7. Stormwater Management Options

A range of stormwater management options have been identified to address the stormwater issues identified in *Chapter 6*. Both structural and non-structural options have been identified to minimise or remove stormwater pollutants and achieve the objectives for stormwater management (refer *Chapter 5*).

The stormwater management options identified for the Cooks River were developed through:

- community and stakeholder workshops, and responses to questionnaires;
- discussions with stormwater managers;
- review of existing management strategies such as those proposed in the Cooks River Foreshore Strategy and Alexandra Canal Water Environment Plan;
- identification of existing stormwater management practices and demonstration projects currently undertaken by Councils and stormwater managers within the Cooks River Catchment;
- existing knowledge of best practice stormwater management techniques;
- field inspections of identified hot spot problem areas throughout the catchment; and
- application of expert knowledge and the principles of stormwater management to address outstanding issues.

All stormwater management options identified in this way have been investigated and evaluated according to stormwater management principles and cost-benefit methodology detailed in this chapter. The scope and timeframe for preparation of this Stormwater Management Plan did not allow for detailed investigation of the feasibility of all the structural options. Therefore, some of the proposed options will require further investigation and evaluation to determine their feasibility and detailed cost. Many options however, can be implemented without the need for further investigation/evaluation. This classification of options is discussed further in *Chapter 8*.

Sewer overflows and leaks from sewage pipes were identified in *Table 6.1* as potential causes of elevated nutrients and bacteria in waterways. Options have not bee developed to address sewer overflows and leaks, as Sydney Water are addressing this issue as part of the sewer overflow licensing project and options developed as part of their sewage action plan.

7.1 Stormwater Management Principles

The general principles of stormwater management follows a hierarchy of options:

1. Retain and restore the natural processes of the waterway. Options which maintain the natural drainage and treatment processes (such as wetlands, riparian zones, intertidal zones and natural creek lines) are considered at the top of the hierarchy.

2. Control pollutants at the source. Source control options prevent pollution of stormwater at the source and/or minimise the generation of excess stormwater run-off. Source controls include education programs, innovative design, and management procedures to change polluting behaviour, as well as the installation of infiltration devices to treat pollutants before they enter the river system.
3. Develop "end of pipe" solutions. Options that treat pollutants which have made their way into the river system are considered "end of pipe" solutions. These options are often structural and include gross pollutant traps, sediment detention basins, and litter booms. These options are lowest in the hierarchy as they are often costly and are not preventative.

This hierarchy (NSW Environment Protection Authority, 1998) is consistent with the principles of ecologically sustainable development and also represents the order of cost effectiveness. The development of stormwater management options for the Cooks River follows closely this hierarchy, by focusing on actions which restore a naturally functioning waterway, and control pollutants before they enter the river system. However, in a catchment as modified and polluted as the Cooks River a range options from each level of the hierarchy are required in order to achieve the short and long term stormwater management objectives.

7.2 Options for the Cooks River

The stormwater management options proposed for the Cooks River are listed and ranked in *Appendix G, Table 7.1*. The options aim to address the stormwater issues with a focus on the protection of areas of high ecological value and solving existing "hotspot" problems. Many options are based on pilot studies and trials which have been undertaken within the Cooks River catchment, or on best practice stormwater management techniques. Many of these initiatives are undocumented and require further explanation than can be provided in the table format. Therefore, a summary is provided below.

7.2.1 Natural Processes

Many of the stormwater problems of the Cooks River are a result of large scale removal and modification of the natural processes of the water cycle. Valuable features such as wetlands, floodplains, mudflats, mangrove forests, riparian vegetation, and natural drainage lines have been removed from the majority of the catchment. Many options proposed in this Stormwater Management Plan aim to restore these natural features.

Use of Native Vegetation in the Management of Weeds

Weeds and the existing weed management techniques are identified stormwater management issues for the Cooks River catchment. Weeds occur along waterways, in concrete stormwater channels and along stormwater verges. Weeds out-compete native vegetation communities, reduce habitat for native animals, and may block stormwater flows. The control of weeds can require high maintenance, considerable cost, and spraying stormwater channels with herbicides contributes to stormwater pollution. Current weed management practices within areas of the catchment which contribute to water quality and quantity problems include:

- slashing and mowing weeds and leaving them to enter stormwater drains;
- spraying weeds in concrete stormwater canals with herbicides/weedicide which then flow immediately into the waterways; and
- lack of control such that weeds choke creek lines and cause upstream flooding.

Some innovative weed management techniques have been trialed within the Cooks River Catchment. These include the use of boiling water rather than herbicide to spray weeds.

This technique has proven effective, but costly, as weeds need to be treated more regularly. In addition, there are some concerns regarding the impacts of high temperature water on the waterways.

A more successful trial has investigated the management of weeds through revegetation of stormwater verges with native species. Revegetation trials have been conducted by the Environmental Unit of Sydney Water in four sites within the Cooks River catchment (Durham, 1997). The trials involved the hand weeding and planting of stormwater verges with different combinations of native plants and maintained them, initially for three months. All plants were found to establish well and, after an initial maintenance period, the natives prevented the weed species from growing. *Figure 10* illustrates the success of the program in managing weeds and at the same time recreating a more natural riparian zone to filter stormwater run-off.

The average cost for revegetating with native plants was $22 per metre and $1.20 per metre for maintenance once the plant become established (Durham, 1997). It was found that the larger the site the more cost effective the option, with costs predicted to be as low as $10 per metre for installation and 50 cents per metre for maintenance (Durham, 1997). It was also noted that the types of native plants used on a site must be chosen carefully taking into consideration the soil and sun conditions as well as the type of environment, that is, urban street-scape or bushland. A native species vegetation list for the Cooks River Catchment is provided in *Appendix E*.

The trial concludes that sufficient experience has been gained with native planting's to demonstrate that it is a feasible, attractive, low maintenance alternative to spraying with herbicide (Durham, 1997). Due to the success of these trials this approach to weed control has been identified as an action in the Stormwater Management Plan (refer *Table 7.1*).

Figure 10 Results of Sydney Water Stormwater Revegetation Trials (Source: Durham, 1997)

Marrickville Valley Stormwater Channel
Native plants following installation in December 1995

The same site in January 1997.
The *Lomandra longifolia* and Pigface (*Carpobrotus glaucescens*) are thriving.

River Bank Stabilisation and Rehabilitation

There are a number of best management practices which can be utilised for the stabilisation and rehabilitation of stream banks. Most of the waterways within the Cooks River catchment have been lined either with concrete, stone walls, or sheet piling. Many of these artificial banks are reaching the stage where they require maintenance, particularly the steel piling in the lower section of the Cooks River. This represents an opportunity to rehabilitate the banks with a more natural stream profile where possible, providing the flooding consideration are met. The restoration of natural stream banks addresses key stormwater issues and may result in:

- improvement in water quality as natural vegetation filters some pollutants;
- reduction in sedimentation and erosion as riparian vegetation limits soil loss from stream banks;
- improvement of aquatic and riparian habitat for native species;
- provision of bank stability as root systems can reinforce the soil and thus add substantially to its strength to minimise the potential for bank collapse;
- creation of more visually pleasing waterway and green corridor; and
- reduction of stream velocity in some circumstances where vegetation growth can be used to slow the flow of water in a creek and thereby reduce the potential for scour.

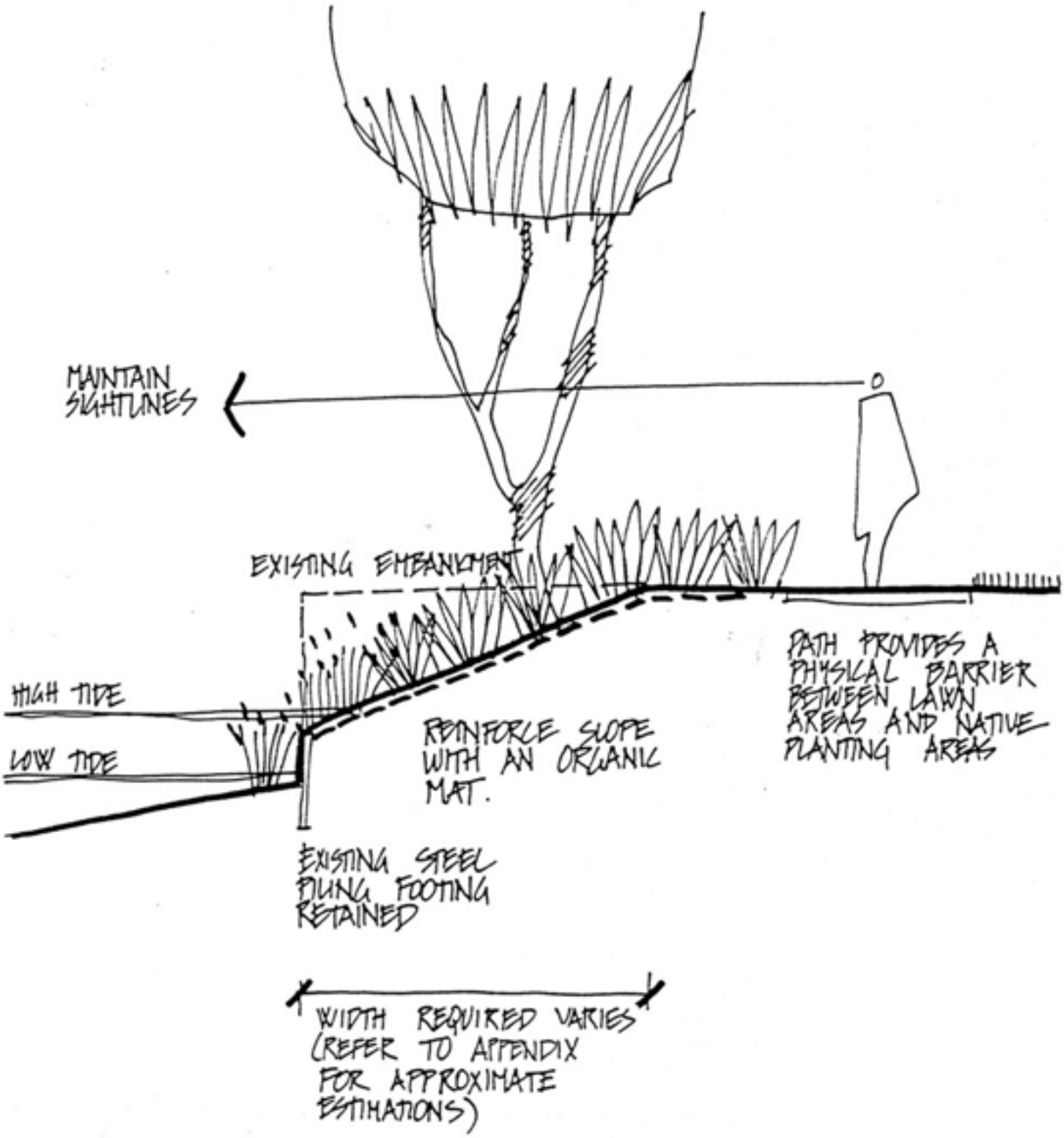
There are a number of hot spot locations along the Cooks River where the banks require urgent stabilisation works. It is most effective to undertake such works in a comprehensive manner rather than addressing small isolated sections. River banks affected by erosion and requiring urgent stream stabilisation works occur mostly along the section of the Cooks 0River where the channel is sheet pile lined (refer to *Figure 8*). Key hot spot areas include the Upper Cooks River at Freshwater Park, Cox's Creek Reserve and Bardwell Creek. The proposed profile for the replacement of steel banks has been illustrated in the Cooks River Foreshore Strategic Plan as illustrated in *Figure 11*. Trial stabilisation planting's using this approach have been successfully undertaken by Marrickville Council between Warren Park and Steele Park along the Cooks River.

The responsibilities for undertaking such works need to be further investigated as ownership and management of these banks is uncertain. The original steel piling works were undertaken by the Department of Public Works and are currently the responsibility of the Department of Land and Water Conservation.

Dechannelisation

Structured watercourses may be dechannelised to enhance the aesthetics of the bank areas and surrounding habitats. Essentially this involves removing the structured element of the channel (that is, concrete pipe or drain) and replacing with natural vegetation, rock, and gently graded banks, to resemble a more natural waterway. Although it is favourable to remove existing concrete lined sections in the tributaries of the Cooks River, the opportunity for dechannelising will be determined by a number of key constraints including:

Figure 11 **Alternative Bank Rehabilitation Profile to Replace Eroding Steel Piling (Source: Cloustans, 1997)**



ALTERNATIVE FOR ERODING STEEL EMBANKMENTS

Where open space widths allow for embankment reconstruction, the benefits are a long term secure embankment, an opportunity for a native vegetation planting, while maintaining sight lines

- the availability of space;
- adjacent land uses and land ownership;
- impacts on flooding and channel hydraulics;
- impact on bank stability; and
- impacts on safety.

Options to enhance the character of the waterways through dechannelisation have been identified in *Figure 16*. Further investigation is required to determine the feasibility of these option. *Figure 12* illustrates the dechannelisation of a concrete drain.

Where space is limited, and flooding is a problem, one alternative is to recreate a natural channel to carry normal flows and pipe flood flows underneath the natural channel. Sydney Water are currently undertaking a feasibility study and concept design for such dechannelisation works in Sheas Creek. The draft concept plan involves a box culvert with gross pollutant trap to convey flood flows, overlain by a macrophyte bed to filter nutrients from normal flows.

Mangrove Management

Mangroves have been successfully re-established in sections of Muddy Creek and are recolonising in other areas of the Cooks River. Mangroves assist in stormwater quality management and are an important habitat for aquatic and intertidal species. Because of the highly altered nature of the river, mangroves re-establishing on recently sedimented sections of the river can cause flooding problems. In addition, mangroves may invade remnant saltmarsh areas. This is occurring at both the Eve Street and Firmstone Gardens wetlands resulting in reduced bird habitat values.

It has been suggested that a Mangrove Management Plan be prepared on a catchment basis for the Cooks River to identify suitable areas for mangrove re-establishment and areas where mangroves are to be controlled. The Plan would be prepared in accordance with the NSW Rivers and Estuary Policy, the Fisheries Management Act and Fish Habitat Protection Plan (No. 1). The Department of Fisheries has supported the preparation of such a catchment wide Mangrove Management Plan.

7.2.2 Source Control

Stormwater quality is potentially influenced by all the land uses and activities undertaken in the catchment. Most of the stormwater management options aim to ensure that each one of those activities is carried out in such a way that the impacts on water quality are controlled at the source. Source control options identified for the Cooks River include a range of education, operational, planning, and management actions as well as' at the source' water quality treatment.

Source control is often the most cost-effective way to manage stormwater. Once the pollution enters the waterway it is far more difficult and costly to treat and mitigate the environmental impacts (NSW Environment Protection Authority, 1998). Most of

Figure 12 **Recent Dechannelisation of a Concrete Lined Drain through Parkland. Works undertaken by Landcom in 1998.**

the options proposed in this Stormwater Management Plan are considered source control options.

Education Programs

Community education is a process used to create awareness of issues, enhance people's knowledge, understanding and skills. Education programs relating to stormwater management aim to influence people's values and attitudes and encourage more responsible behaviour. Education programs can be an effective and powerful tool in preventing pollution of stormwater at the source.

A number of education program have been, or are currently being undertaken in the Cooks River Catchment by various Councils, State authorities, community and environment groups. Some examples of these education programs include:

- *The Drain is Just for Rain*, a comprehensive campaign being conducted by the NSW Environment Protection Authority;
- *Gutters and Garbage Night*, a campaign by Cooks River Valley Association encouraging other residents to clean the leaves out of the gutter and stormwater drain every time you put the garbage out;
- *Solutions to Pollution*, an initiative being trialed in various industries by Councils around NSW;
- *Streets to River Program*, linking the activities of residents in their backyard to impacts on the health of the river; and
- *Stream Watch Program*, a water quality sampling program undertaken by school children.

There are also various information guides available in relation to setting up and carrying out an education program such as, "What we need is - A Community Education Project!" produced by the NSW Environment Protection Authority, to assist Councils in establishing education programs to address environmental issues such as stormwater. The guide is currently available in all Council libraries. The NSW Environment Protection Authority also currently has a stormwater education officer as part of their Education Unit who can assist in the development of stormwater education programs.

Case Study - Streets to Rivers Project

A pilot education program aimed at increasing awareness of the "Cooks River as a natural waterway under stress", is currently being carried out by Marrickville and Canterbury Councils. The program is being implemented in conjunction with the installation of two gross pollutant traps which illustrate ways to reduce the stress on the river.

The results of this pilot program will be used to develop a comprehensive stormwater education package. The program targeted residents, shop owners, school children, builders and contractors, council staff and multicultural groups.

Some of the strategies used in the education program included:

- visiting schools and discussing the project with children, conducting street cleaning excursions, and promoting a launch with school students and the local mayor;
- training volunteers from Sydney University, interested residents, Australian Trust Volunteers, and Green core, in simple stormwater management techniques. Six street parties were held, which included displays, barb-b-ques and even a mural painting. The trained volunteers discussed stormwater issues with residents and distributed information in the form of flyers on preventing pollution of stormwater, stickers and carwash vouchers;
- trained volunteers visited shop owners in local communities and talked with them about preventing pollution of stormwater, waste disposal and self auditing;
- council staff, including street sweepers and cleaners were educated in best practice stormwater practices;
- education officers visited building sites in the catchment to discuss improvement in stormwater management practices with builders and contractors; and
- a team of multilingual volunteers are currently being trained and will also participate in street parties and education of shop owners.

A number of education programs have been suggested as actions in the stormwater management plan (refer *Table 7.1*)

Best Practice in Litter Management

Litter in waterways poses a threat to aquatic ecosystems, human health and is visually unattractive. Providing bins in public places such as parks, shopping centres and on footpaths seems an obvious way to reduce the amount of litter that finds it way into waterways and stormwater channels. People are able to conveniently dispose of takeaway containers, newspapers, drink cans and other wastes in a receptacle rather than drop the rubbish on the ground.

There have been arguments put forward, however, that providing bins can actually lead to more litter as a result of the following:

- animals such as birds, dogs and feral cats disturbing the bins and dispersing the rubbish;
- high winds, blowing litter directly into waterways;
- public bins being used by resident who have filled their personal bins and therefore bins overflowing before being emptied;
- inadequate or untimely waste management service resulting in overflow of bins; and
- recycling bins which allow bottles and paper to blow out or overflow onto the street.

North Sydney Council has removed all bins from public places based on these arguments and considers the litter problem to be improved. Many of the problems proposed above can be prevented if, for example, the bins are provided with lids,

emptied and cleaned regularly, clearly labelled and otherwise well managed. Public Place Waste Management Guidelines are currently being prepared by the NSW Regional Waste Planning and Management Boards to assist local Councils and other public authorities to implement effective public place waste management systems and encourage the provision of recycling facilities. Due to the success of these trials in some local council areas, it has been suggested a trial be carried out of the various approaches to determine the best solution for the Cooks River Catchment.

Street Sweeping

Most Councils within the Cooks River already undertaken an extensive street sweeping program. Dry street sweeping removes litter and sediments (which toxicates land) from roadways in commercial and residential areas. Street sweeping is a relatively costly stormwater management action, however, street sweeping is undertaken to address a number of additional Council responsibilities such as maintaining the visual amenity of business centres and suburban areas as well as being public health and safety measures.

For this reason, it si a management action that Councils consider is required, even though it appears expensive as a stormwater management option.

Education/Training and Auditing of Industry

Auditing of industry and commercial activities in relation to stormwater management is an effective enforcement and regulation tool as well as an education tool. Auditing of an industrial or commercial premises will enable detection of illegal stormwater connections, illegal discharges to stormwater, potential discharges from material not properly contained, for example, oils drum not contained in a bunded area, poor practices such as sweeping materials into gutters etc. Regular audits are currently carried out by (which councils) of premises which they are responsible for regulation of under the *Clean Waters Act*, *Clean Air Act* and *Noise Control Act* as well as commercial premises.

An example of an effective audit program which focused on education, training, review and, as a last resort, enforcement was recently carried out in the Alexandra Canal Catchment. The project funded through the NSW Environment Protection Authority involved auditing of all industrial and commercial premises in the Alexandra Canal catchment.

The program was 100 percent successful with all industry complying with guideline within a six month period. Options to continue such a program in other areas of the catchment are included in the Stormwater Management Plan.

Non-Polluting Alternatives

Many polluting practices can be prevented with the implementation of alternative methods which do not impact on stormwater quality or quantity. A number of innovative source controls are currently being trialed throughout the Cooks River Catchment.

Fertilisers applied to sports grounds, parks, golf courses, and used in commercial nurseries are a source of nutrients in stormwater run-off. Worms are being trialed by

Marrickville Council as a replacement for fertiliser on Steele Park Oval. To compare results, both worm casting and fertiliser techniques have been used on half of the oval and a visual assessment is being recorded.

Another natural alternative being trialed is the use of Dung Beetles to process pet droppings. Strathfield Council is currently trialing this innovative strategy in its public parklands and Randwick Council has successfully trial this strategy.

Stormwater Filtration Systems

Several methods are available to treat stormwater by filtration prior to discharge to the municipal system, including:

- sand filters - collected run-off passes through coarse graded sand media before discharging into the drainage system; and
- drainage cells - plastic drainage cells surrounded in a geotextile and buried within an amended media that filters run-off. Removes both dissolved and suspended pollutants.

Opportunities for installation of such filtration systems at minor stormwater pipe discharge points are recommended for further investigation in the Stormwater Management Plan.

Landfill Remediation

There are a number of landfill sites within the catchment, as shown in *Figure 8*. These typically consist of original drainage gullies and riverside areas that have been infilled over the last 90 years or so with domestic and (at times) industrial waste. These areas are a potential pollutant source due to ongoing migration of pollutants to the stormwater and drainage system in leachate.

Control and treatment measures include systems for recycling of leachate and treatment of leachate by bio-remediation. Further investigation into suspected sites where leachate generation is a potential problem is recommended.

7.2.3 Structural “End of Pipe” Options

Structural options for stormwater management generally involve high capital costs for installation. In addition, as these structural solutions tend to ‘clean up’ rather than prevent the problem there will always be ongoing maintenance costs.

The capital costs can be prohibitively high, and in addition there are ongoing maintenance costs to the community, local Government and Sydney Water Corporation. Therefore, in identifying structural options for the Cooks River, the following criteria have been applied to identify areas where structural options would be most appropriate:

- hotspot areas - these are areas that are presently very degraded and require treatment and improvement within a time scale which cannot quickly be met by non-structural options;

- areas of high ecological value - including existing areas of high ecological significance which require environmental safeguarding, and degraded areas of ecological significance which are in need of enhancement or improvement;
- areas of high community value - including existing and potential areas of high community use such as public recreation areas;
- public health and safety - areas where public health and safety is at risk, or is in danger of becoming so;
- effectiveness - that a structural facility would result in tangible and measurable improvements in stormwater quality;
- flow conditions - the location needs to be suitable in terms of water levels, tidal variations and flooding conditions;
- land constraints - particularly land requirements and topography which allows the development of a facility without considerable land resumption or other disturbance;
- adjacent land uses and available access areas for continued operations and site maintenance; and
- aesthetics - the siting of a facility should not result in a degradation of the aesthetics of the area.

The following discussion briefly outlines the merits and issues for some of the structural strategies most applicable to the constraints of the Cooks River catchment.

Trapped Street Gully Pits

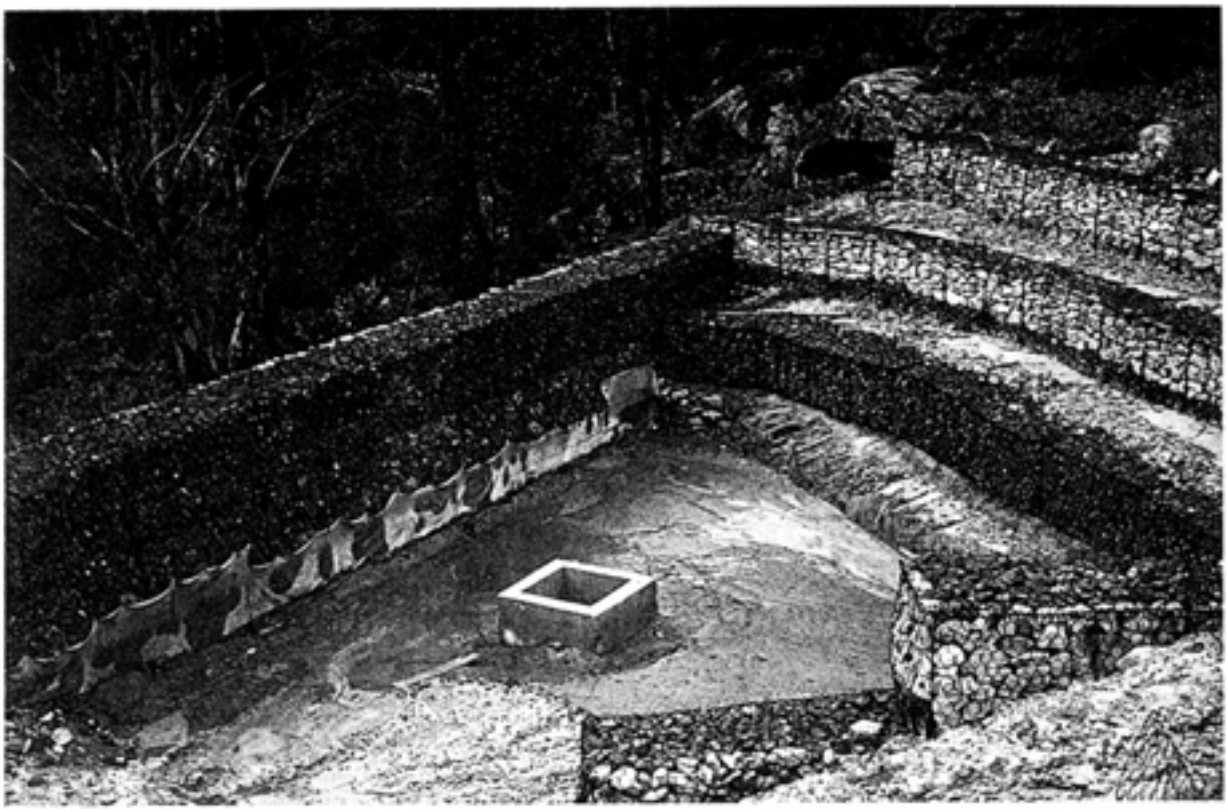
These are modified pits with baffles used to retain sediments and floating material from road run-off. Baffle plates fitted in the drainage pits are used to facilitate the settlement of heavy sediments and the containment of floating debris (including litter, grease and oil) inside the pit. There are some 26,000 pits in the stormwater system of the Cooks River Catchment. The effectiveness of the pits has been demonstrated by South Sydney Council, who notes that their effectiveness is dependent on regular maintenance.

Trapped street gully pits have been recommended for installation at appropriate hot spot locations along roadways (refer Litter Hot Spot Actions in *Table 7)*. The costs associated with installing (and ongoing maintaining and cleaning) are substantial. For that reason it is recommended that a pit would only be modified to include traps at hot spot locations or at the last pit before discharge to waterways.

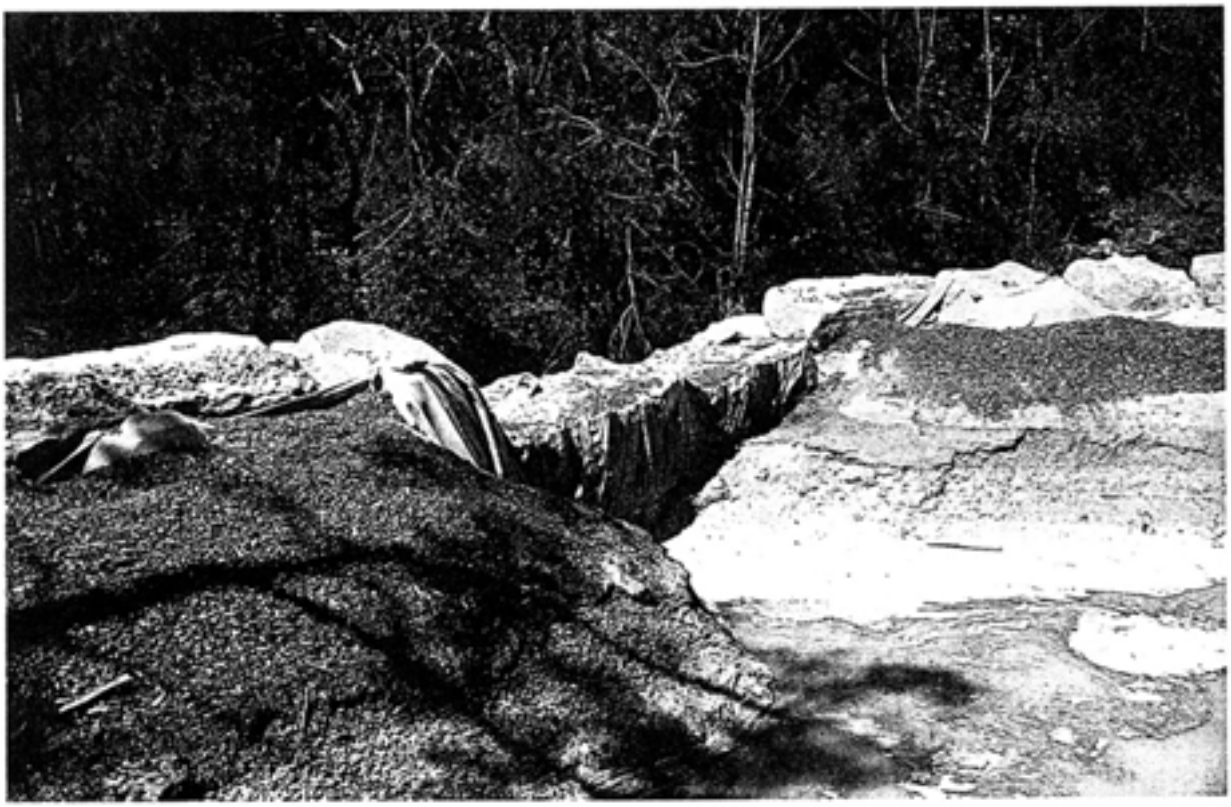
Detention Basins

Where space is available detention basins might be constructed to temporarily hold the floodwaters and release them at a rate no greater than the downstream system capacity, see *Figure 13*. Detention basins for small urban catchments are best located near the top of the catchments. Level open space areas suitable for construction of a detention basin (for example, within public reserves) are very limited in developed areas. When siting detention basins on public reserves, consideration should be

Figure 13 **Sediment Retention Basins**
(Source: Managing Urban Stormwater, 3rd edition 1998, Landcom and Housing)



A sediment retention basin constructed on Type C soils with gabion baskets in very steep country. The structure has recently been converted to a constructed wetland.



A sediment retention basin constructed on Type C soils from local sandstone gibbers

given to incorporating existing uses of the reserve, and in maintaining aesthetics, and existing vegetation wherever possible.

The development of detention basins in parkland area such as Hughes Park along Cup and Saucer Creek requires detailed investigation. There may be potential for detention basins to be developed on lands planned for redevelopment although this has not been identified in this plan.

On-Site Detention

On-site detention is a method of reducing peak stormwater flowrates through temporary storage in basins or tanks within a development (residential lot, block of units, etc). On-site detention also has a subsidiary (and generally unquantifiable) benefit in reducing sediment and nutrient transport from a development to the municipal stormwater system. The benefits of on-site detention depend heavily on appropriate maintenance of the system by the landowners. On-site detention policies are in effect with most of the Councils in the Cooks River catchment.

Sediment Traps and Gross Pollutant Traps

A sedimentation trap is typically installed to prevent coarse sediments from being conveyed to receiving waters, which would lead to siltation problems and increases in nutrients. A trap is generally designed to remove approximately 75 percent of medium silt and coarser fractions of sediment. This is achieved by reducing inflow velocities to allow differential settling of the particles to occur. Regular maintenance of the trap is required to remove the build-up of sediments. In general, a minimum of three months depositional volume should be provided.

The incorporation of a trash rack with the sediment trap constitutes what is known as a Gross Pollutant Trap, see *Figure 14*. The additional function of this facility is to remove trash and debris from the stormwater flow. These types of structures are used near the outlet of an urban drainage system, upstream of a watercourse, water body or wetland.

The major function of the gross pollutant trap is to protect the aesthetic and environmental quality of downstream water bodies or wetlands by limiting the rate of sedimentation and intercepting trash and debris. This ensures protection of macrophyte and bird habitats and maintains the visual quality of downstream areas.

As detailed in the issues report there are a number of existing gross pollutant trap's installed within the Cooks River system. These traps catch enormous volumes of litter and have significant ongoing maintenance costs. The five traps managed by Sydney Water captured just under 1000 cubic metres of litter and cost over $330,000 to maintain per year (Sydney Water, 1998).

The use of sediment traps has been recommended for further investigation at industrial sites such as Chullora Railway Workshops and Enfield Marshalling Yards. Gross pollutant traps have been identified as an option at a number of locations in the upper catchments (Bardwell Creek, Upper Cooks River) and would require further investigation particularly in terms of their effects on mainstream flooding, land requirements and available access to the site. There is limited scope for the development of gross pollutant traps in the tidally affected portions of the creeks.

Figure 14 **Gross Pollutant Trap**
(Source: Pollution Control Manual for Urban Stormwater, State Pollution Control Commission)

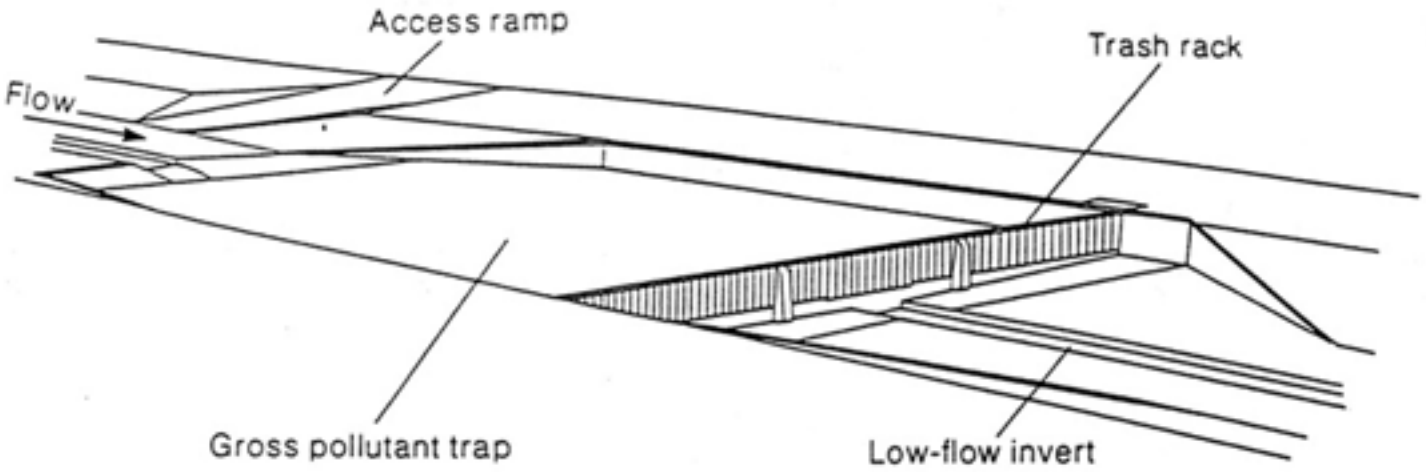
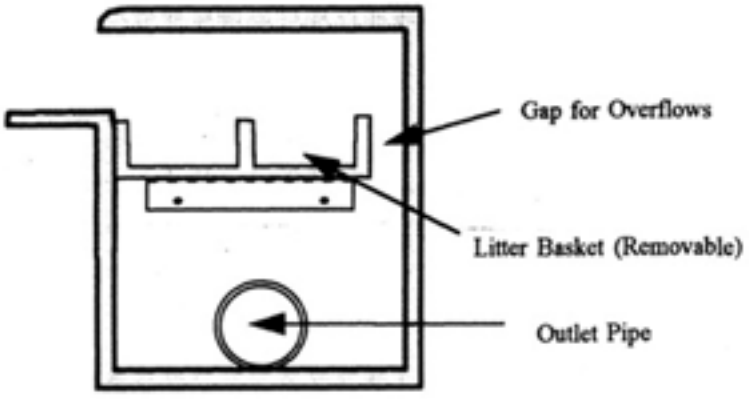


Figure 15 **Litter Basket**
(Source: Managing Urban Stormwater, Treatment Techniques, NSW Environment Protection Authority)



Schematic of a Litter Basket

Other Litter Control Devices

There are a number of alternative devices available to control litter and debris depending on the situation. These include:

- litter baskets - a wire or plastic basket installed in a stormwater pit to collect rubbish either directly entering the system from road surfaces, or from within the upstream piped drainage system, see Figure 15;
- litter booms and nets - these are floating booms with mesh skirts placed across a waterway (channels or creeks) to collect floating and partially submerged (waterlogged) trash and debris;
- minor gross pollutant interceptors/traps - end of line treatment comprising collection bags or nets which require regular replacement; and
- proprietary devices designed to separate coarse sediments, trash, debris, and some sediments within the stormwater drainage system. These include such devices as the Continuous Deflective Separator units (CDS), Downstream Defender and In Line Litter Separator.

A coarse log trash structure is recommended for investigation along Bardwell Creek, whereas trash racks are considered as part of gross pollutant traps as previously discussed.

Litter baskets are recommended at several locations and would require a high degree of maintenance to be effective.

Litter booms were not generally recommended, as appropriate locations for their installation was limited. The booms tend not to be effective along the tidally affected sections of the river and creeks as litter washes back upstream with the change in tides. There are insufficient flows to support the use of these structures in the upper reaches of the waterways. Litter booms also require a high degree of maintenance and are susceptible to vandalism.

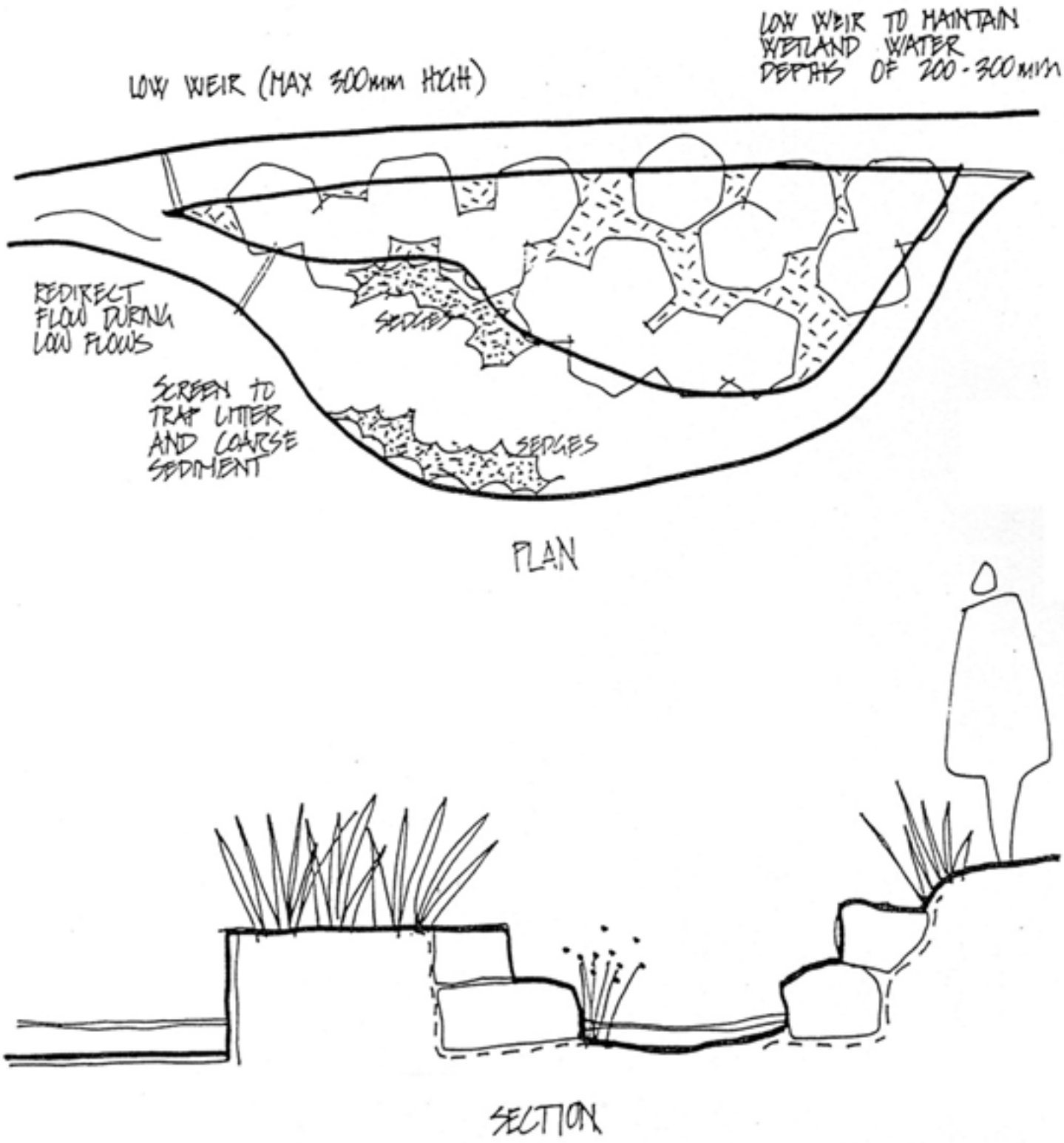
Minor gross pollutant interceptors/traps and proprietary devices are recommended at the end of several drainage lines. Further investigation is required particularly on the impact of the device on the aesthetics of the area and the level of maintenance required for these structures.

Constructed Wetlands

Constructed or artificial wetlands have been used for some years for treatment of sewage effluent, and are now also being adopted for stormwater quality improvement, see *Figure 16*. The main purpose of these wetlands is to encourage settlement of suspended sediment particles including organic and mineral solids, and to reduce nutrient concentrations. Approximately 10 percent of nutrients are removed through plant (macrophyte) uptake, nitrogen is released to the atmosphere by bacteria (microfilm) on plant surfaces and phosphorus typically attached to sediments is settled out.

Additional benefits include improving the aesthetic and recreational quality of the area and providing faunal habitat. Providing a gross pollutant trap upstream of a

Figure 16 Typical Linear Wetland
(Source: Cloustans, 1997)



It should be noted that the area of constructed wetland technology is one requiring input by professionals with expertise in wetland ecology and hydrology. Artificial wetlands usually have a relatively short life-span of 5-10 years before major reconstruction is required. They can also become a source of weed infestation if not carefully managed.

TYPICAL LINEAR WETLAND CONSTRUCTION

wetland reduces the load of coarse sediments and trash introduced into the wetland, thereby preserving the aesthetics of the wetland and reducing the maintenance requirements.

Wetlands are recommended for investigation at several areas including along Cup and Saucer Creek, Cox's Creek at Cox's Creek Reserve, Greenacre Park SWS, Muddy Creek, Upper Cooks and Omaha Canal. Some areas have existing remnant vegetation or are situated within or along side parkland which have the potential for incorporation into a wetland area.

It should be noted that to attain adequate stormwater quality improvements, wetlands have large land area requirements (typically between 0.5 percent and 2.0 percent of the upstream catchment). In a fully developed catchment such as the Cooks River, available space is very limited, and it is unlikely that the optimal amount of space would be available. The benefits of a wetland need to be carefully evaluated at the investigation stage, taking account not only of the water quality improvements, but also the associated environmental, recreational and aesthetic values.

A number of locations have been identified for installation of offline wetlands which run parallel to the river channel.

7.3 Evaluation of Options

All the options proposed for management of stormwater in the Cooks River Catchment (*Appendix G*, *Table 7.1)* have been assessed on the basis of their costs and benefits. The methodology developed by the NSW Environment Protection Authority (1997) has been adopted with minor changes to assess the identified management options. This methodology provides a management tool to enable the prioritisation of solutions to stormwater problems. This simplistic and somewhat objective methodology has a number of limitations. However, the basis for evaluation of each option is transparent and judgement may be used in the interpretation of the results.

Each of the columns in *Table 7.1* is described below along with details of the methodology used to evaluate and rank the options. The location of the structural options presented in *Table 7.1* are indicated on *Figure 17* according to the Option number.

Options

The first four columns in *Table 7.1* provide information on the option as follows:

OPTION NO. : This is the management option number assigned for ease of reference.

WATERWAY: This column indicates the sub-catchment the action is targeting. Refer to *Figure 5* for sub-catchment boundaries.

ALL- the whole catchment
UP - Upper Cooks River sub-catchment
CO - Middle Cooks River sub-catchment

LC - Lower Cooks River sub-catchment
AC - Alexandra Canal and Sheas Creek sub-catchment
MA - Underground piper system in Marrickville area
MC - Muddy Creek sub-catchment
BC - Bardwell Creek sub-catchment
WC - Wolli Creek sub-catchment
CS - Cup and Saucer Creek sub-catchment
CX - Coxs Creek sub-catchment

AUTHORITY: This column indicates the responsible agent for co-ordinating the implementation of the action. Many actions are most successful if all stormwater managers work together.

ALL- C - All Councils to implement as a co-co-ordinated effort
ALL - All stormwater managers to implement in their areas
ASH - Ashfield Council
AUB - Auburn Council
BANK - Bankstown City Council
BOT - Botany Bay City Council
BUR - Burwood Council
CANT - Canterbury City Council
HUR - Hurstville City Council
KOG - Kogarah Council
MAR - Marrickville Council
RAN - Randwick Council
ROC - Rockdale City Council
SSC - South Sydney Council
STRA - Strathfield Council
RTA - Roads and Traffic Authority
Rail - All Rail Authorities including SRA, NRS, RAC, FC
EPA - Environment Protection Authority
EDDept- Education Department
FISH - Department of Fisheries
GA - Greening Australia
SWC - Sydney Water Corporation
CRCMC- Cooks River Catchment Management Committee
WA - Waterways Authority

STRATEGY TYPE: The options have been categorised into:

ED - Education
MAN - Management
ST - Structural
AU - Auditing / Enforcement

DESCRIPTION: Describes the option.

Costs

In this cost benefit evaluation of options, costs are determined as follows:

INSTALLATION: The estimated initial cost involved to implement the option. Includes feasibility studies and structural costs. See *Table 7.2* for relative weightings.

MAINTENANCE: The estimated cost for ongoing maintenance over a 10 year period. It was decided by stormwater managers to use a period of 10 years as it is envisaged that most of these options, and in particular the structural options will be carried out for a long period of time. Therefore over 10 years the cost of installation will be more fairly balanced against the maintenance cost. See *Table 7.2* for relative weightings.

Table7.2: Costs - Installation and Maintenance/Operating

Cost	Weighting
less than $50,000	1
$50,001 - $100,000	2
$100,001 - $200, 000	3
$200,001 - $400,000	4
$400,001 - $600,000	5
$600,001 - $800,000	6
$800,001 - $1,000,000	7
$1,000,001 - $5,000,000	8
$5,000,001 - $10,000,000	9
$10,000,001 +	10

NOTE: If all councils are to implement as a co-ordinated effort (ALL-C), costs identified are total approximate cost for implementing the option. Councils will need to negotiate proportional payments.

Where an action requires investigation only, no ongoing maintenance cost is required. Also, where options require a Council Officer's time to implement, costs are estimated using a guide of $1000/week/officer.

COST INDEX: Is the combined total of the capital and maintenance cost. An index of 10 indicates the highest cost options and an index of one indicated the lowest cost option. It should be noted that this is a relative, not a definite index.

The capital and maintenance costs used to rank and assess the structural options have been selected from a range of source material which includes:

- Stormwater Management Plans previously developed by the consultant team;
- The Cooks River Foreshores Strategic Plan;
- discussions with Council and Sydney Water Corporation personnel;
- supply costs provided by manufacturers of proprietary systems; and
- construction costs for stormwater facilities designed by the consultant team.

The costs shown are indicative of the type of facility indicated, and reflect to some degree the size or complexity of a facility placed in the location shown. However, these costs are very approximate, and are used solely for the purposes of comparative ranking of the options. The cost for any particular option will need to be refined and confirmed by further, more detailed, investigation.

Benefits

The benefits of each option have been assessed based on the following considerations:

TARGET POLLS: The pollutant most likely to be affected by implementation of the management option. See *Table 7.3* for weightings of the relative harm of each target pollutant. In this context relative harm refers to potential environmental impact.

Table 7.3: Target Pollutants and their Relative Harm (NSW Environment Protection Authority, 1998)

Target Pollutant	Relative Harm
Litter	2
Nutrients	4
Sediments	4
Weeds	5
Bacteria	5
Oil & Grease	6
Organic Matter	7
Heavy Metals	7
Toxins	8

NO. POLLUTANTS: The number of pollutants which are likely to be captured/affected by the management option.

REL IMPACT: Based on the existing water in the Cooks River Catchment, stormwater managers allocated relative weightings to each pollutant. This allows for catchment specific weighting of stormwater pollutants. See *Table 7.4* for relative weightings.

Table 7.4: Relative Level of Pollutants for the Cooks River Catchment

Impact	Weighting
Litter	6
Nutrients	5
Sediments	5
Weeds	5
Bacteria	5
Oil & Grease	6

Organic Matter	7
Heavy Metals	7
Toxins	8

AREA: The area of the catchment that the management option potentially benefits - described in hectares. See *Table 7.5* for relative weightings.

Table 7.5: Area - Proportion of Catchment the Management Option Potentially Benefits

Hectares	Area percent	Weighting
0 – 1000	0 - 10 %	1
1001 – 2000	11 - 20 %	2
2001-3000	21 - 30 %	3
3001-4000	32 - 40 %	4
4001- 5000	41 - 50 %	5
5001-6000	51 - 60 %	6
6001-7000	61 - 70 %	7
7001-8000	71 - 80 %	8
8001-9000	81 - 90 %	9
9001-10000	91 - 100 %	10

EFFECTIVENESS: The effectiveness of the option in managing the pollutant. See *Table 7.6* for relative weightings.

Table 7.6: Effectiveness - The Effectiveness of the Option in Managing the Pollutant

Effectiveness	Weighting
Low	1
Med-low	3
Medium	5
High-med	7
High	10

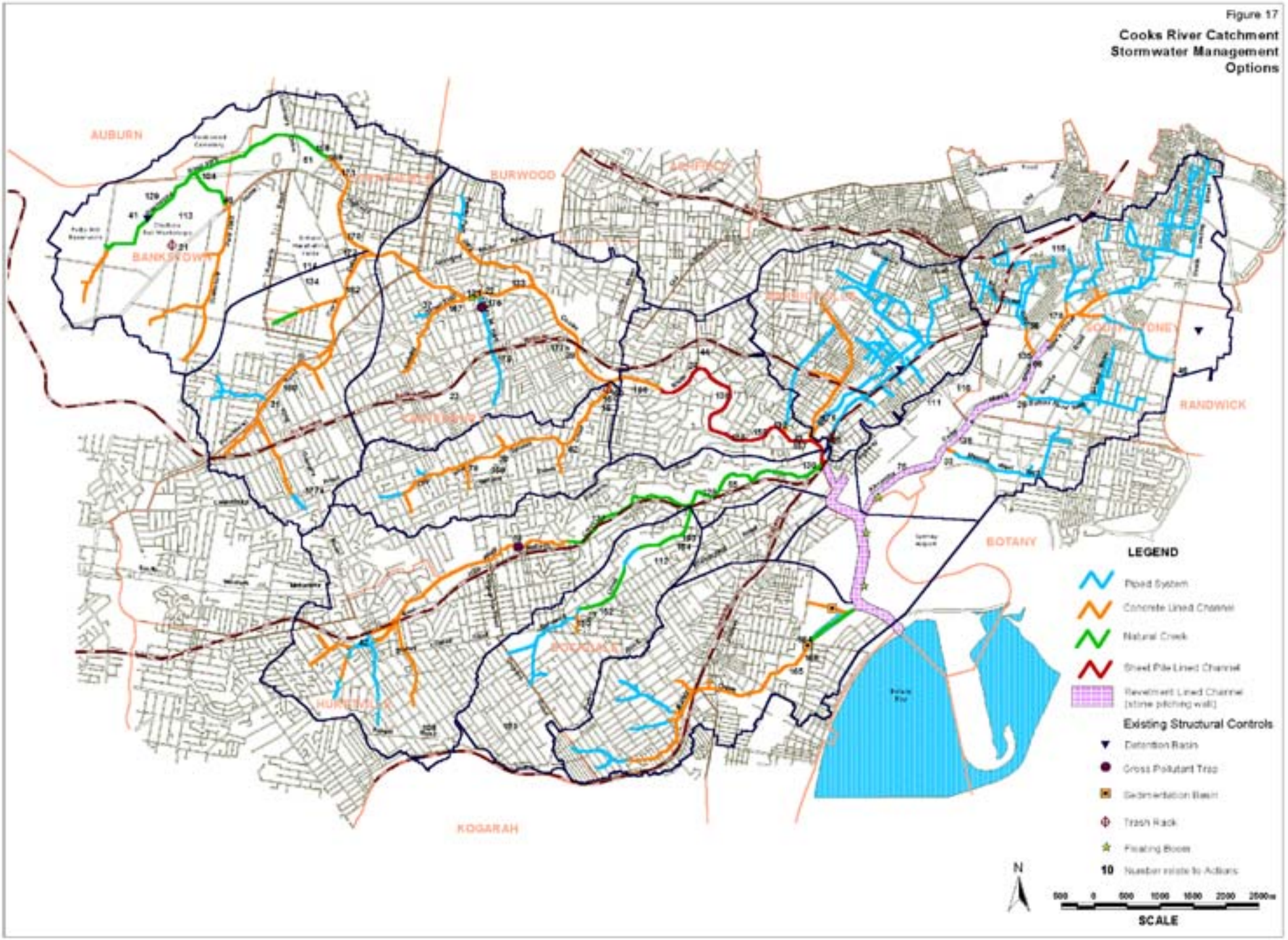
EDUCATION: The level of education awareness, and consequently enhanced source control, the option will provide to the community. See *Table 7.7* for relative weightings.

Table 7.7: Education - The Level of Education Awareness the Option will Provide to the Community

Effectiveness	Weighting
Low	1
Med-low	3
Medium	5
High-med	7

Figure 17

Cooks River Catchment Stormwater Management Options



High	10

BENEFIT INDEX: The sum of the benefits divided by six. Note each benefit column has been assigned a number between one and 10, 10 being the most desirable outcome and one being the least desirable benefit.

Ranking of Options

Finally each option is ranked according to its cost- benefit which is calculated as follows:

COST/BENEFIT: The cost benefit ratio is calculated by dividing the cost index by the benefit index. The lower the number the more desirable the option. that is, one is the best and ten is the worst.

Cost Benefit score	=	Cost Index	/	Benefit Index
(the smaller the number the "better" the option)		(the lower the number the cheaper)		(the higher the no. the better)

RANK: The overall rank of the option, one being the most favourable ranking.

7.4 Current Stormwater Management Practice

There are many stormwater managers within the Cooks River catchment who can influence the quality of stormwater through internal operations, management and planning controls. As part of the Stormwater Management Planning process, the Environment Protection Authority has requested that Councils review their internal activities and ensure they are setting an example to the community (NSW Environment Protection Authority, 1998). The existing stormwater management actions undertaken by Councils and key stormwater managers within the Cooks River catchment are summarised in *Table 7.8.*

One option put forward in the Stormwater Management Plan aims for consistency in stormwater policy across the entire catchment. This is an important action which involves setting criteria and guidelines for stormwater management to be increased by all Councils in their Planning Controls and Management Plans. The generic Stormwater Policy would standardise sedimentation controls, development requirements, revegetation policies, contractor performance criteria, industry standards and other actions relevant to best practice stormwater management policy and procedure for the catchment. This exercise would draw on existing policies and management plans implemented by Councils throughout the catchment and produce a powerful management tool. In other catchments, such a stormwater management policy has been incorporated within a Regional Environmental Plan. This is one option for incorporating guidelines within the planning framework. An alternative is for all Councils to incorporate the Policy within their Local Environmental Plans. The second method is more readily implementable in the short term.

Councils currently have limited powers to prevent, prosecute or order the clean-up of pollution of waters under existing legislation such as the *Clean Waters Act 1970*, *Pollution Control Act 1970* and *Environmental Offences and Penalties Act 1989*. However, with the introduction of the *Protection of the Environment and Operations Act*, to replace the above Acts, Councils will receive much stronger regulatory powers very similar to those currently held by the NSW Environment Protection Authority, excepting control of scheduled activities regulated by the NSW Environment Protection Authority. Notable key powers relate to clean up and prevention notices, on-the-spot fines, powers of entry and obtaining information and legal action. These increased powers under the new legislation are detailed in *Appendix F*.

Table 7.8: Existing Stormwater Management Actions

Existing Stormwater Actions	Councils												
	Ashfield	Auburn	Bankstown	Botany	Burwood	Canterbury	Hurstville	Kogarah	Marrickville	Randwick	Rockdale	South Sydney	Strathfield
Internal Management													
Allocation of stormwater management responsibilities and resources (people and funding).	✓	p	P	p	p	p	p	✓	✓	p	P	✓	✓
Internal communication between departments of organisations and with community regarding stormwater issues.	✓	p	P	p	p	p	×	✓	p	p	P	✓	✓
Internal procedures for operations staff and contractors.	✓	p	p	p	p	p	×	✓	p	×	×	p	p
Education and training of employees in stormwater management practices.	p	×	×	p	p	p	p	p	✓	×	p	p	p
Performance monitoring of staff in following stormwater management procedures.	×	×	×	×	p	×	×	p	p	×	×		p
Stormwater Planning Controls													
Stormwater Policy	✓	×	×	p	✓		p	✓	✓	✓	×	✓	✓
Strategic Planning for Stormwater and Catchment	p	×	p	×	p	p	×	✓	p	p	p	p	p
Development Controls	✓	×	p	p	✓	✓	✓	✓	✓	✓	p	✓	p
Building Approvals and Inspection	✓	p	p	p	✓	✓	✓	✓	p	p	p	✓	p
Planning provisions for stormwater management (eg. Shopping centres required to install at source GPT, residential subdivision required OSD):													
• Residential	✓	×	×	×	×	p	p	✓	✓	✓	p	p	✓
• Commercial	✓	×	p	p	×	p	p	p	✓	✓	p	p	✓
• Industrial	✓	×	p	p	×	p	p	p	✓	✓	p	p	✓

Key
- ✓ Action already adequately addressed
- p Action partly undertaken but could be improved
- × Action not undertaken
- n/a Action not applicable

Existing Stormwater Actions	Councils												
	Ashfield	Auburn	Bankstown	Botany	Burwood	Canterbury	Hurstville	Kogarah	Marrickville	Randwick	Rockdale	South Sydney	Strathfield
Stormwater Related Actions/Operations													
Street sweeping.	✓	✓	✓	p	✓	✓	✓	✓	✓	✓	✓	✓	✓
Auditing of illegal stormwater connections.	×	p	p	×	×	×	p	×	✓	×	×	✓	n/a
Regular auditing of industry.	×	×	p	p	×	p	×	✓	✓	p	P	p	p
Community education campaigns:													
• Litter	×	×	p	×	×	p	×	p	✓	×	×	p	p
• Sediment and erosion	×	×	p	×	×	p	×	p	✓	×		✓	p
• Nutrients (fertilisers, carwashing)	×	×	p	×	×	p	×	p	p	p	p	p	p
• Weeds	×	×	×	×	×	p	✓	✓	×	p	×	✓	p
• Toxicants (oils and grease, chemical use)	×	×	×	×	×	p	×	p	p	p	p	✓	p
Provision of GPT's, litter baskets etc	p	p	p	p	×	p	p	✓	p	p	p	p	✓
Weed removal and bush regeneration	✓	p	p	p	n/a	p	✓	n/a	p	n/a	p	✓	✓
Drain Stencilling	×	×	✓	p	p	p		p	p	×	p	✓	✓
Maintenance of stormwater infrastructure (eg. Clean drains and traps)	✓	p	p	p	✓	p	✓	✓	✓	✓	p	✓	✓
Waste management procedures	✓	p	×	p	×	p	×	p	✓	p	p	✓	p
Leachate management and remediation of owned contamination sites	✓	×	p	n/a	n/a		✓	n/a	×	n/a	×	p	p
Other: Promotion of water conservation and reuse									✓				
Monitoring													
Mapping of stormwater infrastructure	✓	×	×	p	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water quality monitoring.	×	p	✓	p	×	×	×	×	×	×	p	✓	p
River health assessment.	×	×	p	×	n/a	n/a	×	n/a	p	n/a	p	p	n/a
Other: Monitoring sediment in gully pits												✓	

Key
- ✓ Action already adequately addressed
- p Action partly undertaken but could be improved
- × Action not undertaken
- n/a Action not applicable