ISSUES AND STRATEGIES

Management of the land must take into account the objectives of the Plan.

4.1 BIODIVERSITY CONSERVATION

A number of relevant observations can be made with regard to biodiversity conservation, as follows (Fallding *et al.* 2001):

- Protection of biodiversity is essential for maintaining ecological processes and contributing to ecologically sustainable development. Conversely, biodiversity conservation is dependent on the maintenance of supporting ecological processes;
- Biodiversity provides ecosystem services of inestimable economic value such as flood control, erosion control, water quality control, insect control, carbon absorption, and climate stabilisation;
- Natural areas which are larger, less disturbed and connected with other natural areas are more likely to retain a higher degree of biodiversity in the long run;
- Biodiversity, as an expression of the unique Australian environment, is an intrinsic part of Australian culture. It supports recreation, tourism and national identity;
- Biodiversity maintains the gene pool of wild plants, animals and microrganisms. This is a useful resource for future generations;
- Greater biodiversity promotes more resilient environments that are capable of better withstanding unpredictable events;
- Ecosystems are characterised by local uniqueness and complexity. Landscapes present a non-repeating mosaic, displaying individual site-specifc responses, and
- Corridor systems can provide landscape connectivity. They require retention and maintenance of existing links, and the restoration of former links.

Experience overseas and in Australia indicates that the greatest impacts on stream health as a consequence of urbanisation are:

- changed hydrology, and
- the loss of vegetation, in particular loss of riparian vegetation.

4.1.1 Endangered Ecological Communities

There are currently three remnant vegetation communities present in the riparian open space areas listed as endangered ecological communities under the *Threatened Species Conservation Act 1995* (TSC Act). These are Cumberland Plain Woodland (CPW), Sydney Coastal River-Flat Forest (SCRFF) and Elderslie Banksia Scrub. These remnants have become fragmented and degraded by weed invasion and erosion.

Although not specifically protected by legislation, freshwater wetlands present in the Hawkesbury Nepean flood plain are also in need of protection and management. These include the previously mentioned wetland in Cowpasture Reserve and the SREP 20 wetland north of the Camden Town Centre (Town Farm site).

A comprehensive review of flora and fauna issues was conducted by Gunninah Environmental Consultants (1999) as part of the Camden Structure Plan Report (Don Fox Planning, 2000). Areas of primary, secondary and tertiary biological constraints within the LGA were identified. A process was then formulated that prioritises for biodiversity conservation and appropriate development controls being put in

place. Many areas identified under primary and secondary biological constraint categories are within riparian corridors, including the whole of the Nepean River corridor.
(Refer to Strategy 1a)

4.1.2 Biodiversity Inventory

Using NPWS 'Native Vegetation of the Cumberland Plain' mapping (NPWS 2000), Council has incorporated the location of some of the endangered ecological communities within the LGA on its GIS system, e.g. Sydney Coastal River-Flat Forest and Cumberland Plain Woodland. Due to the NPWS mapping having been undertaken at a broad scale, it was not possible to pick-up some smaller endangered ecological communities, e.g. Elderslie Banksia Scrub (Council is currently facilitating the mapping of this community). The mapping sometimes shows these communities simply as 'Unclassified Vegetation'.

Additionally, the NPWS mapping does not appear to have picked up any of the freshwater wetlands within the LGA, e.g. the previously mentioned important wetlands in Cowpasture Reserve and the SREP 20 wetland. During the course of this study, other excellent wetland remnants were also located which, although known to Council, have not been mapped on it's GIS mapping system because they are not on the NPWS mapping, e.g. an excellent wetland remnant on Kenny Creek, immediately upstream of the development currently taking place in Smeaton Grange Industrial Estate.

Therefore, notwithstanding the fact that Council currently has a highly developed GIS mapped inventory locating most of the endangered ecological communities within the LGA (as defined under the *Threatened Species Conservation Act 1995* (TSCA)), including those associated with riparian areas), amplification of the system to incorporate other communities not currently listed under the TSCA such as Freswater Wetlands and Elderslie Banksia Scrub Forest is warranted. Having a complete mapped inventory of these natural assets:

- will increase Council's ability to conserve and enhance them, and
- allow Council to give a fuller account of the LGA's biodiversity for state of the environment reporting purposes.

(Refer to Strategy 1b)

4.1.3 Habitat Corridors and Connectivity

Drainage systems have been developed in accordance with prevailing accepted practices. However, in hindsight and with an increasing ecological focus, we see that the drainage systems of the Camden LGA have been seveverly disturbed and are under continuing stress, with typical impacts including loss of riparian vegetation, erosion of stream banks, weed infestation of riparian remnants, poor water quality, modified flow patterns, loss of fish passage due to the construction of on-line dams and weirs, channelisation and installation of low-flow pipe systems. This has resulted in serious fragmentation of the larger riparian corridors, e.g. Nepean River and Narellan Creek, and the near complete loss of remnant vegetation to many of the smaller order streams.
(Refer to Strategy 1c)

4.1.4 Nepean River Weirs

The section of the Nepean River flowing through Camden LGA is 33km in length and regulated by eight weirs (including Bents Basin), which provide a water source to agricultural and horticultural industries in low rainfall times. Two of these weirs (Bergins Weir and Thurns Weir) have failed due to erosion of the sandy soils within which they were set, and Sharps Weir is in the process of slowly failing for the same reason (*pers. comm.* Richard Neville - DLWC, 04 March, 2002). Weirs impact upon the River in a number of ways (refer NSW Weirs Policy for more fulsome list), including:

- the River has been transformed from a pool and riffle system to a series of long still lakes;
- these still lakes can become stagnant and subject to blue-green algal blooms in summer (*ibid.*)
- they can create barriers to fish migration (Note: All of the weirs within the Camden LGA other than Thurns and Bergins Weirs have fish ladders. The existing fish ladder at Brownlow Hill is currently not working and is proposed for upgrading (*ibid.*);
- the water now laps along the steep river banks rather than along the valley floor exacerbating bank erosion. Further, fluctuating water levels prevent the establishment of grasses and weeds at the waterline, which would provide bank protection from wind waves and habitat for aquatic life;
- thermal stratification occurs in deep pools, causing water quality problems, and
- the release of water from the upstream dams for environmental flows is thwarted by the weirs, which take up all of the release water, allowing nothing to get downstream. Unsustainable quantities of water are required for release to both fill the weirs and facilitate the necessary environmental flows. DLWC is currently investigating a mechanism to overcome this problem, e.g. some form of release valves in the weirs (*ibid.*).

Management of weirs is complex as they provide a reliable water supply. The Healthy Rivers Commission Report (1998) recommends a review program for all weirs, and states that weirs should not be removed if an alternate source of water is not available for extraction users. Sharpes Weir is considered to have potential for removal, in part because a review of the extraction licenses for this section of the River suggests that it is feasible to supply the relatively low quantity of extracted water from other sources (*ibid.*). There is a strong possibility that the weirs will be bypassed by the stream as the river widens over the next 50-100 years (Adams, 2000).

NSW Fisheries have recently conducted a review of all weirs in NSW in accordance with the requirements of the NSW Weirs Policy and assessed them for (among other things) fish passage. Three weirs within the Camden LGA were recommended for removal, being Bergins Weir, Thurns Weir and Sharpes Weir (*pers. comm.* Richard Neville - DLWC, 04 March, 2002). The Sydney Catchment Authority (SCA) is currently collecting information on the feasibility of implementing this recommendation and assessing potential environmental impacts. At the time of preparing this Plan, the process is still at the investigative stage, and as yet there is insufficient information upon which to make an informed decision (*pers. comm.* Greg Green, SCA, 26 September, 2001).

As mentioned above, as Bergins and Thurns Weirs no longer function anyway, it may be more effective to remove other weirs such as Camden Weir for example, to restore a pool and riffle system to this section of the Nepean River. A decision in this regard would need to weigh the ecological benefits of the removal of this weir against issues such as:

- the quantity of water required for extraction that cannot be reasonably obtained from another source;

- the capability of the current stretch of water to be used for recreational pursuits such as non-powered boating, and potentially in the future swimming (performance measure from the Camdem 2025 Strategic Plan), particularly within the context of the extent of adjoining public reserve land;
- the highly visible nature of this reach of the River between the Cowpasture and Macarthur Bridges and any perceived preference with regard to the aesthetic appeal of a long open stretch of water as opposed to a pool and riffle system, and
- the cultural landscape values of the existing situation within the context of the Camden Township setting.

The Statement of Joint Intent (SOJI) for the Hawkesbury Nepean River System (EPA, *et. al,* 2002) states that the NSW Weir Review Committee, as a priority, is to review the nine weirs on the upper Nepean. The review is to be in accordance with the principles already established by the NSW Weir Review Committee. Its primary goal is to remove the maximum number of weirs, consistent with providing alternate, secure water supply to existing users, and to ensure that any remaining weirs provide for futiure fish passage.
(Refer to Strategy 1d)

4.1.5 Opportunities

Notwithstanding the above problems, and unlike many other LGA's within the Cumberland Plain, Camden is in the fortunate position of still having significant riparian remnants that continue to exhibit their naturally meandering form. Although generally highly disturbed and fragmented, these comprise a substantial base from which to re-build a connected and bio-diverse system of riparian corridors within the LGA. Additionally, some of the old dams have potentially ecologically valuable locally endemic flora and fauna (e.g. macroinvertebrates) which are available for ecological transfer when these areas are developed (e.g. Elderslie Release Area). The process of ecological transfer from farm dams to constructed wetlands was demonstrated to have been successfully employed at The Cascades, Mount Annan (Hunter Wetlands Research. 1999).
(Refer to Strategy 1e)

4.2 VEGETATION MANAGEMENT

4.2.1 Native Riparian Vegetation

Much of the remnant riparian vegetation within the LGA is in a highly degraded state, exhibiting reduced species diversity and being subject to heavy weed invasion. Due to the inherent linear nature of these corridor remnants, they tend to have a high edge to area ratio. This makes them particularly vulnerable to edge effects such as weed invasion and nutrient enrichment from adjacent and upstream urban / rural development. Additionally, even when bush regeneration has taken place, if the size and form of these areas cannot be improved, they can continue to be relatively demanding of on-going maintenance resources, compared for instance with regenerated patches within more natural areas, or larger areas with a smaller edge to area ratio.
(Refer to Strategy 2c)

4.2.2 Aquatic Weeds & Pest Plants

A number of noxious and serious aquatic weeds or pest native plants either occur within wetland systems or the catchment. These present a serious threat to wetlands and watercourses. Ongoing monitoring

and early management of weeds will be required to avoid large and unsightly infestations. Large infestations will greatly reduce habitat and aesthetic values. In most cases, serious weed infestations will require the use of herbicides and in extreme cases, may also become economically insurmountable to control. Weeds occurring within the sites/catchment are detailed below.
(Refer to Strategy 2a & 2b)

4.2.2.1 Alligator Weed (*Alternanthera philoxeroides*)

Classified as noxious throughout Australia and must be controlled under the *Noxious Weeds Act 1993*. This species is capable of dominating large areas of marsh and open water in wetlands and is moderately salt tolerant. There is currently no effective herbicide control available in Australia (*pers. comm.* P.Gorham, Dept. of Agriculture) although research continues. The largest problem with available herbicide application is the ability of Alligator Weed to prevent translocation of the herbicide by senescing plant material affected above nodes, underneath which the plant remains viable. The best method of control is early detection and manual removal, ensuring excavation of all root material and careful disposal of all plant material.

4.2.2.2 Salvinia (*Salvinia molesta*)

A floating fern classified as noxious throughout Australia, which must be controlled under the *Noxious Weeds Act 1993*. This species can form dense carpets over open water zones, limiting light penetration into the water column. Where herbicide is required, control using diquat is partially effective. Manual removal is the best option. Allow wind to drive the floating plants to a collection point and kill the weed by drying in the sun before disposal as mulch. In enriched water growth will be rapid, with plants doubling in size every 10 days. Control in a small pond is best by hand removal before the infestation gets too large.

4.2.2.3 Water Hyacinth (*Eichhornia crassipes*)

An aquatic floating plant with spongy leaves and blue flowers which spreads by seeds. Water Hyacinth is noxious throughout Australia and must be eradicated. Biological control to date has been relatively ineffective in the Sydney Region. Manual control is most appropriate for small infestations and herbicide control for larger infestations, including diquat (Reglone) and Roundup Biactive.

Water Hyacinth has the potential to expand into open water and become a greater problem. This species sets seed that can remain viable for at least 15 years in the substrate. Any development that increases the area of open water will enhance the spread of Water Hyacinth. Treatment may be costly if left unchecked, but early recognition and hand removal will easily control the outbreak.

4.2.2.4 Spiny Rush (*Juncus acutus*)

Juncus acutus is a serious weed, which has a spiny leaf and bract tips that are hazardous, particularly to children, and make it difficult to control. *Juncus acutus* has the capacity to take over the areas occupied by the native *Juncus kraussii*. Control of mature plants is difficult, being only partially affected by glyphosate; repetitive application over a number of years is necessary to eradicate the population. *Juncus acutus* infestations are wide spread throughout wetlands, floodplains and watercourses within the Camden Local Government Area.

4.2.2.5 Water Couch (*Paspalum distichum*)

A native aquatic grass that is capable of forming dense mats, making it a major weed of drainage channels and shallow water bodies. Water couch is also problematic due to its provision of habitat for mosquitoes. Water couch is widespread growing naturally in wetlands, however, in constructed wetlands this species is of concern given the proximity of most wetlands to residential estates, schools, etc. During the carrying out of this Plan, Water couch was observed to have been planted as part of a relatively newly constructed drainage treatments (Reserve – Kenny Creek [see Map 3, Area CH2]). The swale did not appear to be capable of completely draining following rainfall events, with isolated ponding evident. Ponding in this situation provides excellent opportunity for mosquito breeding. It would be useful to identify the extent to which this type of treatment has been applied within the LGA, and assess whether any remedial works are warranted to reduce mosquito habitat opportunities.

4.2.2.6 Algae

Algal populations are present in most of the freshwater wetlands and watercourses in Camden. Algal blooms occur periodically in constructed wetlands and in the Nepean River behind weirs. Enriched conditions (particularly phosphorus) can cause algal blooms. Therefore managing water quality in wetlands and watercourses will be critical to preventing blooms. Many of the existing algae populations present in wetlands appear to be limited where dense macrophyte growth alters the microclimate of the water, providing shade and limiting algal photosynthesis. Algal growth is usually denser where macrophytes are absent.

Algal blooms will generally impact on the visual amenity provided by the wetlands. However, if the algal species are blue-green algae or cyanobacteria, then more serious impacts could occur (e.g. toxicity to fauna, humans, strong odours, etc.).
(Refer to Strategy 2d)

4.2.3 Terrestrial Weeds

Much of the remnant riparian vegetation within the LGA is in a highly degraded state due to the impacts from surrounding agricultural and urban landuses, with many areas dominated by woody weeds such as willows, elms, gleditzias, privet, olive, blackberry and lantana. These woody weeds and other weeds such as wandering jew, honeysuckle and balloon vine all present a significant threat to native riparian vegetation. Long-term management of weeds is best achieved by maintaining healthy native bushland with intact canopy, limiting both disturbance and the flow of nutrients.
(Refer to Strategy 2a & 2b)

4.3 FAUNA

4.3.1 Native Fauna (Aquatic/Terrestrial Habitat)

Riparian vegetation provides habitat to fauna species of international, national, state and local conservation significance.
(Refer to Strategy 2c)

4.3.2 Pest Fauna

Pest fauna impacting or likely to impact on the wetlands and watercourses covered by this plan are Mosquito fish (*Gambusia holbrooki*), Carp (*Cyprinus Carpio*), Mosquitoes, domestic and nuisance native waterfowl, feral cats, foxes and rabbits.

4.3.2.1 Mosquito Fish (*Gambusia holbrooki*)

Mosquito fish was recently classified as a Key Threatening Process under the *Threatened Species Conservation Act 1995* and requires suppression and/or control. This species is present throughout the wetlands and watercourses of the Camden LGA and will impact deleteriously on native fish, insects and frogs.

Permanent eradication of *Gambusia* is impractical in open systems because of the ever-present risk of re-invasion, as well as deliberate and accidental introductions. For similar reasons, one-off management is unlikely to provide permanent protection. In closed systems a combination of targeted and sustained management should effectively minimise the risk of loss of biodiversity from this species. In open systems, sustained management will offer some form of control.
(Refer to Strategy 3a)

4.3.2.2 Carp (*Cyprinus carpio*)

These species are bottom feeders and in large numbers are believed to stir up the mud, increasing turbidity. The water body can then be prone to outbreaks of blue-green algae and is generally aesthetically unpleasing. Carp have been observed within the Nepean River at Belgenny Reserve (*pers. comm.* Tony Ross, 29 August, 2002) and Camden Lagoon (*pers. comm.* Jeff Bell, 02 October, 2002). As a first step to determine the presence or otherwise of the fish in waterways other than the Nepean River or those areas prone to flooding from the River, Council will monitor the soon to be undertaken draining of Harrington Park Lake. Depending upon the outcome of that event, Council will consider a trial use of electro-fishing in other selected water bodies.
(Refer to Strategy 3b)

4.3.2.3 Mosquitoes

In a well-designed and managed wetland, mosquitoes are rarely a problem and in most cases community education is part of the solution. The creation of diverse habitats that support predatory insects, minimise areas for mosquito larvae to hide, maintain flow through the wetland, avoid small puddles, restrict algae build-up on structures, and allow control over water levels are the main management strategies.

Due to the ability of the mosquito to act as both a nuisance pest and a vector for disease, management of wetlands and watercourses to minimise mosquito breeding in residential areas requires careful

consideration. It is advantageous to always determine mosquito populations in the local area before construction of wetlands or watercourses to determine potential hazards in advance. This is particularly relevant as residential areas can support large numbers of mosquitoes that breed in roof gutters (that are not regularly cleaned of debris), ponds, and generally any areas that collect and retain water (e.g.pot plant dishes, old tyres, etc.).

In general, mosquitoes will breed in isolated ponded areas that result from unlevel substratum in drainage ways and wetland verges, with some species inhabiting wetland plants. Water Couch (*Paspalum distichum*) has the capability of forming dense floating mats over shallow water, which provides mosquito habitat, while other mosquitoes utilise the culms of taller emergent vegetation.

Many areas in the Camden LGA either support Water Couch naturally, or in some areas the species has been deliberately planted in drainage swales in new developments.
(Refer to Strategy 3c)

4.3.4 Domestic and Nuisance Native Water Birds

Large populations of domestic and nuisance native water bird species can impact on the performance of wetlands. Public feeding of water birds often increases the attraction of the birds to a wetland, if undertaken on a regular basis. The number of open water habitats at many sites has already attracted a diverse range of native water birds.

The potential exists for large populations of domestic, or nuisance native water birds to place additional stress on many of the wetland systems. The Purple swamp hen [*Porphyrio porphyrio*] in particular can impact heavily on macrophytes. This is particularly important to wetlands that have aesthetic and/or water quality treatment functions. The Purple swamp hen cause severe damage to aquatic plants by trampling, eating shoots and the more succulent leaves, and using plant parts for nesting material. Such impacts have been observed in The Cascades, Lake Annan and Sedgewick Reserve Water Quality Control Pond.
(Refer to Strategy 3d)

4.3.5 Other Feral Animals

Other feral animals include feral cats, foxes and rabbits, which compete with and/or prey on native fauna. As these species are virtually impossible to eradicate and be prevented from reintroduction, sustained management is required. The Rural Lands Protection Board may trap feral cats when requested.
(Refer to Strategy 3e)

4.3.6 Companion Animals

Companion animals residing in urban areas surrounding wetlands and watercourses can be problematic if owners do not take responsibility for their pets. These animals may impact on native fauna and water quality. Dog faeces can contribute substantial inputs of nutrients and faecal coliforms to water bodies. Additionally, fauna can be disturbed by dogs and successfully hunted by cats.
Council currently has bins for dog droppings in a limited number of locations including Kings Bush Reserve. At all other locations signage is provided which directs the need to pick-up after dogs and control animals.
(Refer to Strategy 3f)

4.4 WATER QUALITY

Wetlands and watercourses are already suffering from detrimental water quality impacts by surrounding landuses. Rapid urban development is placing further pressure on the drainage system. Further, some existing constructed wetlands for stormwater quality control and detention are unable to cope with the stormwater volume and pollution load off the catchments for a range of reasons including:

- undersizing (e.g. flow volumes and velocities into the Water Quality Control Ponds (WQCP) in Sedgewick Reserve and Currans Hill are much higher than desirable for efficient functioning of the pollutant removal process (SMEC 1998)),
- operational problems (e.g. reduced macrophyte coverage, problems associated with the GPT, and short-circuiting at Lake Annan have impaired performance of the pond (ibid.));
- inadequate maintenance (e.g. infrequent cleaning of trash racks results in collected trash being washed into Lake Annan and Sedgewick Reserve WQCP's during flood events (ibid.)), and
- catchment activities (e.g. the high use of fertilisers and extent of construction works in The Cascades catchment has had a detrimental impact on water quality through the introduction of excess nutrients and sediment to the system).

The majority of the existing waterbodies (including Lake Annan, Sedgewick Reserve WQCP, Harrington Park Lake and The Cascades) have been designed primarily for water quality control and flood detention (SMEC 1998, SMEC 2000, Winning 2000). These waterbodies, in particular the more recently constructed systems such as The Cascades, have also been designed for a number of other functions including habitat provision and aesthetic and recreational amenity (SMEC 2000, Winning 2000). Water quality management is difficult due to the multiple and often conflicting functions of a system such as the Cascades e.g. water quality problems such as odour, turbidity and excessive algal growth result in a detrimental impact on the aesthetic and habitat functions of the system.

Strategies need to be implemented to achieve Camden Council's vision and objectives for the protection and rehabilitation of water quality of the rivers, creeks and groundwater as stated in the Camden 2025 Strategic Plan (1999). These need to meet specified performance measures.

4.4.1 Stormwater Pollution

A stormwater management plan has been prepared for The Upper Nepean River Catchment (Boyden and Partners, 1999) and identifies rapid and massive urban expansion in the Narellan Creek sub-catchment as a major environmental threat to the health of the whole Upper Nepean River Catchment.

Significant components of stormwater include sediment, nutrients, toxic substances (pesticides, herbicides, heavy metals), oil, grease and litter, all of which have been identified as having major impacts on the riparian environment in Camden (Boyden and Partners 1999, Healthy Rivers Commission 1998, Camden Structure Plan, 2000).

4.4.2 Water Clarity

The clay soils within the LGA are of a highly dispersive nature, with resultant fine colloidal material remaining in suspension within the water column for often highly extended periods of time. A combination of on-going events such as periodic storm events, basic sediment and erosion control practices within the catchment associated with development, and /or colonisation of the water body with pest fauna such as carp which further exacerbate turbidity problems, means that the water in constructed wetlands in particular may virtually never have good clarity. This causes a range of problems, including:

- reduced light penetration, and therefore:
  - potentially reduced effectiveness of UV disinfection processes for faecal coliforms and other water borne pathogens,
  - inability for submerged / attached aquatic plants to establish and survive. If able to be established, these plants can significantly increase water clarity, with the fine suspended material being attracted, and attaching to the submerged foliage (Note: There is a need for locally based research / trials to determine which attached / submerged aquatic plants would be suitable. This is due to the fact that this type of plant material can cause its own problems, as occurred with the Olympic Rowing Facility at Penrith Lakes, where Ribbonweed *Vallisneria gigantea* reached nuisance proportions). This in turn provides a level of water quality and range of habitat types conducive to successful stocking with native fish, which in turn favourably increases the predator / prey ratio for Mosquito fish control, and increases the potential for achieving a relatively robust ecosystem;
- an aesthetic issue of poor water clarity and in some cases a muddy brown colour to the water. This is most noticable in constructed wetlands adjoining residential developments, and
- an educational problem whereby recreational users over a period of time learn to expect nothing better. If users perceive the water body to be of poor quality, this can translate into a lack of concern for its on-going well being. A problem of this nature may be substantially remedied with an education campaign.

(Refer to Strategy 4a)

4.4.3 Litter

Litter is a chronic problem that markedly detracts from the visual quality of wetlands and watercourses. It is usually most obvious when park users are in close proximity to the waters edge, looking to observe the aquatic environment in detail, e.g. children looking for fish or yabbies, watching water birds, picnicing near the waters edge, etc. The presence of litter (particularly in significant quantities), greatly detracts from user enjoyment of these areas, and by inference suggests that these areas are of low importance, and are certainly not special areas of high value.

(Refer to Strategy 4b)

Catchment Generated Litter

Litter is a major problem of wetlands and watercourses where these are connected via the stormwater system to significant upstream areas of urban development. The most noticeable problem is floating litter such as plastic bottles, polystyrene, aluminium cans, tetra packs, plastic wrapping, etc. Much floating litter may concentrate at one end of a water body as a result of being wind blown, or being carried towards an outlet point in high flows, but in addition a lot of material lodges in fringing vegetation around the perimeter.

Locally Generated Litter

In addition to catchment based litter, locally generated litter is also a problem. This takes a number of forms, including:

- tipping of garden waste into adjoining park areas (over the fence), especially grass clippings. There is potential for this issue to be dealt with on a local basis in conjunction with site-specific education programs; eg. if garden waste was first composted on resident properties or designated composting areas within the park, and then spread to designated mulched areas (eg. above the limit of regular inundation and where existing soil conditions are poor), this would provide a local, low energy solution to re-use of this waste material. Additionally, it would have the potentially greater benefit of encouraging community ownership of the park, through active, regular and essentially unstructured participation in its care and management (i.e. work that can be done when convenient to each individual resident);

4.4.4 Stormwater Treatment Infrastructure

Water quality infrastructure installed to-date predicably exhibits a diverse range of types, reflective of best practice at the various times of installation. These include:

- water quality control ponds (WQCP);
- various configurations of gross pollutant trap (GPT), ranging in efficiency from large open sediment and trash collection structures (e.g. Lake Annan) to concealed Continuous Deflective System (CDS) units which effectively capture sediment down to very small sizes, and
- various configurations of litter traps, including large underground cage structures.

Council is currently employing new water quality treatment technology in the form of sub-surface wetlands and sub-surface bio-ribbons as a major component of its water quality control program in the Elderslie Infill. These facilities are all to be housed within waterproof membranes in response to local soil salinity issues. The proposed system has a number of advantages, including that it does not provide habitat for mosquitoes or algae, and nor does it comprise a drowning risk.

A range of issues are relevant, including:

- the diversity of infrastructure types is not conducive to efficient management. A range of machinery types are required to undertake the work, e.g. bob cats, front end loaders and tip trucks, as well as specialist machinery such as large truck-mounted vacuum pumps for wet wells, and hydraulic arms to lift large underground litter baskets. Council is not resourced with sufficient machinery or staff to undertake all of this work itself. Council currently does most of the backhoe/bobcat work itself and contracts out the heavy lifting and specialist machinery work to private companies;
- the various infrastructure types are generally expensive to maintain.Council's current level of expenditiure is insufficient to meet the annual maintenance requirements of these systems;
- Council currently has no coordinated maintenance regime in place that incorporates all of the GPT's and litter traps it is responsible for. Cleaning of GPT's is scheduled for every three months, but this regime is not always being met. Maintenance of these facilities in some cases tends to be reactive to complaints from the local community, and
- Recent literature suggests that wet well GPT's (i.e. that hold rubbish wet at the bottom of a holding 'well') are releasing nutrients in soluble form within 3 days of organic matter being trapped. Council

curently has two (2) of these units (Cross Creek on Lodges Road and Stewart Street Narellan). The problem of nutrient release should not occur with dry storage systems.

Based on these preliminary results it appears that in order to avoid significant leaching of most pollutants, it is desirable to quickly remove organic debris from collection devices that retain water. It would be best to design trap basins that retain the solids in a dry area, rather than dealing with the engineering and economic hardship of removing these released pollutants from the stormwater stream (Strynchuk et al., 1999). This study suggests that traditional wet detention ponds or wetlands would benefit from upstream, dry, inlet devices to reduce pollutant loadings by removing them as solids, rather than dealing with the leachate in the liquid form in the ponds. A significant source of nutrient input to water bodies is from yard debris washed into drainage systems during storms. Leaves, grass clippings, and organic matter from yards increase oxygen demands and may contribute nutrients to algal blooms.

(Refer to Strategy 4c)

4.5 EROSION

Extensive bank erosion has occurred along the Nepean River and tributary creeks in Camden causing scouring and slumping of the banks, and incising of channels. Bank erosion is a major source of sediments and nutrients entering waterways, and impacts on instream habitat. Removal of native vegetation destabilises banks leading to erosion and it follows that along the Nepean River bank, stability is best in areas with intact native vegetation and full vegetative cover (Adams, 2000). Flooding, urban stormwater runoff and overland flow also act to scour and erode banks and incise channels. Re-establishment of streambank vegetation is essential for managing bank erosion.

(Refer to Strategy 4d)

4.6 SALINITY

DLWC and Camden Council have identified areas where evidence of salinity is present within the catchment. Evidence where salinity has been recorded include at Narellan (around the golf course), Smeaton Grange, Kirkham, Narellan Vale drainage corridor and Elderslie. Additionally, evidence of salinity has been recorded at the WQCPs at Lake Annan and Sedgewick Reserve, identified by bare scald patches around the edges of the water bodies (SMEC 1998). The report hypothesises that the constructed wetlands have elevated the water table and brought saline groundwater to the surface. The Camden 2025 Strategy highlights the environmental impacts of salinity as a water quality issue and requires that the nature and extent of salinity is contained within acceptable standards. Much of the landscape of Camden is vulnerable to salinity, and the occurrence of the problem is possibly more prevalent than currently understood.

In both the 1998/1999 and 1999/2000 State of the Environment Reports, Council has stated its intention to identify the nature of salinity within the LGA and develop a Salinity Management Plan. However, Council has since decided to adopt the 'Salinity Code of Practice' (currently in preparation) being undertaken by the Western Sydney Regional Organisation of Councils (WSROC). The Code of Practice will be used in conjunction with site specific hazard mapping and guidelines for development (e.g. extra cover over steel in concrete slabs, extra thickness for the waterproof membrane under concrete slabs, no

planting of shrubs close to buildings, avoidance of situations that lead to waterlogging, etc.), such as is currently being implemented for the Elderslie Infill.
(Refer to Strategy 4e)

4.7 RECREATION

4.7.1 Appropriate Types of Recreational Usage

Certain types of recreational activities are occurring in reserves that are inappropriate and are impacting on the natural environment. In particular, BMX bike users have created a number of informal tracks in remnant riparian vegetation in Kings Bush Reserve. The construction of these tracks has involved very substantial earthworks, given that it would all have had to be undertaken by hand, which has resulted in the clearing of vegetation and erosion, which is in turn contributing to the instability of the already heavily degraded bank.

With regard to the building of these BMX tracks, Council has provided a formal setting for this activity at Kirkham Park (approximately 1.5km from the site in Kings Bush Reserve). However, a major attraction of areas like Kings Bush Reserve for this activity is likely to be its hidden and adventurous setting, which incorporates substantial levels of danger, conditions which Council cannot and would not want to reproduce. Council may therefore be hard-pressed to effectively 'replace' this activity. However, measures to address this problem could include a combination of increased policing by Council rangers, and the remediation of the earth works in the damaged areas (removing the current source of the impacting activity). Additionally, Council could consider as a trial the provision of a temporary, rudimentary facility within the immediate vicinity of the problem, e.g. on the adjacent open grassed area of the Reserve.
(Refer to Strategy 5a)

4.7.2 Public Access

Many reserves are underutilised as a recreational resource, e.g. Cobbitty Walk, Jack's Gully, the riparian edges of Elizabeth Macarthur Park and Kings Bush Reserve, and the broad undeveloped areas of Bicentennial Park where Matahil Creek runs through an open unmown paddock setting adjacent to the formal recreation facilities (see Map 3 for locations). In many areas, the riparian edges are criss-crossed with informal 'goat tracks', indicating a desire for some level of access to these areas (including the waters edge), and causing further degradation of the banks, e.g. Elizabeth Macarthur Park and Kings Bush Reserve. If the riparian edges of these areas were made more accessible for public use, the potential arises for community ownership to develop, which can create an additional impetus for the care of the reserves, including discouraging inappropriate usage and encouraging of bushland restoration. Access to riparian edges and in particular the waters edge should generally be managed by constructing formal tracks and boardwalks, etc., and limiting indiscriminate access to the waters edge.

Additionally, the vision of this Plan with regard to 'green corridors' provides the impetus and opportunity for an integrated series of regional scale walking (and in some cases cycling) trails.
(Refer to Strategy 5b)

4.8 LANDSCAPE CHARACTER

4.8.1 The Nepean River

The Nepean River provides a dominant landscape feature as it meanders through Camden LGA. However, there are few areas where the public can gain access to the River, and hence many sections throughout the LGA are invisible to the public. The river will not be valued if it cannot be seen. The importance of preserving a distinctive landscape character and scenic quality in Camden and the Upper Nepean River has been documented in the Hawkesbury-Nepean Scenic Quality Study (DUAP, 1996).

Remnant native riparian vegetation communities (CPW & SCRFF) which contribute to the visual amenity and distinctive rural character of the Camden area, have been identified in the 2025 Strategy (Camden Council, 1999) as essential for protection and conservation.
(Refer to Strategy 6a)

4.8.2 Catchment Drainage Lines

With the exception of sections of Narellan Creek, Sickles Creek, Jack's Gully and some minor unnamed tributaries, e.g. as running through Spring Farm, most of the tributaries to the Nepean River within the Study Area covered by this Plan (see Map 3), have no significant riparian remnants left. In many cases the creeklines have been channelised or piped underground. This situation is in stark contrast to the vision for this Plan. Specific issues that arise are detailed below.
(Refer to Strategy 6b)

4.8.3 Stream Morphology

Even though the above mentioned drainage lines have lost their riparian vegetation, many retain their remnant meandering forms, e.g. Matahil Creek (especially where it passes through Bicentennial Park); the upper reaches of Oxley and Herbert Rivulets in Elderslie, and sections of Kenny Creek upstream of both Smeaton Grange and the Currans Hill development.

These geomorphological remnants are important landscape character resources that can form a sound basis for future riparian restoration (including provision of diverse habitat and recreation opportunities). However, they appear to have been lost in large part until more recent times due to the urban development process. Major reasons for this approach are likely to be developer driven, in that:

- these meandering forms can take up a land area greater than that required by a 'rationalised', more heavily engineered 'stormwater management' approach, and possibly also
- are not perceived as being 'neat and tidy', and therefore as readily saleable as the more engineered / landscaped approach.

As stated in Council's adopted 2025 strategy, and consistent with current policy of the Department of Land and Water Conservation, management of these areas must now move beyond the mind set of simply stormwater management, to one that encompasses all of the existing and potential values associated with these important corridors, particularly their biodiversity values.

Therefore, where the morpohology of watercourses and wetlands remnants remain substantially intact, careful consideration should be given to their incorporation into new developments, such as is currently being proposed for the Elderslie Infill.
(Refer to Strategy 6c)

4.8.4 Landscape Character

Many of the newer urban developments within the LGA have incorporated WQCP's into their layout, e.g. Lake Annan, Sedgewick Reserve, Harrington Park and the Cascades. These features tend to comprise essentially open water body elements within an open, mown parkland setting.

Additionally, a range of new constructed watercourses are being incorporated into developments, e.g.:

- a wet invert constructed channel vegetated with a native grass (Water couch *Paspalum distichum*) at the downstream end of the Currans Hill subdivision. Developments such as this comprise a monoculture planting, with the Water couch comprising a habitat type highly conducive to mosquito breeding;
- a wet invert constructed pool and riffle watercourse meandering through an open parkland setting, located at the upstream end of the Currans Hill sub-division. The watercourse comprises a shallow channel with sandstone boulder edging and rubble stream bed armouring. The watercourse is fringed with sporadic remnant mature eucalypts, small planted stands of Casuarinas and mass planting of a limited palette of native shrubs, grasses and wetland sedges. This treatment begins to provide a model for both a quite attractive landscape character that may facilitate reasonable levels of biodiversity. However, the current levels of maintenance could be improved, with Council's current resourcing focussing on mowing upto the edge of fringing mass planting;
- a formalised, gardenesque sandstone 'boulder' stream, fringed with a limited palette of low native shrubs such as at 'The Cascades', and Cross Creek at Harrington Park, adjacent to James Flynn Avenue, and
- a channelised low flow pipe system, the channel fully vegetated with swathes of low native shrubs, grasses and wetland sedges and rushes, and lined along its banks with an open planting of native trees, such as at Mount Annan South, alongside and upstream of Bursaria Road. As with the more common fully turfed channels, these channels flood irregularly, in storm events greater than the design capacity of the low flow pipe system which runs beneath them, e.g. at the 3 month or 12 month storm, and therefore provide lesser habitat opportunities (particularly with regard to macroinvertebrates) than wet invert channels.

What is apparent when viewing the above systems is:

- the broad variation in treatments, ranging from the manicured formality of 'The Cascades', to the naturalistic, wet invert watercourse construction on Kenny Creek, and
- a generally missed opportunity to reference the landscape character and diverse palette of species that would have preceded development in these areas. This opportunity is in keeping with many of the objectives of the Camden 2025 Strategy, e.g.:
  - 1.1.1: To manage urban development to ensure:
    - stresses on the natural environment are minimised and degraded areas are rehabilitated,
    - Camden's landscape setting is retained and enhanced;

- 3.0: Outcome: A Camden in which its unique natural systems have been protected and enhanced:
  - Opportunities for the retention and development of vegetation and wildlife corridors should be embraced,
  - Objective: To preserve and enhance the visual, cultural and scenic landscape qualities;
- 3.5: Landscape Strategies and Actions:
  - (i) Conserve the important cultural and scenic landscapes that characterise the Camden area,
  - (ii) Ensure development controls are consistent with landscape preservation objectives.

Additionally, healthy wetland remnants such as the aforementioned Smeaton Grange example, provide a natural example of a potentially biodiverse and sustainable response to many of the environmental conditions current within its catchment.

The Elderslie Infill is a good example of the implementation of the above objectives, which will incorporate the retention of natural creek corridors, bushland remnants and the use of WSUD principles. The principles set out within the Elderslie Infill aim to address the above mentioned descriptions of earlier development, seeking to ensure that there is not:

- a proliferation of visually disparate riparian treatments;
- of variable quality,
- with a plethora of different maintenance requirements.

With regard to the issue of what the landscape character of riparian corridors may have been prior to development, some existing remnants potentially provide good examples, such as the section of Kenny Creek in Smeaton Grange between the new industrial development and the Currans Hill sub-division. In addition to providing high quality remnant wetland and watercourse habitats, it provides an excellent landscape character reference type for those watercourses and wetlands in the LGA associated with Cumberland Plain Woodland, as opposed to the more common situation of riparian remnants being associated with Sydney Coastal River-Flat Forest. If only from this point of view, areas such as this should be a priority for conservation and management.
(Refer to Strategy 6d)

4.9 CULTURAL HERITAGE

Sites of cultural and historic significance exist in many riparian open space areas.

Aboriginal heritage sites are likely to occur even if not currently known or protected, as campsites were concentrated along the Nepean River and tributary creeks in the area, taking advantage of the abundance and diversity of food plants avaliable in riparian areas (Benson & Howell, 1990).

The principal New South Wales State legislation dealing with the management of Aboriginal heritage is the *NSW National Parks and Wildlife Act 1974*, administered by the NSW National Parks and Wildlife Service. This Act provides for the protection, preservation and management of all Aboriginal relics throughout New South Wales, irrespective of land tenure.

European heritage sites are largely associated with rural history of the area, which includes river and creek crossings (an excellent example is of an old log bridge crossing that occurs immediately downstream of Bicentennial Park).
(Refer to Strategy 7)

4.10 PUBLIC SAFETY & HEALTH

Wetlands and watercourses, especially in urban areas, can create a number of potential safety and health issues for the public, contractors and maintenance staff. These issues are of particular importance in and around stormwater control wetlands constructed in close proximity to residential areas.

Stagnant water becomes a breeding ground for bacteria and viruses as well as insect pests such as mosquitoes, which can be vectors for a number of diseases. Faecal pollution poses a risk to human health, particularly where secondary recreational use may be considered (e.g. boating, fishing) and where children play at wetland edges (regardless of recreational designation).

Litigation may be possible over issues such as pollution and disease. Council should seek guidance from the Department of Local Government and Department of Land and Water Conservation with regard to the most appropriate strategy for signage describing the risks associated with contaminants in stormwater. The provision of all "Due Care and Diligence" in the implementation and management of these systems will minimise the opportunity for litigation.
(Refer to Strategy 8)

4.11 MAINTENANCE

Wetlands and watercourses, both constructed and occurring naturally within an urban environment, suffer from a number of adverse impacts arising from development within the contributing catchment. Consequently a wetland or watercourse in an urban environment cannot be expected to perform as a natural system without regular maintenance. The operation and maintenance of these systems must ensure that:

- they operate as designed and the objectives are met;
- their active lifespan is extended, delaying the need for a major retrofit or decommissioning;
- operational staff are trained such that they can make informed decisions and ensure new staff can effectively manage the wetland; and
- money is saved by providing the mechanism through which problems such as weed infestations can be detected in the early stages. This often results in solutions that are much cheaper and simpler to implement than later remedial action (DLWC, 1998).

Major issues with regard to the maintenance of constructed wetlands within the Camden LGA include:

- following development, the handover from developer to Council has historically not been undertaken in a manner that clearly informs Council of what maintenance requirements and ongoing costs will be required to be met by Council;
- this has contributed to the issue of responsibility and adequate funding not being allocated within Council to carry out the necessary tasks, which has resulted in a number of constructed wetlands operating without the sufficient level of maintenance required to meet its design objectives;
- wetlands have not been designed with low maintenance as a primary objective, and

- there is no opportunity to change or fix aspects of wetland and watercourse developments that are found after handover to be flawed.

(Refer to Strategy 9a, 9b, 9c & 9d)

4.11.1 Constructed Wetland / Watercourse Design

Up until recent times (e.g. Elderslie Infill), there has not been a strong enough emphasis on the design of constructed wetlands and watercourses with regard to long-term maintenace, especially that will match Council's ability (financial / expertise) to maintain them optimally. As developers generally hand over these facilities to Council within a few years of completing their developments, they have no incentive to ensure the long-term viability of these inherently complex systems which, without careful stewardship, are prone to ecological imbalance and low biodiversity values.

(Refer to Strategy 9a, 9c &11a)

4.11.2 Council Structure

Current Structure

Currently, different areas of Council undertake the various maintenance and management roles associated with riparian areas, being:

- Engineering Branch (Parks Division) - in the main mows grass up to the wet / dry edge of wetlands and fringing mass planting of watercourses, and removes the litter that can be readily reached from the waters edge;
- Assets Branch - maintains GPTs / litter racks, and undertakes general maintenance as required of inlet and outlet structures;
- Environment & Health Branch – undertake water quality monitoring, co-ordinate Council's response to algal outbreaks, treat outbreaks of noxious aquatic weeds and co-ordinate bush regeneration, and
- Outcomes Branch – co-ordinate the functions of the other branches to ensure an integrated delivery of services.

A range of issues either fall outside traditional roles of the various branches or coordination is required, e.g.:

- litter, including that floating, lodged in fringing macrophytes or dumped materials such as shopping trolleys and car tyres;
- serious environmental (but not 'noxious') weeds (e.g. *Juncus acutus*);
- pest fauna, e.g. carp, mosquito fish, nuisance levels of mosquitoes, and
- general water quality issues such as surface scum from oil, algae or decaying vegetation, or aquatic pest plant outbreaks (eg *Azolla spp.*).

Wetland management emphasises the requirement for a management structure that can co-ordinate the activities of the branches. This requires a highly proactive approach by the Outcomes Branch, and specifically the Environmental Systems Officer, to ensure comprehensive and integrated whole of wetland system management.

In particular, the Outcomes Branch must be vigilant in maintaining a feed back loop between the above mentioned branches (which are responsible for maintaining wetlands and watercourses) and Development Branch, which is involved in the assessment of new proposals for these. Development Branch liaises

direct with land developers with regard to the design of constructed wetlands and watercourses (or less frequently the incorporation of riparian remnants into new sub-divisions), and provision of management plans for the same. Open lines of communication between Development Branch and the branches responsible for wetland and watercourse maintenance ensure that valuable on-the-ground insights from those branches are able to feed into the design and documentation process.

Council currently has no structured maintenance schedules for either the constructed or remnant wetlands and watercourses that fall under its care, control and management (with the exception of The Cascades, Mount Annan). Maintenance schedules exist specifically for noxious weeds in constructed and remnant wetlands, but not for the overall management of the systems.
(Refer to Strategy 9b & 11c)

Need for Greater Co-ordination

Historically, Council responsibilities with regard to stormwater management (drainage) have focussed around the design and maintenance of built forms, e.g. channelling of water to avoid localised flooding; maintenance of engineering structures including litter and (more recently) sediment removal, and mowing / maintenance of landscape treatments within the drainage line, etc. Within only the relatively recent past, a paradigm shift has been and is still in process with regard to environmental outcomes, as evidenced by a raft of recent environmental legislation, studies commissioned by Council, and Council's own 2025 Strategy.

Historically therefore, with regard to riparian systems, it could be said that Council's structure has been framed to deal with a series of simple / mechanical and not necessarily interconnected tasks, eg. clearing of a drainage line choked by water weeds was a simple, mechanical and repetitive process that was carried out on a needs basis, without reference to upstream factors such as high instream nutrient loads that may have been contributing to the problem. Treatments were kept simple (e.g. turfed swales with low flow pipes) to minimise both the required size of the structure (it would require a greater volume if it were to contain significant levels of planting), and maintenance.

It is still only a relatively recent phenomenon that these areas are now being required to be managed for a far broader range of values, including biodiversity values. Constructed wetlands (a relatively new form of pollution control device) are a good example of the management strains this puts on Council's existing structure. Rather than Council now having responsibility for systems that can essentially be maintained in a relatively simplistic / mechanical way, these wetlands now comprise and need to be designed and managed as inherently complex biological systems. This applies not only to the water body, but also to the fringing riparian communities, and the catchment of which it is an inherent component. Previously if Council was unable to regularly maintain a drainage channel, in the short to medium term, the outcome was likely to be no worse than the area appearing unkempt. In the current situation, if Council does not adequately maintain a constructed wetland, it can readily become eutrophic, infested with mosquitoes or subject to toxic algal blooms, all of which potentially have both serious public liability and public relations implications for Council.

In the Outcomes Branch, Council has in place a structure to provide the co-ordination necessary to manage these new contiguous, biologically driven systems. With regard to the example of constructed wetlands, these need to be managed as biological systems, with close reference to system inputs and outputs, and incorporating all aspects of the wetland, e.g. water quality, aquatic and riparian vegetation management, fauna management (e.g. predator / prey relationships), litter and sediment control, education, etc. For this to occur, the pivotal co-ordinating role of the Outcomes Branch needs to be reinforced and facilitated within the overall Council structure.
(Refer to Strategy 9b & 11c)

4.11.3 Staff Acquisition / Training

The above brings into focus the need for acquisition of specialist staff and training of existing staff. Due to the inherent complexity of, and background knowledge (science / ecology) required to manage riparian corridors as complex biological systems, Council will need to ensure it has appropriately skilled staff.

With regard to staff training, interviews with Council's maintenance staff demonstrated a ready willingness to expand current roles to incorporate environmental management principles in conjunction with appropriate training.
(Refer to Strategy 9e)

4.12 MONITORING AND EVALUATION

As previously described, Council has over the recent past taken over the care, control and management for a range of both constructed and remnant wetlands and watercourses. Most of these areas are not subject to regular performance monitoring e.g. water quality. Nor do they have Specific Area Plans of Management drawn up for them (excluding the Cascades, Mount Annan). Therefore it is in most instances not possible to measure and evaluate the success or otherwise of their management. This data is critical for implementation of further capital works in future, especially upstream works, e.g. the proposed 'Garden Gates' subdivision development upstream of Lake Annan.

4.13 URBAN DEVELOPMENT PROCESS

4.13.1 Development Controls

Currently there is an inconsistency in the design of constructed wetlands, watercourses and GPTs, and the design intent is not well understood by Council personnel or the community. Additionally, water bodies are not designed with consideration of future maintenance requirements and costs (e.g. the use of pumps that are expensive to both run and maintain).

There are currently no LGA specific design guidelines for development within and adjacent to riparian corridors. Development guidelines would include a consistent approach to:

- goals and objectives for constructed wetlands and watercourses;
- incorporation of existing riparian remnants into new developments and protection of their values;
- consistency of landscape character;
- plant species composition and community structure relevant to location within catchment;
- preferred wetland and watercourse configurations;
- range of recreation types appropriate to riparian areas;
- provision for regional linkages;
- designing to minimise maintenance;
- aquatic and terrestrial habitat creation, and
- ecological transfer to new riparian treatments where decommissioning old farm dams.

Water Sensitive Urban Design (WSUD) is now a recognised approach to new development areas and incorporates source controls, conveyance controls and discharge controls. Camden Council have developed a *Water Sensitive Urban Design Position Paper* (2001), which provides guidelines to the overall planning and design of new neighborhoods and urban precincts within the Camden LGA.

WSUD controls have a number of benefits, including:

- reduced amounts of stormwater piping infrastructure required,
- reduced construction costs;
- low maintenance designs;
- reduced mains water usage, and
- reduced stormwater discharge volume and velocity of flow (pollution and erosion protection for wetlands and watercourses).

(Refer to Strategy 11a)

4.13.2 Handover Process

Additionally, the hand over from developer to Council should be improved with regard to:

- on-going management / maintenance requirements;
- on-going management / maintenance costs, and
- loss of opportunity to change / fix wetland / watercourse aspects of the development that are flawed.

The hand over process to various divisions within Council should be improved, ensuring that the branches responsible for management and maintenance of wetlands and watercourses are well briefed on the design intents, anticipated performance / operational benefits, and on-going maintenance tasks/indicative costs applicable to the facilities. In the past these areas have been handed over to the Parks Section on basis of rate/ha to mow.

(Refer to Strategy 11c)

4.14 COMMUNITY ISSUES

4.14.1 Communicating the Vision

Council has in front of it a highly challenging task with regard to the environmental management of riparian areas, as reflected in the adopted 2025 Strategy. At the time of writing this Plan, Council has 37 separate

parcels of riparian land falling under its care, control and management. Given the rapid rate at which the LGA is developing, it is likely that this number will quickly increase (refer Map 3).

It has been noted that with regard to the Nepean River in particular, many large natural areas are simply unseen by the general public (DUAP, 1996), and therefore unlikely to be appreciated by them (recognising that many of these areas are not in public ownership). However, Council has strategically located land under its care, control and mangement which, if developed to facilitate public access, would provide substantial views to well vegetated reaches of the River, e.g. (refer Map 3):

- Cobbitty Walk – Nepean River, from a future short jetty or lookout platform viewing up and down the River (Map Ref CO2). Developing an attractive, short bushwalk from the Cobbitty Township to the River would increase the range of tourist visitation attractions in a manner well in keeping with its Desired Future Character;
- Ellis Reserve – Nepean River, looking across the River to a visually uninterrupted line of heavily vegetated riparian forest (Map Ref EL2);
- Reserve near Sharpes Weir (Map Ref EL1);
- Macquarie Grove Reserve – Nepean River, looking downstream to a 1.5km. reach of heavily vegetated riparian corridor down both sides of the River (Map Ref CO1), and
- Jacks Gully – Nepean River (possible future – currently inaccessible by public road), where a lookout from what is currently a private road within the Glenlee Clutha Quarry at the top of an escarpment provides magnificant views of the River for kilometres both upstream and downstream, including over Council's own large and fully vegetated land holding (Refer Map SF3).

Further, given the current highly degraded state of many riparian remnants, and lack of adequate maintenance to constructed facilities, it is likely most riparian areas are not recognised or valued with regard to their existing and potential values.

There is a need to get the message out to the public about what the vision is for Camden's riparian corridors (perhaps on a sub-catchment basis), and show how each component (or sub-catchment) fits within the overall vision. Council has already commenced a process of this kind in the Cross Creek sub-catchment. This educational process may help to generate general community support for the process, as well as active involvement at both the local and regional level.

The following strategies may be relevant with regard to communicating the vision and facilitating community participation:

- the formation of community place based groups that meet regularly with representation from local Councillors, Council personnel, and State Government (i.e., DLWC, EPA where necessary), to facilitate involvement in management projects and grant funding applications;
- development of a Community Information Program relative to wetlands (remnant and constructed) within the LGA, stormwater drainage, good catchment/land use activities, etc. Should include a "welcome kit" for residents moving into areas adjacent or directly draining to wetlands or other water courses;
- encourage community involvement, e.g. through volunteer works such as bush regeneration, general maintenance e.g., light weeding in localised areas, formation or utilisation of LandCare groups, and involvement of secondary and tertiary educational institutions, and

- the naming of new WQCP's as ponds rather than lakes (e.g. Lake Annan), as the word more accurately reflects their function.

4.14.2 Design Intent

The design intent for constructed wetlands and watercourses is not well understood by the Council personnel responsible for their maintenance and the general community, i.e. that these areas provide a for a multi-objective range of functions including stormwater detention, water quality control, local biodiversity, recreation and as an aesthetic setting, etc. Because these facilities are biologically driven, significant fluctuations can occur with regard to different waterplant populations for instance. If the facility has not been designed with sufficient capacity to meet catchment loads, or is not sensitively maintained, all of these objectives can quickly be lost, e.g. if the water body turns eutrophic.

A recent example of a lack of community understanding with regard to the carrying out of maintenance operations was demonstrated at the Sedgewick Reserve WQCP in 2001. Council was confronted with public outrage when the eradication of a major Salvinia outbreak necessitated the burning of the riparian edge and mechanical harvesting of the weed.
(Refer to Strategy 12)

4.15 CATCHMENT ISSUES

4.15.1 Water Quality

Water quality is directly related to conditions within the catchment that drain to the wetland or watercourse, for example, but not limited to:

- level and type of development;
- proportion of landscape developed/undeveloped;
- sediment and erosion controls during development, and
- catchment landholder behaviour and land usage post development.

Poor water quality arises from catchment generated issues, primarily by:

- altered hydrology;
- enrichment through elevated levels of nutrients and other pollutants in stormwater, and
- turbidity of water column in wetlands/lakes, due to the transport of sediments in stormwater runoff. This is of particular concern in the Camden LGA given the predominance of dispersive clays within many catchment areas proposed for development, and subsequent high concentrations of colloidal particles that do not settle out.

Significant sources of stormwater pollutants and threats to water quality in the Camden LGA include:

- nutrient rich runoff from the Studley Park Golf Course;
- high amount of litter and pollutants from roadways and carparks generated from the urban centres of Narellan and Camden;
- high concentrations of nutrients and sediments from turf farms in close proximity to the Nepean River;
- erosion from cattle grazing near the creeks in rural areas of Camden;
- sand mining on the Nepean River between Menangle and Theresa Park;
- nutrients and heavy metals in discharges from the West Camden Sewage Treatment Plant, and
- excessive sedimentation from urban development construction.

Stormwater management is an integral part of development control planning, albeit stormwater management is still in its infancy and should be treated with an adaptive management response as research and new development progresses. WSUD is now a recognised approach to new development areas to manage and reuse stormwater (see section 4.13.1).

There are currently a number of stormwater proprietary devices available that are marketed as solutions to stormwater runoff problems. However, a number of factors must be taken into consideration prior to selecting an appropriate stormwater treatment device, as follows:

- captured gross pollutants that are stored "wet" are capable of re-mobilising trapped nutrients and heavy metals in as little as three days, and releasing these contaminants to the downstream system (Stormwater Industry Association, 1999), and
- in smaller catchments (less than 10 hectares), most pollutants are contained in what is commonly referred to as the "first flush", or first 25mm of rainfall runoff. In larger catchments, pollutants are "diffusely" generated, and continue to be present in high concentrations throughout the storm event. A great proportion of the pollutant loading from larger catchments will not be captured in GPTs and will be discharged downstream through high flow bypasses inherent to these systems. Where GPTs are successfully capturing pollutants, they need to be regularly cleaned, especially after storms, to ensure captured material is not re-released in subsequent storm events.

Additionally, many GPTs cost as much as 10% of the capital cost each year to maintain.

Therefore, future consideration of stormwater proprietary devices should consider the following:

- catchment size;
- storage of gross pollutants in a dry state, and
- maintenance requirements, costs and responsibilities.

Anecdotal evidence suggests that with regard to the Cascades development, the total catchment management approach seems to be lacking, e.g. the wetlands within the Cascades are already suffering negative impacts from catchment pressures, yet more of upstream catchment is to be developed in future.

4.15.2 Water Quantity

Experience overseas and in Australia indicates that the greatest impacts on stream health as a consequence of urbanisation are changed hydrology, and the loss of vegetation, in particular loss of riparian vegetation. Traditionally, stormwater management has focused on treating specific requirements directly related to water quality, with lesser consideration to increased quantities of water impacting on downstream ecosystems.

Consideration must be given to controlling the more frequent smaller recurrence interval storms (e.g. 2 year) at or below the pre-development peak discharge rates. This does not alleviate the need to control peak discharges from the larger storm events that have been identified as critical for flood control in a specific catchment. This should be incorporated into an Integrated Catchment Management strategy that incorporates a WSUD approach.

Although a consistent stormwater management approach throughout the catchment is desirable, Council may impose on developers its own conditions regarding pollution control and site management during construction. Consequently, construction activities throughout the catchment will have to comply with the Council's Development Consent Conditions (i.e. Water Sensitive Urban Design approach, which can be implemented through Section 94 of the *Environmental Planning and Assessment Act 1979* — used to levy contributions on development impacts, primarily for infrastructure).
(Refer to Strategy 13)