

# Chapter 5

## Maintaining and Enhancing Ecosystem Health

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### Key Points

| <b>Indicator</b>                   | <b>Status of Indicator</b>  |
|------------------------------------|---|
| <b>5.1</b> Ecosystem water quality | Current water quality within the Catchment has the potential to affect ecosystem health.  |
| <b>5.2</b> Macroinvertebrates      | A 'low' AusRivAS health rating was found in 41% of locations sampled in the Catchment.  |
| <b>5.3</b> Fish                    | The diversity of fish species is generally poorer above the dams and characterised by a higher proportion of exotic species.  |
| <b>5.4</b> Riparian vegetation     | The extent of riparian vegetation within the Catchment ranges from large areas with almost intact native vegetation cover to areas such as the Upper Wollondilly River and Mulwaree River sub-catchments with little or no native vegetation in their riparian zones.       |
| <b>5.5</b> Native vegetation       | Native vegetation covers approximately 63% of the Catchment and has a similar pattern of distribution to native riparian vegetation. While almost half of this cover is protected within National Parks over 37% is dispersed across the Catchment on privately owned land. |

### Pressures in the Catchment

Healthy and intact natural systems play a crucial role in maintaining water quality. Largely taken for granted, these ecosystem processes provide both the conditions and processes that purify water and mitigate the effects of drought and flood. These ecosystem services are free, but, should they fail, the cost of replacing them is extremely high.

Many water supply authorities have secured these services by closing off, or in some way protecting, the hydrological catchments of their storages. The managers of the Sydney Drinking Water Catchment have historically taken a similar approach by creating the Special Areas around the major water storages. However, while the Special Areas do enclose the entire Catchments of some storages, they make up only approximately one quarter of the whole Catchment.

The previous audits have clearly challenged the view that the Special Areas can provide enough ecosystem services to play a sufficient role as the first barrier in a multi-barrier\* approach to protecting water quality. These barriers appear effective under low and moderate flow conditions when water can take several years to travel between the outer catchment and the dam wall. However, under periods of high flow, the barrier effect of the storage breaks down and the capacity of the broader ecosystem of the Catchment becomes critically important. This capacity is strongly dependent on the integrity and health of the ecosystems.

The main driving forces threatening ecosystem health are population growth, water demand, and current and intensifying land use. Each is responsible for placing pressure on parts of the ecosystem, including raw water quality and quantity, biodiversity, and riparian and native vegetation.

Land use often involves the clearing of native vegetation. This affects water quality, land condition, and biodiversity and is a key threatening process in the *Threatened Species Conservation Act 1995*. In the context of a catchment, riparian vegetation is particularly crucial for water quality and as habitat for fauna. Managing the clearing of native, and particularly riparian vegetation, and the rehabilitation of degraded areas is vital to maintaining ecosystem health. Exotic fauna are another pressure on ecosystem health, and can cause physical damage to soil and vegetation or prey on natives. Pest species can out-compete native species for resources.

Bushfires, like drought or flood, is part of the landscape context within which the Catchment needs to be managed. A regime of regular bushfires is a natural and often vital component of the Australian environment. Modified regimes of either very frequent or occasional but extremely intensive fires, however, can have detrimental effects on ecosystem health, especially in the short-term. Hazard reduction burns are a common management practice to reduce fuel on the land and decrease the likelihood of bushfires of devastating intensity. Management actions can also mitigate the post-fire impacts, for example by preventing sediment and particulates from entering the waterways. Treating the protection of riparian zones as a priority for fire management is advantageous in protecting water quality. In this audit, the result of bushfires is not treated as an indicator of catchment health, although it can influence it. Rather it is seen as a contextual pressure with limited management options.

## State of the Catchment

### 5.1 Ecosystem water quality

#### Background

Healthy ecosystems generate and maintain good water quality. This indicator is a composite indicator that draws together 12 parameters (Figure 5.1) that signal whether water quality may be impacting on ecosystem health. These parameters were assessed against the guidelines for ecosystem health in the ANZECC and ARMCANZ 2000 guidelines. The only exception was conductivity. The ANZECC and ARMCANZ 2000 guideline for conductivity (30  $\mu\text{S}/\text{cm}$ ) is based on typical values for Tasmanian lakes and reservoirs, which is not relevant for NSW given its different geology. Therefore, the conductivity criteria used for the audit was 300  $\mu\text{S}/\text{cm}$  which is based on values typically found in NSW lakes and reservoirs.

**Recommendation 19:** That SCA adopts 300  $\mu\text{S}/\text{cm}$  as a practical conductivity trigger value for compliance monitoring of lakes and reservoirs in its Water Quality Monitoring Program.

In order to provide a visual presentation of ecosystem water quality across the Catchment, the 12 parameters were combined into 4 groups (Physical – turbidity, pH and conductivity; Toxicants – total Al and total Fe; Nutrients – total nitrogen, total phosphorus, oxidised nitrogen, ammonia and filtered phosphorus; Chlorophyll-a and Dissolved Oxygen). The parameter with the highest level of exceedence within a group

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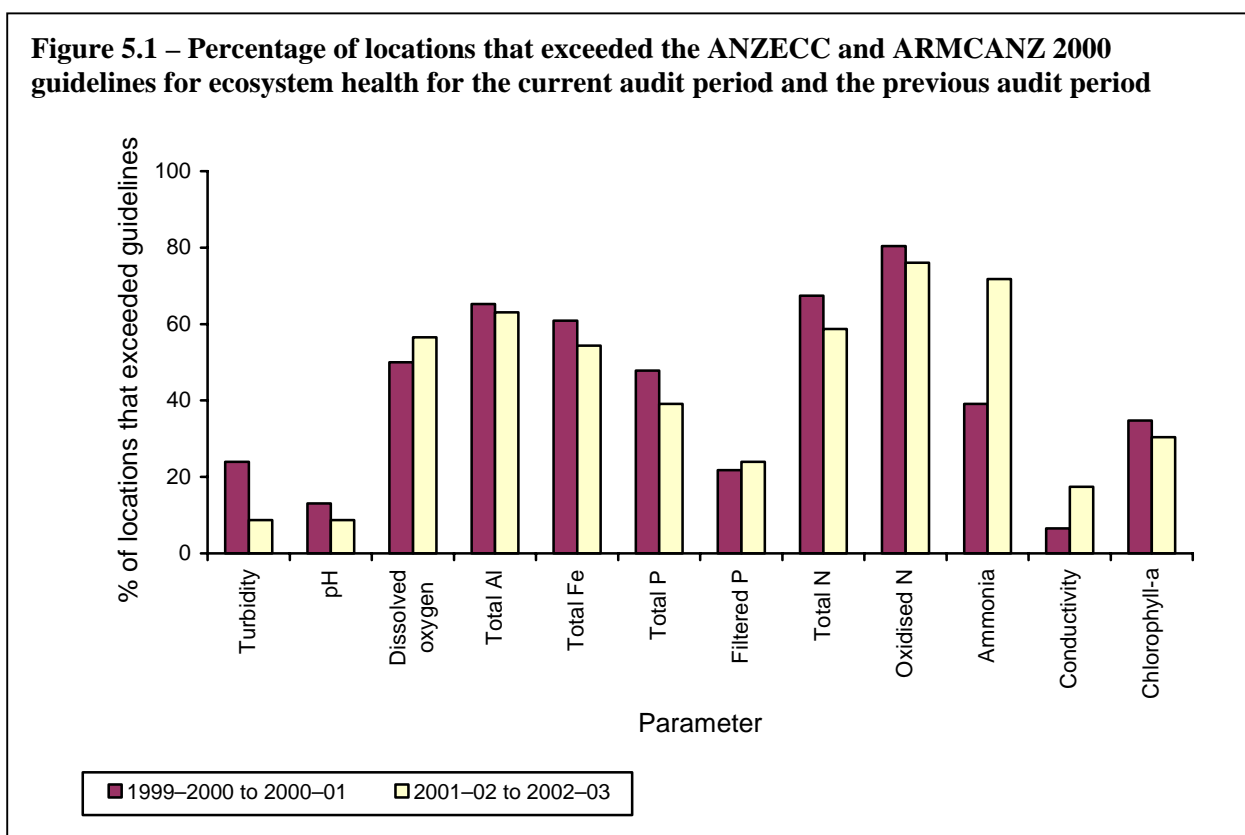
\* The other barriers are the storages themselves, water treatment processes and the delivery system to the tap.

was then used to rate that group. If one or more parameters exceeded the ANZECC and ARMCANZ 2000 guideline more than 75% of the time, then the group was rated very poor. If one or more parameters exceeded the ANZECC and ARMCANZ 2000 guideline between 50–75% of the time, then the group was rated poor, between 25–50% fair and less than 25% good.

The change in percentage exceedence of the guidelines from the previous audit period was shown as a negative or positive symbol in Appendix G Table 3 and 4. A negative symbol indicated an increase in the percentage exceedence and therefore a decrease in the health of the location.

## Findings

The percentage of locations that exceeded the guidelines was lower in the current audit period for 8 out of the 12 parameters tested than in the previous audit period (Figure 5.1). The parameters that had a greater percentage of locations in exceedence of the guidelines in the current audit period were dissolved oxygen, filtered phosphorus, ammonia and conductivity (Figure 5.1).



Source: SCA data, as at 2003

As described above, Figure 5.2, identifies water quality rating for four groups of water quality parameters at locations across the Catchment. Two locations were rated very poor for all 4 groups. They were Gibbergunyah Creek (CD) and Mulwaree River (CK). A number of other locations had three groups rated very poor. They were Gillamatong Creek (CV), Wollondilly River (CI), Lake Yarunga (L), Wingecarribee River (CH) and Werriberri Creek (CM).

The majority of the high exceedences were in the toxicant and nutrient groups (Figure 5.2). There were 33% of locations that exceeded the guideline for physical attributes in both the catchment and lakes and reservoir locations (Figure 5.2). Seventy to ninety percent of locations exceeded the guideline for toxicants and nutrients (see Appendix G Table 3 and 4 for details). The percentage exceedence of the guideline for ammonia increased at 54% of locations from the previous audit period (Indicated by a negative symbol in Appendix G Table 3 and 4).

Pesticides are monitored at certain locations within the Catchment, and specific projects have been undertaken to identify and maximise the detection of pesticides in the Catchment (see Case Study –Pesticides in the Sydney Drinking Water Catchment).

## Implication

Water quality indicators have long been used as surrogates for assessing aquatic ecosystem health. In recent years monitoring has increasingly shifted to measuring ecosystem health indicators directly (see 5.2 below). Water quality, however, continues to be used while additional ecological indicators are being developed and trialled.

Water quality monitoring in the Catchment is largely restricted to the northeastern region. There are no unambiguous patterns in the data. Clearly water quality is influenced largely by local inputs and processes with poor readings recorded mainly around towns and areas with pollutant inputs. Broadly, the groups ‘toxicants’ and ‘nutrients’ show greater exceedences than the other two categories. This stresses the need for reductions in the parameters of those two groups to improve water quality as a whole.

Water quality monitoring programs are often designed to monitor particular areas of impact and so data tend to reflect this with most sites sampled showing some form of impact. The current SCA monitoring program, thus, probably does not give a comprehensive picture of water quality throughout the Catchment, because many areas of the Catchment do not have monitoring sites. There are several sub-catchments with few or no monitoring sites where water quality could be expected to be under stress (see Future Directions below).

## Future directions

Routine ecosystem water quality monitoring is currently undertaken at 18 out of 28 sub-catchments. Some of the sub-catchments with few or no routine water quality monitoring have been identified as areas under environmental stress by other indicators. These include the Upper and Mid Coxs River, Upper Wollondilly and Wollondilly Rivers, Reedy Creek and Mulwaree River sub-catchments. These sub-catchments have been identified with other indicators as being under threat and have few or no water quality sampling sites.

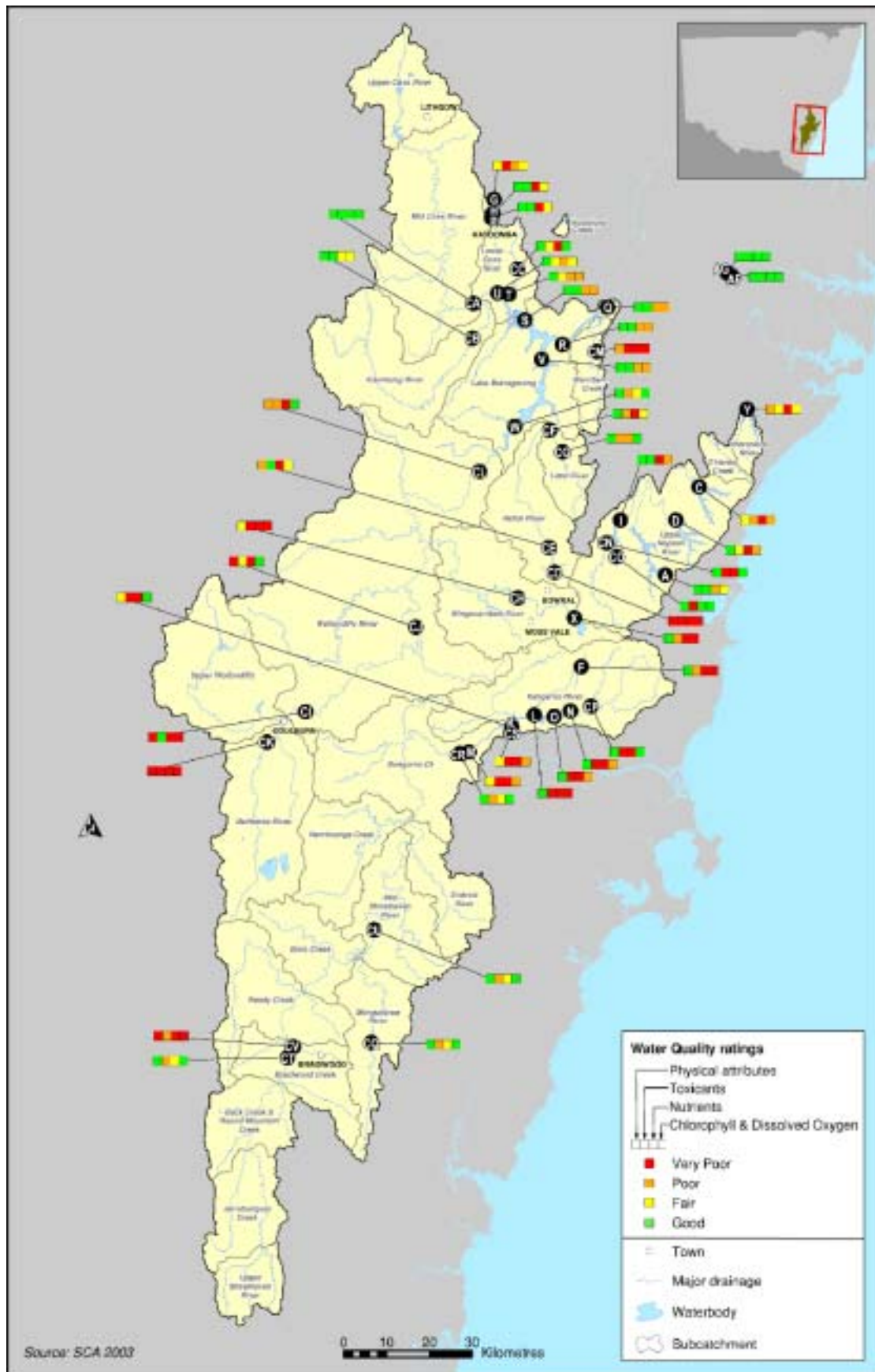
Further it would appear that the frequency of actual water quality monitoring as reflected in available datasets is less than what was committed to by SCA in its *Water Quality Monitoring Program July 2002 to December 2004*. While explanations were provided regarding the gaps in the dataset, the information available to the audit did not fully explain all the gaps. It is important that the monitoring program is reviewed to ensure that it is delivering relevant water quality information under reasonably anticipated conditions including drought.

Additional water quality monitoring (both frequency and location) would contribute to a better understanding of other indicator trends.

**Recommendation 20:** That SCA reviews its water quality monitoring program to ensure that appropriate ecosystem water quality monitoring is undertaken in areas of the Catchment identified by other indicators as subject to environmental stress.

## Target

Progressive reduction in number of exceedences for each parameter of the ANZECC and ARMCANZ 2000 guidelines. Ultimately, water quality that meets the guidelines for the protection of ecosystems.



**Figure 5.2 – Map of water quality monitoring sites showing the 4 parameter groups and the colour code in the Sydney Drinking Water Catchment**

**Note:** Location codes are provided in Appendix G Table 1



## Case Study – Pesticides in the Sydney Drinking Water Catchment

A 2001 review and risk assessment of pesticides (Bales 2001) in the Catchment discovered that while pesticide use in the Catchment was mostly of very low to moderate intensity, there could be areas of more concentrated use. SCA has undertaken sampling in the Catchment for the practical quantification of pesticides in the raw water supply. In 2000, the SCA commissioned a project aimed at detecting pesticides in the water supply using special lipid samplers that accumulate pesticides over time to enable detection of pesticides in normally undetectable concentrations. Since 2000, SCA also monitors inflows to water filtration plants (WFPs) for the presence of pesticides. In 2002, sampling for pesticides was done for a wet weather event, and pesticides were also sampled in the treated effluent from eight major STPs.

From the pesticides that are being detected, the vast majority of samples reveal concentrations below practical quantitation limits or below the National Health and Medical Research Council (NHMRC) drinking water guidelines. Three pesticides detected, Chlopyrifos, Diazinon and Malathion were above ANZECC and ARMCANZ (2000) guidelines. The trigger values (Table 5.3) equate to the percentage of species protected if not exceeded. It has been suggested that the very low amount (below NHMRC drinking water guidelines) of pesticides reaching WFPs is due to the biological and physical cleansing properties of the catchments, storages and Special Areas.

**Table 5.3: Pesticides detected by SCA sampling, and if any samples exceeded the ANZECC guidelines or NHRMC drinking water guidelines.**

| Sampling location/type                                  | Sampling date  | Pesticides detected   | Exceeded ANZECC trigger values (TVs)               | Exceeded NHMRC drinking water guidelines |
|---|----------------|---|--|--|
| Lipid samplers – Inflows to Lake Burragorang and Nepean | July–Dec. 2000 | Many types, including unregistered organochlorines (may be remnant of historical use) | N/A  | N/A                                      |
| Water samples – Inflows to WFPs                         | 2000 onwards   | Chlopyrifos (in 0.74% of samples)   | Yes, exceeds 99, 95 and 90% TVs                    | No                                       |
| Water samples – Discharged effluent from 8 STPs         | May 2002       | Diazinon (nine samples)   | Yes, maximum concentration sampled exceeds all TVs | Yes                                      |
|   |                | 2,4,5-T (one sample)  | No   | Yes                                      |
|   |                | 4 Others  | Insufficient data or no TVs specified              | No                                       |
| Water samples – Wet weather event                       | 21 Feb. 2002   | Malathion (one sample)  | Yes, exceeds 99 and 95% TVs                        | No                                       |

## 5.2 Macroinvertebrates

### Background

Macroinvertebrates are the invertebrates that are typically visible with the naked eye, and exist in a variety of habitats in streams, lakes and wetlands. Freshwater macroinvertebrate assemblages are good biological indicators, because they are sensitive to various pollutants, react quickly, are ubiquitous, abundant and relatively easy to collect. The Australian River Assessment System (AusRivAS) generates river health assessments by predicting the macroinvertebrates that would be present (expected) and compares this with the macroinvertebrates collected (observed) to create an index of health. The lower the observed/expected value, the more impaired the macroinvertebrate assemblage.

An AusRivAS assessment of the Catchment is carried out each year in Spring, however, the first year's sampling was undertaken in Autumn 2001. A catchment map of the current macroinvertebrate health rating and an indication as to whether a positive or negative change from Spring 2001 to Spring 2002 is shown in Figure 5.3, locations without a change symbol were not sampled in 2001. Due to the relocating of some monitoring sites to new locations in 2002, the present limitation to measuring meaningful trends across all sites should be resolved when these new 2002 sites are sampled in the future. See Appendix G Table 6 for all location codes and description used in Figure 5.3.

### Findings

Four locations were given an AusRivAS health rating of severely impaired: Farmers Creek (NQ), Yosemite Creek upstream of Minnehaha Falls (NS), Kedumba River at Scenic Railway (NT) and Mulwaree River at the Towers (MI).

The AusRivAS health rating decreased from Spring 2001 to Spring 2002 at seven sites: Coxs River at the McKanes Bridge (NP), Woodford Creek at the Woodford Dam (NR), Yosemite Creek upstream of Minnehaha Falls (NS), Little River at the Six Foot Track (OC), Mulwaree River at The Towers (MI), Tarlo River at Tarlo (MB) and Boro Creek at the Marlowe River (MR).

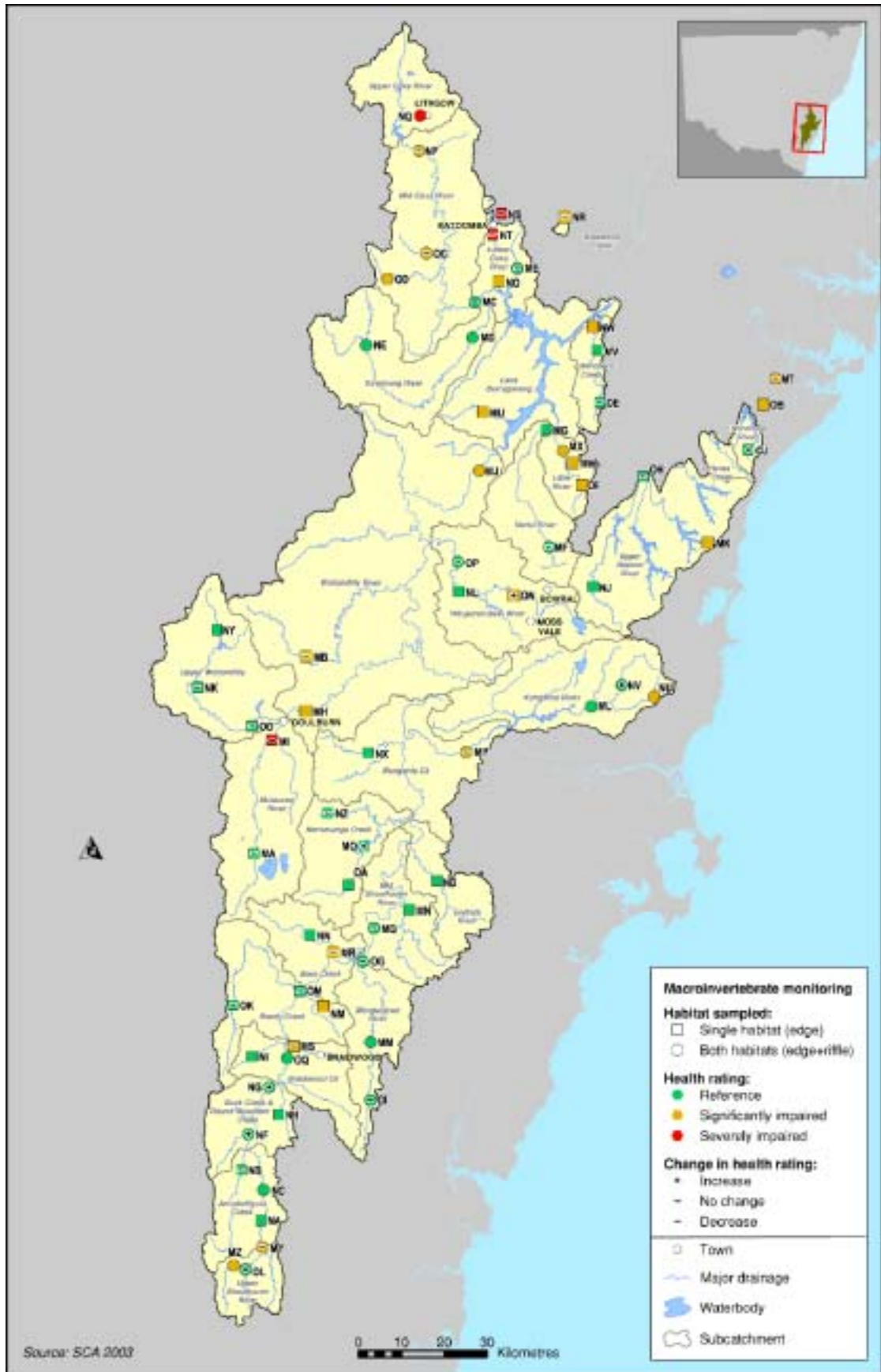
There was also a decreased from a AusRivAS health rating of 'richer than reference' to 'reference' at three sites: Coxs River at Kelpie Point (MC), Wollondilly River at Goonagulla (NK) and Mongarlowe River at Monga (OI).

The AusRivAS health rating increased from Spring 2001 to Spring 2002 at seven sites: Waratah Rivulet at Flat Rock crossing (OJ), Wingecarribee River at Berrima (ON), Kangaroo River at Upper Kangaroo (NV), Nerrimunga Creek at Minshall Trig (MO), Shoalhaven River at Farrington Crossing (NG), Witts Creek at the Krawaree Rd crossing (NF) and Currembene Creek at the Krawaree Rd crossing (OL),

The AusRivAS health rating remained unchanged at the other 19 sites since the 2001-02 survey. A number of locations with a health rating of significantly and severely impaired macroinvertebrate assemblages also exceeded ANZECC and ARMCANZ 2000 guidelines in 3 or 4 groups of physico-chemical water quality (Figure 5.2 and Figure 5.3). These locations include Gillamatong Creek (CV), Mulwaree River (CK), Wollondilly River (CI) and Wingecarribee River (CH).

### Implication

Overall, coverage of the Catchment by macroinvertebrate monitoring is better than that using water quality indicators. Fewer large gaps in coverage exist. There were sites with an AusRivAS health rating of 'severely impaired' at the Upper and Lower Coxs River and Mulwaree River sub-catchments that suggests these sub-catchments are very disturbed and the aquatic ecosystems are already degraded. Apart from those sites, stream health throughout the Catchment is generally reasonable although about a third of the remaining sites show quality significantly less than reference.



**Figure 5.3 – Map of macroinvertebrate AusRivAS health rating for Spring 2002 and change from Spring 2001**

**Notes:** Sites without a 'change' symbol in health rating were sampled only in 2002. Location codes are provided in Appendix G Table 6. Location codes are provided in Appendix G Table 6.



To be able to use a combination of water quality and macroinvertebrates in assessments of stream health in the Catchment it is essential that the two monitoring programs be better integrated. The value of this is seen in the few sites where both water quality and macroinvertebrate monitoring takes place and where, as a consequence, a more comprehensive assessment is possible.

### **Future directions**

The monitoring program for Spring 2002 (68 locations spread across all 28 sub-catchments) is supported as appropriate. For the full benefit of this monitoring effort to be realised and for trend data to be established it is essential that a significant majority of these sites becomes fixed sites for future years.

### **Targets**

Improvements in the health ratings of sites currently rated as severely and significantly impaired, and the preservation of ratings at the other sites. An ultimate target should be that all sampled sites in the Catchment have an AusRivAS health rating of those similar to reference locations.

## **5.3 Fish indicator**

### **Background**

Fish are an important component of most aquatic ecosystems. Fish are also seen as useful indicators of riverine health. Fish can reflect disturbances at a range of scales, because fish interact at many trophic levels and because they are sensitive to many kinds of human disturbance (Harris 1995). They are also considered useful for environmental assessments due to their mobility and long life. It has been demonstrated that the abundance of fish and fish species can decrease in areas with degraded riparian vegetation and poor water quality (Growth *et al.* 1998).

Of particular relevance to the fish populations in the Sydney Drinking Water Catchment are the possible negative effects from the modification of river flows by dams, the temperature of water released from dams, barriers to fish passage such as dams and weirs and exotic fish species.

Dams and weirs collect variable flows from rivers and streams and often release water downstream that is of constant or regulated flow. It can also be the case that less water is released. This modification of flows can have negative effects on a wide range of aquatic organisms, including fish, and can reduce the diversity of fish species and increase the success of introduced species (Gehrke & Harris 2001).

Water which is released from dams can often be colder than what should be flowing downstream, especially if the dam has a bottom valve off-take. Cold water pollution can negatively affect fish growth and survival plus potentially limit the distribution of fish within rivers to warmer areas (Astles *et al.* 2003).

Dams, weirs, and many types of in-stream works act as significant barriers to fish passage, reducing the abundance and diversity of fish throughout a river system (Thorncraft & Harris 2000). They prevent the upstream and downstream passage of migratory fish, plus the access of fish to other areas of rivers over shorter distances. Fishways are structures that allow the passage of fish past barriers, but, at this stage, there are very few effective fishways in NSW rivers.

Single parameters, or combinations thereof, of fish populations are used to indicate fish health. The Index of Biotic Integrity (IBI), which uses numerous metrics to assign a health rating to fish communities in an area and indicate the health of that same riverine area, was not used in the audit due to insufficient time. A number of other measures of fish populations used by NSW Fisheries can be used to ascertain the status of fish communities and determine riverine health. There are four measures that were derived in this audit (see Table 5.4).

**Table 5.4 –Fish indicators of riverine health used in the audit**

| <b>Fish indicators of riverine health</b>   |
|---|
| <p><b>Native species richness</b></p> <p>The total number of native species is often used and is a measure of the general health of aquatic ecosystems because it has been shown that the number of native species declines with increasing environmental stress.</p>   |
| <p><b>Proportion of exotic species</b></p> <p>The presence and relative abundance of exotic (introduced) species also reflects the general condition of the aquatic ecosystem and may represent both a symptom and a cause of declines in stream health and disturbance (Harris 1995). The relative abundance of exotic species is expected to increase with increasing environmental stress due to their purported superior competitive abilities and tolerance for degraded water quality and habitat conditions.</p> |
| <p><b>Fish assemblage ratio</b></p> <p>The ratio of observed species (O) to expected fish species (E) in an area (O:E) can reflect the health of the fish community. A low O:E ratio (close to zero) suggests that a site had fewer species than was once there and has been disturbed.</p>   |
| <p><b>Proportion of individuals</b></p> <p>The proportion of exotic to native fish adds detail to the ‘proportion of species’ measure, and reveals how many fish are introduced, and how successful exotic or native species are.</p>   |

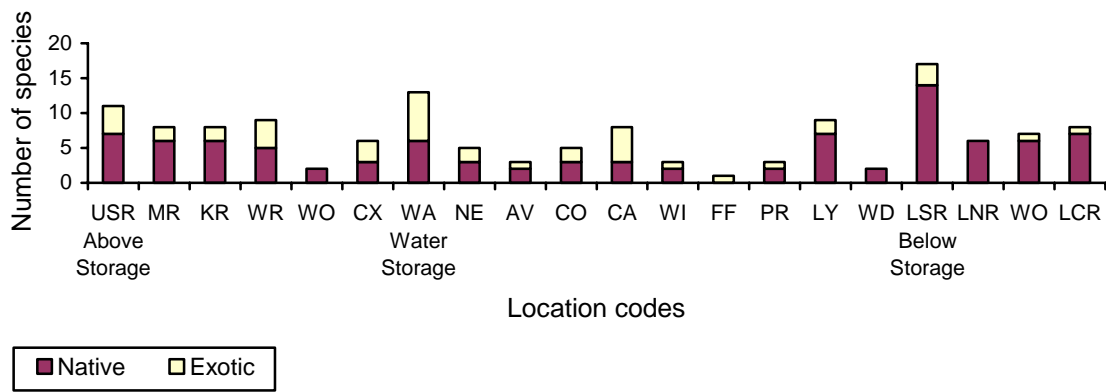
## **Findings**

SCA provided data on fish recorded within the Sydney Drinking Water Catchment. This data suggests that the lower Shoalhaven River had the greatest native species richness; double the amount of native fish species were found at this location than at the other locations (Appendix G Table 5). The Macquarie Perch (*Macquaria australasica*) is listed as a vulnerable species under the Fisheries Management Act and was found in the Mongarlowe River, Warragamba, Nepean, Avon, Cordeaux and Cataract Dams and in the Lower Nepean and Cataract Rivers below the storages. The Silver Perch (*Bidyanus bidyanus*) is also listed as vulnerable and was only found in the Avon and Cataract Dams. The Trout Cod (*Maccullochella macquariensis*) is listed as endangered and was only found in the Cataract Dam within the Catchment.

Warragamba Dam had the greatest percentage of exotic species, more than the other locations (Appendix G Table 5 and Figure 5.4). Water storage locations and locations above the water storages had greater ratios of exotic to native species than locations below the dams (Appendix G Table 5). A list of fish species that were expected in the Sydney Drinking Water Catchment was determined from NSW Fisheries and the Australian Museum records pre 1930s (Table 5.5). Using this list and the SCA supplied data, a ratio of fish species observed to those expected was calculated for each location (Figure 5.5 and Appendix G Table 5). The data used for upstream were a combination of upstream and storages where available. Locations downstream of the water storages had a higher ratio (i.e. fish communities closer to what would occur naturally) than water storages and locations above water storages.

Raw data were supplied by NSW Fisheries including the abundance of fish sampled between 1994–95 (or 1998–99 for the Shoalhaven) in 27 water bodies throughout the Catchment. In a catchment snapshot (Figure 5.6), the proportion of native species and native individuals are similar (59% and 55% respectively). Exotic fish species, however, make up a much larger proportion of the individuals (44%) than proportion of species (22%). This would suggest that, in the Sydney Drinking Water Catchment, the average exotic species is more successful than the average native species. The data also suggest that native species introduced out of their native range (19% of species) are generally not very successful in the Catchment (1% of individuals).

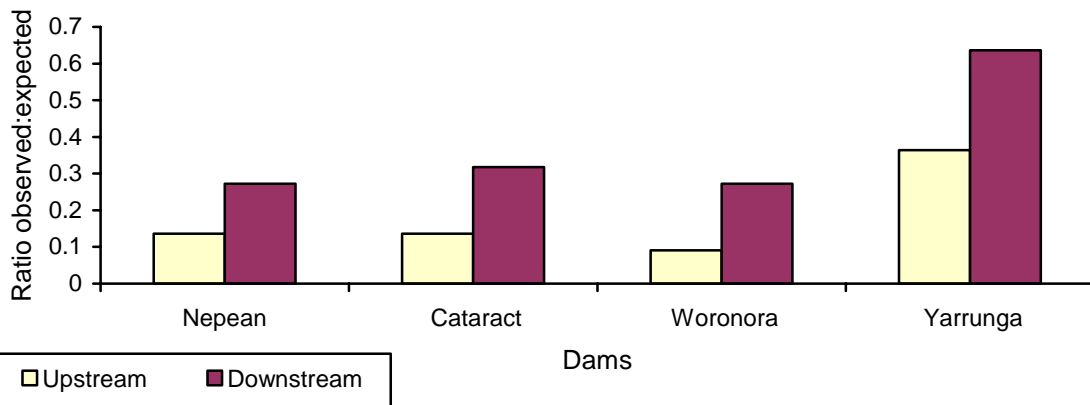
**Figure 5.4 – Number of native and exotic fish species recorded from the Sydney Drinking Water Catchment**



Source: SCA data, as at 2003

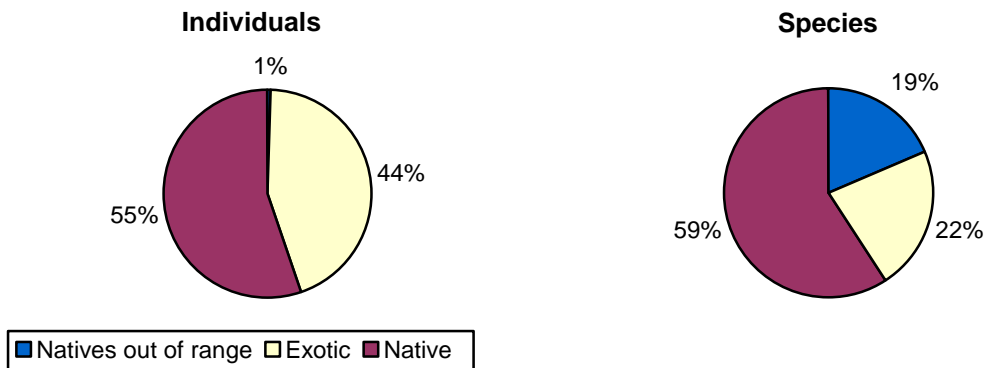
Note: See Appendix G Table 5 for location codes

**Figure 5.5 – Ratio of observed to expected native fish species upstream and downstream dams**



Source: SCA data, as at 2003

**Figure 5.6 – Proportion of native, natives out of range and exotic fish individuals and species collected between 1993 and 1995**



Source: SCA and NSW Fisheries data, as at 2003

**Table 5.5 – Fish species expected in the Sydney Drinking Water Catchment**

| Common Name            | Latin Name                     |
|------------------------|--------------------------------|
| Australian bass        | <i>Macquaria novemaculeata</i> |
| Australian grayling    | <i>Prototroctes maraena</i>    |
| Australian smelt       | <i>Retropinna semoni</i>       |
| Bullrout               | <i>Notesthes robusta</i>       |
| Climbing galaxias      | <i>Galaxias brevipinnis</i>    |
| Common jollytail       | <i>Galaxias maculatus</i>      |
| Coxs gudgeon           | <i>Gobiomorphus coxii</i>      |
| Dwarf flathead gudgeon | <i>Philypnodon sp1</i>         |
| Empire gudgeon         | <i>Hypseleotris compressa</i>  |
| Estuary perch          | <i>Macquaria colonorum</i>     |
| Firetailed gudgeon     | <i>Hypseleotris galii</i>      |
| Flathead gudgeon       | <i>Philypnodon grandiceps</i>  |
| Freshwater herring     | <i>Potamalosa richmondia</i>   |
| Freshwater mullet      | <i>Myxus petardi</i>           |
| Long finned eel        | <i>Anguilla reinhardtii</i>    |
| Macquarie perch        | <i>Macquaria australasica</i>  |
| Mountain galaxias      | <i>Galaxias olidus</i>         |
| Short finned eel       | <i>Anguilla australis</i>      |
| Shortheaded lamprey    | <i>Mordacia mordax</i>         |
| Southern blue eye      | <i>Pseudomugil signifer</i>    |
| Striped gudgeon        | <i>Gobiomorphus australis</i>  |
| Striped mullet         | <i>Mugil cephalus</i>          |

**Source:** NSW Fisheries and Australian Museum records

## Implication

The areas above the water storages have been affected by the presence of the dam and have a reduced observed to expected ratio. This is confirmed by the detailed studies of Lake Yarrunga/Tallowa Dam which record not only changes in fish species, but in size structures of fish populations (Gehrke *et al.* 2000). These results highlight the need for fishways, which is a recognised issue in the Catchment and is receiving attention.

The number of exotic species in the Catchment probably highlights a moderate level of disturbance to riparian structure, flows and vegetation. The large proportion of exotic species highlights the importance of management and the monitoring of trends. Management should act primarily on achieving healthy riparian

areas and on managing pressures. Secondly, management should act on the exotic species directly. For this, consideration should be given to the involvement by SCA with the Murray–Darling Basin Commission and their ‘daughterless carp’ program to reduce this species in the Catchment. This genetics-based program, could considerably reduce carp numbers over the long-term, is currently being undertaken by CSIRO, with ancillary data being collected by NSW Fisheries in Collaboration with the CRC for Pest Animal Control. The same technology may also be used to combat *Gambusia* populations. Manual removal is also an option for exotic species control, but very resource intensive. Management initiatives should be prioritised to infested areas, particularly in storages (Warragamba and Cataract Dams would be a high priority) and inflows into storages (particularly the Coxs River).

### *Cold water pollution*

The Sydney Catchment Authority monitors the temperature of releases downstream from dams at a number of sites, and for 2002–03 the SCA has data for the Nepean, Warragamba and Tallowa Dams. There were differences, usually in the summer months, between outlet temperatures and inflow temperatures for all three lakes. For Warragamba and Tallowa Dams, there is at times a difference of 10–15 degrees between outlet and inflow temperatures. It is possible that this is having an effect on fish and other organisms, as temperatures 10 degrees below ambient have shown to have negative effects on some fish species (Astles *et al.* 2003).

For the Nepean and Warragamba Dams, the downstream temperature monitoring sites are approximately 20 and 40 km downstream. The temperatures are generally similar to the inflows of the lakes at these points, but it is uncertain how far downstream the differences in temperature last. A monitoring site for Tallowa Dam is 400 metres downstream, and measures temperature differences of 4–7 degrees between released water and inflows. This released water is reportedly a combination of water from off-takes and warmer water spilling over the dam.

### *Barriers to migration*

SCA has confirmed the presence of 68 weirs, excluding dam walls in the Catchment. Weirs are a major barrier to fish migration, and none of these has effective fishways.

Tallowa Dam, which separates the Upper Shoalhaven River and Lake Yarrunga from the Lower Shoalhaven River, has been well studied in recent years to assess the effect of the dam on fish passage (Marsden & Harris 1996; Marsden *et al.* 1997). Gehrke *et al.* (2000) have shown most recently that the dam is a major barrier to fish movement through the river, and that species richness is greatest downstream of the dam. It was found that 10 fish species accumulated directly below the dam in significantly larger numbers than anywhere elsewhere upstream or downstream, demonstrating the dam’s inhibition of fish migration and passage. It was also shown that, for the fish species found on both sides of the dam, their size distributions were significantly diverged between upstream and downstream populations, with the exception of the common carp. There is considerable evidence that also suggests the extinction of 10 migratory species upstream of the dam wall.

### **Future directions**

Monitoring and management of fish in the Catchment is needed. Sampling of fish at designated sites should be carried out approximately every 3 years to determine the status of, and changes in, the composition of fish communities and to measure the success of any pest-control initiatives. This time frame is consistent with that used in the Sustainable Rivers Audit of the Murray Darling Basin.

**Recommendation 21:** That a monitoring and management strategy for fish stocks in the Catchment be developed.

## Targets

The flow regime and connectivity of streams should be improved using fishways and flow design to allow free passage of fish within the Catchment.

Further declines of any native fish species should be avoided.

## 5.4 Riparian vegetation

### Background

Riparian zones typically consist of vegetated corridors adjacent to stream channels where the vegetation is influenced by the water. Riparian vegetation is very important in determining the health of stream ecosystems. These areas can be effective natural barriers, which prevent agricultural pollution from being exported and contaminating the larger ecosystem. The riparian zone plays a crucial role in the protection of water quality by also providing shade, stabilising banks and minimising erosion, limiting downstream flooding, supporting fisheries, storing and uptake of nutrients and contaminants and providing important habitat for a range of species. Riparian zones are often the most fertile part of the landscape and are subject to many pressures from land use change and human activities.

Willows and stock access have been identified as potential risks to native riparian vegetation. To date there has been no estimation of how many hectares are covered by willows or other exotic species. The number of applications to clear exotic weeds along rivers and streams was used to assess change in the condition of the riparian zone.

### Findings

SCA estimated that the predominant land cover in the riparian areas is native vegetation (SCA 2003a). The Mid and Lower Coxs River, Kowmung River, Lake Burragorang, Werriberri Creek, Little River, Nattai River, southern area of Endrick River and the Upper Shoalhaven River sub-catchments have 80–100% native vegetation cover in the riparian zone (Figure 5.7). The lowest percentage of riparian area covered with native vegetation occurs in the Upper Wollondilly River and Mulwaree River (0–20%) and Reedy and Braidwood Creek (20–40%) sub-catchments.



**Figure 5.7 – Native vegetation in the riparian zone of Glen Quarry Creek, August 2003**

A number of clearing applications were approved within the audit period to remove 16.8 hectares of exotic species including willows, from the riparian zone of the Wollondilly River, Mulwaree Ponds, Wingecarribee River, Paddys River and Gillamatong Creek. The SCA also removed 202 hectares of willows within the audit period which was a decrease of 77 hectares from the previous audit period (Figure 5.8).



**Figure 5.8 – Willow removal carried out by SCA along the Coxs River at Duddawarra Bridge, August 2003**

It was estimated in SCA's Annual Environment Report (2001) that 29% of the riparian zone of the Catchment is subjected to agricultural activity and that 21,000km (38%) of watercourse within the Catchment is presently being, or has the potential to be, accessed by stock (Figure 5.9). As data was not available, it was not possible to assess the extent of any change during the current audit period.



**Figure 5.9 – Stock access to Wallaby Creek causing the removal of vegetation, bank erosion and water contamination, August 2003**

## Implication

Healthy riparian zones assist in maintaining the health of streams and rivers in the Catchment, thereby enhancing the first of the multiple barriers in protecting drinking water quality (Section 2.2). These are particularly important in areas where the adjacent sub-catchments are subject to agricultural activity or where stock has ready access to stream banks. Overall, much of the riparian zone in the Catchment is in good condition but there is less than 40% cover of native vegetation along riparian zones in the Braidwood Creek, Mulwaree River, Reedy Creek and Upper Wollondilly River sub-catchments. Water quality and ecosystem health is at risk in these sub-catchments.

The absence of accurate, quantitative information on area or length of fencing and relatively intact riparian zone in non-protected areas and its condition is preventing any informed analysis of trends from one audit to the next.

Removal of willows is in itself a disturbance and it is important to follow such removal with further remedial action such as planting of appropriate native vegetation. This is a stated intention in the SCA Healthy Catchments program, and in other government programs, but data were not available for this audit.

## Future directions

The SCA Riparian Strategy outlined a program for the mapping of the condition and extent of the riparian zones within the Catchment by June 2006. This database would provide a benchmark for determining trends on riparian zone health in the longer-term. Given that the Catchment contains 55,000 km of riparian areas, a broad scale indicator of riparian zone health should be supplemented by activity indicators and areas of riparian zone protected or rehabilitated (e.g. area of fencing or area of weed removal/revegetation).

**Recommendation 22:** That Riparian Management programs undertaken by government agencies in the Catchment be funded and integrated to achieve Catchment-wide mapping and aid in increasing the amount of riparian vegetation in a good or near intact condition.

**Recommendation 23:** That SCA creates an integrated database to allow monitoring and assessment of all works undertaken that affect the quality of riparian vegetation and streambank stability.

## Target

Protect and repair the riparian zone native vegetation communities:

- complete the mapping of the extent and condition of riparian zone within the Catchment by June 2006
- reduce the extent of weed infestation
- increase the length fenced where appropriate and practical
- progressive revegetation and regeneration of disturbed riparian zones (Figures 5.10 and 5.11).



**Figure 5.10 – Degraded section of the Upper Cocks River, August 2003**

There is a link between the above target and the Warragamba Catchment Blueprint target RHMT10: Maintain existing native riparian vegetation along riparian zones within the Catchment and by 2012, improve the ranking of the condition of 10% of streambank from ‘good’ to ‘near intact’ as mapped in *Geomorphic Categorisation of Streams* (DLWC 2001).



**Figure 5.11 – Section of the Upper Cocks River (immediately downstream of Figure 5.10) undergoing revegetation, August 2003**

## 5.5 Native vegetation

### Background

Native vegetation within the Catchment is important for maintaining ecosystem, species and genetic diversity and health. The extent of native vegetation cover is used as a general indicator of the state of ecosystem health. The condition of the native vegetation is also important; diversity will be different between areas which are in good condition compared to areas which have been degraded by human activities. Degradation of native vegetation can impact on critical ecosystem services such as clean air and water, recycling nutrients and resources such as food and fibre. The decline of native vegetation can also induce soil salinity or acidity, soil erosion and loss of nutrients, changes to flow regimes and climate change.

The rate of biodiversity loss accelerates dramatically when a vegetation community declines below approximately 30% of its original area. In the Wollondilly River, Mulwaree River and Wingecarribee River sub-catchments, clearing has been extensive. These areas where native vegetation communities have been heavily modified and/or cleared are likely to have extinctions of species.

The Eastern Bushlands Database (EBD) was finalised by the National Parks and Wildlife Service (NPWS) in 1998. The database consists of broadscale mapping (1:100,000) of structural vegetation in three GIS datasets, Northern EBD, Central EBD and Southern EBD. The digital vegetation maps were created by visual interpretation of 1989, 1990 and 1991 satellite imagery using vegetation description outlined by Roberts (1992) (NPWS 1998). The three regions were mapped to a different level of detail; this creates problems when trying to match the three datasets. Unfortunately, the Catchment is covered by the Central and Southern EBD and where these two datasets join there is some discontinuity in vegetation communities which can be seen in Figure 5.12. The NPWS concluded that the benefits of edge matching the datasets were far outweighed by the effort required to do so, particularly given the general limitations of the mapping (i.e. scale and detail of analysis) and the fact that it does not provide any information about disturbances or condition of vegetation. Eight categories of native vegetation were extrapolated from the database, *Allocasuarina nana* Heath, dry forest, forest, moist eucalypt forest, plateau complex, rainforest, severely disturbed forest and woodland.

The areas of National Parks, Special Area and State Forests were overlaid onto the native vegetation cover from the EBD to estimate the percentage of native vegetation that was protected and managed in the Catchment (Figure 5.13).

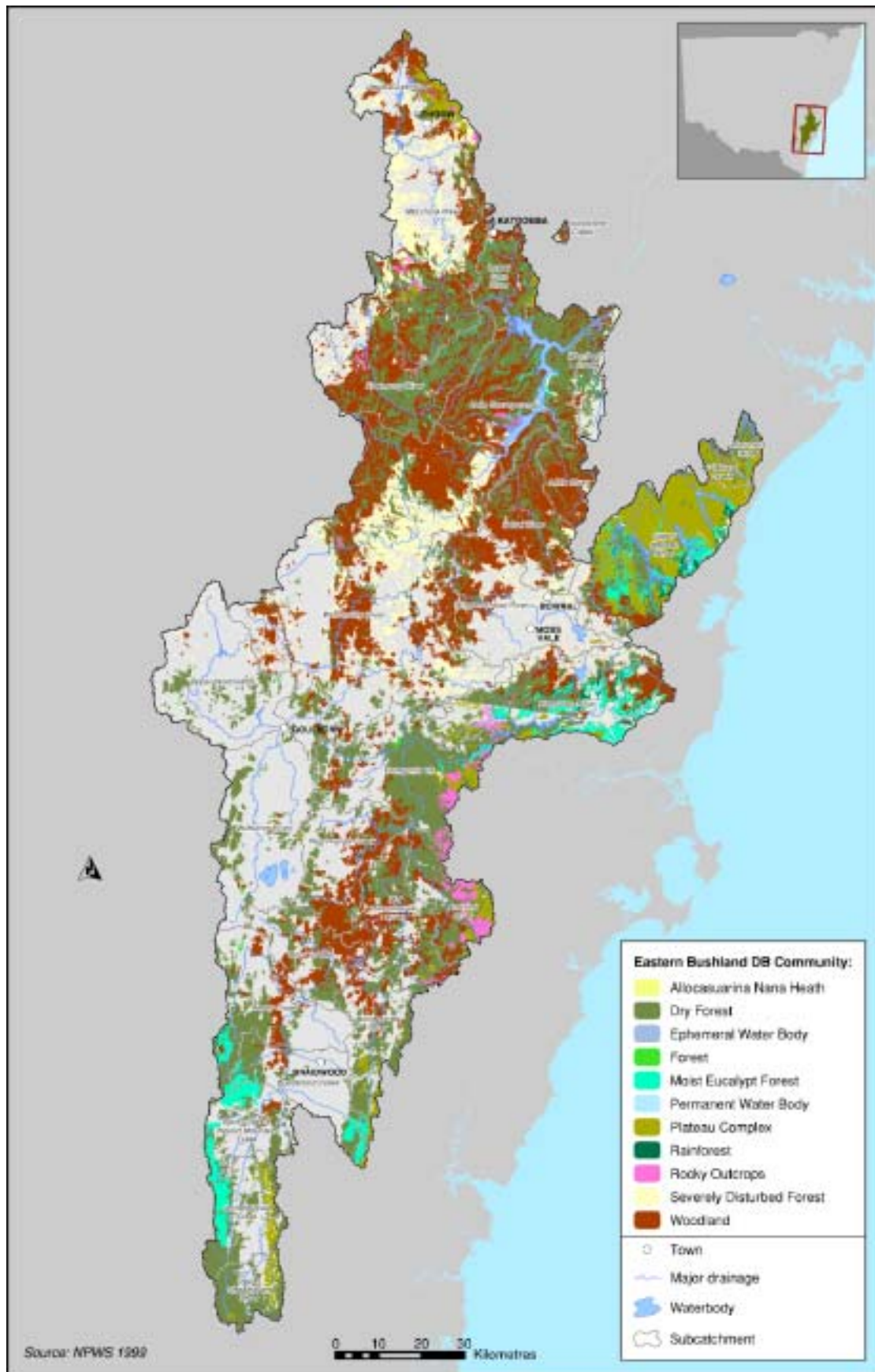
Figure 5.13 also highlights a number of anomalies in the current boundary of the Special Areas, particularly where Special Areas border the National Parks Estate. It may be appropriate to review the boundaries of the Special Areas as part of an overall review of the role and effectiveness of Special Areas.

The NPWS and SCA completed more detailed vegetation mapping (1:25,000) of the Warragamba and Woronora Special Areas which describe and map all the native vegetation communities across the Special Areas including comprehensive information on disturbance and condition. This process has provided valuable information for both benchmarking the condition of vegetation and providing a sound basis for program development and planning for a number of agencies. An example of the output from this work is provided in Appendix G Figure 2.

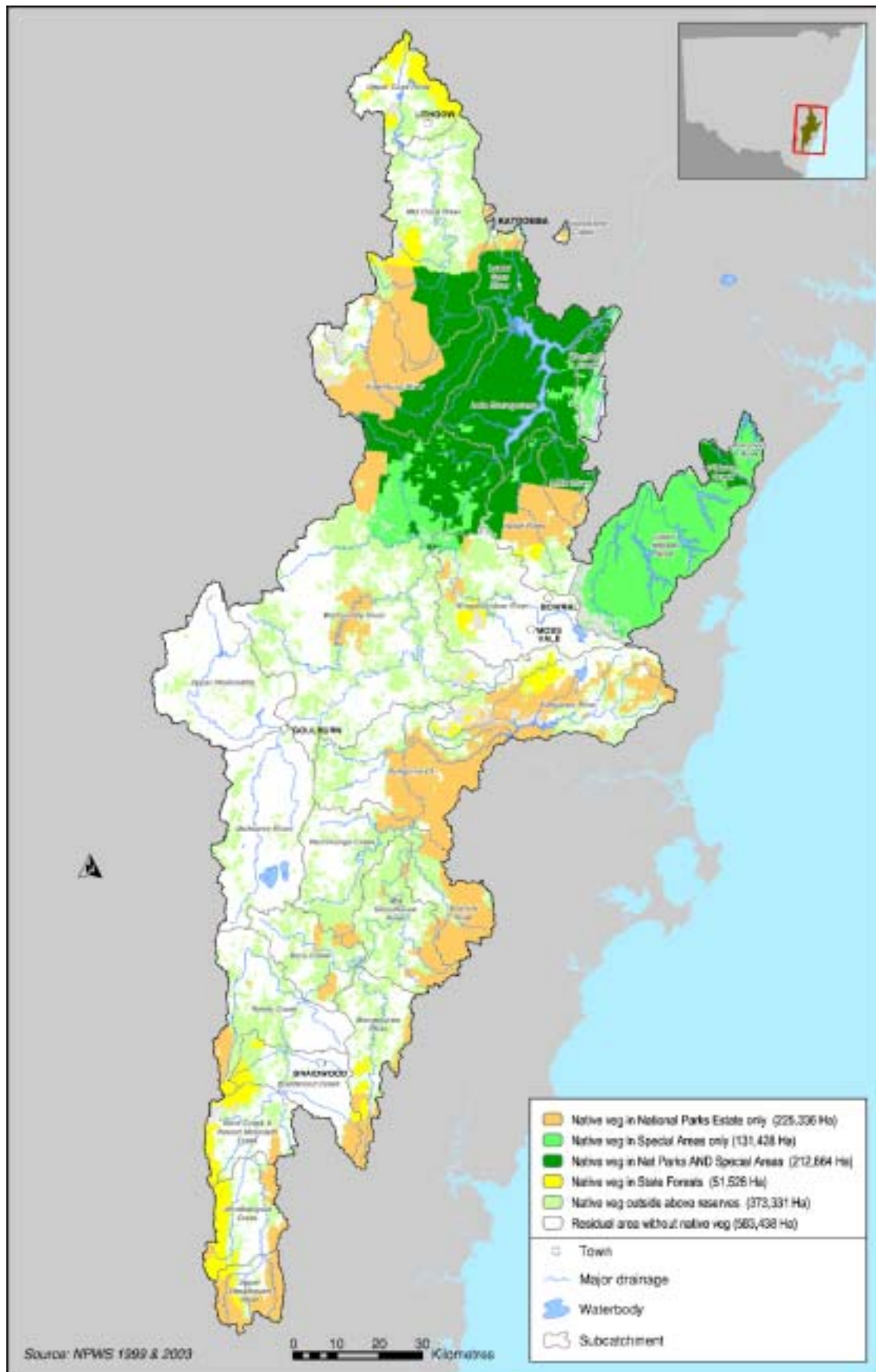
The Special Areas primarily contain native vegetation and cover 23% of the Sydney Drinking Water Catchment. Almost 13% of the land within the Special Area which consists of privately owned lands which are not subject to the high level of control as the publicly owned areas (e.g. restrictions regarding access).

### Findings

Sixty-three percent of the Sydney Drinking Water Catchment is covered by native vegetation and of that 57% is in National Parks and Special Areas and 5% is managed in State Forests (Figure 5.13). Thirty-eight per cent of native vegetation is outside the above designated areas and is dispersed across the Catchment



**Figure 5.12 – Map of native vegetation derived from the Eastern Bushland Database for the Sydney Drinking Water Catchment**



**Figure 5.13 – Map of native vegetation in National Parks, Special Areas and State Forests for the Sydney Drinking Water Catchment**

(Figure 5.13). The majority of this native vegetation is privately owned and the condition and importance of this vegetation is not well understood.

The Kowmung River, Lower Coxs River, Lake Burragorang, Little River, Nattai River, Woronora River, O'Hares Creek, Upper Nepean River and Upper Shoalhaven River sub-catchments have a large percentage of native vegetation cover (>80%). The sub-catchments with the lowest percentage of native vegetation cover (<20%) are the Upper Wollondilly River and Mulwaree River. A number of clearing applications were approved within the audit period to log native vegetation. The total area actually cleared was 728.76 hectares, all within the Braidwood district.

The detailed mapping of the Warragamba Special Area identified that privately owned land was likely to be disturbed (e.g. cleared, bare soil/erosion, used for urban or industrial activities). Areas which were undergoing revegetation were also included. The information gained from the mapping can be used to prioritise remediation works within the Special Areas.

### **Implication**

Data about the extent and condition of vegetation cover across the Catchment presents a generalised picture of the likely overall health of the Catchment and its capacity to yield high quality water. Certain areas of the Catchment, however, play a particularly important role in preventing pollutants entering the water supply and proper management and ongoing monitoring of vegetation within these areas is clearly important to maintaining water quality and quantity. These areas include those in immediate proximity to the water storages, riverine corridors (over 18 degrees) and flood liable lands.

Vegetation in other areas may play a less direct role in maintaining water quality but clearly has a significant role in maintaining ecological processes within these priority areas (for example – there are difficulties in maintaining the ecological integrity of a wetland without also managing vegetation within the immediate sub-catchment).

The lowest percentage of native vegetation cover was in the Upper Wollondilly River and Mulwaree River sub-catchments. The low percentage cover of native vegetation in these sub-catchments may put water quality and ecosystem health at risk.

### **Future directions**

Undertake new mapping of native vegetation communities in the Catchment at a comparable scale and resolution. The condition, relative significance and disturbance categories similar to the Special Areas mapping of vegetation needs to be determined; incorporated in this should be the identification of threatened vegetation communities and the amount of fragmentation. The condition and relative significance of the native vegetation that is not in protected or managed areas should be the basis of prioritisation and management. To determine change over time in the cover of native vegetation, the amount of native vegetation area cleared and revegetated should be collected.

**Recommendation 24:** That SCA undertakes vegetation mapping in conjunction with DIPNR and the Department of Environment and Conservation (NSW) for the remaining areas of the Catchment with priority being given to areas of native vegetation. This mapping should be consistent with the mapping undertaken of the Special Areas and include information on disturbance and condition.

**Recommendation 25:** That SCA ensures that mapping of riparian and native vegetation is appropriately integrated to ensure full compatibility of data.

## Target

Improve condition and decrease the degree of degradation of native vegetation through rehabilitation, restoration and revegetation. Appropriate management of native vegetation outside protected and managed areas.

There is a link between the above target and the Warragamba Catchment Blueprint targets.

BMT11: Increase to 60% by 2007 the proportion of all lands in the Catchment covered by an actively implemented integrated property management plan that addresses threats to biodiversity.

BMT12: By 2012, maintain the condition of all significant remnants of native vegetation and improve the condition of 20% of the area covered by priority native vegetation communities.

BMT13: By 2012, improve the value of the links (as indicated by number, width and native vegetation quality of links) between significant remnants of native vegetation by 10%.

## Actions and Response

### Response to issue

*There are many responses to the degradation of ecosystem health including programs to reduce the impacts of pollution (Chapter 2), new water management rules under statutory water sharing plans (Chapter 3) and programs to improve land management (Chapter 4). In addition to these issues previously discussed are a number of other government responses to the degradation of ecosystem health that are discussed below. These include:*

- *programs to maintain and enhance fisheries*
- *programs to maintain and enhance riparian zones*
- *programs to maintain and enhance native vegetation.*

### Programs to maintain and enhance fisheries

The impact of instream structures, such as weirs and other mechanisms that alter natural flow regimes has been recognised as a key ecosystem health issue. The Threatened Species Conservation Act and the Fisheries Management Act have established Scientific Committees who have both listed the alteration of natural flow regimes of rivers and streams and their floodplains and wetlands as a Key Threatening Process under each respective Act.

#### *Weir Review Program*

The Weir Review Program is responding to fish ecosystem health measures include improving fish passage at identified weirs within the Catchment where currently no effective fishways exist.

In 2001, NSW Fisheries, in collaboration with the then Department of Land and Water Conservation (DLWC), conducted an initial weir review of all licensed weirs in NSW, including those in the Sydney Drinking Water Catchment. The assessment identified those barriers which were a high priority for potential removal, modification or required a fishway to be installed. Also in 2001 the Statement of Intent (SOI) for the Hawkesbury–Nepean River System specifically identified the need for a review of the nine weirs on the upper Nepean with the primary goal of removing the maximum number of weirs, consistent with providing alternate, secure water supply to existing users, and to ensure that any remaining weirs provide for fish passage. Following the initial weir assessment, the DLWC (now DIPNR) commissioned further independent expert assessment of the upper Nepean weirs. The report recommended Thurns and Bergins weirs be removed, low level fishways be installed on Wallacia and Brownlow Hill and the remaining weirs of Mount

Huner, Cobbity, Sharpes, Camden and Menangle to be modified. SCA has indicated a willingness to assist in the remediation of the impacts of the upper Nepean weirs. However on-ground action at any of these sites has been delayed while an overall effluent management strategy is being finalised. This is because if highly treated effluent is used to provide an alternate water supply, flow regimes needs to be taken into consideration when determining where weir removal will create the greatest benefits to river health. NSW Fisheries has gained funding from the Environmental Trusts to complete detailed weir reviews of two priority structures in each catchment in NSW as well as undertaking works at four of these sites in NSW.

### *Fish pass at Tallowa Dam*

Currently a number of migratory fish species are prevented from gaining access to the Shoalhaven River habitat upstream of the 42-metre high dam wall at Tallowa. The SCA and NSW Fisheries have undertaken investigations into development of a detailed design of a combined fishway and multi-level off-take at Tallowa Dam. The SCA has advised that the detailed design phase of the Tallowa Dam Fishway has commenced. The SCA will further assess the project based on information gathered during this phase and the development of final designs and costing. NSW Fisheries will continue to assist the SCA with the design and follow-up of fish monitoring to test the effectiveness of the fishway on construction.

## **Programs to maintain and enhance riparian zones**

The SCA's Healthy Catchment Program being rolled out over a five-year period to 2007 has initiated a program of riparian improvement through the implementation of the Riparian strategy which requires the application of: grants and assistance schemes; community and industry assistance programs; education programs and regulatory processes in consultation with appropriate authorities to determine the condition of riparian zones within the Catchment and in consultation with landowners and other responsible agencies to develop and undertake riparian protection and rehabilitation programs in priority areas.

## **Programs to maintain and enhance native vegetation**

Of the two main responses to addressing native vegetation decline, the first is to slow down or stop the clearing of native vegetation and the second is to focus on revegetating cleared areas to restore biodiversity values.

### *Protection of native vegetation*

The major tools for addressing clearing of native vegetation are:

- legislation to control clearing
- protection of native vegetation from clearing by establishing conservation reserves
- conservation covenants and financial incentives for native vegetation protection on private land e.g. Native Vegetation Incentive Scheme in the Warragamba catchment with funding from the Natural Heritage Trust matched by state funds to enable landholders to identify and protect high conservation value communities in perpetuity.
- policies for the sustainable management of public native forests.

Within the Catchment 10-year targets are reinforced by the relevant Catchment Management Blueprints that use native vegetation as a surrogate for terrestrial biodiversity. The blueprints also have close links with the implementation of regional vegetation management plans. Actions identified under the blueprints include:

- mapping and analysing native vegetation, high conservation areas and cultural heritage values to identify priority areas for conservation.
- developing a regional vegetation management plan prioritising areas for conservation management
- negotiating voluntary conservation agreements with landowners for the protection of priority native vegetation communities and areas

- promoting the adoption and implementation of best management practices for managing native vegetation through education and incentive programs and in government planning instruments (eg. Environmental Services Scheme)
- implement a monitoring program on native vegetation status to determine that there is no net loss and that conservation targets are being achieved.

### *Revegetation of native vegetation*

Invasions of exotic plant species can make catchment areas vulnerable to erosion, reduce water quality, restrict the regeneration of native plants, and limit biodiversity. The SCA is providing \$110,000 in a two-year funding agreement with the Jenolan Caves Reserve Trust to begin a management program to control an infestation of sycamore trees at Jenolan Caves. Sycamore removal is a priority identified in a comprehensive weed management plan for the Jenolan region, commissioned by the NPWS.

### **Effectiveness of response**

A number of actions are required to effectively manage fish stocks in the Catchment. Partnerships between a number of stakeholders is needed to ensure major projects, i.e. removal or modification of barriers to fish passage, control of pest fish species and restoring aquatic habitats, can be achieved. The issue of river connectivity within the Catchment has progressed slower than expected during the audit period. Even for the priority streams of the upper Nepean, the program has been delayed while funding of capital works is resolved and consistency with an effluent strategy and wider State weir removal strategy is determined.

The issue of riparian zone protection and enhancement is progressing slowly. A riparian strategy under the Healthy Catchment Program is a positive response, however the capacity to undertake more works is limited by the absence of a prioritised work program. Once priorities are identified better use needs to be made of the capacity to influence and undertake on-ground riparian work by developing environmental services schemes, joint partnerships and grant funding.

The *Native Vegetation Conservation Act 1997* (NVC Act) established a system of community-based Regional Vegetation Committees to prepare Regional Vegetation Management Plans to identify and protect areas of high conservation value, but at present there are no NVMPs covering the Sydney Drinking Water Catchment.

The ability to assess the effectiveness of programs designed to maintain and enhance native vegetation remains impaired by the lack of knowledge as to the amount of vegetation cleared and the amount revegetated. The scoping study of mapping conducted by NPWS to provide a basis for mapping disturbance as well as the native vegetation communities, health and fragmentation in catchments under extensive private ownership is a positive step forward (see Recommendation 24). This work will match that which has already been undertaken for the sub-catchments within Special Areas. If approved, this will take approximately 6 years to be completed.