Executive summary

The significance of biodiversity resources, and the need for planning to deal with them, is recognised in a suite of international, national and state policies and statutes. These policies and statutes provide a mandate within which regional and local planning must take place, with the aim of ensuring that biodiversity resources are managed in a sustainable way. Therefore, in order to provide a basis for sound planning and decision-making processes, the planning framework for the Georges River catchment must identify the scope for, and the best application of, preventative management (such as riparian buffer zones) necessary to protect biodiversity values. As well, the precautionary principle establishes a critical starting point in addressing the complex problem of arresting environmental decline by instructing to be protective in the first instance. In addition, NSW legislation provides a number of mechanisms (e.g. development and planning approval processes, recovery and threat abatement planning) that are pivotal in protecting biodiversity values under threat. Recognising that in some situations there will be compelling community needs that will result in the modification of aquatic habitats, opportunities to rehabilitate such habitats must be pursued, and must draw on innovative techniques (e.g. impact credits and trading systems, compensatory habitats) where primary habitat modification is unavoidable. To this end, an understanding of predicted population growth and distribution in the catchment is essential information for the formulation of effective management strategies.

Continuing land releases in the catchment of the Georges River for urban development pose a threat to aquatic resources. Inappropriate development, including unchecked urban expansion and poor practices in urban consolidation, compound existing problems. For example, increases in human population coupled with widespread areas of impervious surface increase the total volume of particulate and nutrient matter collected and swept into waterways (i.e. stormwater). Particulates can enhance the rate of estuarine infilling and reduce sub-marine light levels. Nutrients can stimulate phytoplankton growth, effectively compounding the reduced light availability and contributing to the growth of epiphytic algae on submerged vegetation (e.g. seagrasses). These inputs, as well as influencing water quality, can also influence the distribution of freshwater and estuarine habitats, and the types, abundances and distribution of plant and animal populations.

In contrast to the terrestrial ecosystems within the catchment of the Georges River that are fundamentally influenced by the distribution of sandstone and shale geologies, aquatic ecosystems are primarily dependent on the extent of fresh and salt environments. Relative to the pre-colonial era, some of the freshwater reaches of the catchment have been highly modified, especially because of urban expansion. Other freshwater features remain in a relatively undisturbed condition due to a variety of factors, including reservation of land for conservation and military purposes. The Liverpool Weir, built in 1836, fixed the upper boundary of the estuary, altered tidal flow, modified the salinity regime in the mid-reach of the river and inhibited the passage of

migrating fish. Below the weir the estuarine ecosystem can be broken into four geomorphic zones, each zone defined in terms of sediment type, depth and geomorphic setting. Some species of plants, such as the Grey Mangrove, as well as species of animal such as the Sydney rock oyster, occur within more than one zone. Other species are more limited in their distribution.

The fisheries of the Georges River have had a varied history. The rock oyster fishery was once an important industry, with farms along much of the lower estuarine foreshore, but because of disease, the volume of oysters harvested is now a fraction of what it was in the 1970s. Until recently the harvest of finfish centred on Botany Bay, where beach haulers could operate year round but prawn trawlers were only allowed to operate during weekdays during the summer months. Other types of commercial fishing were controlled by closures of parts of the river, fishing times, and species and sizes that could be taken. No commercial fishing was carried out in the freshwater reach. From mid-2002 commercial fishing within the whole of the Georges River and Botany Bay system was prohibited. The recreational fishery is a major pastime for hundreds of anglers, particularly in summer months, and continues to grow in popularity.

One key aspect of biodiversity conservation is the appropriate management of aquatic habitat. A component of such management is spatial and temporal knowledge of the distribution of wetland vegetation. To this end, maps of the distribution of littoral rainforest, paperbark, swamp she-oak, reed, saltmarsh, mangrove and seagrass were produced for the estuarine portion of the catchment. Littoral rainforest and saltmarsh are considered of conservation significance for a number of reasons, one of which is that the distribution of each has progressively declined over time. Littoral rainforest is limited to a few small areas on the Kurnell peninsula and is now afforded some protection due to *Regional Environmental Plan No.17—Kurnell Peninsula*. Three species of saltmarsh are considered to be of special significance due to their limited distributions in the catchment. A conservation strategy for the saltmarsh of the Georges River is needed.

Seagrass is also of importance due to its role in providing habitat for fish. In the mid-1970s its distribution in Botany Bay was disrupted due to storms and increased wave energy brought about by dredging at the mouth of the Bay, but remaining seagrass patches appear to be establishing a new equilibrium—with *Zostera* filling in bare areas once colonised by *Posidonia*. Seagrass also occurs in the river, and *Zostera* was located at a number of sites where it had not previously been mapped. The historical distribution needs to be further assessed and the condition of seagrass needs to be ascertained where beds appear sparse or are covered with epiphytes. Some of the latter locations occur adjacent to stormwater drains and in Kogarah Bay generally.

Activities such as dredging, sand mining, and reclamation can cause direct destruction of seagrass and other aquatic vegetation, and are best managed through conditions set before or during the approval process. Other activities such as poor land use practice (e.g. increased turbidity from eroded sediments and liberated nutrients) can be more difficult to control. A number of options exist for the rehabilitation of degraded aquatic vegetation. Investigation of types, distribution and degree of degradation of freshwater vegetation above Liverpool Weir is needed.

Sixty-five species of fish, nineteen species of crustaceans and three species of molluscs were found in the estuary; these numbers are equivalent to other NSW coastal rivers. Approximately half of the individuals caught were of economic importance. Species such as Port Jackson glassfish, sand whiting, silver biddy, yellow-fin bream and blackfish were found throughout the estuary. Other fishes, such as species of pipefish, goatfish and leatherjackets were limited to the lower estuary, while a third group (including some species of gobies) was limited to the upper estuary. In each of the estuary's four geomorphic zones the number of species was greater in seagrass than over bare substratum, and hence, the conservation of seagrass is fundamental to biodiversity management in the catchment. At the time of sampling only one patch of seagrass was found in the Riverine Channel (upper estuary)—it supported a diverse array of fishes. Other small patches of seagrass were subsequently located and should be sampled to determine if they too carry a diverse community. To maintain biodiversity in the river, particularly of the estuarine part of the river, seagrass needs to be protected, monitored, and enhanced wherever possible.

Freshwater creeks flowing through urbanised parts of the Georges River catchment, relative to non-urbanised freshwater sites, contain fewer native species, elevated abundances of introduced alien fish, higher incidences of fish with visible signs of disease, and relatively low numbers of species known to be intolerant of environmental disturbance. This study, one of the first of its kind in an urban NSW waterway, supports the hypothesis that human population pressure within the catchment has the potential to increase stress on freshwater habitats. Further investigation is required in order to generate a disturbance model to predict, prepare for and prevent the impacts of future population growth in the catchment. Possible management measures are suggested and further investigation of the scope for, and how best to apply, preventative management techniques (e.g. riparian buffer zones) in planning future development in the Georges River catchment is recommended.

The data acquired during this project were compiled in the form of a conservation assessment, akin to the precedent set in the terrestrial biodiversity component of *Biodiversity of the Georges River catchment*. A series of steps resulted in the identification of parcels of land needing special land management action in terms of assignment with Biodiversity Core, Biodiversity Support or Biodiversity Enhancement criteria. The frequency with which aquatic vegetation, an important mediator of biodiversity, needs to be monitored was set out.

There is no doubt that the historical development of land to accommodate population growth in the southern and south-western areas of Sydney has modified aquatic habitats and hence the aquatic biodiversity within the waterways of the Georges River, but the nature and extent of these disturbances is not fully known. Catchment clearing, freshwater impoundment, oyster farming, discharge of sewage, and sand mining are some of many practices that have contributed to the alteration of habitat types, modification of water quality and alteration of plant and animal communities. The relative impacts resulting from these practices have changed over time, with activities such as oyster farming and sand mining effectively no longer factors in environmental modification. On the positive side, effluent is now reticulated and exported from the catchment for treatment, with discharges generally only occurring during wet weather or as a result of poorly maintained sewerage infrastructure. It is assumed that via the

fishway completed in 1997 at least some fishes, previously prevented from upstream migration by the tidal barrier presented by the Liverpool Weir, have found their way to the upper river. While some of the inadvertently destructive processes of the past have been redressed through improved planning and management practice, habitat modification will continue to result from existing activities, and may arise from new development. Steps to minimise the latter, and rehabilitate habitat damage to the former, are needed.

Summary of recommendations

Recommendations set out in Parts 1, 2, 3, 4, 5 and 6 of this report are consolidated below. The recommendations are consistent with the findings of the Independent Inquiry into the Georges River–Botany Bay System (HRC 2000, 2001) and the NSW Government Statement of Intent for the Georges River–Botany Bay System (2002). An abridged schedule of the Healthy Rivers Commissioner's recommendations and the NSW Government Statement of Intent are attached as Appendices L and M.

Part 1 General

- Areas of the catchment where increase in population may impact negatively on riparian and aquatic ecosystems need to be identified.
- The potential impacts of increasing population pressure on riparian and aquatic ecosystems need to be assessed.
- A data management and acquisition strategy needs to be developed for the aquatic resources of the Georges River.

Part 2 Study area

- The four estuarine zones identified in Part 2 need to be recognised as planning units. Terms such as 'mid-river', 'upstream' or 'lower estuary' need to be carefully defined or they are meaningless in an ecological and planning sense.
- Provision needs to be made to manage each of the four estuarine zones of the GRC in a distinct and separate way.

Part 3 Estuarine vegetation

- Planning instruments must progressively integrate threatened species recovery plans for vegetation identified in a threatened condition.
- To confirm changes in the cover of estuarine vegetation over the past 20 years, the aerial photos studied by West *et al.* (1985) should be analysed by the method described in this study or an analogous GIS method.
- To put the dynamics of estuarine vegetation in context, a chronology of land use activities that have impacted on water flow, depth, nutrient input, sediment input and other relevant factors should be undertaken.
- Biodiversity Core Areas on Towra Point should be added to by the acquisition of private lands.
- The distribution of the Common Reed *Phragmites australis* should be monitored, especially as its occurrence along the river appears to be increasing.

- As saltmarsh is limited in its distribution and, relative to other types of estuarine plants, appears to be decreasing in extent, its cover needs to be regularly monitored.
- Special recognition and monitoring needs to be given to at least three sensitive species of saltmarsh: *Gahnia filum*, *Sellieria radicans* and *Wilsonia backhousei*. Conservation measures relevant to the long-term management of these species must be implemented.
- An off-road vehicle management plan should be implemented to prevent further damage to saltmarsh communities.
- A control program for terrestrial weeds, especially the spikey rush *Juncus acutus*, should be implemented, given the present limited distribution and ease of access to weeds in some locations.
- The distribution of the mangrove species *Avicennia marina* and *Aegiceras corniculatum* should be monitored, especially as the general distribution of mangrove along the river appears to be increasing.
- All beds of seagrasses in the Riverine Channel should be located and monitored.
- The distribution and extent of seagrass in Kogarah Bay should be more fully assessed and a monitoring program established to identify water quality–seagrass interactions and whether special ongoing management is required.
- Planning instruments must integrate pest species management plans for species such as *Caulerpa taxifolia*.

Part 4 Estuarine fish

- Planning instruments must integrate recovery plans for currently listed threatened species of fish such as black cod *Epinephelus daemelii* and green sawfish *Pristis zijsron*. Planning instruments must be flexible and able to contend with species that might be listed at some future time.
- Planning instruments are to integrate pest species management plans for fish identified as pests at some future time.
- Separate management strategies need to be devised for the fish communities of each of the four estuarine zones of the Georges River.
- The fish communities of Kogarah Bay need to be defined better, particularly those species associated with seagrasses.
- The fish communities of the Riverine Channel, particularly those species associated with seagrass need to be defined better.
- The potential benefits of restrictive land management practices (e.g. foreshore building restrictions) for the better conservation of estuarine fish at Biodiversity Core, Support and Enhancement sites needs to be assessed.

- Where there is potential to enhance fish habitat, particularly in the Riverine Channel, foreshore rehabilitation programs should be initiated.

Part 5 Freshwater fish

- Additional investigation is needed to ascertain the merits of preventative management practices for the conservation of freshwater fish, such as the establishment of riparian buffer zones.
- In the degraded portions of the GRC, where freshwater fish communities are substandard (e.g. more alien species), further investigation is needed to determine the relative merits of rehabilitation programs such as instream habitat restoration works and riparian habitat restoration works.
- Further assessment of the instream freshwater vegetation in, and the freshwater wetlands adjacent to, the Georges River should be commissioned in order to determine the extent and sensitivity of these communities.
- The adequacy of the Liverpool fishway should be investigated.
- The impact of cracks in the stream bed on the fish communities of the upper catchment should be assessed.

Part 6 Synthesis

- The planning responses set out in Tables 39, 40, 41 and 42 should be adopted in relation to Biodiversity Core, Support and Enhancement Areas.
- The monitoring schedule for estuarine vegetation set out in Table 6.2A should be adopted.

For many of the above recommendations, well-established implementation mechanisms are in place. A challenge exists for the implementation of others.

About this report

The final report of *Biodiversity of the Georges River catchment* is presented in three parts, as summarized in Table 1 below. This is the third part of this report and details the methodologies and results of the study of aquatic biodiversity in the catchment. It also discusses the broader catchment analysis implications and provides key recommendations on the management of aquatic biodiversity values in the catchment. The studies were conducted between 1998 and 2001 and are a cooperative initiative of the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR), NSW Fisheries and the NSW Department of Environment and Conservation (DEC—formerly NPWS & DEC).

Table 1 Summary of the contents of the *Biodiversity of the Georges River catchment* final report

Context for regional biodiversity planning	Introduction, synthesis and discussion of issues: • Concept of biodiversity • Overview of biodiversity conservation frameworks • Introduction to the studies and reports.
Terrestrial biodiversity of the Georges River catchment	Details the study of terrestrial biodiversity resources in the catchment, including: • Introduction and background • Methodologies • Results • Discussion of results • Key recommendations.
Aquatic biodiversity of the Georges River catchment	Details the study of aquatic biodiversity resources in the catchment, including: • Introduction and background • Methodologies • Results • Discussion of results • Key recommendations.

For the purposes of this study, aquatic biodiversity includes those ecological communities and species that are permanently or largely water-based, including all ecological communities, populations and species, and their habitats, defined by the *Fisheries Management Act 1994* (FM Act).