.
- biofilms:** Bacterial and algal communities living on rocks and logs submerged or partially submerged in rivers.

biogeographical regions:

Areas defined by broad similarities based on climatic, topographic and geological factors that influence the hydrology, habitat and biological communities

blue green algae:

Strictly these are *Cynobacteria* (not algae), being an ancient group of photosynthetic bacteria without a nucleus that produce their own energy from sunlight. Some can assimilate dissolved gaseous nitrogen. A number of species produce toxins. Cells can also cause irritation of the skin and eyes on contact.

CAMBA:

China Australia Migratory Bird Agreement

capital investment:

Physical capital formation such as dams, roads, equipment, irrigation development etc.

channel capacity:

Flow in the river just before overbank flow commences. The flow volume varies with each river section.

COAG:

Council of Australian Governments

CSIRO:

Commonwealth Scientific and Industrial Research Organisation

dissolved oxygen (DO):

The concentration of oxygen dissolved in water or effluent, measured in milligrams per litre (mg/L).

DLWC:

NSW Department of Land and Water Conservation

domestic and stock rights:

The rights conferred on a landholder under Section 52 of the *Water Management Act 2000*.

ecological functioning:

A measure of the ecological health of an ecosystem that can be defined as the maintenance of the structural and functional (or biotic) attributes of that system.

ecologically sustainable:

This is an objective of the COAG Water Reform Policy. This means development and use is to be undertaken in a manner that improves the total quality of life, both now and in the future, and in a way that maintains the ecological processes on which life depends. In relation to NSW, it refers to action which is consistent with the principles of ecological sustainable development as described in Section 6 (2) of the *Protection of the Environment Administration Act 1991*.

economic efficiency:

An action that is efficient in economic rather than physical or chemical terms. Examples of economic efficiency are maximum return per unit of resource used, minimum cost per unit.

ecosystem:

A term used to describe a specific environment eg lake, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.

effluent:

Human and animal waste in a liquid form.

- effluent creek:** A creek which takes flow away from the main river but which does not return water to it.
- environmental flow:** A flow regime or volume protected or released to meet specific environmental requirements or triggers and for the general maintenance of ecosystem functions.
- environmental water rules:** Water sharing and operational rules to provide environmental protection or specified ecosystem requirements, established under Section 8(2) of the *Water Management Act 2000*.
- EPA:** NSW Environment Protection Authority
- extraction limit:** A limit on the amount of water that can be taken from a water source for licensed purposes and includes both the water pumped directly from the water sources as well as those volumes extracted from the water source via irrigation or other channels measured at the offtake point, and therefore includes the transmission losses associated with those extractions.
- flood – 5 year return period:** Refers to a flood that has a statistical probability of occurring once in five years on average. The 5 year flood level is generally defined as the contour on the floodplain to which a flood this size will rise. The flood has a 20 percent chance of occurring in any given year.
- floodplain water harvesting:** The extraction or capture of water from overland flow across a floodplain during high flow events, generally into offtake storages for later use.
- flow frequency:** The percentage of time (or days) that a flow equal to or larger than a nominated level will occur for a given historical record of flows (often quoted for a long term eg 100 year record)
- groundwater:** Water that occupies the pores and crevices of rock or soil.
- habitat:** The environment or place where a plant or animal grows or lives (can encompass aspects of climate, water, other organisms and communities).
- IMEF:** Integrated Monitoring of Environmental Flows
- investment efficiency:** An activity that provides the highest returns to investment, usually measured in the maximum return to capital or percentage rate return per annum.
- IPART:** Independent Pricing and Regulatory Tribunal
- irrigation efficiency:** A measure, expressed as a percentage, of the volume of water used to meet crop water requirement (ie crop water requirement less effective rainfall) relative to the total volume of water delivered to the farm or farms (normally measured at the river offtake point or bore).
- JAMBA:** Japan Australia Migratory Bird Agreement
- long term average annual extraction:**

The amount of water that can be extracted on average per year based on a long term climatic assessment.

- macro-invertebrates:** Animals without vertebrae (backbones) that can be seen without a microscope, and include mussels, limpets, water snails, worms, leeches, water spiders, water mites, crayfish, shrimps, beetles, bugs, insect larvae and nymphs.
- MDBMC:** Murray-Darling Basin Ministerial Council
- megalitre:** A commonly used term to measure large quantities of water, equal to 1,000,000 litres or 1000 cubic metres.
- NPWS:** NSW National Parks and Wildlife Service
- overland flow:** Water that runs off the land following rainfall, before it enters a watercourse and floodwaters that overflow a watercourse onto a floodplain.
- protected:** Ecological function and condition maintained by limiting the potential for any further harm eg by maintaining water level variability and connectivity, and ensuring wise and compatible land and water management practices.
- reliability of supply:** Probability associated with a water access licence-holder obtaining the volume or some proportion of the volume of water specified in the water entitlement.
- restored:** Returned to good condition, healthy ecological functioning, and biodiversity, generally requires a move towards a more natural, although not necessarily a reinstatement of the complete range of natural characteristics
- regulated river:** River where flows are supplemented and rescheduled by artificial means eg via a government owned headwater storage and declared by the Minister by an order published in the Gazette to be a regulated river.
- RFO:** River Flow Objective
- riparian vegetation:** Vegetation growing along the banks of rivers or other waterbodies.
- riparian zone:** The zone along or surrounding a water body where the vegetation and associated ecology are influenced by the passage and storage of water, and conversely the aquatic environment benefits from the proximity of the vegetation (eg from bio-filtering of sediment or pollutants, inputs of detritus, shading etc).
- salinity:** The measure of total soluble (or dissolved) salt ie mineral constituents in water. May be expressed as Total Soluble Salts (TSS) or Total Dissolved Salts (TDS) which are measured by different processes but both define the salt load measured in milligrams per litre (mg/L) or parts per thousand (ppt). Salinity may also be expressed as electrical conductivity, measured by an electrical probe (conductivity meter).
- salinisation:** The process, normally associated with rising water tables, by which land becomes salt affected.
- stormwater:** Rainwater that has run off the ground surface, roads, roofs, paved areas etc and is usually carried away by drains.

Sustainable Yield:	The limits on potentially extractable water from an aquifer at or below the average recharge level which takes into account “in situ” values and environmental water needs, so that water extraction does not cause lowering of the water table, intrusion of more saline water or environmental damage.
SWMOP:	State Water Management Outcomes Plan
threatened species:	Animal or plant species which are either vulnerable, endangered or presumed extinct.
unregulated river:	A natural surface water source that is not supplemented by releases from a dam. A river which is not a declared regulated river but which may still be subject to water extractions and include on-river storages for town water supply or industrial purposes.
water allocation:	A volume of water which is available to a holder of a water access licence from time to time as a result of an available water determination.
watertable:	The saturated level of the unconfined groundwater. Some wetlands and lakes or base flows in streams may be surface expressions of the water table.
water use efficiency:	Volume of crop or other product produced (eg harvested dry matter) per unit of water delivered. (for irrigation water use efficiency this is normally expressed as tonnes per megalitre.
wetland:	Area of seasonal, intermittent or permanent waterlogged soils or inundated land, fresh or saline, eg swamp or lake.
weir:	A structure (including a dam, lock, regulator, barrage or causeway) across a defined watercourse that will pond water, restrict flow or hinder the movement of fish along natural flow paths, in normal flow conditions (NSW Weirs Policy 1997)
WQO:	Water Quality Objective
WWF:	World Wildlife Fund

