Managing Urban Stormwater: Source Control

Draft

December 1998

NSW Environment Protection Authority

Acknowledgments

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FOREWORD

Urban stormwater management is a complex and challenging issue. There is no single answer to our stormwater management problems and we need to derive innovative approaches using a mix of strategies. The effective management of urban stormwater is also a shared responsibility, requiring the active involvement of many State Government agencies, local councils, the private sector and the community.

The preparation of catchment-based stormwater management plans provides an opportunity to involve all stakeholders in the development of an appropriate and coordinated suite of strategies to address the specific management issues for each catchment. These plans will highlight the significant conceptual shift that has occurred in stormwater management, focusing on issues that affect the health and amenity of our waterways rather than perpetuating the limited and traditional focus on flood mitigation and drainage. Many of the solutions will be found by looking upstream to find ways we can manage a range of day-to-day activities, rather than focusing on managing the impacts downstream.

The NSW Government recognises the need for a whole-of-government approach to stormwater management and for an effective partnership between State and Local Government. As part of this partnership, the Government has committed funding of $60 million over three years to tackle stormwater pollution throughout NSW. This funding will be allocated for:

- assisting councils and certain State Government agencies either individually or in groups, to pilot innovation in stormwater management or to undertake remedial activities
- providing assistance to councils for the preparation of stormwater management plans, and
- a State-wide education program to be coordinated by the Environment Protection Authority.

To provide further assistance to local councils and other organisations, the NSW Government is releasing a series of *Managing Urban Stormwater* documents to improve our urban stormwater management practices.

Comments

Comments are invited on this draft document and should be forwarded by **31 March 1999** to:

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MANAGING URBAN STORMWATER:
SOURCE CONTROL – DRAFT

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List of Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARC	Auckland Regional Council (New Zealand)
ARI	Average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASCE	American Society of Civil Engineers
BMP	Best management practice
BOD	Biochemical oxygen demand
CDM	Camp Dresser McKee
CMC	Catchment Management Committee
CRC	Cooperative Research Centre
DCP	Development control plan
DLWC	Department of Land and Water Conservation
DUAP	Department of Urban Affairs and Planning
EIS	Environmental impact statement
EMC	Event mean [pollutant] concentration
EPA	Environment Protection Authority (NSW)
EPAV	Environment Protection Authority (Victoria)
EP&A	Environmental Planning and Assessment [Act]
FAO	Food and Agriculture Organisation (United Nations)
FC	Faecal coliforms
GIS	Geographical information system
GPT	Gross pollutant trap
IMEA	Institute of Municipal Engineering Australia
LEP	Local environmental plan
LES	Local environmental study
MAV	Municipal Association of Victoria
NCPA	New South Wales
OMEE	Ontario Ministry of Environment and Energy (Canada)
OMNR	Ontario Ministry of Natural Resources (Canada)
REF	Review of environmental factors
REP	Regional environmental plan
SEE	Statement of environmental effects
SEPP	State Environmental Planning Policy
SPCC	State Pollution Control Commission (now EPA)
SS	Suspended solids
STM	Stormwater treatment measure
TP	Total phosphorus
TN	Total nitrogen
USCS	Unified soil classification system
USDA	United States Department of Agrigulture
US EPA	United States Environmental Protection Agency
WEF	Water Environment Federation

PART A - STORMWATER SOURCE CONTROL

1. INTRODUCTION

1.1. Managing Urban Stormwater

This document is part of a package of documents on managing urban stormwater published by NSW Government agencies. The other components of the package are:

- *Managing Urban Stormwater: Council Handbook*. This document provides guidance to Councils on the preparation of stormwater management plans.
- *Managing Urban Stormwater: Treatment Techniques*. This document contains a range of techniques for treating the runoff from urban areas.
- *Managing Urban Stormwater: Soils and Construction*, which describes soils management and stormwater management of construction activities.

It is important that this document be read in the context of the information contained in these companion documents, particularly the *Council Handbook*.

1.2. Purpose of this document

The aim of this document is to provide guidance to local government, State government agencies, developers as well as community and business groups on a range of source control techniques that can be adopted to minimise impacts on the stormwater environment.

1.3. Source Control in Stormwater Management

There are a number of broad stormwater management principles that can be followed and the hierarchy of these principles is noted in Figure 1. This hierarchy is consistent with the principles of ecologically sustainable development.

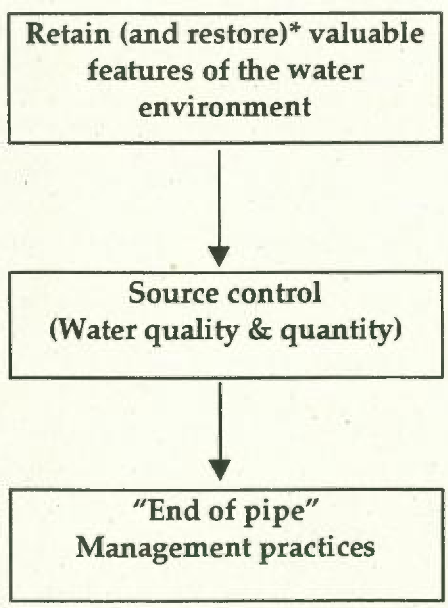

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Figure 1 – Stormwater Management Hierarchy

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It aims to preserve valuable features of the water environment such as wetlands, natural watercourses and floodplains and riparian corridors. This hierarchy also promotes cost-effective stormwater management by principally controlling stormwater at the source through effective planning, design, maintenance and education. Structural 'end-of-pipe' techniques may then be employed to treat the residual stormwater impacts that cannot be cost-effectively controlled at source.

2. WHAT IS SOURCE CONTROL?

There appears to be no universally accepted definition of source control. It is sometimes referred to as 'Non-Structural Control', 'Non-Structural Best Management Practices', 'Infiltration Devices' or simply 'Pollution Prevention'. These terms essentially have a similar philosophy.

> ***Source control involves minimising the generation of excessive runoff and / or pollution of stormwater at or near its source. Source Control techniques can be categorised into:***
>
> - *Non-Structural Source-Control*: techniques that aim to change human behaviour to reduce the amount of pollutants that enter stormwater systems (pollution prevention).
>
> - *Structural Source-Control:* techniques that aim to reduce the quantity and improve the quality of stormwater <u>at or near its source</u> by using infrastructure or natural physical resources.

'Structural Source-Controls' differ from the more conventional, structural 'end-of-pipe' techniques. Examples of structural and non-structural source control measures are provided in section 3.2.

3. WHY USE SOURCE CONTROL?

Once a natural system is polluted or excess run-off is generated, it is often difficult and costly to mitigate the resultant impacts on the environment. Source control reduces the generation of run-off and the accumulation of pollutants on surfaces, therefore minimising the need for treatment measures.

Source control is frequently a cost-effective way to manage urban stormwater. Source control techniques can minimise the generation or discharge of many pollutants:
- Nutrients
- Oil and grease
- Sediment
- Toxic material including trace metals
- Bacteria
- Litter.

'End of Pipe' solutions generally rely on a significant dedicated budget for stormwater pollution control. Most source control techniques can be implemented quickly and are often a refinement or extension of activities already undertaken within council. Source control is predominantly concerned with prevention, and minimises the ongoing mitigation (operations and maintenance) costs that are inherent in end-of-pipe solutions.

3.1. Non-Structural Source Control Options

Non-structural source control can include community education, council management activities, operations and maintenance activities and land use and site planning.

Non-structural source control is concerned with changing behaviour to reduce the amount of pollution that enters the stormwater system through community education and participation activities. Community education approaches are discussed in Part B of this document.

Systematically evaluating and improving council's operations and maintenance activities such as street sweeping and bin collection can also be a cost-effective way of reducing stormwater pollution at the source. Council management activities such as planning and development control, including enforcement of erosion and sediment controls on construction sites, are some of the activities that can improve stormwater at the source. Guidance for improving council's management and operation activity is given in Part C of the document.

The main advantages of using non-structural source controls are:
- long term sustainabilty
- cost-effective
- minimisation or prevention
- reduced ongoing operation or maintenance liability (cf. 'end of pipe')
- effective use of all resources – including the community

3.2. Structural Source Control

Structural source controls aim to reduce the quantity and/or improve the quality of stormwater at or near its source, commonly through filtration, infiltration and detention. These controls include; swales, buffer strips, infiltration basins and trenches for quantity control and small stormwater treatment measures such as stormwater pit gross pollutant traps for quality control.

It is important to note that structural source controls generally focus on managing the impacts of frequent flood events:
- Rainfall events up to the 2 year Annual Recurrence Interval (ARI) event, for *environmental flow management.*
- Rainfall events up to the 3 month ARI event (approximately 25% of the 1 year ARI event), for *water quality management.*

This approach is based on:
- The greatest change to the streamflow regime following urbanisation occurring for frequent floods (< 2 year ARI).
- 90-95 % of the mean annual runoff occurring at flows less than the 3 month ARI peak flow.

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By comparison a flood control design has a different design approach whereby the sizing criteria and function focus on infrequent floods such as the 100-year ARI.

Structural source controls can be incorporated into both developed and developing urban areas. Some can be designed to fit aesthetically into the open space landscaping. The main advantage of structural source controls are:

- Cost-effective for targeting particular site pollutants and 'hot spots'
- Fits into available open space
- Aesthetically pleasing (if well designed and maintained)
- Protects downstream environment

4. WHY HAS SOURCE CONTROL NOT BEEN USED MORE IN THE PAST?

Source control techniques have not traditionally featured in the management of stormwater. Greater community expectations in relation to the protection of receiving waters and aquatic and riparian ecosystems are now encouraging a multi-disciplinary approach to stormwater management.

One of the reasons it has not featured strongly in the past is that it is difficult to predict or assess the effectiveness of many source control techniques, where as for end of pipe structural controls, there are a range of techniques such as water quality computer models that can be used to predict effectiveness. There may have been a tendency to prefer measures whose performance can be predicted or assessed prior to commissioning.

For example, an evaluation of source control techniques against structural techniques may require comparing the effectiveness of a 'gross pollutant trap' to a 'community education project for litter control'. It is difficult to quantify the effectiveness of a program where the assessment techniques usually applied to the stormwater environment are not directly applicable to education or community involvement projects.

While there is logical connection between more people sweeping the street gutter in front of their home and reduced load of plant material, litter and sediment in the receiving waters, the success of a program to encourage such behaviour is not easy to prove. Changes in community attitude and behaviour are best monitored using social research techniques such as surveys.

Quantifying and evaluating source controls requires a different approach and the use of tools that incorporate a qualitative approach. With emerging multi-disciplinary approaches there will inevitably be evaluation tools for quantitative and qualitative analysis of stormwater management techniques. A traditional technical approach alone is no longer sufficient to address the complex issues involved in stormwater management.

5. CHOOSING SOURCE CONTROLS

The process outlined in *Managing Urban Stormwater: Council Handbook* for preparing a stormwater management plan identifies the need to identify and evaluate management options. Clearly, source controls should be included in that assessment. The *Council Handbook* and this document identifies a broad range of measures which may be suitable for incorporation into stormwater management plans.

It will be difficult to predict the beneficial effects of several source control options from a purely technical perspective. It is therefore recommended that a qualitative and intuitive approach for assigning beneficial effects for source control options such as community education be used, as currently there is insufficient available research in this area.

The options will, however, need to be evaluated in terms of their estimated effects and the values, objectives and issues identified in the stormwater management plan. Some suggested criteria for evaluating source control options might include:

- Effectiveness of pollutant removal
- Number of pollutants targeted
- Percentage of catchment targeted
- Public acceptance
- Ease of implementation
- Longevity.

Effectiveness of Pollutant Removal

Does the Source control option have a high likelihood of reducing pollutants of concern? This is difficult to quantify especially for source control. Available knowledge of the effects of source control in this area is lacking and consequently some source control options may receive a low rating. This low rating is not because the options are ineffective rather they may be given a lower rating because of the difficulty in quantifying the pollutant removal.

Public Acceptance

Does the Source Control option have public support?
Some source control options will have more public support then others, such as stream clean-up versus tighter land-use controls. The successful implementation of source controls depends to a large extent on the amount of public support. Such support can be gauged by community understanding of the issues.

Ease of Implementation

Can the source control be implemented through existing programs or departments?
The ability for council to implement a source control is influenced by whether existing programs can be used or expanded and also which other organisations are involved. Another issue to be considered is the availability of staff and equipment. Those source controls that apply to a larger or more sensitive catchment area should receive higher consideration.

6. FURTHER INFORMATION

This document is not an exhaustive selection of techniques, but a 'source book'. The document is not intended to stifle the development or application of innovative management practices.

There are a range of publications from Australia and overseas on stormwater source control which can provide further assistance. These include:

- *Stormwater Management – Source Control: Seminar Proceedings* (IMEA and EIA 1998)
- *Planning and Management Guidelines for Water Sensitive Urban (Residential) Design* (Whelans et al 1994)

- *Stormwater Management Practices Planning and Design Manual* (Ontario Ministry of Environment and Energy 1994)
- *Urban Runoff Quality Management* (WEF and ASCE 1998)
- *California Storm Water Best Management Practice Handbooks: Municipal* (Camp Dresser and McKee 1993)
- *Fundamentals of Urban Runoff Management: Technical and Institutional Issues* (Horner et al 1994)
- *A Watershed Approach to Urban Runoff: Handbook for Decision Makers* (Terrene Institute, 1996)

PART B – COMMUNITY EDUCATION

7. INTRODUCTION

Community education can play a significant role in the improvement of stormwater quality. Stormwater pollution from residential, industrial and commercial areas is the result of many actions at various locations within a catchment. The impact of allowing a can to leak oil, washing paint brushes into drains, not cleaning up after dogs or inappropriate use of household chemicals may seem relatively minor. However, when the individual impacts are added across the catchment, these actions become a significant source of pollution entering our waterways.

In addition to stormwater pollution, other impacts of community activities on the health of waterways include:

- increased runoff rates caused by increased impervious areas (such as roads, roofs and paving);
- removal of riparian vegetation adjacent to watercourses and other waterbodies; and
- degradation of aquatic habitats such as pools and rapids in creeks and wetlands.

People are often unaware that their activities at work, while travelling or at home can impact on stormwater. Once they are aware and have learnt simple solutions to reduce or avoid causing stormwater pollution, changes to their behaviour are more likely. There is a valuable role for local community networks, local councils and State Government agencies to assist communities to play a constructive role in stormwater management.

Education programs may not result in an immediate change as it is not the only factor that influences a person's behaviour – particularly in the short term. A person's behaviour is also influenced by:

- The social values and standards passed on in the home, at school, through social groups and the media.
- Age, gender, ethnicity, income and occupation.
- Recent events.
- Laws, regulations and policies – and how these are monitored, implemented and enforced.
- The availability of technology, products and services.
- Economic factors such as financial incentives or disincentives.

Education programs are more likely to show results if they are planned and implemented as one of a number of complementary approaches that address issues arising from people's behaviour.

Complementary approaches to consider are:

- Enforcement: making better use of policy, legislation and regulation.
- Economics: examine market incentives and disincentives for changing behaviour.
- Engineering, science and technology: promote and assist development of new technologies and services.
- Evaluation, monitoring and research: examine the barriers and information needs to facilitate change.

8. WHAT IS COMMUNITY EDUCATION?

Community education is a process used to:

- Create **awareness** of issues
- Enhance people's **knowledge, understanding and skills**
- Influence people's **values and attitudes**
- Encourage more responsible **behaviour**

What We Need Is... A Community Education Project, prepared by the NSW Environment Protection Authority and Department of Land and Water Conservation, provides comprehensive guidance on developing community education projects. This part provides a brief summary of the steps in preparing a community education project described in *What We Need Is...A Community Education Project* and provides additional information on preparing a community education project for stormwater quality management. These programs can be developed by local government, catchment management committees and community groups.

9. COMMUNITY PERCEPTIONS OF STORMWATER

The EPA has undertaken a variety of research on the community's understanding of stormwater issues, including: *Who Cares About the Environment* (EPA 1994); qualitative research on stormwater and waste (1995); an evaluation of *Solutions to Pollution* (1995/96); *Who Cares About the Environment in 1997* (1997); *Beachwatch Social Research* (1997); qualitative research on stormwater (Young 1998). The DLWC undertook *TCM Community Research* in 1996. The findings from this body of research is summarised below and provides a basis for a stormwater education strategy.

Values and attitudes

Water was found to be the single most important environmental issue in NSW today, being mentioned by 35% of respondents in 1997 - up from 27% in 1994 (EPA 1997). Specific issues mentioned most frequently were - fresh water pollution of creeks and rivers (17%), pollution of beaches or the ocean (7%), sewage treatment and sewerage problems (5%), other water pollution/quality, general, including tap water (6%).

When asked "what would you say is the single most important thing that the NSW government could do to protect the environment over the next few years", "education about the environment" was mentioned most frequently (15%), followed by water issues (12%), including "cleaner water/ waterways/to stop pollutants entering the water" (10%), and "improved water quality" (2%).

Comparison of EPA research findings on stormwater from 1994 to 1997 and qualitative research undertaken in early 1998 show there are now new norms around stormwater, with most people spontaneously recognising it as an important issue and strongly in support of measures to address stormwater problems. There is however a group of people in the community that has the attitude that doing something about stormwater "is too hard".

Levels of support for actions to address stormwater issues depend on a number of interconnected factors:

- Intimacy of contact with water (ranging from swimming, diving and sailing to occasional visual contact)
- "Will what I do make a difference?"
- "Will I get caught?" (guilt/peer pressure/regulation/enforcement)

It is therefore important that stormwater education acknowledge and reinforce current community values and norms, identify social and regulatory sanctions against polluting stormwater and facilitate actions people can do to clean up stormwater.

Knowledge and Understanding of Stormwater Issues

The community has become increasingly aware of stormwater pollution and some of its impacts on waterways. People generally have a good knowledge of:

- the visible components of stormwater pollution
- the stormwater system
- some of the sources of stormwater pollution

The concept *stormwater* has variety of levels of understanding. There is now a significant level of knowledge about:

- the variety of sources of pollution
- the stormwater infrastructure
- visible outputs and impacts

Current knowledge of stormwater pollution is mainly about the visible or aesthetic components such as litter and muddiness. There is a lack of an ecological and health perspective and consequent lack of knowledge about non-visible pollutants (such as fertilisers, dissolved compounds etc) and pollution by naturally occurring material (such as soil and leaves).

People gained their knowledge from a variety of sources; mass media, councils, events (eg Clean Up Australia Day), the EPA's stormwater education campaigns, children, and direct experience.

The research has indicated that the community needs a more diversified understanding of the range of stormwater pollutants, and in particular, to understand that non-visible and naturally occurring materials can also pollute stormwater.

Behaviours

Qualitative research undertaken in 1998 identified four behavioural segments around stormwater issues:

- *It's my place* (positive attitudes and positive behaviour)
- *It's not my place* (negative attitudes and negative behaviour)
- *It's too hard* (positive attitudes and negative behaviour)
- *I have to* (negative attitudes and positive behaviour)

Most people were found to be able to identify a number of behaviours that impact negatively on water quality. No one person, however, is doing the whole range of appropriate behaviours. There was also a lack of understanding of why many behaviours are appropriate or inappropriate. The key issues regarding behaviour are that:

- there is a need for facilitation of the appropriate behaviours to make these easier (analogy with kerbside recycling)
- many people were willing to behave in positive ways but did not know how
- those that behaved positively were most likely to interact directly with water in some way (swimming, fishing etc).

The key issues arising from these findings concerns the need for education to support and facilitate decisions by individuals about what behaviours are appropriate in a range of contexts – at home, at work and when out and about.

10. STEPS IN DEVELOPING AN EDUCATION PROGRAM

This section follows the steps for developing an education program which are detailed in *What We Need Is... A Community Education Project*. These steps are:

1. **Analyse the issue or problem**
2. **Identify stakeholders**
3. **Know your target group**
4. **Objectives and outcomes**
5. **Design your methods**
6. **Consider funding**
7. **Make an action plan and implement it**
8. **Monitor and evaluate**

> It is important that this section be read in conjunction with *What We Need Is... A Community Education Project*, as that document contains important information on developing and monitoring education programs which has not been repeated in this section.

Specific ideas potentially useful for a stormwater education project are noted below for each step. Hypothetical stormwater education examples for litter, oils and grease and nutrients have been developed and included in Appendix A to illustrate these steps.

Step 1 – Analyse the issue or problem

Find out what's causing concern and break the issue down into its components. Find out how much is already known about the problem by professionals working in the area and the community members who are associated with the issue or problem location.

A list of potential issues/problems and their possible causes is provided in Table 1.

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Table 1 – Possible Stormwater Issues and Causes

Issue	Potential negative impact	Possible cause
Sediment deposited in the bottom of ponds, lakes and streams	• smothering of plants and animals that live on the bottom of ponds, lakes and steams	• erosion of sediment from building sites • erosion from bare earth areas eg: unsealed roads, driveways and car parks, poorly maintained lawns • soil and sand piled on nature strips, footpaths, driveways and gutters • washing cars in the street • air pollution carried by rain into stormwater systems
Turbidity in waterways	• reduced aesthetic value (water looks "muddy") • reduced aquatic plant growth • clogging of fish gills • hinders the ability of aquatic predators (eg certain fish species) to see their prey.	
Vegetation washed into waterways	• oxygen dissolved in the water is used up when plant matter decays. Fish and other water life need this oxygen to live.	• leaf drop from gardens and street trees, particularly when they fall onto paved surfaces • hosing or sweeping lawn clipping and leaves into gutters • mulch washed or blown from gardens
Bacteria and other pathogens	• makes contact with water unsafe for humans • causes disease in aquatic organisms • contaminates shellfish	• animal (dog and cat) faeces • food wastes disposed improperly • leaky or overflowing sewerage systems
Nutrient enrichment	• nitrogen and phosphorus stimulates the growth of algae and aquatic plants • decay of algae and plant matter reduces dissolved oxygen levels • excessive growth of algae and aquatic plants reduces waterway aesthetic values	• washing cars with detergent containing phosphorus • excessive use of fertilisers, which is washed off lawns • decay of plant material • leaky or overflowing sewerage systems
Gross pollutants	• reduces aesthetic appeal of waterways • can kill some marine aquatic life (eg fish, turtles, sea birds) • decay of some gross pollutants can decrease dissolved oxygen levels	• littering e.g. bottles, plastic wrapping and caps, cigarette butts • overflowing rubbish bins • waste dumping • uncovered loads (eg trailers)

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Table 1 – Possible Stormwater Issues and Causes

Issue	Potential negative impact	Possible cause
Trace metal pollution (heavy metals)	• stress on aquatic plants and animals • contamination of the food chain with trace metals	• runoff from roadways or car parks • deterioration of building surfaces (eg rusting galvanised iron roofs) • by product of burning fossil fuels • swimming pool water
Petrol, oils and grease	• reduces aesthetic appeal of waterways • can harm some aquatic life • decay of some hydrocarbons can decrease dissolved oxygen levels	• leaks from vehicles • car washing or maintenance • illegal dumping of waste lubricating or food oils
Pesticides and herbicides	• harms aquatic plants and animals	• pesticides and herbicides (weed killers) used on gardens and nature strips and washed off during rain
Loss of aquatic habitats and/or riparian vegetation	• weed infestation of urban bushland • nutrients in stormwater and the transport of weed propagules from urban areas by stormwater • reduced fish population • water pollution due to loss of filter strips adjacent to creeks • increased water temperature	• riparian vegetation cleared • changed flow characteristics resulting from change of land use • bank erosion • unrestricted access • creeks "channelised" or "piped"
High runoff rates	• increased pollutant loads • erosion of creek banks • changed pattern of water levels in wetlands, affecting aquatic flora and fauna • increased frequency of disturbance to aquatic ecosystems, reducing the diversity of aquatic life	• impervious surfaces (eg roads, roofs, paved areas, footpaths) directly connected to the stormwater system

Step 2 – Identify stakeholders

Identify the stakeholders, involve them and find out where they stand in relation to the issue and look for common ground where the stakeholders may be able to work together to solve the issue.

Potential stakeholders who have an interest (or stake) in a stormwater education project include:

- Local residents and their political representatives
- Local conservation and community groups
- Local shops, possibly represented by a local Chamber of Commerce
- Schools, TAFE colleges and Universities.
- State or nationwide interest groups, representing recreational, environmental, industrial or commercial interests.
- Councils and regional organisations of councils
- State Government agencies, including the Environment Protection Authority, the Department of Land and Water Conservation, the Roads and Traffic Authority, the National Parks and Wildlife Service, NSW Fisheries,
- Sydney or Hunter Water Corporations

Step 3 – Know your target group

Identify, get to know and involve your target group early in the project.

Potential target groups for a Stormwater education campaign include:

- Residents and landowners
- Young people
- Gardeners
- Shoppers
- Tourists or visitors to the area
- Builders and associated contractors
- School children with the help of their teachers
- Local businesses (owners and staff), particularly small businesses. These can include take-away food shops, convenience stores, service stations and car repair businesses, light industrial premises.
- Business or industry organisations.
- Land and property developers

Step 4 – Objective and outcomes

Determine the result you want from your community education project.

It is important to adopt realistic goals and objectives for the project, and consider how the project can be evaluated to find out if they have been met. The objectives may be both short and long-term. Be clear and specific about the purpose and outcome of the project.

Goals for a stormwater education project will be generally of two types.

1. Goal that focus on changing general community understanding or **awareness** that streets, gutters, stormwater systems, and waterways interconnected.
2. Goals that focus on **changing** specific polluting **behaviours** that result in stormwater pollution.

"Type 2" goals are more often long-term goals and require the program to first influence community and individual values by encouraging a sense of appreciation and responsibility for our waterways.

Potential objectives for a stormwater education project may include:

- Increase knowledge about the environmental impacts of urban stormwater
- Highlight the connection between activities undertaken by the target audience and the resulting environmental impacts
- Identify potential ways to change community behaviours to minimise environmental impacts
- Develop an understanding of the benefits of improved environmental management to the audience, which may be economic or publicity.

Possible outcomes related to these objectives may include:

- Evidence of improved management practices by the target audience
- Evidence of a reduction in the magnitude of the problem that has initiated the education campaign
- Educational products including brochures, posters
- Positive media feedback
- A report on the project which shares the experiences gained on this project with other groups planning similar projects.

To be effective in meeting pollution reduction goals, the majority of a program's resources may initially be spent on short-term goals. As the program succeeds in changing specific behaviours and in addressing all identified problems, greater resources could be allocated to the long-term goals of increasing community understanding, appreciation, and values.

Step 5 – Design your methods

Investigate the methods, tools and techniques you could use to achieve your goal, objectives and outcomes.

(a) Methods

There are a range of potential educational methods, with their relative advantages and disadvantages discussed in *What We Need Is... A Community Education Project*. It is important to keep in mind the target group and the techniques likely to be most effective for this group. These methods can range from **informing techniques** used to increase knowledge and awareness, to **demonstration and involving methods** for improving skills. People learn differently, so a variety of methods could be considered to increase your effectiveness. Community education projects which use only "information giving" methods rarely have long term success. Budgetary considerations may influence the methods chosen.

Methods previously used in stormwater education programs include:

Business and groups	• Audio-visual tools such as video recordings, audio recordings and slides • Awards to encourage and recognise achievements • Highlighting case studies of innovative projects or good practice • Courses through schools, universities, TAFE and community colleges. This could include certification of participants who have attended training courses. • Demonstrations such as water quality monitoring, which could be part of a community water quality monitoring program (eg *Streamwatch)* • Targeted grants to groups to encourage community involvement. • Talks, presentations and seminars • Tours, open days and field days • Training, train-the-trainer and training modules • Workshops • Meetings and discussions – steering, advisory and consultative groups
Individuals	• Launches of products or projects • Mass media, including advertising and publicity • Exhibitions, displays and models. These can be displayed at events such as trade shows, community days, festivals, shopping centres or field study centres • Community planting and clean up days that focus on a waterway degraded by stormwater • Permanent displays and signs erected adjacent to waterways • Stormwater pits stencilled with messages such as *Drains to Beach* • A tagged litter survey carried out in conjunction with media coverage • Individual advice, communication or instruction to members of the target group on appropriate management practices • Peer education • Print material, eg brochures, posters, booklets, letters, newsletters, stickers, book-marks • Interactive computers packages including the Internet and CD ROMs

(b) Messages

There are two basic concepts which can form the basis of the messages in a stormwater education program, namely highlighting:

- the **impacts of community activities** on stormwater quality and the natural environment; and
- suggesting **appropriate actions**.

A key element to the success of your program will depend on how well you can make the connection between people's daily activities which create pollution and the resulting damage to the environments that they care about. When individuals understand that stormwater pits are the entry point for many pollutants which flow to nearby waterways through the stormwater system they are more likely to keep pollution out of the drain. Many people assume that stormwater pits are connected to the sewerage system and stormwater is therefore treated at sewage treatment plants.

There are a range of impacts that can be included in an education campaign, and these are noted in Table 1. Highlighting the "cause-effect" relationship in an education campaign can assist individuals and groups to recognise that their actions can reduce their environmental impact. This can also enable the community to identify and implement their own actions to address the issues.

When choosing the key message(s) important to consider your target groups and to choose facts that the target group will easily understand and find relevant and believable. The methods chosen for a program may also relate to the message(s) that you wish to send to your target audience.

Sample messages, supporting facts and suggested actions are noted in Table 2.

(c) More Effective Communication

It is important that the message(s) in an education program are communicated effectively. The following points can assist with more effective communication:

Keep it simple	• Break down complicated messages into simpler concepts. These messages can be presented to the public in an organised way to avoid 'overloading' and confusing the audience.
Keep it clear	• Use 'plain English' in all educational material and reduce the technical terms, acronyms and jargon.
Ensure the message is correct	• Ensure that all statements have a sound technical basis to avoid the spread of misinformation.
Use your audience's language	• Translate the message into languages other than English in catchments where a high proportion of the population is from a non-English speaking background. This will avoid misinterpretation of the message. The message may also need to be modified, not just translated.

Table 2 – Example Messages for Stormwater Education Projects

Key message	Actions to do more often	Actions to avoid
Bin it securely Litter can blow or fall out of bins or recycling containers and be washed into the stormwater system	• pick up litter in the park or on the street	• never drop packaging or cigarette butts on the ground • don't leave rubbish where bins are already full • prevent litter from blowing out of recycling containers (eg place heavy recycleables on top)
Clean up after your dog Imagine 300,000 dogs and think about 90 tonnes of dog droppings produced every day. Some of it is washed into stormwater drains. Dog droppings contain bacteria and nutrients.	• clean up pet droppings and dispose of them in the garden, rubbish bins or in the toilet	• don't let your dog out on its own
No grass clippings and leaves down the drain Decomposing organic matter pollutes waterways with excess nutrients and reduces the level of oxygen in water necessary for aquatic life. Debris can block drains and cause local flooding	• sweep the gutters and driveways regularly and place the sweepings on the garden, the compost or in the bin • rake up leaves or lawn clippings and use them as mulch on the garden or place them in the compost	• prevent soil or mulch being washed or blown off the garden • never hose leaves and grass clippings into gutters
Painting Clean-up Paint, solvents and cleaners can be toxic to aquatic life.	• wash brushes and rollers over a sand filter on the lawn • for water-based paints, paint out brushes on scrap materials and rinse into the garden or into an older container	• never pour paint, solvent or cleaners in the gutter or where they may enter drains.

Table 2 – Example Messages for Stormwater Education Projects

Key message	Actions to do more often	Actions to avoid
Washing the car If you wash the car on the street, soapy water, dirt, oils and grease flow down the gutter and ends up in the nearest creek. The increased nutrients from detergents contaminate our waterways.	• use the minimum amount of detergent • wash cars on the lawn or gravel. • empty the soapy water down the sink or toilet. • take your car to a car wash, where the water gets treated and recycled	• avoid washing your car on the street • don't tip buckets with soapy water down the gutter or drain
Changing motor oil It takes only one litre of oil to contaminate one million litres of water	• maintain the car making sure there are no oil or radiator water leaks and that fuel is burnt 'cleanly' by keeping your car tuned • many councils have drop-off centres which will take oil	• don't maintain cars (including oil changing) where oil and grease may wash into gutters • never pour oil into the street gutter
Fertiliser, Herbicides and Pesticides Fertilisers can encourage algal growth in waterways. Herbicides and pesticides intended to kill weeds and insects in the garden can also kill aquatic plants and aquatic life.	• consider natural alternatives to pest control chemicals	• avoid using too much fertiliser (follow the instructions) • don't use pesticides, herbicides and fertiliser when rain is forecast the same day
Landscaping and Construction These activities can result in sediment being eroded from disturbed areas, which can end up deposited in waterways.	• grass or replant areas of disturbed soil • protect stockpiles from wind and rain by storing under secured plastic sheeting or tarpaulins • schedule grading and excavation projects for dry weather periods	• avoid piling sand and soil on areas where it can wash into the stormwater system • ensure soil and sand stockpiles are not covering street gutters • don't wash cement mixers into the gutter • don't drain your pool water into the stormwater system – use the sewerage system

Create a coordinated campaign	• Implement public education as a coordinated campaign in which each message is related to the last.
Make it relevant	• Create an awareness of local catchment issues, to encourage identification by the public of impacts on an area that they are familiar with (eg a popular swimming beach).
Build on existing programs	• Model the education program after the many existing programs prepared by the Environment Protection Authority, the Department of Land and Water Conservation (through Total Catchment Management) and other councils. Where possible, integrate stormwater public education and participation into existing programs operated by other council departments (e.g. precinct committees). Check that the program that you are building on has been successful.
Involve the community	• Encourage community involvement in the preparation of the educational material. This has the potential to create better educational material and promote ownership of the strategy by the community.
Include small business	• Expand the definition of 'public' to include small businesses who often possess the same limited awareness of the problems, regulations and solutions as the 'general' public. As a results small businesses need the same level of technical assistance (education) and participation in the stormwater management process as the 'general' public.

Step 6 – Consider funding:

Identify possible funding sources and the benefits for potential funding organisations.

Funding may be either financial or in-kind contributions. Potential sources of funding may include:

- Grants from councils
- State Government grants
- Private sponsorships.

Step 7 – Make and action plan and implement it:

Prepare an action plan to ensure that you achieve your project's goal and objectives.

An action plan identifies who has to do what by when, and what resources will be needed. The plan is designed to keep all participants on track.

Step 8 – Monitor and evaluate:

Monitor and evaluate the project and tell people about it.

This may be the most difficult step in education project planning and is therefore left out of many project designs. Increasingly, however, groups who want to attract funding and support for projects are being asked to show how they will determine a project's success.

It is very rare for all aspects of a project to be successful. So it is as important to identify opportunities for improving your project as it is to report on the project's success.

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PART C – COUNCIL ACTIVITIES

12. INTRODUCTION

Local councils can influence the quality of stormwater within a catchment when planning and managing its construction and maintenance activities and during its day to day management decisions. It is also important for councils to be seen to be setting the right example for the community and other organisations to follow.

Table 3 lists some council management activities that have a direct or indirect influence on stormwater management of these activities. It is important that these direct or indirect influences on stormwater management be recognised and considered.

This Part identifies activities performed by local councils that may affect stormwater quality and provides guidance on appropriate management practices which can be adopted.

Councils sometimes contract their operations or services which results in the need to establish performance criteria and the required benchmark standard to be achieved by the successful contractor. Where appropriate, elements of this Part may be incorporated in contracts that involve activities that are likely to introduce pollutants to the stormwater system. This Part has been prepared so that much of the good practice guidance as presented can be used in contract specifications. Sample contract clauses have been provided for selected activities.

Although this Part focuses principally on the management function and operations most commonly performed by local councils, many of the activities are applicable to other public and private sector organisations including road maintenance organisations (eg the Roads and Traffic Authority) and transport companies.

Table 3 – Council Activities and their Potential Influence on Stormwater

Council Activities	Potential Influence on Stormwater
Environmental Planning - strategic planning	• Urban capability assessment • Section 94 plans for stormwater management
Environmental Planning - development control	• Stormwater management practices for new developments
Building approvals and inspection	• Soil and water management for building sites
Environmental Health	• Trade waste, discharges to stormwater
Parks and Gardens	• Maintenance activities (eg tree planting, fertiliser application, grass cutting)
Road Maintenance	• Various maintenance activities
Drainage system maintenance	• Various maintenance activities
Waste collection	• Litter management
Road and drainage design	• Road route selection, drainage system design
Finance	• Budgets for stormwater management
Library	• Community education

13. COUNCIL MANAGEMENT ACTIVITIES

Management activities undertaken by council that can be to maximise councils effort in managing stormwater pollution are:

- Conducting internal reviews
- Performance monitoring
- Internal training and education
- Internal communication
- Financial management
- Development and Building Approvals
- Enforcement of Site controls

13.1. Internal Reviews of Policies and Procedures

Preventing pollution is generally more cost-effective than treatment of pollution after the event. However, prevention is an ongoing process which requires planning and commitment from the organisation and its staff.

Many local government infrastructure construction and maintenance activities deal with potential pollutants close to their source. Examples are erosion controls during construction, and control of sedimentation and litter through maintenance activities such as street cleaning, clearing litter bins, slashing and mowing..

Local councils are encouraged to examine their current procedures and practices and consider these guidelines. It is important to undertake the examination in a planned and systematic manner to allow recommendation to be formed and the priorities for controlling pollution at the source, at reasonable cost, to be determined. Appendix B provides an example form to document a review of council's stormwater related activities.

There are a number of approaches that can be used to conduct a review of stormwater related activities within council. The technique which is most suitable will depend on the organisation. For example, council could:

- Form a working group involving supervisory and field staff to audit the existing practices and procedures. This method has the distinct advantage of involving those who will be responsible for implementing any changes recommended.

- Appoint a team of staff from three or four councils to review each organisation's procedures and practices in turn. Some members of the team may "rotate" so that specialisations necessary to conduct the review are available to the team. This method will bring new approaches to council's operations and allow issues to be discussed with "an outsiders" perspective.

- Engage an environmental consultant to conduct the review. This approach will minimise the time commitment for council staff and maximise the opportunities for "expert advice" on how to improve council's operations.

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13.2. Performance Monitoring

There are many established reporting mechanisms used which may aid council in monitoring its performance against these guidelines and the objectives set out in its stormwater management plan. These include:

- Review of cyclic reports from the contractor
- Site inspections including photos and site reports
- Review of operational processes to ensure operation procedures are followed.
- Monitoring the number and type of complaints
- Plant & equipment inspections

Performance monitoring can be carried out through inspections, interviews, reviewing the number and type of complaints and through contract reporting mechanisms. Good record keeping and the use of computer technology are important to be able to interpret information so that it may be applied to the specified standards. For example by recording quantities of materials swept for each road or designated area, and the effectiveness of any changes can be determined in terms of its cost and benefit.

13.3. Council's Internal Education and Training

Improvement in council's stormwater management practices is largely dependent on the skills and commitment of staff who perform the functions and services highlighted in this Part. Training staff to implement these practices will greatly increase the effectiveness of any program to reduce pollutants entering the stormwater system.

Training should be considered for planners, designers, managers, supervisors and field workers, whether contractors or in-house staff, to continually update their knowledge on council's commitment to minimise environmental impact and to assist each staff member become a "good practice" stormwater manager.

In most organisations, information can be held in various forms and locations and its existence and availability may not always be obvious. Conducting stormwater education workshops within council may be an efficient and cost effective way of drawing together and circulating the data necessary for preparing a stormwater plan.

It is important that the maintenance and operations staff are included in this process because of their practical knowledge of the catchment. They will generally be aware of stormwater pollution 'hotspots' and current community behaviour which is important in formulating management options.

Internal education programs play an important role in the refinement and improvement of council's management practices. For example, an internal education program may encourage staff to focus on the best manner of applying fertilisers. Conducting internal education and training can emphasise the cause and effect relationship of stormwater pollution.

Good Practice Guidance:

- ☑ Involve staff work groups in the review of current work practices and developing appropriate new work practices
- ☑ Develop key performance indicators as part of the review process
- ☑ Train staff to routinely check activities and the stormwater system
- ☑ Schedule regular training updates to continually develop skills
- ☑ Plan induction training for new staff members
- ☑ Provide training for all levels of staff tailoring the content to their specific needs
- ☑ Periodically audit employee work practices and their application
- ☑ Provide general information (awareness) to staff, and target issues and technical developments
- ☑ Write contracts that provide sub-contractors with clear instructions for activities in accordance with guidelines.

13.4. Enhanced Internal Communication

A strong commitment from the senior levels of council management is important for the effective implementation of an integrated stormwater management planning. This could be achieved by incorporating the following points within a stormwater management plan:

Good Practice Guidance:

Structure and responsibility

- ☑ Senior management should have clear responsibility for good stormwater management
- ☑ Nominate particular divisions or units as responsible for improving stormwater practices and procedures
- ☑ Co-ordinate council's approach with other stakeholders
- ☑ Allocate resources to stormwater management requirements, including
    - People
    - Information and expertise
    - Equipment
    - Funding

Training, awareness and competence

- ☑ Assess training needs for personnel, stakeholders and community groups
- ☑ Ensure all staff whose work impacts on stormwater are aware and are well trained

Communication

- ☑ Define and maintain procedures for communication with stakeholders and contribute to regular forums at a catchment level
- ☑ Define procedures for receiving, documenting and replying to communications from interested parties
- ☑ Define procedures for appropriate internal communication at all levels, including communication between operational staff.
- ☑ Report to the local community on stormwater plan implementation management at least on an annual basis

13.5. Financial management

Clearly, implementation of any stormwater management activity is reliant upon supporting financial management arrangements.

Internal financial implications of the stormwater management and recommended improvements will typically extend beyond the capital works budget designated for stormwater management. A stormwater management plan may impinge on other internal budgeting, including:

- Waste management
- Maintenance
- Library
- Development Approvals
- Community Education
- Environmental
- Open Space Management.

Council may also consider strategies for funding stormwater management above what is already allocated by attracting external funds.

Good Practice Guidance:

- ☑ Consider opportunities and benefits of re-profiling some of existing budgets to encourage source control of stormwater and obtain better value from council's overall financial strategy.
- ☑ Identify areas where cooperation with other councils and State Government departments will reduce costs to each individual council (e.g. regional education campaigns)
- ☑ Identify sources of funds at State and Commonwealth Government level paying particular attention the funding priorities of the programs
- ☑ Identify areas where the support of local organisations can contribute to better outcomes for the community
- ☑ Explore community willingness to pay a small levy to fund environmental works.

13.6. Development and Building approvals

Enforcement of erosion and sediment controls on developments is very important. The *Managing Urban Stormwater: Soils and Construction* document published by the Department of Housing describes urban soil conservation and stormwater management of construction techniques.

Good Practice Guidance:

- ☑ Include requirements for stormwater management for all development and building applications.
- ☑ Use *Managing Urban Stormwater: Soils and Construction* and other guidelines to review current practice with regards to development
- ☑ Provide information in 'plain English', including examples of how to control sediment and other potential pollutants on site.
- ☑ Set up procedures for routine inspection of all works. Councils are encouraged to develop a standard inspection protocol and well-trained staff to perform this function.

14. OPERATIONS AND MAINTENANCE ACTIVITIES

14.1. Overview

Simple maintenance activities that can be implemented at minimal cost can also achieve significant improvement in the quality of stormwater run-off. Proper planning of operational procedures for each activity is the key element to success in minimising the impact each may have on the stormwater quality.

The impact of pollution can be significantly reduced through better maintenance practices and flexible programming such as adjusting and concentrating programs to target areas with greatest pollution potential prior to a storm (eg. sweeping kerb and channel, pit cleaning and cleaning up litter).

The following sections note a range of good practices that could be adopted for activities commonly undertaken by local government.

14.2. Planning Operations and Maintenance Activities

Opportunities exist for local government asset construction and maintenance operations to adopt a holistic approach to stormwater management and the quality of stormwater. These occur at three stages:

- Planning of construction and maintenance projects and works.
- Construction activities
- Maintenance operations

Good practice involves addressing the issues of stormwater quality in the three stages rather than an independent approach at each stage.

In the planning of all asset construction and maintenance activities it is important that consideration be given to the impact and potential effects on stormwater quality. An analysis of each activity's potential to pollute can be undertaken and treatments or operational methods can be designed to capture or reduce the pollutants thereby minimising the impact of that activity on stormwater quality.

In formulating a brief or specification for the function of planning of asset construction and maintenance the specification could contain a clause which identifies the need to consider stormwater quality management. Two key principles that can be addressed are:

- Plan for the management of stormwater run-off quality during construction or maintenance activities.
- Plan the necessary treatments or operational methods for each activity to control erosion, sedimentation and pollution.

<u>Sample Contract Clause</u>

"The impact of any activity of asset construction and/or maintenance must take into consideration the issue of stormwater quality and include treatments and operational features to minimise the pollution of the stormwater. Potential techniques are contained in the *Managing Urban Stormwater: Source Control, Soils & Construction* and *Treatment Techniques* documents."

14.3. Pothole Patching and Bitumen Works

Pothole patching, bitumen works and bitumen spraying and similar activities should be undertaken in a manner to limit the amount of over spray, excess screenings, loose pavement materials, soil disturbance and excess bitumen from entering the stormwater drainage system. Patching of potholes can reduce the amount of pavement material that is washed into the stormwater system.

Good Practice Guidance:

- ☑ Remove all excess material before leaving the site
- ☑ Place only required amount of screenings on bitumen
- ☑ Immediately after sealing and rolling, sweep and collect all excess screenings by using a vacuum sweeper or equivalent
- ☑ Install temporary inlet filters to side entry pits where there is potential for material to enter the drainage system.
- ☑ Avoid bitumen spraying in windy conditions

14.4. Concrete and Segmental Paving Works

Residues and wastes generated from segmental paving and concrete works should be prevented from entering the stormwater drainage system. Where this is not possible, work practices need to be reviewed to minimise pollution.

Good Practice Guidance:

- ☑ Mixing of concrete or mortar to be carried out at a designated location capable of containing excess water
- ☑ When using a concrete pump from a roadway or area where excess material could enter the drainage system, appropriate bunding to trap any spilt material should be installed
- ☑ Clean the site each day before leaving
- ☑ Concrete mixing equipment should be washed at an approved facility and not onto roadways, footpaths or reserves.
- ☑ Allow concrete waste and slurry to set before disposal off site to an approved waste disposal site
- ☑ Waste water from brick & concrete cutting activities should be contained and either recycled or allowed to dry before disposal

14.5. Footpath Maintenance

Grinding of footpaths is a technique used to level movement between adjacent concrete slabs in a footpath. Grinding is preferred to the replacement for differential movements up to 25 mm. As the grinding process produces a fine particle residue and uses water, work practices need to be designed to minimise the potential for these fine particles to enter the stormwater system.

Good Practice Guidance:
☑ Refer best practices as for footpath grinding in Section 14.4
☑ Remove and dispose of old concrete, packing material and soil from the site.
☑ Remove any cover material and formwork from the site once concrete has cured.
☑ Stockpiled material, such as packing sand, gravel or crushed rock and excavated material to be used as backfill at the end of the job, should be placed outside any drainage flow path and be covered to prevent erosion of the material.
☑ Dispose of excess unused concrete at nominated disposal sites
☑ Do not dispose of excess unused concrete into a stormwater pit or drainage system

14.6. Stormwater System Maintenance

Maintenance of the existing stormwater systems includes inspection, cleaning and repair of open and piped drains, pits, treatment devices and outfall structures. These activities should be planned and coordinated in order to reduce pollution. Frequent inspections and cleaning of known "hot spots" will assist in reducing material being transported within the system and ultimately, into local waterways.

All stormwater treatment measures (STM) require maintenance to ensure their pollutant removal efficiency does not reduce over time. The actual maintenance activities and frequency of maintenance will vary with the type of STM and the catchment characteristics. This is discussed further in *Managing Urban Stormwater: Treatment Techniques*. There are difficulties associated with predicting the frequency of maintenance, with a monitoring program being an appropriate method for designing a maintenance schedule.

Good Practice Guidance:
☑ Determine the accumulation rates of litter, silt, debris, leaves etc in the drainage system to provide a fuller understanding of the problem and response needed. Estimates can be made by through measuring actual quantities of material in a specified area (kg), counting the number of items or the area affected (sq.m).
☑ Identify stormwater drain inlets/pits that require cleaning more frequently than minimum for additional cleaning or require change in design.
☑ Determine "hot spots" by review of maintenance programs, including pit cleaning, inlet cleaning etc and take into consideration factors such as type of trees in vicinity, terrain, rain characteristics, topography and other relevant characteristics
☑ Develop drainage facility cleaning programs including allowance for cleaning which matches the rate of build up of materials as determined through the review process.
☑ Inspect stormwater drainage facilities in "hot spot" areas prior to rainy season and particularly prior to the predicted 'initial flush' rain.
☑ Develop cleaning programs to meet requirements of a clean up prior to an 'initial flush'.
☑ Use appropriate machinery to collect material and cart away for disposal at a suitable site (eg. Suction sweeper, hand sweep and pick up sweepings, or other machinery which does not sweep material into the drainage pits).

14.7. Waterway Maintenance

Material that is illegally dumped in waterways can cause pollution and increase flooding. Dumped material may include car bodies, batteries, tyres, hazardous material, metallic items (eg shopping trolleys) and vegetation. Dumping of vegetation can also result in the spread of exotic vegetation in riparian zones.

Bank erosion in waterways can provide a significant source of sediment and other pollutants to waterways. This erosion may be linked to increased flow rates associated with urbanisation. Erosion is a normal process in watercourses. Erosion only needs to be addressed when rates are higher than those that would occur under "natural" conditions. Where erosion is abnormal, mitigation of flows upstream of the erosion area may be required in addition to bank stabilisation.

Good Practice Guidance:

- ☑ Identify waste dumping "hot spots" by regular inspection and by surveying council files and community reports
- ☑ Remove all waste material dumped in the channel and in adjacent reserves (not just the material likely to contribute to water pollution) This does not include material placed by councils such as mulch.
- ☑ Stabilise eroding banks and monitor for further disturbance
- ☑ Provide signs to inform offenders of the likely penalties
- ☑ Enlist local residents to watch for dumpers and record vehicle details and then report the information to council enforcement officers
- ☑ Involve local community in clean up days and activities to restore degraded areas to increase community ownership of the areas
- ☑ Conduct education campaigns to increase awareness of the impact and costs of illegal dumping

14.8. Bridge Maintenance

Road bridges provided with scuppers discharge untreated stormwater directly into waterways. Bridge maintenance can increase pollutant load if waste material is washed into scuppers or material is permitted to fall into the waterway.

Appropriate siting of new bridges can minimise impacts on receiving waters. The use of scuppers can be avoided on short bridges or bridges crossing sensitive waterways, and stormwater directed to the ends of the bridge for treatment. If scuppers are used, compensatory treatment could be provided.

Good Practice Guidance:

- ☑ Clean scuppers on a regular basis to minimise accumulation of sediment and debris. The scuppers should not be directly cleaned into the waterway.
- ☑ Use suspended traps, a vacuum or booms in the water to capture paint, rust and other chemicals when bridges are being maintained.
- ☑ Include bridges in street sweeping programs (refer to Section 14.10)

14.9. Open Space management

Improvements in work practices within this area can reduce the amount of pollutants entering the stormwater system particularly now that grass clippings, leaves, prunings and other material are recognised as pollutants. These plant materials cause significant damage the waterway system by reducing dissolved oxygen levels in receiving waters.

Erosion in existing urban areas can occur due to a range of urban activities. Walking and vehicle tracks and eroding batters can be a major source of sediment pollution to waterways. Details of stabilisation techniques for these areas are provided in *Managing Urban Stormwater: Soils & Construction.*

Good Practice Guidance:

Planning and Co-ordination:

☑ Management Plans for major parks or reserves should consider the impacts of future and current development and maintenance work practices on the quality of stormwater.

☑ Identify and assess the pollution risks for particular parks and reserves taking into consideration such factors as:
- Potential for effect on stormwater flows across the park
- Proximity to a defined open waterway. If the potential of contamination is high, there may be a need to consider other maintenance techniques such as use of a catcher where grass material could pollute sensitive areas.
- Type and its potential to produce pollutants. (Playground, open area, natural reserve, etc)
- Type of usage (eg. playground with large areas of softfall which can be readily spread)
- Number of visitors (potential for other pollutants such as litter)
- Existing planting layout including use of indigenous grasses, and the amount of open grass areas directly adjacent to open waterways.
- Maintenance methods where specialist equipment may be required (eg. grass catcher) and where development of structural controls to trap pollutants should be undertaken.

☑ Determine work practices as outlined within the guidelines to meet the various risk categories of each park.

☑ Coordinate mowing and pruning activities adjacent to kerb and channel with the street sweeper operation so that even after the initial clean up by the field staff a sweeper is following up to ensure thorough collection of waste materials.

Grass Cutting:

☑ Prior to grass cutting remove all loose litter, rubbish or debris from the area.

☑ Cut grass so that the mower throws grass cuttings away from a waterway, open drainage structure or kerb

☑ Sweep up grass cuttings, leaves or prunings left on carparks, roadways, footpaths etc at the completion of the days work or earlier if rain is imminent.

☑ Where practical use a catcher in areas of high pollution risk

☑ Replace high maintenance grass areas with low ground cover

☑ Reduce grass mowing activities in sensitive areas adjacent to open waterways or drainage pathways by:
- Use of indigenous grass where possible
- Replacing grass with low ground cover where appropriate or practical.

Good Practice Guidance:

Garden Development & Maintenance

☑ Choose appropriate plant species which will enhance flora and fauna to the area. (Where practical simulate nature)

☑ Choose plants that have minimal leaf loss in areas near waterways and drainage systems

☑ Establish low ground cover adjacent to open waterways and drains to assist in filtering surface water flow

☑ Remove litter after completion of works including all gardening and tree pruning materials resulting from the days activities eg. Weeds, left over mulch, excess soil, tree prunings etc

☑ Use mulch covers over garden areas to assist in absorbing and filtering water flows.

☑ Use natural grasses and appropriate selected indigenous plantings for better infiltration

Fertilisers & Herbicides

☑ Use slow release organic fertilisers where possible

☑ Avoid areas where wash off can result in the fertiliser entering the drainage system

☑ Avoid spraying adjacent to open waterways or on windy days.

Sample Contract Clause:

"Prior to grass cutting all loose litter, rubbish or debris shall be cleared from the mowing area." {Performance Criteria: "Absence of litter, rubbish or debris"}.

"All grass clippings and other debris to be swept or cleared from adjoining paths, gutters, paved surfaces and garden areas." {Performance Criteria: "No Clippings or other debris after cutting operations."}

14.10. Street Cleaning

Roads, carparks, footpaths and other hard stand areas provide a large area where pollutants collect before entering the stormwater drainage system. Adopting good practice in street cleaning will contribute to a significant reduction in these pollutants entering the stormwater system, particularly as roads comprise approximately 70% of impervious surface in urban areas.

Coordination of this activity with other maintenance activities is important to maximise the benefit in reducing pollutants. Street sweeping should be part of a regular program as well as an integral part of construction and other maintenance activities.

Good Practice Guidance:

☑ Review the accumulation rates of litter, silt, debris, leaves etc to provide a full understanding of the problem and quantum of material.

☑ Assess all maintenance and operational activities to determine their potential pollutant source onto these hard standing areas (eg grass cutting, vegetation pruning).

☑ Based on an assessment of maintenance activities, including street sweeping prepare maintenance programs which consider factors such as vegetation type, terrain, rain characteristics, prevailing winds and topography.

☑ Consider the following program for frequency of sweeping:
- All residential streets swept at an interval not exceeding six weeks
- All roads adjacent to shopping areas or areas of high pollutant concentration swept at the appropriate interval not exceeding one week
- Immediately prior to predicted 'initial flush' (Monitor weather patterns and forecasts so that thorough cleaning occurs before major rainfall, particularly after a long, dry period)

☑ Develop & distribute information to the community on street sweeping schedules to encourage off street carparking or develop schedules to sweep these areas during off peak periods.

☑ Install temporary parking restrictions in areas of greatest pollution to assist in leaving these areas free of vehicles at the time of sweeping.

☑ Adjust/modify sweeping schedules to maximise the period when there are fewer vehicles parked in a street. ie. sweep around schools prior to or after school hours and shopping centres either early morning or late evening.

☑ Establish database recording system for recording and monitoring kilometres swept and quantities of material collected and adjusting programs to maximise the collection of pollutant material.

☑ Do not flush footpaths, kerbs etc unless there is a specifically designed storage and filtration system prior to water entering the stormwater system (refer *IMEA Street Cleansing Code of Practice*).

☑ In areas where a mechanical sweeper cannot access either hand sweep, or cover inlets and flush material to designated location and then remove material.

☑ Street sweepers should not discharge waste water or material into drainage system

Sample Contract Clause:

'Sweeping shall be carried out in accordance with the specified schedule and no dirt, debris, paper, rubbish or waste shall be swept into any drainage system"

14.11. Depot Operations

There are a number of areas within council's deport that warrant particular care; including:

- Unloading and loading areas that are generally heavily trafficked with a variety of materials continually being moved. These areas possess a high pollution risk of spillage and breakage.
- Plant and equipment storage are potential sources of lubricants, coolants and fuel, which pollute stormwater.

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- Washing and cleaning areas for plants that produce contaminated water not suitable for release into the stormwater system.
- Vehicle fuelling areas which should be designed and operated to minimise the potential for the contamination of fuel into the stormwater system.

Good Practice Guidance:

Vehicles Storage

☑ Plant vehicles & equipment should be parked under cover to reduce the potential of rain water washing pollutants into the stormwater system

☑ Establish a data base for the recording of plant inspections

☑ Assign responsibility for the regular inspection of all plant & equipment

☑ Designate parking areas for each vehicle to assist identification of leaky vehicles

☑ Identify, record leakages and arrange for vehicle to be repaired

☑ Develop procedures for the identification, reporting, repairing and cleaning up of leaking fluids or spilled materials.

☑ Inspect storage & parking areas at least weekly

Cleaning/Washing

☑ Provide designated wash area

☑ Grade, seal and kerb the wash area to ensure no wastewater can enter storm water system

☑ Where required to wash on the job select grassed area

☑ Provide signage for staff that prohibits changing oils, washing with solvents outside designated areas.

☑ Equipment, such as triple interceptor devices, for the capture, treatment and disposal of wash water should be installed to ensure none of this material can enter the stormwater system without prior treatment.

Fuelling

☑ Concrete area designated for fuelling (bitumen deteriorates from fuel or oil spillage)

☑ Clean spills using a "dry" method. Do not hose area clean.

☑ Maintain supply of dry clean up material adjacent or within fuel area.

☑ Fuel storage and handling areas to be covered to reduce potential of stormwater run-off washing fuel area.

☑ Post signs to remind operators not over fill fuel tanks.

☑ Inspect fuel area daily and identify any leakages etc.

☑ All spillages or sorption material contained within the fuelling area should be collected, treated and disposed of appropriately.

Good Practice Guidance:

Vehicle Maintenance

- ☑ Vehicle maintenance should be performed in a designated indoor garage, not in an outdoor parking area
- ☑ If performed outdoors, designate specific area, keep it clean at all times, use dry clean up practices and ensure the site is correctly designed to prevent pollutants entering the stormwater drainage system
- ☑ To assist in preventing stormwater pollution:
  - Keep equipment clean
  - Drain fluids from any retired vehicles kept on-site for scrap or parts
  - Keep drip trays under vehicles at all times when working on them
  - Place drip trays as soon as a leak is identified

Loading and unloading

- ☑ Provide wet weather cover for all loading and unloading areas
- ☑ Transport vehicles should be regularly checked for leaking motor fluids
- ☑ Develop and implement procedures that encourage drivers to immediately clean up any spillage or leaks associated with their plant or operation

14.12. Material Storage

Pollution from stored materials occurs from either from water flowing through the stored material or rainfall washing the material directly into the stormwater system. Small or large stockpiles of any uncompacted matter are a potential source of stormwater pollution. Materials to consider are crushed rock, gravel, packing and bricklayers sand, loose timber, screenings and prunings.

Good Practice Guidance:

- ☑ Store materials on paved surface, which ideally drains to a water storage basin.
- ☑ Provide weatherproof cover, kerbing or bunding around material storage areas to prevent stormwater run-off going directly into stormwater system
- ☑ Prevent stormwater from washing through a materials storage area by locating stockpiles high on the site or redirecting stormwater away from the pile
- ☑ Consider both temporary and permanent storage practices
- ☑ Move the materials to a permanent storage site as soon as possible
- ☑ Inspect storage areas and liquid containers for damage or leaks at least every 6 months
- ☑ Store scrap metal and parts under cover and regularly dispose of to a metal dealer
- ☑ Ensure stormwater inlets are protected from any spillage or leaks.
- ☑ Clean up any material washed out from the site
- ☑ Store hazardous materials in accordance with current regulations

14.13. Building Management

Building repairs result in substantial potential for pollution when not managed well. Project or site managers should understand the nature of the materials they have on site and that dust, paint, solvents, steel filings, timber residue and other wastes pollute the stormwater system.

Good Practice Guidance:

Building Repairs

- ☑ Store building materials under cover or in contained areas
- ☑ Clean the building site each day
- ☑ Do not use water for site cleaning
- ☑ Spread a ground cloth prior to scraping, sanding, painting to collect dust and paint residue etc.
- ☑ Mix material indoors
- ☑ Design the site to ensure that no leakage or spillage of paint or solvent materials can enter the stormwater system.
- ☑ Clean water based paint equipment where residue can not enter stormwater system
- ☑ Clean oil based paint equipment where material can be collected and disposed of as hazardous waste.
- ☑ Outdoor spray painting should not be undertaken on windy days.
- ☑ Follow procedures noted in the EPA's Lead Safe Fact Sheet when maintaining pre 1970's buildings.

Stormwater from Buildings

- ☑ Stormwater drains should be either connected directly into a stormwater system or pass via a grassed area of sufficient size to accommodate the size of storm required.
- ☑ Inspect the building stormwater system at least annually.
- ☑ Clean drain inlets, spouting, downpipes & pipes at least twice per year
- ☑ Identify debris and sediment "hot spot" areas and program inspections and removal of materials to minimise the potential for blockages etc.
- ☑ Arrange cleaning of spouts and inlets prior to rainy season and regularly at known "hot spots"
- ☑ After each major storm inspect inlets etc and remove debris and sediments.
- ☑ In "hot spot" areas where high siltation occurs, install catch pits/sediment basins.

14.14. Waste Collection

In retail areas, entertainment venues and sporting fields, litter bins can provide a continual source of pollutants if the type of bin, its location and frequency of emptying is not suitable. The following good practices are from the Victorian "Best Practices in Litter Management – A Guide for Local Government". This document also gives examples of bin selection, siting and emptying frequencies.

Kerb side waste collection and recycling collections generate considerable amounts of pollution through spillage and the collection and emptying processes. The amount of litter created is related to wind, lack of care by recycling and garbage operators and householders and the type of collection systems used. Other issues creating litter can include spillage from unstable smaller bins, dogs scavenging and the "pace" of the collection operation.

Good Practice Guidance:

Domestic Waste Collection

- ☑ Use vehicles which are fitted with lifting and emptying mechanisms which minimise the risk of spillage
- ☑ Require collection contractor to immediately clean up all spillage using dry methods
- ☑ Require collection contractor to immediately notify Council of the location of any spilled material not resulting from the collection operation

Waste Collection Plant & Equipment

- ☑ Keep garbage compactor, recycling collection vehicles etc, etc on hard standing (Paved) areas, as identified in Section 14.11.
- ☑ Pick up litter and rubbish dropped and sweep storage areas regularly
- ☑ Do not use a hose to clean plant & equipment unless stormwater drains are protected
- ☑ Where possible store waste collection vehicles under cover.

Recycling Containers

- ☑ Provide fully enclosed containers which include a lid
- ☑ Ensure container is of a sufficient size to cater for the volume of material deposited between collections
- ☑ Cater for all recyclable materials including newspapers

Green Waste

- ☑ Provide a fully contained receptacle storage for green waste (eg. mobile bin)
- ☑ If green waste is deposited on nature strips it should be collected on the same day as often as possible. Follow up with street sweeper to reduce pollutants where spillage is identified.
- ☑ Residue from on-site chipping to be collected or swept so that it does not enter the stormwater system. (refer Section 14.10)

Hard Rubbish Collection

- ☑ Program collection of hard rubbish so that all materials remain on nature strip for a minimum period
- ☑ Establish local laws prohibiting the storage of hard rubbish materials on nature strips to restrict the period of storage to no longer than 7 days prior to the nominated collection date

Good Practice Guidance:

Litter Collection

- ☑ Select bins that look clean, attractive and are easily identifiable
- ☑ The aperture of the bin should be small enough to discourage illegal dumping yet acceptable for normal litter
- ☑ Bin size should be based on minimising emptying frequency whilst discouraging illegal dumping.
- ☑ Bins should be located close to the source of the litter. eg. ATMs
- ☑ Frequency of emptying should be determined to ensure that bins do not overflow
- ☑ Require clearing contractor to clean up litter within specified radius of the bin.
- ☑ Bin should not to exceed 75% of full capacity before clearing
- ☑ Pick up any spilt rubbish within 3 metres of the bin
- ☑ Undertake initial audits to identify where heavily used bins are near drainage pits - make special reference to these bins in the clearance program.

Sample Contract Clauses:

Clearing of bins - Contractor should empty litter bins at frequency specified in the schedule. Not withstanding that a collection frequency for litter bins has been specified, the contractor should ensure that the litter bins are useable by the public at all times and that the volume of matter in the litter bin never exceeds seventy-five percent (75%) of the capacity of the bin.

Spilt Litter - At the time of emptying the litter bin the contractor should clean up any spilt litter within a two (or three) metre radius of the litter bin whether the spillage was caused by the contractor or other causes

14.15. Graffiti Removal

Good Practice Guidance:

- ☑ Wash down water and materials resulting from removal of graffiti to be prevented from entering stormwater system
- ☑ Temporary Inlet pit filters to be placed where required to prevent entry of pollutants
- ☑ Temporary bunding to be used to contain potential pollutants
- ☑ Site swept and any waste materials collected and disposed of at designated site
- ☑ Refer to sections 14.4 and 0.

14.16. Emergency Response

An Emergency Management Plan, which identifies procedures for response to various types of emergencies, is useful to all councils. The procedures need to include guidance on managing for spillage and other activities which may result in pollution entering the drainage system.

Good Practice Guidance:

☑ Incorporate in the Emergency Management Plan a response plan for spillages.

☑ Include a current drainage network plan in the response plan showing:

- Catchment boundary
- All inlet points (Side entry, grated pits etc)
- Location and direction of flow of the drainage network
- Location of outfalls and open water ways
- Location of environmentally sensitive areas
- Location of potential upstream spill containment sites

☑ Hazardous spills shall be immediately reported to the NSW Fire Brigades.

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PART D – URBAN LAND CAPABILITY ASSESSMENT

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16. INTRODUCTION

16.1. Background

Over 80% of the New South Wales population live in cities or towns. Compared with most rural land uses, urban development is capital intensive and usually involves significant modification of land. With escalating intensity of land use there is a parallel requirement for more detailed land resource information.

The economic and social costs associated with poor land use planning are high. It is been recognised that lack of consideration of soil and land attributes when planning new urban development, has resulted in unnecessary private and community maintenance costs or even disaster (Goldman *et al* 1986, Hannam and Hicks 1980, Hunt 1992).

Examples at least partially attributable to poor and avoidable urban land use planning include:

- destruction of habitat and amenity in waterbodies through sediment pollution associated with urban development
- poor land management associated with urban development contributing to eutrophication of water bodies. Increased nutrient, heavy metal, suspended solid and bacteria concentrations in stormwater and other urban runoff have long been recognised as degrading riparian communities (eg Bliss *et al* 1983, Banks 1990)
- repeated flooding of communities. In addition to poor location of buildings on flood-prone areas, flood hazard is increased by greater proportions of impervious surfaces contributing to higher downstream flood peaks and flow velocities
- unnecessary seasonal maintenance of buildings and infrastructure because soil reactivity was not matched to foundation design; and
- recurring and occasionally spectacular mass movement damage is a significant issue in some communities.

During the process of urban development, large tracts of land are usually denuded of a protective cover, often exposing erodible, compacted and smooth soil surfaces. Runoff from these services is usually considerably higher and remains high in the post-development phase, because of a large increase in the proportion of impermeable surfaces such as paved areas and roofs. Consequently, the risk of land degradation increases substantially both during and after urban development unless appropriate remedial actions are taken.

Consequences of poor planning are becoming increasingly critical due to:

- Expanding urban populations placing greater development pressure on agriculturally valuable lands
- Expanding populations placing greater development pressure on fragile and marginal lands where flat land with suitable soil has been almost totally urbanised
- The intensification of land use within many catchments to an extent where the ecological viability of many lakes and rivers has been severely degraded.

This Part considers the physical limitations affecting urban development. It outlines special problems encountered in urban development and introduces the concepts of *Soil Landscape Mapping* and *Urban Capability Planning* as a means of identifying and recording these limitations.

This Part focuses largely on the soil-related aspect of land capability assessment, presented in Section 18. Other water environment aspects are discussed in Section 17 and further details can be obtained from *Managing Urban Stormwater: Council Handbook*.

16.2. The Differing Needs of Organisations for Land Assessment

Participants in the planning process have different views, requirements and responsibilities. For land assessment to be useful and effective it should ideally address the needs of all involved.

- Developers and landowners are usually obliged to provide information on biophysical and other impacts of development to gain development consent. They seek adequate, cost-effective advice on site opportunities and constraints to make their own planning decisions.

- Local government and consent authorities seek information to make land use decisions with confidence. In many cases they must bear costs of mistakes arising from misinformation or errors at the development stage which may not become evident for some years after development has occurred. Local government and consent authorities therefore need objective and reliable information.

- The community requires assurance that risk of damage to the environment and community amenity from change in land use is within acceptable limits.

The aim of any development should be to undertake site earthworks and construction while at the same time protect downslope areas from the effects of sediment pollution and increased flooding.

It is in the interests of any land developer to identify the physical limitations of a particular site prior to development. By doing so, the specific limitations can be considered during the design stage and action taken to manage or overcome them. The advantage to the developer is to reduce both the construction costs and the level of future maintenance of the development. They should also be aware of the possible effects of any action done - or not done - to mitigate these limitations.

Development consent authorities should also be aware of the physical limitations of a site and the constraints they place on the development process, to ensure that it proceeds in an environmentally sound manner.

16.3. The Importance of Urban Capability Assessment

In this document urban capability is considered as the capacity of an area to sustain a proposed land use without having a significant impact on the health of aquatic ecosystems or exceeding the physical capability of the land to support the development.

Urban capability assessment is an important part of stormwater management. If an assessment is not carried out, the opportunity to mitigate many of the impacts of a development may be lost or may only be overcome at significant cost to the developer or the community. It is important that each development is tailored to the characteristics of a development site.

The optimal time for assessing urban capability in the development process is at the land use planning stage. Assessments can be undertaken as part of regional and local environmental studies, which provide the framework for regional environmental plans (REPs) and local environmental plans (LEPs) respectively. A broad assessment can be undertaken when regional studies are being prepared, with a more detailed assessment occurring for local studies.

The results of an urban capability assessment can be presented in a *Constraints and Opportunities Map*. These maps indicate the features of the water environment and any limitations imposed by the environmental and physical characteristics of the site. The maps may be presented as a series of overlays, each containing a different suite features or limitations.

This Part describes the features and limitations which may constrain a particular form of development. The relevance of the constraints will depend on the nature of the development, including the proposed management practices. For example, the constraints to the development of a walking trail adjacent to a creek will be considerably less than if a medium density housing development is proposed for the same area.

Urban capability assessment is the first stage in environmental planning to address stormwater management. The second stage involves applying water sensitive urban design principles to the land that has been identified as capable of supporting the proposed development. There is also some overlap between these two phases as the form of the development and the capacity of the site to support the development is inter-related. In turn, there is a degree of overlap between water sensitive urban design and the adoption of structural management practices (eg grass swales) as illustrated in Figure 2.

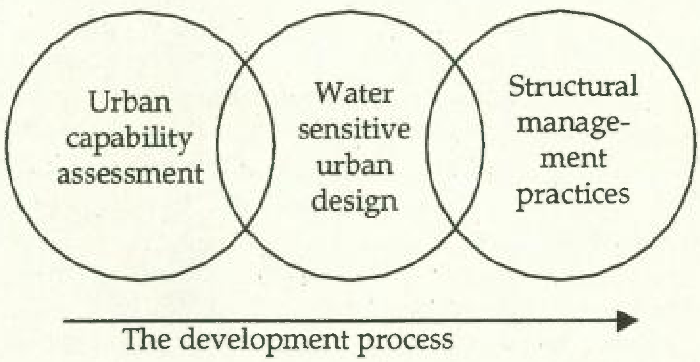

Figure 2 – Relationship between stormwater considerations in land use planning

However, where limitations can be adequately addressed, at a cost or by implementing specific treatments, development should not be automatically precluded

There can be significant cost savings associated with consideration of stormwater issues in the environmental planning process.

These can include:
- Reduced cost of earthworks and associated works (eg retaining walls).
- Reduced tree clearing costs.
- Lower servicing costs.
- Enhanced value of blocks with mature trees.
- Increased sale prices for blocks located adjacent to buffer zones.
- Reduced long-term maintenance costs incurred by local government.
- Reduced cost for implementation of structural management practices.

17. WATER ENVIRONMENT: FEATURES AND CONSTRAINTS

17.1. Features

Features of the water environment that can be relevant during an urban capability assessment are:

- **Watercourses:** Creeks, rivers and their floodplains are a fundamental feature of the water environment. The capability assessment can also include an assessment of the health of the watercourse, including its aquatic habitat and fluvial geomorphological characteristics (eg erosion patterns).

- **Lakes:** Lakes and other freshwater waterbodies receive inflows from watercourses.

- **Estuaries:** Estuaries receive both freshwater and tidal inflows.

- **Wetlands:** Both freshwater and estuarine wetlands are an important part of the water environment. Particular attention needs to be placed on wetlands nominated under State Environmental Planning Policy (SEPP) No 14.

- **Riparian and floodplain vegetation:** This vegetation is an important energy source for aquatic ecosystems and performs other important roles.

- **Foreshore vegetation:** In estuarine and coastal environments this vegetation plays a similar role to riparian vegetation.

- **Groundwater recharge areas**: Areas with significant infiltration capacity that recharge aquifers.

- **Groundwater discharge areas:** Areas which discharge groundwater (eg seeps, some swamps).

17.2. Constraints

The potential constraints imposed by the water environment on development include:

- **Flood extent**: One of the major constraints to urban development is the extent of the designated flood (eg 100 year average recurrence interval). This is discussed further in the *NSW Floodplain Development Manual.*

- **Buffer zones**: Buffer zones can be located around all waterbodies, although their width will vary with the type of waterbody (and stream order). Their primary functions include filtering pollutants from overland flow and reserving areas of riparian, floodplain, and foreshore vegetation. They may also act as wildlife corridors.

- **Existing water quality**: If existing water quality within a catchment is degraded, a decision may be made that no further urban development should occur until actions are taken to improve water quality.

Figure 3 is an example of a water environment feature and constraints plan.

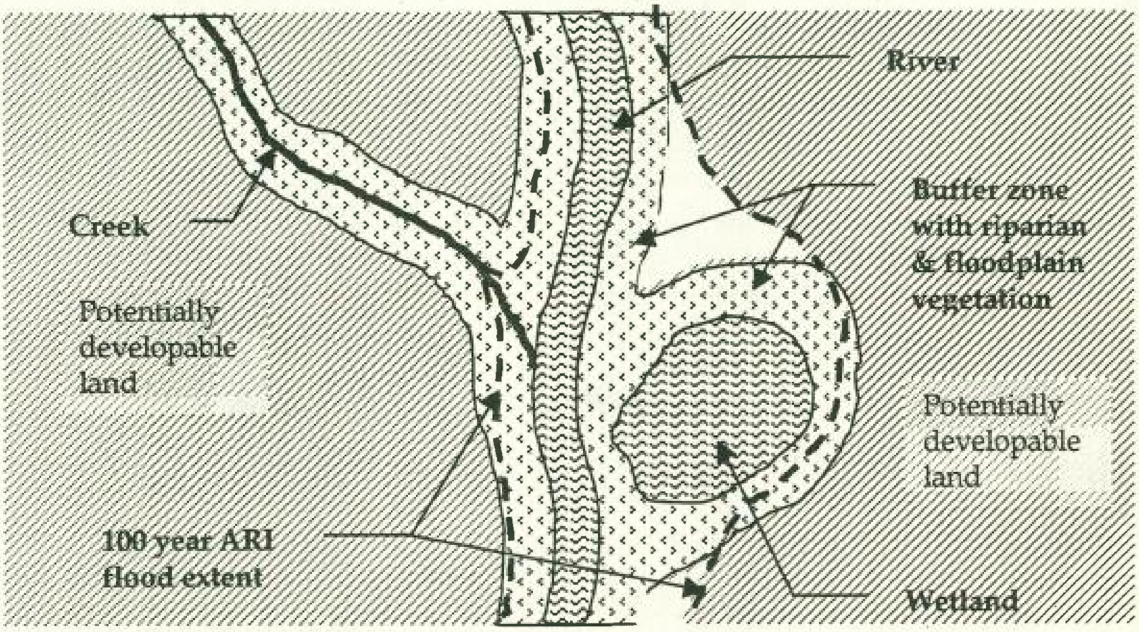

Figure 3 – Water environment constraints map (example)

18. LAND ENVIRONMENT: FEATURES AND CONSTRAINTS

18.1. Categories of Features and Constraints

The physical features and constraints of a site can be divided into two broad categories:
- landscape qualities and limitations; and
- soil qualities and limitations

This information should be based on examination of soil and landscape facts. The assessment should not prescribe solutions or judge the proposal; instead it should serve as a tool for individuals, groups and the community to achieve informed and sustainable land management.

Sections 5.1 and 5.2 discuss a range of soil and landscape qualities and limitations that may constrain urban development or the revegetation of disturbed areas.

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18.2. Landscape Qualities and Limitations

Landscape qualities and limitations are land-related properties that can affect land use. The effect is positive in the case of qualities and negative in the case of limitations, and will vary with site conditions and land use. The following qualities and limitations are listed for each soil landscape in Soil Landscape Reports and in each soil landscape description. Where qualities or limitations are not widespread throughout the landscape, they are noted as being localised.

Landscape qualities and limitations usually considered in land capability assessment are:

- Dieback
- flood hazard
- groundwater pollution hazard
- inherent erosion risk
- permanently high watertable
- potential/known discharge area
- productive arable land
- rock outcrop
- salinity (dryland/irrigation induced)
- seepage scalds
- sheet erosion risk
- steep slopes
- drainage
- engineering hazard
- gully erosion risk
- mass movement hazard
- poor moisture availability
- potential/known recharge area
- rockfall hazard
- run-on
- seasonal waterlogging
- shallow soils
- soil fire hazard
- wind erosion risk

These terms are described in the glossary (Appendix C).

18.3. Soil Qualities and Limitations

Soil qualities and limitations are properties that can be assessed on an individual soil material basis and can affect the viability and sustainability of land uses. The effect of any particular soil quality or limitation may be positive or negative and will vary with site conditions and land use. In a Soil Landscape Report, qualities and limitations are listed for each soil material and in each soil landscape description. Where soil qualities or limitations are not widespread throughout a landscape a localised qualifier may be used.

Soil qualities and limitations usually considered in land capability assessment are:

- (potential) acid sulfate soils
- alkalinity
- plant available waterholding capacity
- fertility
- non-cohesive soils
- permeability
- poor seedbed conditions
- shrink-swell potential
- soil acidification hazard
- water repellence
- periodically frozen soil (frost action potential)
- acidity
- aluminium toxicity potential
- erodibility
- hardsetting surfaces
- organic soils
- plasticity
- salinity
- sodicity/dispersion
- stoniness
- wet bearing strength at field capacity

These terms are described in the glossary (Appendix C).

18.4. Soil Landscape and Urban Capability Mapping

The physical qualities and limitations to urban development can be depicted by soil landscape mapping or urban capability assessment. Landscape mapping is a broad-scale approach applicable for regional planning, where as urban capability mapping is suited to assessing the capability of a particular site.

There are a number of possible approaches to urban capability assessment from the perspective of physical limitations. The approach used in NSW since the early 1980's (Hunt 1992) assesses general urban capability. A more recently developed technique (Chapman *et al* 1992; Morse *et al 1992*), known as Specific Urban Capability, is more extensive, and assesses the capability of the land to support a particular form of development.

18.5. Soil Landscapes

It is intended that soil landscape maps and accompanying reports be prepared for all of eastern and central NSW, based on standard 1: 100 000 topographic sheets.

The soil landscape map concept permits the integration of both soil and landform constraints into a single mapping unit because similar causal factors are involved in the formation of both landscapes and soils. Similarly, constraints to rural and urban development of land are related to both landscape and soil qualities.

The soil landscape maps provide a soil and landscape inventory of the area and identifies major soil and landscape qualities for urban development. The map and report are intended to assist the planning and development process and are designed to provide soil and landscape resource information that can be easily understood.

Capability statements in the reports are intended for regional planning purposes. For detailed planning at the local level, more intensive capability assessments dependent on additional information are often necessary. Additional site-specific factors such as slope angle, position on slope, terrain element and specific soil conditions need to be examined and, where necessary, geotechnical engineering reports obtained.

Landscape limitations identified in the reports have caused major continuing problems such as flooding, cracking of roads and buildings, sedimentation of streams and blocked drains. These are all expensive problems to overcome. If limitations for urban development are taken into account during planning, design and construction phases, these unnecessary long-term costs can be reduced or avoided.

19. URBAN CAPABILITY

19.1. Data Sets Required for Urban Capability Planning

Urban land capability investigations are based on information collected for an inventory of physical data including geology, landform, soils and surface drainage. These data when combined in association with climatic data, indicate limitations to urban land use, are used to derive urban capability classes. The physical data includes:

- **Geology:** General geological descriptions, as applied to the formation of the landscape and soils, are included in certain localities, with terrain and soils subject to slope instability, geological factors such as structural formations and rock types strongly influence stability.

- **Landform:** Landform affects urban land capability both directly and indirectly. The land surface with it's topographic variations made up of slopes, local relief amplitude, natural drainage courses and catchment basins can influence the cost of urban development directly by determining the area of land that can be practically developed. Landform is a composite of two individual components; namely slope gradient interval and terrain class.

- **Slopes:** Landform classification using a series of slope intervals (0 - 1%, 1-5% etc.) identifies potential differences in the land surface's reaction to different intensities of utilisation within one type of land use e.g. high density, medium density and low density residential uses.

19.2. Broadscale Urban Capability

The Framework

Urban capability mapping is developed from an assessment of the interaction between the landform, soils and hydrological features of proposed urban lands. It is designed to assist responsible planning and management in developing urban areas.

The urban land capability classification developed by Hannam and Hicks (1980) entails collection of data on soils, landform, drainage, erosion and geology, and the evaluation of these data in relation to proposed urban uses. Out of this evaluation, urban capability maps are produced.

The resultant map indicates physical constraints to conventional urban development and, in light of these, the maximum intensities of urban use the different areas will accept and the management and protective measures required to prevent degradation.

This broadscale urban capability procedure divides land into five primary classes, as noted in Table 4.

Depending on the detail required for a particular study, the categories may be further divided into sub-classes on the basis of the types of constraints affecting different areas. For this purpose, the classes have subscripts attached with each subscript indicating a particular constraint. These are noted in Table 5.

Table 4 – General Urban Capability Classes

Class	Description
A	Areas with little or no physical limitations to urban development.
B	Areas with minor to moderate physical limitations to urban development. These limitations may influence design and impose certain management requirements on development to ensure a stable land surface is maintained both during and after development.
C	Areas with moderate physical limitations to urban development. These limitations may be overcome by careful design and by adopting site management practices to ensure the maintenance of a stable land surface.
D	Areas with severe limitations to urban development which will be difficult to overcome, requiring detailed site investigation and engineering design.
E	Areas where no form of urban development is recommended because of very severe physical limitations which are very difficult to overcome.

Table 5 – General Urban Capability Constraints

Soil Limitations:		Other Limitations:	
Subscript	**Limitation**	**Subscript**	**Limitation**
c	Very high permeability	F	Flooding
d	Shallow soil	M	Mass movement
e	Erodibility	R	Rock outcrop
g	Low wet strength	S	Slope
l	Salinity	T	Topographic feature (wave erosion, rock fall, run-on, etc)
p	Low permeability	W	Seasonal waterlogging
v	Shrink/swell	Y	Swamp (ie permanently high water table)

Subclass B-sv, for example, represents land with moderate physical constraints to urban development, the constraints being slope and shrink-swell characteristics of the soil. Similarly, subclass E-m represents land with an extreme constraint to urban development, the existence of a mass movement hazard.

Using this approach, the classification system divides an area into a number of homogenous units which have been evaluated on the basis of their potential for urban landuse and management. These classes help planning authorities to assess development proposals and a range of landuses which are compatible with site conditions.

These classes should not be used as a basis to preclude development in their own right. Specific sites require consideration of all factors, constraints and limitations, as well as techniques for managing each factor.

Broadscale urban capability is useful for broad planning purposes at a regional level. However, for more detailed land use planning, specific urban capability information can be obtained for more precisely defined land uses.

Steps Involved in Broadscale Urban Capability Assessment

Information collected for an inventory of physical data (geology, landform, soils and surface drainage), in association with climatic data indicate limitations to urban land use and, when combined, is used to derive the urban capability. The steps involved in broadscale urban capability assessment are noted in Figure 4 (Hannam and Hicks, 1980).

An extract from a broadscale urban capability map is presented in Figure 5.

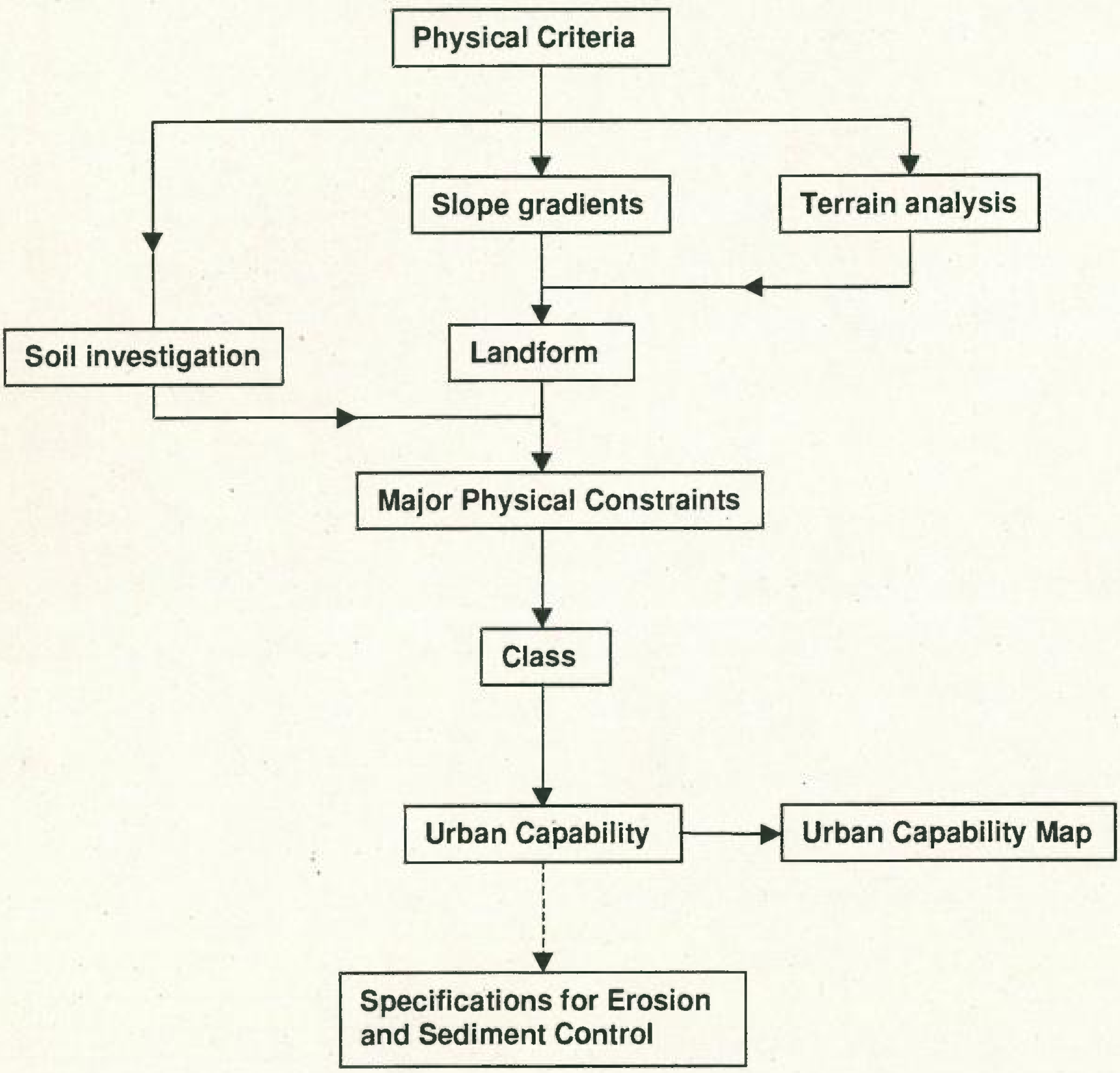
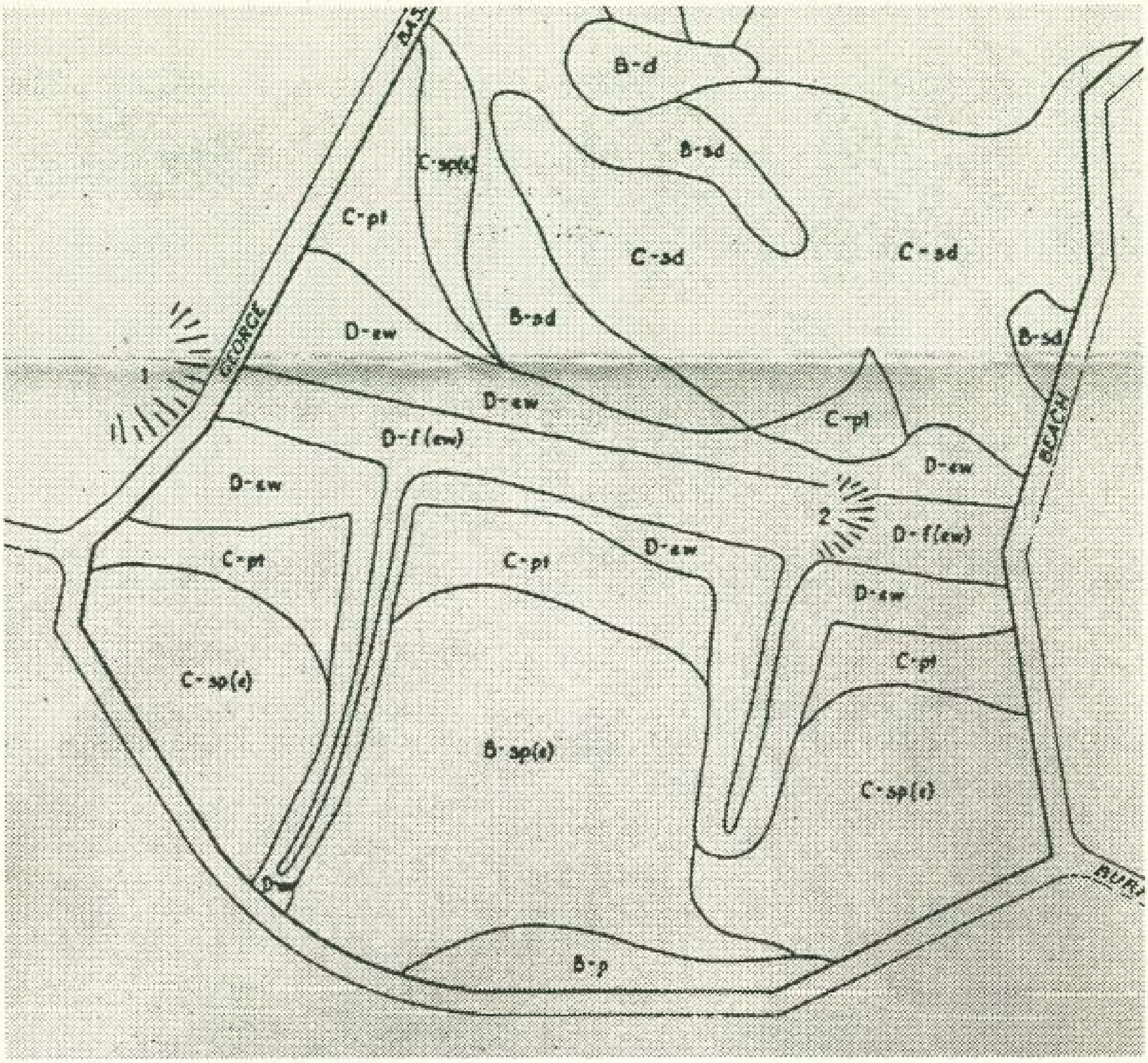


Figure 4 – Steps involved in Broadscale Urban Capability Assessment
(after Hannam and Hicks 1980)



Legend:

Degree of Limitation	Major Limitation	Capability	Class
Minor – moderate	Shallow soil	Extensive Building complex	B – d
Minor – moderate	Permeability	Extensive Building complex	B – p
Minor – moderate	Slope, shallow soil	Residential	B – sd
Minor – moderate	Slope, permeability, erodability	Residential	B – sp(e)
Moderate	Slope, shallow soil	Residential	C – sd
Moderate	Slope, permeability, erodability	Residential	C – sp(e)
Moderate	Permeability, topographic location	Low density residential	C – pt
Severe	Slope, shallow soil	Strategic residential	D – sd
Severe	Flooding, erodability, waterlogging	Drainage reserve	D – f(ew)
Severe	Erodability, waterlogging	Reserve	D – ew

Figure 5 – Example Broadscale Urban Capability Map
(Hannam and Hicks 1980)

19.3. Specific Urban Capability

Introduction

In this section, land capability assessment is defined as 'the systematic arrangement of land into various categories according to their capability to sustain particular land uses without land degradation' (Houghton and Charman 1986). The land and water attributes investigated include soil, landform, hydrology and existing sources and levels of pollution. The section discusses specific urban land capability assessment and its application.

Chapman *et al* (1992) have distinguished specific urban land capability from the traditional form of broad urban land capability assessment that has been used in Australia to date. They propose that the former system is far more suitable for:
- assessing capability for semi-detailed land uses (eg. residences that require pier foundations rather than raft slab construction); and
- application to detailed local planning.

Specific urban capability is the ability of a parcel of land to support a particular intensity of urban development without serious erosion and sedimentation occurring during construction, as well as possible instability and drainage problems in the long term (Houghton and Charman 1986). Specific urban capability is ranked on the basis of the severity of the limitations that are likely to affect urban land uses (Hannam and Hicks 1980). There are three classes:

1. **low limitations** for urban development are areas with little or no physical limitations. Standard building designs may be used;
2. **moderate limitations** may influence design and impose certain management requirement on developments to ensure a stable land surface is maintained during and after development. These limitations can be overcome by careful design and by adoption of site management techniques that ensure land surface stability;
3. **high to severe limitations** for urban development include areas with limitations that are difficult to overcome, requiring detailed site investigation and engineering design. Some areas may be so unsuitable for urban development that they are best left undisturbed.

While none of the specific capability classes exclude any particular form of urban development, they do provide land planners and managers with valuable information to aid their decisions, including the identification of constraints and possible measures or strategies to address them. The process may finally result in any particular parcel of land being unsuitable for development because the cost involved in addressing the constraints, and the maintenance implications cannot be met at that time. Alternatively, the information can be used to derive a set of 'development standards'.

Proper analysis of both site and downslope constraints to urban development is an important prerequisite to identification of suitable remedial actions. To this end, a system of classifying urban lands in terms of land capability is required to aid in identifying constraints to development. These constraints can form an integral part of the planning process.

In addition to dealing with matters relating to land suitability, land capability information can provide a basis for soil and water management plans to be prepared for the construction process. These plans contain a range of management practices which are intended to minimise soil erosion and water pollution. Further details are contained in *Managing Urban Stormwater: Soils & Construction.*

It is recognised that some of the details of the urban capability assessment process will evolve over time. Further new technology and design solutions, together with changing community expectations, may require that land currently classified with a low urban capability is managed in a way that changes the suitability of land to permit particular usage and development

The Framework

The system of specific urban land capability assessment involves the identification and delineation of similar land units based essentially on the degree of climatic, geomorphological and pedological constraints, each considered in terms of a particular form of land development. The process:

- assumes that different forms of urban land uses affect the likelihood of land degradation differently. For example, some forms of land use increase the soil erosion hazard much more than others, and this needs adequate consideration in the assessment process; and

- takes into account that different land uses have different land requirements. For example, a very steep slope may be a limitation to development of urban lands but where the extra cost associated with architect design of a dwelling is not a barrier, on-site control of sediment pollution is possible and the high cost of site rehabilitation can be met, the limitation can be overcome.

The three classes of specific urban capability in this system are defined in Table 7. Each capability class indicates progressively greater constraints to development. A fourth class has been included to allow for sites where further assessment is required. For example, where the land, soil or water constraints are unable to be delineated adequately at the scale of mapping and/or where further detailed site investigations are necessary.

The specific urban capability class that may apply to any land unit is dependent upon the relationship between two variables:
- the particular form of intended land use; and
- the constraints present and their degree.

Steps involved in Specific Urban Capability Assessment

The steps that can be followed in Specific Urban Capability Assessment are noted in Figure 6, and described below.

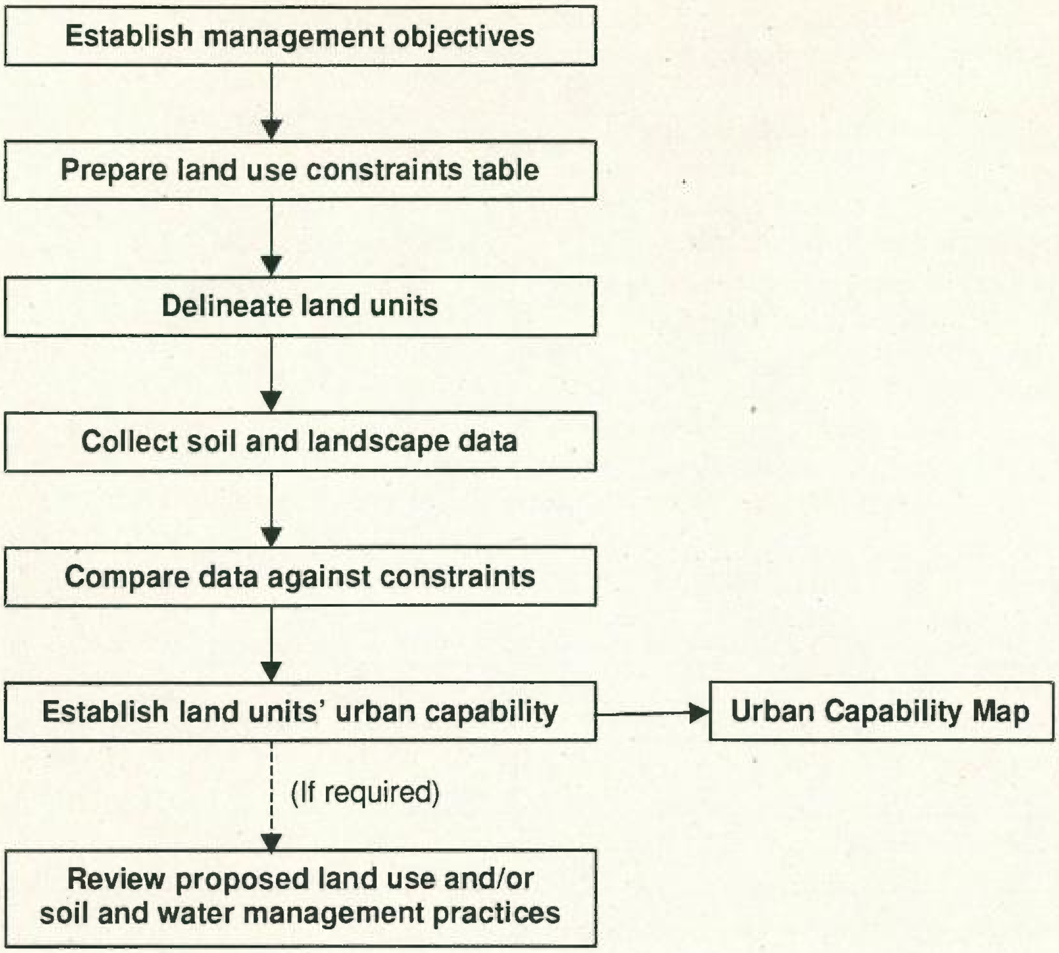


Figure 6 - Steps involved in Specific Urban Capability Assessment

1) Establish Management Objectives

The initial step in the assessment process generally involves establishing the framework for the assessment. The developer or landowner and the consent authority can be consulted regarding the proposed land uses for the study area. In addition, the consent authorities can also be consulted to determine the level of off-site impacts (if any) acceptable. In some cases a reconnaissance survey of the study area may be required. These may be specified in a council stormwater management plan (refer to *Managing Urban Stormwater: Council Handbook* for further details).

2) Prepare Land Use Constraints Table(s)

Specific land use constraint tables can be prepared for the proposed land uses for the site. Sample specific land use are major distributor roads, local access roads, high density residential, low cost housing, rural large lot residential, commercial allotments, passive recreation requiring major earthworks. These tables can outline the soil and landscape constraints that may influence the nature of development of a site. The tables can also include a qualitative assessment of the extent to which the constraint may influence development. Different kinds of development may be affected differently by the same group of constraints and different land use constraints tables can therefore be prepared each land use. The potential constraints that can be included in a table include:

- depth to bedrock or hardpan
- reactive soil
- depth to permanent watertable
- mass movement hazard
- concentrated flow erosion hazard
- potential acid sulphate soils
- seasonal waterlogging
- soil wet strength
- slope gradient
- flooding hazard
- soil loss class
- salinity hazard
- soil hydrologic group

An example table for standard residential urban development is provided in Table 6. This table is not exhaustive and the boundaries at the break between low, moderate and high degree of constraint are not fixed. Further, these boundaries may vary with different forms of intended land use. The table is presented to show how categorisation of degree of constraint can be objective, with the boundaries between various classes clearly indicated

Table 6 – Constraints for Urban Development (example)

Land Attribute	Degree of Constraint			Mapping Symbol	
	Low	Moderate	High	Moderate	High
Depth to bedrock or hardpan (m)	>1.0	0.5-1.0	<0.5	r	R
Soil wet strength	Low	moderate	high	g	G
Reactive soil[1]	$\psi_s \leq 20$	$20 < \psi_s \leq 40$	$\psi_s > 40$	v	V
Slope gradient (%)	<8	8-15	>15	s	S
Depth to permanent watertable (m)	>0.75	0.3-0.75	<0.3	y	Y
Flooding hazard	<100 yr ARI	na	>100 yr ARI	f	F
Mass movement hazard	No	na	Yes	m	M
Soil loss class[2]	1	2	3	e	E
Concentrated flow erosion hazard[3]		moderate	high	c	C
Salinity hazard	Low	moderate	high	d	D
Potential acid sulfate soils[4]	>3 m depth	≤3 m < 1m depth	≤ 1m	a	A
Soil hydrologic group[5]	A, B	C, D	na	h	H
Seasonal waterlogging	No	Yes	na	w	W

Source: adapted from Department of Housing (1992) and USDA (1983)
Notes:
[1] to Australian Standard AS 2870 (1986)
[2] Rosewell (1993)
[3] based on subsoil dispersibility and susceptibility to concentrated flow (gully) erosion
[4] as defined by EPA (1995)
[5] USDA (1983), *Managing Urban Stormwater: Soils & Construction*

These tables may be established for common urban land uses across New South Wales and use standard soil and land attributes, such as those in McDonald *et al* (1990). Tables may, for example, be adapted from prescriptive interpretations, mostly after Rowe et al (1981), Wells and King (1989) and USDA (1983). Construction of further tables may follow the steps outlined by FAO (1983).

3) Delineate Land Units

Land units are tracts of land that can be treated separately for meaningful land assessment. All land allocated to a particular land unit can be expected to have the same rating for the proposed specific land use. This delineation is most likely to be appropriate when a number of land uses are proposed for a site and the land use constraints tables differ, and when there are significant differences in soil or landscape characteristics. This may be an iterative process, as additional land units may need to be delineated when the soil and landscape data is collected.

4) Collect Soil and Landscape Data

The type of soil and landscape data collected is based on the relevant specific land use constraints table(s). The areas of interest are surveyed and data collected for the land units in quantities relevant to the intensity, detail and scale required of the development (eg Morse *et al* 1991). Prior to undertaking fieldwork, any existing data on the site should be collated from sources such as the Department of Land and Water Conservation and the local council. The fieldwork can then focus on addressing gaps in any existing information.

5) Establish Land Units' Urban Capability

Land attribute data in each land unit present on the development site are evaluated for each relevant specific land use suitability table to determine the degree of constraint of the land unit for the specific land use. This means the number of ratings for a survey may equal the number of specific land uses multiplied by the number of land units. This involves relating the soil and landscape data to the specific land use constraints tables for each land unit. The degree of constraint is then determined by the most limiting land attribute. Land capability is defined as the lowest suitability ranking for the specific land uses which comprise the urban land use.

An overall urban capability map can be produced that highlights the degree to which the site's characteristics constrain the proposed development. Urban capability classes can then be allocated to the proposed land units using the protocol noted in Table 7.

Table 7 - Specific Urban Capability Classes

Class	Description
1	The particular land use is acceptable, with any land, soil or water constraints occurring only at a low degree
2	The particular land use is acceptable. However, one or more land, soil or water constraints exist at a moderate (but not high) degree and which require specialised management and/or construction techniques.
3	The particular land use may not be acceptable. However, one or more land, soil or water constraints occur at a high degree and should be subject to special approval by the development consent authority. Usually such constraints are dependent on further specialised geotechnical/engineering, soil or water conservation advice.
X	This special class includes areas with a very high variability of land, soil or water constraints which are unable to be delineated adequately at the scale of mapping and/or where further detailed site investigations are necessary.

If required, separate maps could also be produced showing the nature and/or degree of constraint of each relevant specific land use.

Each similar land unit identified in the urban capability mapping process can be labelled with a land unit code. For consistency it is recommended that the first figure in this code should be the Specific Urban Capability Class and followed by symbols representing the constraints (Table 6). These latter symbols can be shown where the degree of constraint is moderate or high, with those which are high listed first and in uppercase. Symbols can be omitted where the degree of constraint is low.

Maps of specific urban capability may be presented separately for each form of intended land use. Alternatively, a single map may be presented with the capability summarised in tabular form for each land unit and proposed land use, with Table 8 being an example.

Table 8 – Example Specific Urban Capability Summary Table

Land unit code shown on map	Area (%) approx.	Urban capability	
		Major distributor roads	Regular residential low cost
Rh/3/C/2	15	2es	3Es
Rh/1/A/1 etc.	10	2re	3Re

The specific urban capability system is ideally suited to the application of Geographical Information System (GIS) technology. GISs contain a powerful set of tools for collecting, storing, retrieving, displaying and analysing data in a spatial format. Standard land use constraints tables (eg Table 6) can be stored in the relational databases of a GIS.

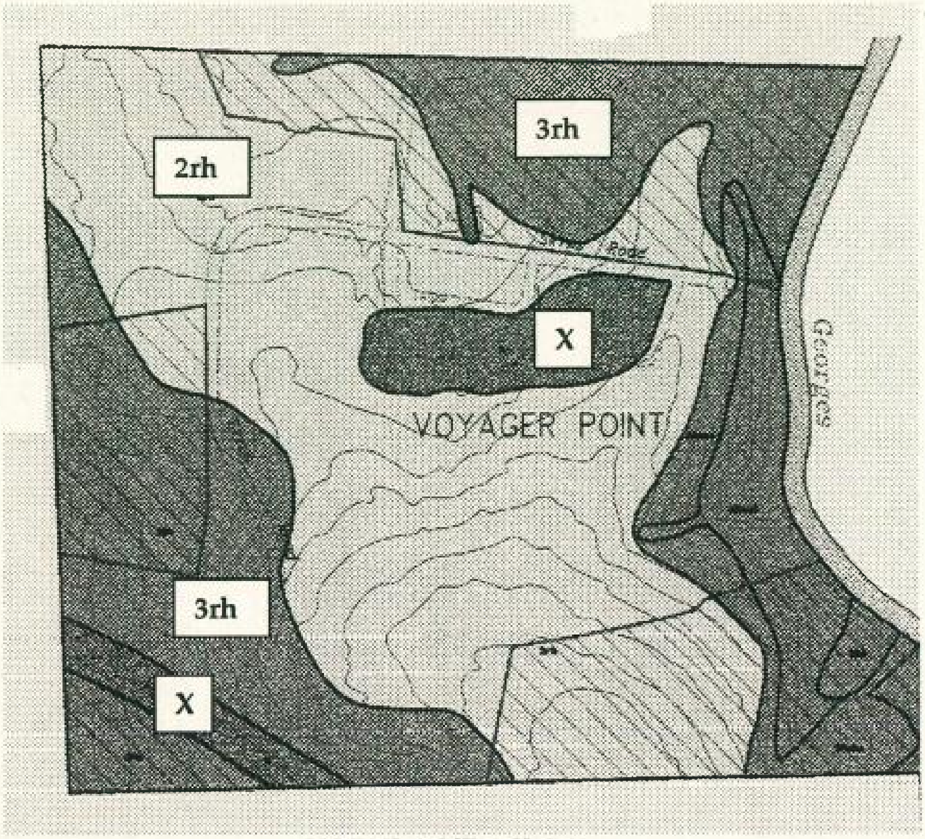
Land capability reports should include the relevant specific land use constraints tables and note any variations to the accepted analysis techniques. It is also important that all the data, interpretations and ratings are verified as authentic and representative of the site.

An example specific urban capability assessment map is presented in Figure 7.

6) Review proposed land use and/or soil and water management practices

In some cases it may become apparent that some specific land uses have an unacceptable degree of constraints at particular sites. In these cases three alternative actions can be considered:

- the nature of the development is altered and reassessed;
- alternative land management practices (such as maintenance or land management) may be used to lessen the impact of some constraints; or
- the proposed development does not proceed in its proposed form.



Urban Capability Classes

Class	Description
1	The particular land use is acceptable, with any land, soil or water constraints occurring only at a low degree
2	The particular land use is acceptable. However, one or more land, soil or water constraints exist at a moderate (but not high) degree and which require specialised management and/or construction techniques.
3	The particular land use may not be acceptable. However, one or more land, soil or water constraints occur at a high degree and should be subject to special approval by the development consent authority. Usually such constraints are dependent on further specialised geotechnical/engineering, soil or water conservation advice.
X	This special class includes areas with a very high variability of land, soil or water constraints which are unable to be delineated adequately at the scale of mapping and/or where further detailed site investigations are necessary.

Constraints to Broad Urban Development

Land Attribute	Degree of Constraint			Mapping Symbol	
	Low	Moderate	High	Moderate	High
Depth to bedrock or hardpan (m)	>1.0	0.5-1.0	<0.5	r	R
Soil wet strength	low	moderate	high	g	G
Reactive soil	$\psi_s \leq 20$	$20 < \psi_s \leq 40$	$\psi_s > 40$	v	V
Slope gradient (%)	<10	10-15	>15	s	S
Depth to permanent watertable (m)	>0.75	0.3-0.75	<0.3	y	Y
Flooding hazard	<100 yr ARI	na	>100 yr ARI	f	F
Mass movement hazard	No	na	Yes	m	M
Soil loss class	1-2	3-4	5-7	e	E
Concentrated flow erosion hazard	moderate	high	na	c	C
Salinity hazard	low	moderate	high	d	D
Potential acid sulfate soils (depth)	>3 m	≤3 m < 1m	≤ 1m	a	A
Soil hydrologic group	A, B	C, D	na	h	H
Seasonal waterlogging	No	Yes	na	w	W

Figure 7 – Example Specific Urban Capability Map

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PART E – WATER SENSITIVE URBAN DESIGN

21. OVERVIEW

Following identification of land broadly suitable for a development (Part D), the form of the development can be based on water (or environmentally) sensitive urban design principles. These principles are based on minimising the impacts of development on the total water cycle and maximising the multiple use benefits of a stormwater system.

The overall goals of water sensitive urban design are:

- preservation of existing topographic and natural features, including watercourses and wetlands;
- protection of surface water and groundwater resources; and
- integration of public open space with stormwater drainage corridors, maximising public access, passive recreational activities and visual amenity.

The broad principles of water sensitive urban design include:

- minimising impervious areas
- minimising use of formal drainage systems (eg pipes)
- encouraging infiltration (where appropriate)
- encouraging stormwater reuse

Water sensitive urban design principles can be adopted at a range of development scales, including:

- the overall extent of proposed development areas;
- the road and block layout within a development; and
- development forms on individual blocks.

Potential water sensitive design techniques include:

- inclusion of natural habitats (eg watercourse) within the development area, primarily within open space areas. This includes the provision of buffer zones adjacent to watercourses and other waterbodies;
- integration of major (above ground) stormwater systems as positive features within the urban design rather than purely functional elements to be 'hidden' (eg avoiding back fences adjacent to drainage reserves);
- adoption of water sensitive road development standards. These can included reduced pavement widths and the use of grass swales in place of kerb and gutter and piped stormwater drains;
- use of compact development forms. For example, reducing individual block sizes and increasing communal open space (and stormwater drainage) areas to achieve the same density as a standard residential development; and
- water sensitive car park design. This can include substitutes for impervious surfaces such as pavers or reinforced grass, particularly in infrequently used parking areas. Runoff can also be managed by grass swales instead of kerb and gutter and piped drainage systems, and the infiltration of runoff can also be considered.

Further details on water sensitive design techniques can be found in:

- *Better Drainage: Guidelines for the Multiple Use of Drainage Systems*, Department of Planning.

- *Planning and Management Guidelines for Water Sensitive Urban (Residential) Design*, Whelans, et al, Western Australia
- *Sustainable Water: Best Practices*, Hornsby Shire Council.
- *Site Planning for Urban Stream Protection*, Metropolitan Washington Council of Governments.

Additional resource material is noted in the Bibliography.

22. EXAMPLES

Figure 8 illustrates the contrast between the conventional treatment of a 'drainage reserve' and the incorporation of a stormwater system within open space.

Other examples of water-sensitive urban design are presented in Figures 2 8. These figures illustrate:

- a technique for incorporating a 'natural' channel system in a residential area (Figure 9)
- an approach for runoff management from a business park (Figure 10)
- stormwater management techniques for urban bushland (Figure 11)
- approaches to stormwater management from a district park and sports field (Figure 12 and Figure 13); and
- an approach to stormwater management from a single residential dwelling (Figure 14).

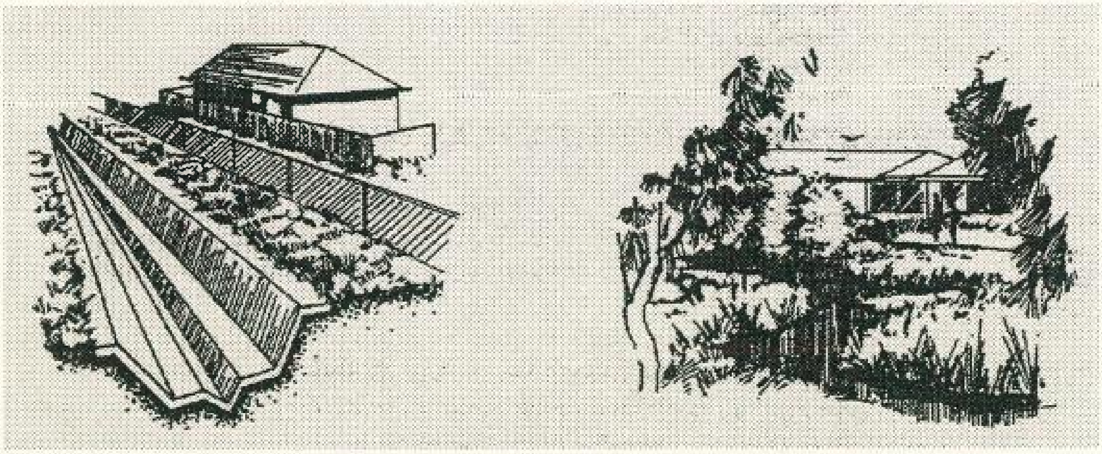

Figure 8 -- Conventional and water-sensitive stormwater systems
(after Whelans et al 1993)

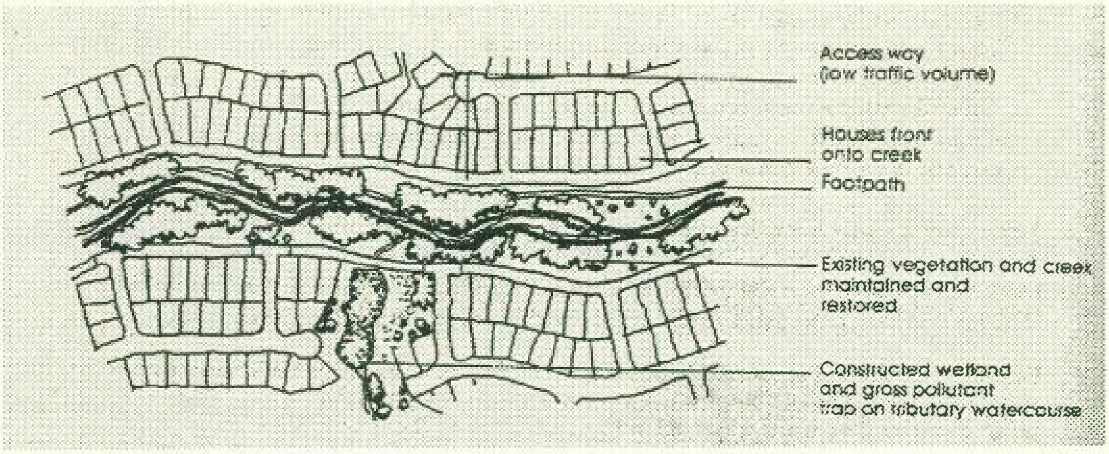

Figure 9 – Integration of a watercourse in a residential area

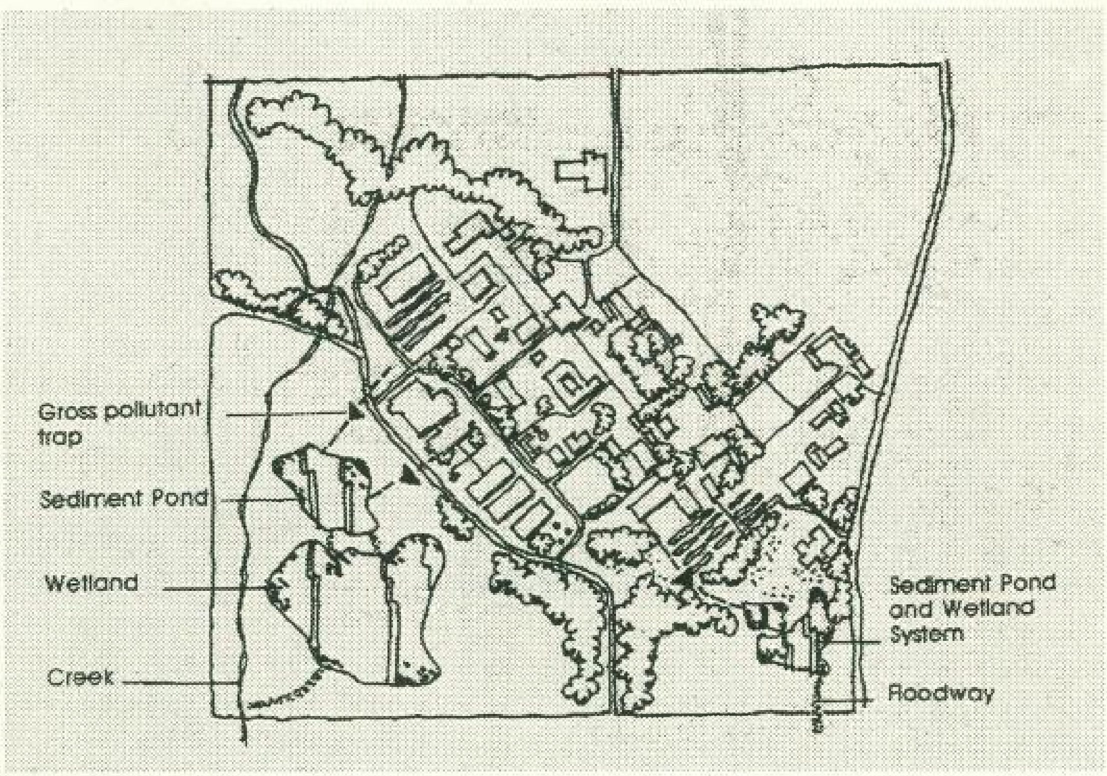

Figure 10 - Water-sensitive business park

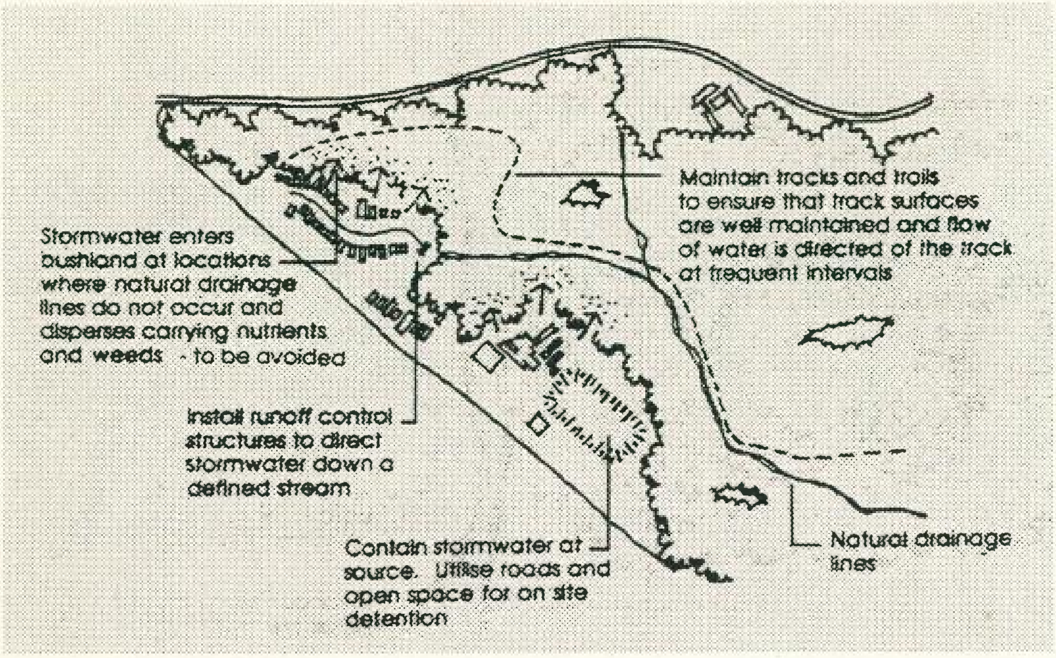

Figure 11 - Stormwater management of urban bushland

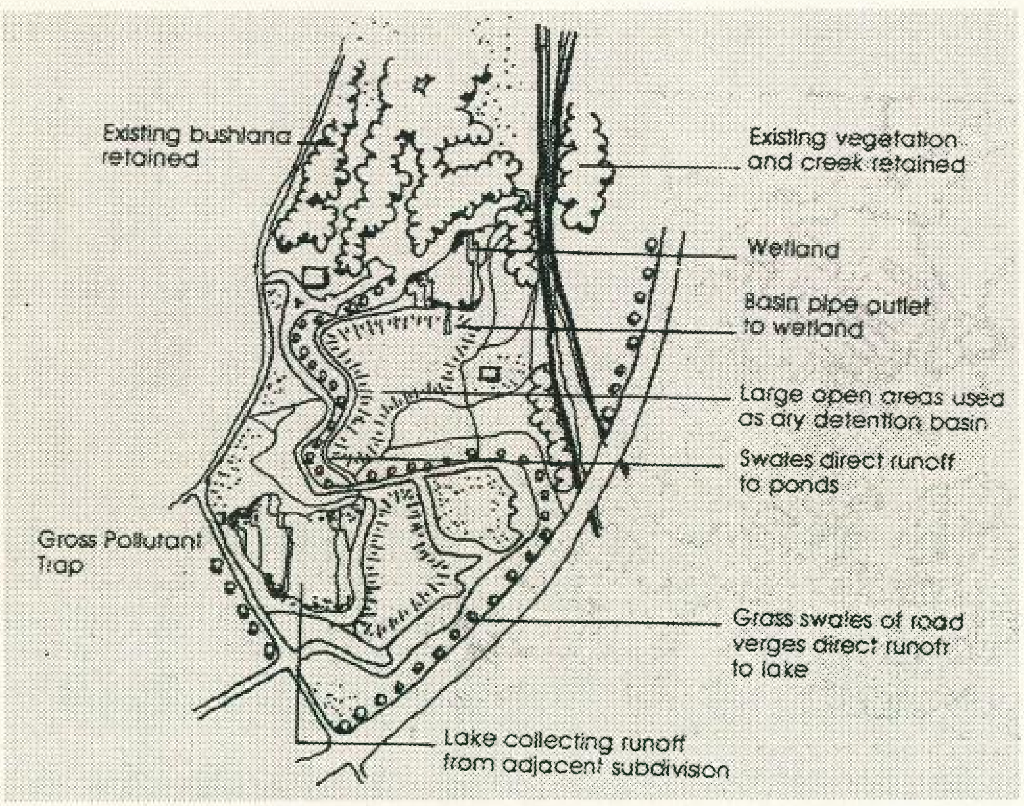

Figure 12 - Water-sensitive district park

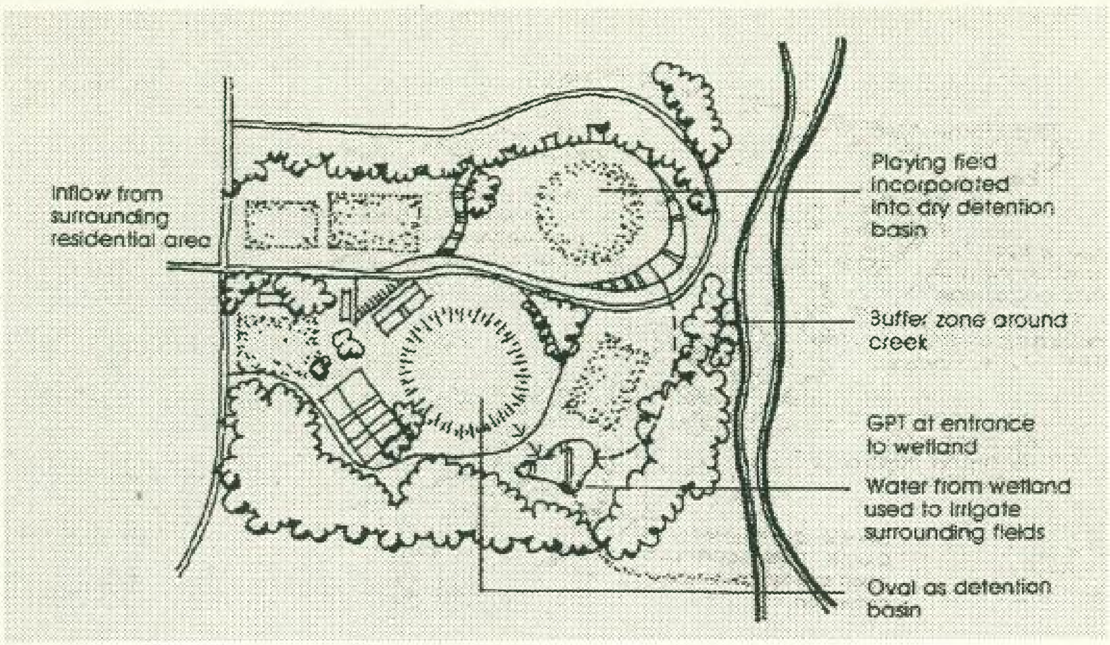

Figure 13 - Water-sensitive sports field

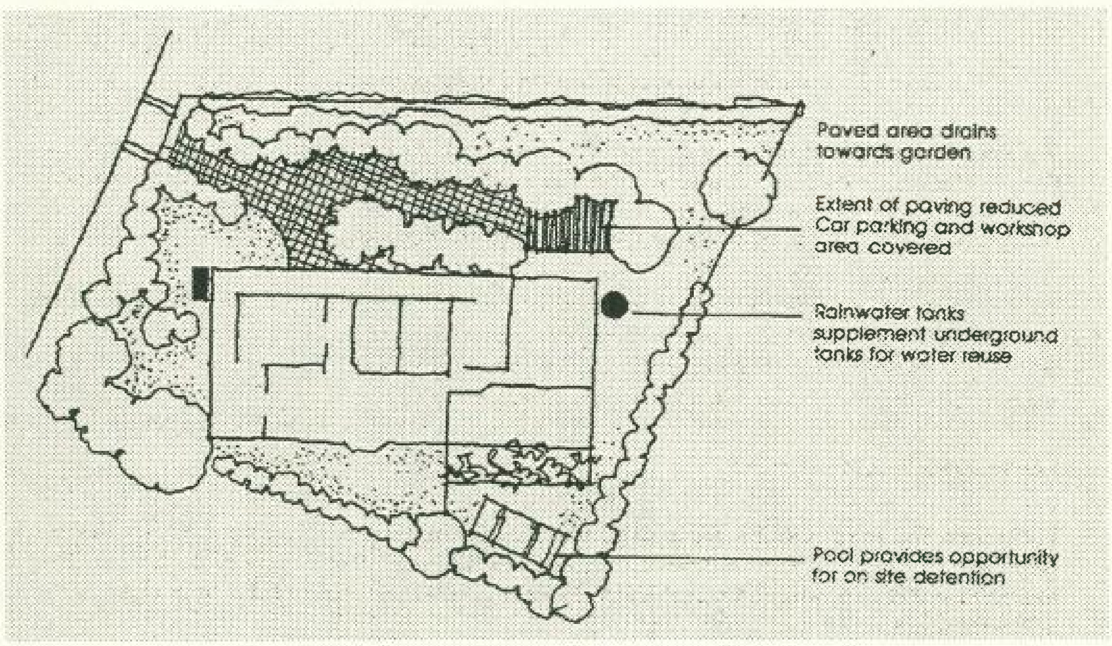

Figure 14 - Water-sensitive dwelling

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APPENDIX A: STORMWATER EDUCATION HYPOTHETICALS

Hypothetical Metropolitan Council: Community profile

- The population is over 150 000 with about 15 % being non-English speaking backgrounds (NESB). There are three main NESB Groups made up of migrants who have arrived in Australia only recently and people who are medium term settled (5-15 years).
- Family units have predominantly a lower middle income. Local employment comprising of some medium sized manufacturing and small enterprises in the retail, motor vehicle and transport industries. Most people work outside the council area. Access to public transport and traffic congestion is a difficult issue for council.
- There is 1 large retail centre and some ribbon retail development and one main sporting facility and interest in sports is high.
- Local sub communities hold events, fairs from time to time. The NESB communities have their own cultural events. There is local newspaper with a foot print (i.e. it is read) across a number of Council areas but no local TV or radio station.
- Council usually communicates with its community via:
  - Press releases to the local paper;
  - Brochures in rates notices;
  - Display boards in council offices and libraries;
  - Letters to residents in the locality of a proposed development; and
  - Public meetings.

Metropolitan Stormwater Issue: Litter in watercourses

Cause	Effect	Infrastructure intervention	Education targets	Possible education interventions
Litter from strip shopping area and residential streets is being washed or blown into stormwater drain and then washed into Example Creek	Litter entwined in vegetation along Example Creek ruins the appearance of the creek. Unkempt appearance encourages dumping of garden waste in riparian reserves Litter washed down stream to lake where it poses a threat to birds and wildlife	Gross pollutant trap stormwater outlet to Example Creek	Local community living close to GPT or that use the catchment Sub groups: shoppers gardeners local householders store managers adolescents (Shopping centre has high use before and after school by students)	**gardeners and local householders** • signage at the GPT site • Community planting day to rehabilitate the site • sponsor local group to maintain planted areas **shoppers** • press releases/editorial for local paper • signage on the street • street theatre **shoppers and gardeners** • launches/open day • fliers/information sheets **store managers** • fliers/information brochures • Council sponsorship program for street pots or trees in return for retailers sweeping the path and gutter regularly **Adolescents** • presentation at school assembly or in classes • integrate with school lessons using debates or surveys (contact teachers well in advance) • signage in the retail areas

Metropolitan Stormwater Issue: Oil and Grease impacting on in stream biota

Cause	Effect	Infrastructure intervention	Education targets	Possible education interventions
Stormwater entering Example Creek from industrial area frequently has an oil sheen after low intensity rainfall events	Oily residue evident in sediment at the inlet to example creek indicates possible localised ecological impact on creek communities	Nil - Oily water separator or under over weir not feasible	Wreckers Automotive repairers Service stations	• face to face visits alerting business to the issue • small business information packages • information evening at function room in a local club or hotel • organise a site visit to a site where the actions or works you are seeking are in place • work with 1 or 2 businesses to develop demonstration sites • distribute case studies of good practice • distribute a simple flier to service station with good housekeeping tips • conduct an environmental audit/review program with local businesses • enlist a local "champion" to take the key messages further • enlist the help of the industry association or local chamber of commerce

Hypothetical Non-Metropolitan Council: Community profile

- The population of the local government area is 20 000 with just under 16 000 residing the main regional centre. The remaining population lives on rural properties or in one of four satellite townships. The NESB population is less than 0.1%.

- Family units have predominantly a lower middle income. Significant employment exists in rural industries. Other employers are the retail industry, an abattoir, pet food manufacturer. Unemployment is higher than the state average, and youth unemployment is a major issue for the community.

- There is 1 large retail center in the main street and a one main sporting facility and interest and participation in sports is high.

- Local sub communities hold events, fairs from time to time. Several groups distribute monthly or quarterly newsletters. One local Newspaper caters mainly to the local government area. A regional rural newspaper also gains good coverage. News bulletin and advertising on TV are localised to the region and one local radio station that broadcasts outside the local government as well.

Non-Metropolitan Stormwater Issue: Litter in watercourses

Cause	Effect	Infrastructure intervention	Education targets	Possible education interventions
Litter from strip shopping area being washed or blown into stormwater drain and then washed into Town Creek	Litter entwined in vegetation along Example Creek ruins the appearance of the creek. Litter washed down stream where it poses a threat to birds and wildlife	Gross pollutant trap stormwater outlet to Example Creek	Local community living close to GPT or that use the catchment Sub groups: shoppers store managers	Example Creek Month **Shoppers** press releases/editorial for local papers signage on street rubbish bins Example Creek month Community picnic launches/open day fliers/information sheets sent home with primary school children **store managers** fliers/information brochures asked to sponsor radio spots or poster print runs display posters and distribute brochures to customers

Non-Metropolitan Stormwater Issue: Elevated phosphorus levels in Example Creek

Cause	Effect	Infrastructure intervention	Education targets	Possible education interventions
Subsurface infiltration of ground water contaminated with effluent from malfunction of septic tanks and transpiration areas. Leaves, twigs and sediment entering stormwater from gutters, and garden in residential areas High fertiliser use in residential areas as gardens and lawn are being established	Concentration of phosphorus exceed ANZECC water quality criteria for maintenance of aquatic ecosystems detected in 80% of bimonthly water samples taken down stream of Example Creek Increase in phosphorus stimulates plant growth in-stream altering habitat. Algal growth affecting swimming areas may be linked to elevated phosphorous concentrations	Wetland to treat stormwater low flows prior to entering Example Creek Long term option for reticulated sewerage system to be reviewed	Local community living close to GPT or that use the catchment Sub groups: shoppers store managers	Example Creek Month **Shoppers** • press releases/editorial for local papers • signage on street rubbish bins • Example Creek month community picnic • fliers/information sheets sent home with primary school children **store managers** • fliers/information brochures • asked to sponsor radio spots or poster print runs • display posters and distribute brochures to customers. Residents in new residential areas • letter box delivery of information sheets on Fridays to selected areas. • distribution of to customers information through local plant nursery and landscaping companies

APPENDIX B:
COUNCIL OPERATIONS ASSESSMENT CHECKLIST

The fundamental objective of the guidelines and this quick reference checklist is to prevent the pollution of the stormwater drainage system. The following Risk Assessment checklist is provided to assist in critically reviewing all operational and maintenance activities and their potential impact on stormwater quality.

Item	Activity Description	Activity		Risk of Stormwater Contamination			Clause Reference
		Yes	No	Low	Med	High	
1.1 Planning							
1.1.1	Has stormwater quality been considered	☐	☐	☐	☐	☐	
1.1.2	Has the activity been audited	☐	☐	☐	☐	☐	
1.1.3	Has the activity been planned	☐	☐	☐	☐	☐	
1.1.4	Has a monitoring procedure been prepared	☐	☐	☐	☐	☐	
1.2 Construction & Maintenance							
1.2.1	Has erosion control been considered	☐	☐	☐	☐	☐	
1.2.2	Are sediment collection devices required	☐	☐	☐	☐	☐	
1.2.3	Is pothole patching/ bitumen works involved	☐	☐	☐	☐	☐	
1.2.4	Is concrete or brick works involved	☐	☐	☐	☐	☐	
1.2.5	Is footpath maintenance involved and does it require	☐	☐	☐	☐	☐	
	• Grinding	☐	☐	☐	☐	☐	
	• Repair	☐	☐	☐	☐	☐	
	• Disposal of excess concrete	☐	☐	☐	☐	☐	
1.2.6	Is drainage maintenance involved	☐	☐	☐	☐	☐	
1.3 Parks, Reserves, Golf Courses & Medians etc.							
1.3.1	Does this activity involve the maintenance of parks, reserves, golf courses, medians etc	☐	☐	☐	☐	☐	
1.3.2	Is grass adjacent to open waterways or hard standing areas.	☐	☐	☐	☐	☐	
1.3.3	Are new plantings to be undertaken near waterways	☐	☐	☐	☐	☐	

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Item	Activity Description	Activity		Risk of Stormwater Contamination			Clause Reference
		Yes	No	Low	Med	High	
1.3.4	Does activity involve plant selection	☐	☐	☐	☐	☐	
1.3.5	Are fertilisers and herbicides to be used	☐	☐	☐	☐	☐	
1.3.6	Is garden development and maintenance involved	☐	☐	☐	☐	☐	
1.4 Street Cleaning							
1.4.1	Is street cleaning involved	☐	☐	☐	☐	☐	
1.4.2	Have minimum sweeping frequencies been established	☐	☐	☐	☐	☐	
1.4.3	Has coordination of sweeping with other construction and maintenance activities been considered	☐	☐	☐	☐	☐	
1.5 Plant & Equipment							
1.5.1	Does the activity involve the use of plant and equipment	☐	☐	☐	☐	☐	
1.5.2	Is there a requirement to store plant/equipment	☐	☐	☐	☐	☐	
1.5.3	Are facilities available for Cleaning/washing	☐	☐	☐	☐	☐	
1.5.4	Are proper fuelling facilities available	☐	☐	☐	☐	☐	
1.5.5	Will maintenance be undertaken	☐	☐	☐	☐	☐	
1.6 Materials							
1.6.1	Are materials to be stored (at deport or on-site)	☐	☐	☐	☐	☐	
1.6.2	Does it involve the storage of hazardous materials	☐	☐	☐	☐	☐	
1.6.3	Does the activity involve the loading and unloading of goods and/or materials	☐	☐	☐	☐	☐	
1.7 Building Maintenance							
1.7.1	Is building maintenance to be undertaken	☐	☐	☐	☐	☐	
1.8 Graffiti							
1.8.1	Does the activity involve removal of graffiti	☐	☐	☐	☐	☐	

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Item	Activity Description	Activity		Risk of Stormwater Contamination			Clause Reference
		Yes	No	Low	Med	High	
1.9 Waste Collection							
1.9.1	Does activity involve the kerb-side collection of domestic waste and/ or recycling	☐	☐	☐	☐	☐	
1.9.2	Is spillage or litter a problem	☐	☐	☐	☐	☐	
1.9.3	Is hard rubbish collected	☐	☐	☐	☐	☐	
1.9.4	Is green waste collected	☐	☐	☐	☐	☐	
1.10 Litter Collection							
1.10.1	Is litter collected from street and/or park litter bins	☐	☐	☐	☐	☐	
1.11 Miscellaneous							
1.11.1	Does the Council Emergency management Plan include consideration of "spillages"	☐	☐	☐	☐	☐	
1.11.2	Are dog faeces a problem	☐	☐	☐	☐	☐	
1.11.3	Has the control of pollutants from building sites been considered	☐	☐	☐	☐	☐	
1.12 Training							
1.12.1	Have staff been trained in stormwater management	☐	☐	☐	☐	☐	

APPENDIX C: GLOSSARY OF LANDFORM AND LAND CAPABILITY TERMS

Term:	Description:
Acidity.	Extremely and strongly acid soils with laboratory measured pH values of <5.5 (1:5 soil:water) often give rise to acid soil infertility. Associated problems include toxic levels of aluminium and/or manganese and deficiencies of most nutrients (especially calcium and molybdenum). While many native plants in eastern NSW have adapted to acid soil conditions, susceptible species may require heavy applications of lime or dolomite and often fertiliser to raise the pH (and nutrient supply) to a satisfactory level. Acid soils may corrode untreated underground metal installations
Alkalinity.	Alkaline soils have laboratory measured pH (1:5 soil:water) values of >8.5. Alkalinity may inhibit the growth of plants. High levels of carbonate or bicarbonate may impair the uptake of iron, manganese, copper and zinc by plants. These soils are frequently also sodic or saline.
Aluminium Toxicity Potential.	High levels of soluble aluminium are often toxic to non-native plants such as some pasture, crop and ornamental species. Toxicity can be expected when exchangeable aluminium levels are >5% and soils are strongly acid. Many native plant species are tolerant of soils with high concentrations of soluble aluminium. Lime or dolomite can be applied to raise soil pH and thus reduce exchangeable aluminium.
Dieback.	Widespread death of branch tips and senescent trees may indicate one or a combination of soil, landuse or landscape-related problems including salinity associated with rising watertables, ecosystem imbalances, high grazing pressure, drought or change in soil fertility. Dieback may be addressed by establishing tree species suited to soil landscape conditions.
Drainage.	Drainage is effected by soil permeability, hydraulic gradient and the permeability of materials below the soil profile. Soils that drain water quickly are highly permeable. They usually have coarse textures (sands) and many interconnected pores. Drainage is assessed according to as either very poorly drained, poorly drained, imperfectly drained, moderately well-drained, well-drained or rapidly drained (McDonald *et al.* (1990). Soils with slow drainage are likely to pond water for long periods. They usually have clayey textures and mottled or

Term:	Description:
	greyish colours. Specialised drainage systems may be required. Rapidly draining soils often have low water holding capacity and may transmit pollutants rapidly to groundwater. Seedlings and newly established plants require regular light irrigation in rapidly drained soils.
Dryland Salinity or Irrigated Salinity.	Excessive salt is toxic to most plants. Saline surface soils are usually bare or have sparse plant cover. These soils have a high erosion hazard and are often poorly drained. Saline soils may be corrosive to untreated underground services. Saline sites have soils with electrical conductivities of >4 dS/m in the root zone. Treatment often involves removal of saline water by drainage and deep ripping as well as establishment of salt-tolerant species. Cover crops and mulches as well as the application of fertilisers and gypsum are often required for successful vegetation establishment. Measures that further reduce concentration of salts within the plant root zone such as reduction of fallow ground and the planting of trees or other deep-rooted perennials in recharge areas, should be planned to ensure long-term rehabilitation.
Engineering Hazard.	Engineering hazard is an assessment of the susceptibility of a parcel of land in consideration of the prevailing soil and landscape qualities that may affect the foundation stability of roads, buildings and related infrastructure. Inappropriately designed structures built on land with high engineering hazard can experience cracks and deformations resulting in damage to underground services. In some areas, entire buildings have been demolished eg, by mass movements. It is recommended that geotechnical engineering advice be sought prior to development on land identified as having moderate or high engineering hazard.
Erodibility.	Soil erodibility is the susceptibility of a soil to erosion. It is based solely on soil properties. For sheet and rill erodibility, the USLE K factor (Wischmeier & Smith 1978) of >0.04 is considered to be highly erodible. In some cases, sheet and rill erodibility is modified according to field assessment of factors such as existing indications of previous sheet erosion, fabric and consistence that are out of range or not taken into account by the USLE. Rankings for USLE K factors are very low (<0.01), low (0.01 - 0.02), moderate (0.02 - 0.04), high (0.04 - 0.06) and very high (>0.06). Landscape properties such as slope gradient, slope length,

Term:	Description:
	landform element and rainfall characteristics are not included in the assessment of Inherent Erosion Risk. Disturbance should be minimised on erodible soils, and disturbed areas should be protected by ground cover as soon as possible. USLE K factors cannot alone be used to determine soil propensity to erosion by concentrated water flows. Dispersible/sodic soils, soils with weak or unstable fabrics such as slaking, or self-mulching or very sandy soils are also prone to erosion by concentrated flows. Wind erodibility is related to the size and coherence of soil clods and only applies to dry and disturbed (or cultivated) soils. Wind erodibility is assessed in terms of percentage of fragments that are finer than 0.85 mm (USDA 1983).
Fertility.	Soils with poor chemical fertility usually require the application of chemical fertilisers, seasoned manure or compost to achieve permanent plant cover. Some soils do not respond well to normal applications of fertiliser. For example, soils with high aluminium or iron oxide contents readily "lock up" phosphate, making it unavailable to plants.
Flood Hazard.	Areas subject to periodic flooding by stormwater runoff and overland flow from rivers and streams should be retained as drainage reserves. Flood hazard is assessed from geomorphic context and the presence of unconsolidated flood deposits.
Groundwater Pollution Hazard.	Areas with high water tables and soils that are highly permeable and hove low nutrient retention ability are prone to groundwater pollution. There is potential for pollutants such as nutrients, pesticides, herbicides, detergents, sewage and other chemicals to leach through these soils and contaminate groundwater.
Gully Erosion Risk.	Areas with erodible or sodic/dispersible soils, high run-on, highly intensive rainfall, and where ground cover has been disturbed or denuded, are vulnerable to tunnelling and gully erosion. Methods to combat gully erosion include engineered gully control structures such as headwalls, sediment traps and weirs, the replanting of affected areas with ground cover species, and the fencing off of gullied areas to exclude stock.
Hardsetting Surfaces.	Hardsetting soils become hard and dense when dry. They do not readily absorb rainwater and cause high runoff with consequent soil erosion. They do not offer favourable environments for seed germination and require careful water management. Regular cultivation should be avoided, although some cultivation may be necessary to break up the hard layer

Term:	Description:
	for successful germination.
Inherent Erosion Risk.	Inherent Erosion Risk is the long-term susceptibility of a parcel of land to erosion if the soil is left exposed and no erosion control management is employed. It is thus a function of the intrinsic attributes of the land, which contribute to potential soil loss including rainfall erosivity, soil erodibility and slope gradient. Inherent Erosion Risk is independent of cover and soil management practices and as such, can be used to determine the relative risk of erosion for a soil landscape, should it be disturbed, compared to other soil landscapes. Refer to individual Soil Landscape Reports for detailed information on the derivation of Inherent Erosion Risk. Inherent erosion risk is ranked as very low (0 - 30); low (30 - 90); moderate (90 - 300); high (300 - 600); very high (600 - 900); and extreme (>900).
Land attribute	A collective expression for land quality and land characteristics. It is a physical property which can be observed, measured or derived. A land attribute can be used to distinguish between land units of different suitability. Examples include annual rainfall, slope gradient, phosphorus sorption capacity, parent material and soil erodibility.
Land Capability	The systematic arrangement of land into various categories according to their capability to sustain particular land uses without land degradation (Houghton and Charman, 1986).
Land characteristic	A directly derived or measured physical trait. Land characteristics may be input directly or used to derive land qualities.
Land quality	A complex of attributes that directly influence suitability for a specified land use. Land qualities are usually derived through compound interactions of multiple land characteristics or other qualities. Surface movement potential, for example, is derived from assessment of reactivity of individual soil horizons, and soil water content fluctuations, which in turn involve climate, soil water entry, storage and deep drainage.
Land Suitability	The fitness of a given type of land for a specified land use. Fitness may include long term environmental/ecological, social or economic sustainability. Land capability information is combined with other data which may include; socioeconomics, transport, proximity to services (shops, schools), availability of water/sewerage, air/noise pollution, heritage constraints, existing native vegetation (sensitive sites) to derive the suitability of each particular land unit. For example, a piece of

Term:	Description:
	land may have a low degree of constraints and therefore high capability for absorbing liquid effluent, but may not be near enough to the source of the effluent to make it suitable for that purpose. It should be noted that land suitability in the sense previously used by the NSW Department of Agriculture is not equivalent to land suitability in the sense of the FAO system.
Land units	Area that is predictable in nature and affects any particular land use consistently. A land unit has a unique set of specific land use suitability ratings and is capable of presentation on maps. Land units include all the biophysical attributes of the environment (eg. Climate, geology, soil, landform, hydrology, vegetation), which affect the potential of the land for any specific urban land use. A land unit may either he a unique mapping area (single delineation or polygon), or map legend unit (occurring as a number of delineations or polygons).
Mass Movement Hazard.	A general term for a number of forms of slope failure including rockfalls and earth creep, slumps, slips and flows on steep, and often wet, slopes. Soil features include shear planes, slickensides and colluvial materials. The most common triggering agent for slips is water in the slip zone, which reduces shear strength and increase slope loads. Other common human induced landslip generating factors include: • removal of material from the toe of a slope (especially on or below a former slip plane); • concentration of surface water or groundwater in slip prone areas; and • removal of trees and other plants that may "pump" down the watertable. Mass movement may lead to severe damage to buildings, roads and services, or may result in recurrent problems such as shifting foundations. Mass movement hazard is assessed on the abundance of mass movement evidence. This can include slip scars, terracette formations, clumps of trees that have died for non-apparent cause, tree trunks which have developed a bend following displacement by slip movement and the lateral displacement of posts.
Non-cohesive Soils.	Loose, sandy soils can be subject to severe wind erosion, gully erosion and batter failure. Batters steeper than 25% should be supported with retaining walls. Batters with slopes less than 25% should be revegetated quickly.
Organic Soils.	Soils with large amounts of organic carbon (generally >12%

Term:	Description:
	(Isbell 1996)) such as peats and sandy peats are generally unsuitable for use as engineering materials because they have low wet bearing strength and their physical properties may be subject to change through decay. They are generally well-structured for plant growth and have high waterholding capacities; however, they are often very acid and may require large quantities of lime and nitrogen as well as other nutrients and trace elements for optimum plant growth. Most topsoils contain sufficient organic matter to be unsuitable for engineering purposes. Also, highly organic soil materials located in swampy areas tend to suffer significant structural decline when drained.
Periodically Frozen Soil (Frost Action Potential).	Frost action potential is a rating for the susceptibility of the soil to upward or lateral movement by the formation of segregated ice lenses. It rates the potential for frost heave and the subsequent rapid loss of soil strength when the ground thaws and the ice crystals and lenses within the soil melt. Unequal heaving and subsidence upon thawing can crack or tip concrete slabs. This hazard is generally recognised by the presence of large ice crystals in topsoils. Although most soils in Australia have zero frost action potential, a few colder areas may exhibit low frost action potential, where damage to buildings and roads is unlikely but still a possibility (USDA 1993).
Permanently High Watertables.	Problems often occur where watertables are permanently within 2 m of the surface. The surface soil materials may dry out, but subsurface soils are often saturated. In these soils, for example, septic effluent disposal often results in groundwater pollution.
Permeability.	Soils that drain water quickly are highly permeable. They usually have coarse textures (sands) and many interconnecting pores. They are not suitable for absorbing effluent from septic systems because liquid drains rapidly into the groundwater where it can cause pollution and potential health problems elsewhere. Soils with high permeability often have low waterholding capacities. Seedlings and newly established plants require regular, light irrigation. Soils of low permeability usually have very slow drainage and are likely to pond water for long periods. They usually have clayey textures and mottled or greyish colours. They are not suitable for absorbing effluent. Special drainage may be required. They may also be sodic and have low wet bearing strengths.
Plant Available Waterholding Capacity.	Soil materials with low available waterholding capacity can store only limited amounts of water that can be extracted by

Term:	Description:
	plants. Plants growing in these soils require small and frequent applications of water for optimum growth. Available waterholding capacity is of greatest importance in areas with seasonal rather than regular or highly unreliable rainfall. Available waterholding capacity ratings are very low (<5), low (5 - 10), moderate (10 - 15), high (15 - 20) and very high (>20).
Plasticity.	Plastic state occurs at water contents where soils deform or change shape without change in volume. It occurs between the semi-solid (crumbly) and liquid state and is defined as the difference between the plastic and liquid Atterberg limits (Hicks 1991a). A soil with high plasticity has plastic properties over a wide range of moisture contents. Highly plastic soils are typically high in clay content and deform easily when mechanically stressed in the moist to saturated state. They are often tough and hard when dry. Highly plastic soils do not support loads well and have poor trafficability when wet. Soils with no or low plasticity change from solid to liquid with little change in moisture content and may be prone to mass movement (Hazelton & Murphy 1992). Highly plastic soils can be very sticky, are unsuitable for foundations and usually have low wet bearing strengths and high shrink-swell potential. Highly plastic (HP) soils have USCS classifications of CH-CL, OH-CL, CL-OH, Pt, CH-OH, OH-CH, CH and MH. Moderately plastic (MP) soils have USCS class of CL-CH, CL, and OH. Low plasticity (LP) soils have USCS classes CL-ML, ML-CL, ML, CL and OL. Non-plastic (NP) soils include all other USCS categories and are sandy or gravelly.
Poor Moisture Availability.	Droughty soil. These soils have very limited soil water storage in comparison with other soils in the same climate zone. Freely draining soils or shallow soils, particularly those that do not receive run-on or allow ready entry of water to plant roots, are prone to drought.
Poor Seedbed Conditions.	Surface soil materials with properties that create difficulty in preparing adequate seedbed conditions, may be naturally cloddy, hard-setting, sandy or sodic/dispersible. Poor seedbed conditions are associated with very low organic matter, very high or low clay contents, and high silt and fine sand contents.
Potential Acid Sulfate Soils	Acid sulfate soils are clays, muds and sometimes sands associated with pyrite-rich marine sediments. They may also occur in association with some sulfitic ore bodies and sulfur-rich parent materials (eg, some coals). These soils become extremely acid following exposure or drainage as sulfur

Term:	Description:
	compounds are oxidised and converted to sulfuric acid. This makes them corrosive to iron, steel, aluminium alloys and concrete. Underground services should be avoided or rust-proofed where these soils are present. Actual acid sulfate soils are too acid for most plant species and are difficult to vegetate. Very acid drainage waters from these soils can profoundly disturb aquatic ecosystems. 1:25 000 acid sulfate soil risk maps and an accompanying report are available for all low lying coastal areas in NSW from the Department of Land and Water Conservation. Refer also to the *Acid Sulphate Soils Manual*
Potential/Known Discharge Area.	Areas where watertables are liable to approach or contact the ground surface and become springs. When this occurs, the ground often becomes wet or boggy and may become saline and quickly erode to form scalds.
Potential/Known Recharge Area.	Areas with highly permeable, generally non-saline soils and fractured geology can allow infiltration to contribute to underground watertables. Recharge areas may need special long-term management strategies, crop rotations or plantings to prevent rising watertables and salinity elsewhere.
Productive Arable Land.	Areas of highly productive arable or productive horticultural land are relatively rare within NSW and have long-term value. Special planning consideration should be given to degradation, sterilisation or alienation of potentially highly productive land by inappropriate land use, tenure or zoning. Productive arable land is assessed on physical characteristics and does not take into account additional social and economic factors used to determine prime agricultural land. Prime Agricultural land is identified on Agricultural Suitability Maps produced by the Department of Agriculture in NSW.
Rock Outcrop.	Rock outcrop restricts excavation and the installation of underground services. Garden establishment is often difficult where there is rock outcrop.
Rockfall Hazard.	Areas immediately below cliffs and unstable scarps are at risk of serious damage from rockfalls and other mass movement debris. The presence of rockfall hazard is assessed by proximity to cliffs, scarps and other potentially unstable hillslopes as well as the presence of unconsolidated scree and talus materials.
Run-on.	Surface water flowing onto an area. It is often a contributing factor to soil erosion. Areas with high run-on are often prone to temporary localised flooding.
Salinity.	Excessive salt is toxic to most plants. Saline surface soils are

Term:	Description:
	usually bare or have sparse plant cover. These soils have a high erosion hazard and are often poorly drained. Treatment of saline soils often involves removal of saline water by drainage and deep ripping as well as establishment of salt-tolerant plant species. Cover crops, mulches and large applications of nitrogenous fertilisers as well as gypsum are often required for successful vegetation establishment. Measures that further reduce concentrations of salts within the plant root zone such as tree or lucerne plantings in recharge areas may be required to ensure long-term rehabilitation. Saline soils may be corrosive to untreated underground services.
Seasonal Waterlogging.	Seasonally high watertables result in similar problems to permanently waterlogged soils. Soils in landscapes with this limitation can become extremely dry for long periods.
Seepage Scalds.	Rising watertables and the accumulation of salts and/or sodium at the soil surface cause seepage scalds. The scalds kill vegetation, resulting in bare areas that can subsequently erode (see **Salinity** and **Potential/Known Discharge Areas**).
Shallow Soils.	Soils are classed as shallow if they are <50 cm deep. Shallow soils restrict plant growth and increase the difficulty of installing underground services. Soil depth is measured from the current soil surface to weathered parent material, or bedrock, or the top of any hard pan layers that would not be considered as soil for plant growth or construction.
Sheet Erosion Risk.	The relative susceptibility of an area of land to sheet (and rill) erosion compared to other areas. It is independent of factors that affect land use. It is a subset of the Universal Soil Loss Equation (Wischmeier and Smith 1978) and is determined by multiplication of rainfall erosivity, slope gradient and soil erodibility. Factors such as crop practice, slope length, and ground cover may be further included for particular land uses to determine actual sheet erosion risk. Sheet erosion risk is equivalent to inherent erosion risk used in forestry harvest plans. Sheet erosion risk is a useful measure for locating land uses with high erosion hazards in the most suitable areas. Sheet erosion risk rankings in SI units for conditions in NSW are very low (<90); low (90 - 325); moderate (325 - 560); high (560 - 1 080); very high (1 080 - 1 600); and extreme (>1 600).
Shrink-swell Potential.	Expansive soil materials shrink and swell with changes in moisture content. Such soil materials have volume expansions of >30% or linear shrinkages of >17% and characteristics such as slickensides, seasonal cracking and high plasticity. When soil moisture content changes, shrink-swell soils can damage

Term:	Description:
	structures such as buildings, roads, dams, walls and underground services that are not appropriately designed. The shrink-swell potential of most soils can be reduced by compaction, the addition of lime or gypsum, or burial with a stable material. Soil movement can be eliminated by keeping soil moisture levels constant.
Sodicity/Dispersion.	Sodic and dispersible soils are often highly erodible and may have low wet bearing strengths. They are often very hardsetting when dry and often form surface crusts, restricting water entry and hampering seedling emergence. They are prone to erosion and structural degradation and require very careful management. Sodic soils may be treated with additions of lime or gypsum. Sodic/dispersible soils exhibit sodic/dispersible soil characteristics in the field and are either highly dispersible (D% >50 or have an Emerson Aggregate class of 1, 2 or 3) or have an Exchangeable Sodium Percentage and sufficient sodium to be considered sodic.
Soil Acidification Hazard.	Poorly buffered soils are usually sandy and have expected buffer capacities <30 kmol(+) ha/10 cm/pH unit. They become more acidic where land use has a net acid input, such as from nitrogen leaching. It is very important to maintain high organic matter levels in these soils. See Soil Acidity.
Soil Fire Hazard.	Highly organic soils such as peat or litter build-up can be ignited by vegetation fires during drought. They may smoulder for months and are very difficult to control. Peat fires lower ground levels, sterilise the soil and in some instances, leave the ground bare and susceptible to erosion.
Specific land use	A component land use that is individually assessed within the framework of broader urban land use. To be relevant to urban land evaluation, a specific land use should have a defined purpose, specified development and maintenance.
Standard urban land capability	The lowest suitability rating of the following combination of 'standard' specific land uses. The specific land uses are: • water quality and soil sediment retention works • fully serviced, detached, median value, residential family housing on pier foundations suited to stable soils • all weather, sealed, low maintenance, local roads and streets • provision of rapid and long term sustainable ground cover.
Steep Slopes.	A number of landscape hazards increase with slope. Soil erosion is more severe, rock outcrop is more common, soils are generally shallower and mass movement is more likely with

Term:	Description:
	increasing slope. Slope is therefore, an important attribute that can limit many land uses. Steep slopes are defined as being steeper than 33% (18°).
Stoniness.	Gravels, stones and rocks increase the cost and difficulty of excavation for underground services and increase the difficulty of cultivation. Gravels, stones and rocks occupy soil volume and thereby reduce exploitable plant moisture and nutrients. Surface stones can have varied effects on water infiltration, soil erodibility and moisture loss through evaporation. Soils that contain more than 20 - 50% coarse fragments are considered to be stony.
Water Repellence.	Water repellence is rated after Roberts and Carbon (1971) according to the amount of time for a droplet of water to be absorbed by a dry soil surface. The effects of water repellence include reduced water infiltration and poor germination and plant growth (Handreck & Black 1984) as well as increased runoff and increased erosion potential.
Wet Bearing Strength at Field Capacity.	A limited range of particle sizes dominate soils with low wet bearing strength. They are pliable and deform easily under pressure when wet. Quicksand is an example. They are unsuitable for foundations if poorly drained and have poor trafficability when wet. Low wet bearing strength soils often suffer severe structural damage if cultivated or mechanically disturbed when wet. They are divided into seven classes: fluid mud, very soft mud, totally unripe, practically unripe, half-ripe, nearly ripe and ripe.
Wind Erosion Risk.	Typically, areas subject to wind erosion are exposed and have easily transported, unconsolidated, loose fine sand-size aggregates, and often dry topsoils. Vegetative cover should be maintained to prevent wind erosion