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Department of **Biodiversity, Conservation and Attractions**

Stormwater management manual for Western Australia

Chapter 7 Non-structural controls

Department of Water and Environmental Regulation

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Disclaimer

Preface

Stormwater is water flowing over ground or built-up surfaces and in natural streams and drains, as a direct result of rainfall over a catchment (ARMCANZ & ANZECC 2000). Stormwater consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow. Stormwater management examines how the runoff quantity and these pollutants can best be managed from source to the receiving water bodies using the range of management practices available.

In Western Australia (WA), where there is a superficial aquifer, drainage channels can commonly include both stormwater from surface runoff and groundwater that has been deliberately intercepted by drains installed to manage seasonal peak groundwater levels. Stormwater management is unique in WA as both stormwater and groundwater may need to be managed concurrently.

Rainwater has the potential to recharge the superficial aquifer, either prior to runoff commencing or throughout the runoff's journey in the catchment. Urban stormwater on the Swan Coastal Plain is an important source of recharge to shallow groundwater, which supports consumptive use and groundwater-dependent ecosystems.

With urban, commercial or industrial development, the area of impervious surfaces within a catchment can increase dramatically. Densely developed inner urban areas are almost completely impervious, which means less infiltration, the potential for more local runoff and a greater risk of pollution. Loss of vegetation also reduces the amount of rainfall leaving the system through the evapotranspiration process. Traditional drainage systems have been designed to minimise local flooding by providing quick conveyance for runoff to waterways or basins. However, this almost invariably has negative environmental effects.

This manual presents a comprehensive approach to management of stormwater in WA, based on the principle that stormwater is a resource – with social, environmental and economic opportunities. The community's current environmental awareness and recent water restrictions are influencing a change from stormwater being seen as a waste product with a cost, to a resource with a value. Stormwater management aims to build on the traditional objective of local flood protection by having multiple outcomes, including improved water quality management, protecting ecosystems and providing liveable and attractive communities.

This manual provides coordinated guidance to developers, environmental consultants, environmental and community groups, industry, local and state government, water service providers and other agencies on current best management principles for stormwater management.

It is intended that the manual will undergo continuous development and review. As part of this process, any feedback on the series is welcomed and may be directed to the Urban Water Branch of the Department of Water and Environment Regulation, at urbanwater.enquiry@dwer.wa.gov.au

Western Australian stormwater management objectives

Water Quality

To maintain or improve the surface and groundwater quality within the development areas relative to pre-development conditions.

Water Quantity

To maintain the total water cycle balance within development areas relative to the pre-development conditions.

Water Conservation

To maximise the reuse of stormwater.

Ecosystem Health

To retain natural drainage systems and protect ecosystem health.

Economic Viability

To implement stormwater management systems that are economically viable in the long term.

Public Health

To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property

To protect the built environment from flooding and waterlogging.

Social Values

To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development

To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian stormwater management principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Contents

Summary

The aims of this chapter are to:

- describe non-structural controls, as well as provide an overview of their benefits, use, effectiveness and evaluation
- provide advice on how to select and implement non-structural controls
- provide technical guidelines on some of the most important non-structural controls to improve stormwater quality that can be applied at the citywide, regional, estate or lot scale.

Non-structural controls are institutional and pollution prevention practices designed to prevent or minimise pollutants from entering stormwater runoff and/or to reduce the volume of stormwater requiring management.

They do not involve fixed, permanent facilities and they usually work by changing behaviour through government regulation (e.g. planning and environmental laws), education and/or economic instruments.

Non-structural controls can be defined into five principal categories (Taylor and Wong (2002a):

1 **local planning controls** – such as the use of local planning instruments to promote water sensitive urban design features in new developments

2 **strategic planning and institutional controls** – such as the use of strategic, regional or citywide urban stormwater management plans

3 **pollution prevention procedures** – such as maintenance practices, operational procedures and staff training at government, commercial and industrial sites to minimise the risk of stormwater pollution

4 **education and participation programs** – such as training programs and involving the community in the development and implementation of stormwater management plans

5 **regulatory controls** – such as enforcement of local laws to improve erosion and sediment control on building sites, the use of environmental licences to help manage premises likely to contaminate stormwater or groundwater, and programs to minimise illicit discharges to stormwater management systems.

Non-structural controls should be used in combination with structural controls (i.e. the 'treatment train approach') to achieve a balanced mix of stormwater management measures.

Potential benefits include:

- cost saving: Some non-structural controls are relatively inexpensive to run, particularly when compared with structural alternatives
- increased coverage: Some non-structural controls cover broad areas compared with structural alternatives
- can be used in developed areas: Some types of structural controls can be difficult and/or expensive to install because of space constraints and existing infrastructure in established areas, whereas non-structural controls generally do not have space/land requirements
- can target specific pollutants of concern: Education and awareness program can target to reduce and/or use of improved fertiliser on gardens
- economic incentives: The polluter pays principle and economic incentives/disincentives can be applied through regulation and/or enforcement programs, unlike large regional structural controls, where the bulk of the life cycle costs are often borne by the wider community

- effective: Some non-structural controls are highly effective. For example, planning controls can change practices over large areas
- community participation: Interactive and participatory programs can provide an opportunity for the community to accept greater responsibility for stormwater pollution and be involved in developing management strategies
- flexible: Unlike structural controls, many non-structural controls can be quickly modified to take advantage of new opportunities or to respond to new priorities
- secondary benefits: Non-structural controls have secondary benefits such as helping build a mandate for increased political support, stable funding mechanisms and new organisational institutions.

Non-structural controls can be highly valuable, and in some cases essential, for urban stormwater management. The non-structural controls with the most potential value are:

- town planning controls involving the implementation of stormwater policy in town planning schemes, requiring stormwater to be addressed in development proposals, and applying development approval/permit conditions
- development of stormwater management plans for a city, shire or catchment to improve stormwater management and the protection of aquatic ecosystems
- illicit discharge elimination programs
- sustained construction site management programs that have strong enforcement elements and address both public and private sector works
- point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry and enforcement activities)
- targeted, intensive and interactive community and stormwater management industry education and participation programs (e.g. community training workshops on good gardening practice)
- the use of a wide variety of citywide maintenance operations to improve stormwater quality, typically undertaken by local government authorities or other drainage service providers (e.g. maintenance of the stormwater drainage network and manual litter collections)
- business/industry programs (e.g. targeted campaigns involving education, incentives, site assessments and/or enforcement to improve procedures and practices relating to stormwater management on commercial or industrial sites).

This chapter also provides advice on how to implement non-structural controls, including:

- seek a complementary balance of structural and non-structural controls
- ensure organisational arrangements are conducive to non-structural controls
- undertake research and use expertise in their design and evaluation
- develop a contingency plan in case of failure to achieve the desired outcome
- clearly state and document the objectives at the start of the project
- be patient and plan for the long-term
- look for synergies
- develop a sound monitoring and evaluation plan at the start of the project
- report honestly and openly, regardless of success
- recognise that non-structural controls also require maintenance
- do not get distracted by the ‘feel good factor’.

There are a wide variety of non-structural controls for managing stormwater. This chapter focuses on the practices that are most effective and applicable to WA.

1 Introduction

1.1 Aims of the non-structural controls chapter

The aims of the non-structural controls chapter are to:

- describe non-structural controls, as well as provide an overview of their benefits, use, effectiveness and evaluation
- provide basic information on the selection of non-structural controls and the use of relevant technical guidelines
- provide technical guidelines on some of the most important non-structural controls to improve stormwater quality that can be applied at the citywide, regional, estate or allotment scale.

1.2 Scope of the chapter

This chapter focuses on non-structural approaches to stormwater management. Non-structural best management practices (BMPs) are one type of 'source control', the other being structural controls that can be applied at the source (e.g. porous paving, rain gardens, bioretention systems). Structural controls are addressed in Chapter 9.

There are a wide variety of non-structural approaches for managing stormwater (see Appendix A for a list that includes references to sections of this chapter or to other information/reference sources). This chapter focuses on those practices that are most effective and applicable to WA (see Table 1, Section 1.7).

1.3 Terminology and key definitions

Non-structural stormwater best management practices (non-structural BMPs) are institutional and pollution prevention practices designed to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management (US EPA, 1999). They do not involve fixed, permanent facilities and they usually work by changing behaviour through government regulation (e.g. planning and environmental laws), education and/or economic instruments (Taylor and Wong, 2002a).

Note that this chapter includes temporary erosion and sediment controls (e.g. mulching and sediment fences) in the definition of non-structural BMPs, as they do not involve the construction of fixed or permanent assets.

Structural stormwater BMPs are permanent, engineered devices implemented to control, treat, or prevent stormwater pollution and/or reduce the volume of stormwater requiring management.

BMPs are devices, practices or methods for removing, reducing or preventing targeted stormwater runoff constituents, pollutants and contaminants from reaching receiving waters (Taylor and Wong, 2002a). Within the context of this chapter, BMPs primarily seek to manage stormwater quality to minimise impacts on the health of water bodies.

Source controls are non-structural or structural BMPs to minimise the generation of excessive stormwater runoff and/or pollution of stormwater at or near the source (NSW EPA, 1998) and protect receiving environments, including groundwater, estuaries, waterways and wetlands.

1.4 Target audience

This chapter has been written primarily for four audiences:

1. agencies (such as local governments; Department of Water and Environmental Regulation; Department of Biodiversity, Conservation and Attractions; Water Corporation; Main Roads; Public Transport Authority; and Department of Planning, Lands and Heritage) who may develop citywide or regional management strategies, or project or site-based management plans to minimise stormwater pollution and protect the health of receiving environments
2. developers and their consultants who may develop stormwater management plans for new developments at the estate to allotment scale
3. managers of commercial or industrial sites who may require guidance on the on-site management of stormwater
4. community groups or community members who may require guidance on better ways to manage stormwater at the catchment to lot scale.

1.5 Why implement non-structural best management practices?

1.5.1 Potential benefits

Potential benefits from using non-structural BMPs in a balanced catchment or citywide urban stormwater management program have been summarised by Taylor (2000) and Taylor and Wong (2002a). They include:

- cost: Some non-structural BMPs are relatively inexpensive to run, particularly when compared with structural alternatives. For example, where major educational and enforcement campaigns aimed at erosion and sediment control have been conducted in Australia, the revenue gained from enforcement has usually resourced the campaign's total operational expenses. Changes to environmental protection legislation in WA are increasing local government powers to issue infringements and collect fines for pollution offences, such as discharges of pollutants into the stormwater system
- coverage: Some non-structural BMPs cover broad areas compared with structural alternatives (e.g. citywide town planning controls)
- can be used in existing developed areas: In established residential, rural-residential, commercial and/or industrial areas where stormwater management needs to be improved, installation of some types of structural BMPs can be difficult and/or expensive because of space constraints and existing infrastructure (e.g. sewer pipes and underground power). Non-structural BMPs generally do not have space requirements
- can target specific pollutants of concern: For example, in Perth's established residential areas located on sandy soils, nutrients and pesticides from lawns and gardens threaten the quality of shallow groundwater, stormwater and receiving waters. Such pollution is managed through non-structural means (e.g. encouraging the use of waterwise/fertilise wise gardens)
- the polluter pays principle and economic incentives/disincentives can be applied through regulation and/or enforcement programs. Unlike large regional structural BMPs, where the bulk of the life cycle costs are often borne by the wider community, regulation and/or enforcement campaigns allow the cost of pollution management to be borne by individuals or sectors of the community that are polluting (e.g. those found to be illegally discharging pollutants to stormwater)
- the high potential effectiveness of some measures: For example, the use of mandatory town planning controls to promote the widespread adoption of water sensitive urban design in new developments

- community participation: Interactive and participatory programs, such as the Green Stamp Programs that include participation techniques such as site assessments and training, can provide an opportunity for the community to accept greater responsibility for stormwater pollution, help develop innovative management strategies and participate in the implementation of these strategies. Such participatory and deliberative[1] processes can have intrinsic value (i.e. they help build 'social and natural capital'), as well as produce tangible outcomes (i.e. improvement in 'natural capital')
- flexibility: Unlike structural BMPs, many non-structural BMPs can be quickly modified to take advantage of new opportunities or to respond to new priorities. For example, ongoing small business/industry education programs involving stormwater management can be continually modified to promote practices that incorporate new technology or knowledge (e.g. targeting problem areas that have been identified through annual compliance auditing)
- secondary benefits: A strong argument for using some non-structural BMPs in a balanced catchment or citywide stormwater management program is their secondary benefits, such as helping build a mandate for increased political support, stable funding mechanisms, new organisational institutions, bolder initiatives and broader catchment management results. For example, the use of high profile, citywide stormwater awareness programs may help a stormwater management agency obtain support for ongoing funding for stormwater management. North American researchers have surveyed communities and found the establishment of a dedicated funding mechanism and investment in educational activities are essential ingredients for success in urban stormwater management (Lehner et al., 1999; Schueler, 2000b).

1.5.2 Trends in the use of non-structural best management practices

Stormwater managers commonly use a mix of structural and non-structural BMPs to achieve their stormwater management objectives, particularly at the catchment or citywide scale. These managers have the challenging task of finding the optimal combination of BMPs using limited funds (Schueler, 2000a; Taylor, 2000). After reviewing 100 stormwater case studies from the United States, Lehner et al. (1999) also stressed the value of a balanced, multi-faceted approach, stating that '…stormwater management efforts build synergistically off each other; the most successful municipal strategies cover all program elements effectively' (pp. 5-16).

During the 1990s, most expenditure on urban stormwater management in Australia was on large, regional, end-of-pipe structural BMPs (e.g. gross pollutant traps, ponds and wetlands) (Taylor, 2000). Since the late 1990s, the funding has increasingly shifted toward source controls for managing stormwater quality and quantity and achieving a more balanced mix of structural and non-structural stormwater strategies (Taylor and McManus, 2002). Such controls include more water sensitive urban design elements in new developments (e.g. the use of stormwater recycling and infiltration at the allotment or streetscape scale) and non-structural BMPs that can be applied on a citywide scale (e.g. town planning controls, education and participation programs, and enforcement programs).

A survey of urban stormwater managers conducted in 2001-02 by Taylor and Wong (2002b) found that non-structural BMPs in Australia:

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[1] The term 'deliberative' means involving deliberation or consideration. Public participation methods such as citizen juries and consensus conferences involve a strong deliberative element, where participants have the opportunity to digest information, formulate views and discuss them.

- are already playing a major role in urban stormwater quality improvement
- are increasing in use
- will continue to increase in use if Australian stormwater programs mature in a similar way to those developed in the US and New Zealand.

These trends are consistent with the current national and state policy direction for the management of urban stormwater through the publication of this manual and similar policies and guidelines by the State Government. Chapter 2 of this manual: *Understanding the context* recommends the following hierarchy be applied to stormwater management in WA:

1. retain and restore natural drainage lines: retain and restore existing valuable elements of the natural drainage system, including waterway, wetland and groundwater features and processes
2. implement non-structural source controls: minimise pollutant inputs principally via planning, organisational and behavioural techniques, to minimise the amount of pollution entering the drainage system
3. maintain runoff to pre-development: retain and/or reuse rainfall as high in the catchment as possible to maintain runoff to pre-development condition. Install structural controls at or near the source to minimise pollutant inputs and the volume of stormwater
4. use of ‘in-system’ management measures: includes vegetative measures, such as swales and riparian zones, and structural quality improvement devices such as gross pollutant traps.

1.5.3 The most effective non-structural best management practices

The Cooperative Research Centre (CRC) for Catchment Hydrology (Victoria) broadly evaluated the potential effectiveness of non-structural measures through the use of a literature review and a survey of 36 urban stormwater managers from Australia, NZ and the US (Taylor and Wong, 2002b & 2002c). Its overall finding was that non-structural BMPs can be highly valuable, and in some cases essential, for urban stormwater management. The non-structural BMPs demonstrated to have the most potential value were:

- town planning controls involving the implementation of stormwater policy in town planning schemes, requiring stormwater to be addressed in development proposals, and applying development approval/permit conditions (such measures can result in widespread adoption of best practice environmental management on construction sites and water sensitive urban design)
- development of stormwater management plans for a city, shire or catchment to improve stormwater management and the protection of aquatic ecosystems
- illicit discharge elimination programs
- sustained construction site management programs that have strong enforcement elements and address both public and private sector works
- point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry and enforcement activities)
- targeted, intensive and interactive community and stormwater management industry education and participation programs (e.g. community training workshops on good gardening practice)
- the use of a wide variety of citywide maintenance operations to improve stormwater quality, typically undertaken by local government authorities or other drainage service providers (such as the Water Corporation) (e.g. maintenance of the stormwater drainage network and manual litter collections)

- business/industry programs (e.g. targeted campaigns involving education, incentives, site assessments and/or enforcement to improve procedures and practices relating to stormwater management on commercial or industrial sites).[2]

1.6 How to use the best management practice guidelines in this chapter

Section 2 of this chapter contains information on various non-structural BMPs. A brief summary of all the BMP guidelines is provided at the beginning of Section 2. The technical BMPs in Section 2 contain summarised background information, recommended practices, factors to consider and additional references for a number of non-structural BMPs. Section 2 can be selectively accessed as needed to gather information on how to apply specific non-structural BMPs (e.g. Section 2.2.1 provides specific advice on street sweeping).

1.7 Non-structural control best management practices addressed in this chapter

Table 1 is a 'BMP matrix' that lists all of the non-structural control BMPs that are addressed in this chapter and highlights the relevance of each BMP to the four target audiences listed in Section 1.4. Some of these BMPs are addressed in other chapters, so chapter references are also provided for each BMP. This chapter addresses the most effective and applicable BMPs for WA. Appendix A provides a comprehensive list of non-structural control BMPs with relevant references.

Non-structural BMPs can operate at two levels according to Taylor and McManus (2002):

- as discrete BMPs (e.g. educational programs), that can be applied at the citywide, regional, estate and/or allotment scale
- as facilitating practices or frameworks that result in discrete structural and non-structural BMPs (e.g. town planning controls are non-structural measures, but they produce new developments that incorporate both structural and non-structural BMPs).

Most of the non-structural BMPs provided in this chapter are *discrete* BMPs (e.g. soil amendment, illicit discharge elimination programs), BMPs of this type are more numerous. However, the non-structural BMPs that play a *facilitation* role could be regarded, more important, as agencies seek to establish a strong stormwater management program. For example, BMPs that relate to the establishment of sustainable funding mechanisms, mandatory town planning controls, environmental management systems, and a total water cycle management philosophy are highlighted as being particularly important.

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[2] It should be noted that the BMPs listed here are those associated with some evidence of higher levels of effectiveness. Other non-structural BMPs may also be effective, but have not been demonstrated as such.

Table 1. Best management practice matrix – relevance to target audiences

	Relevance to the target audiences				
Non-structural control BMPs covered in this manual	**Government stormwater management agencies**	**Developers**	**Commercial or industrial premises managers**	**Individuals, landholders or community groups**	**Section/ chapter referen ce**
Construction practices					
Land development and construction sites: • Drainage controls • Erosion controls • Sediment controls • Housekeeping controls • Dust control	✔	✔	~ (during construction)	~ (during major landscaping)	2.1.1
Soil amendment undertaken to minimise the export of nutrients from gardens and lawns	✔	✔	~	✔	2.1.2
Maintenance practices					
Street sweeping/cleansing	✔	~	✔	✘	2.2.1
Maintenance of the stormwater network (incl. desilting)	✔	✔(during construction and maintenance period[3])	~	✘	2.2.2
Manual litter collections (e.g. roadside collections)	✔	✘	✘	✘	2.2.3
Litter bin design, positioning and cleaning	✔	✘	✘	✘	2.2.4
Road/pavement repairs/ resurfacing and road runoff	✔	✔(during construction and maintenance period)	✘	✘	2.2.5

[3] The period that developers are responsible for maintenance post-construction is usually 12 months, but can be longer depending on the size and staging of the development.

	Relevance to the target audiences				
Non-structural control BMPs covered in this manual	**Government stormwater management agencies**	**Developers**	**Commercial or industrial premises managers**	**Individuals, landholders or community groups**	**Section/ chapter referen ce**
Maintenance of premises typically operated by local government (e.g. parks, cemeteries, sports fields, nurseries, depots, buildings, road reserves, etc.)	✔	✘	✘	✘	2.2.6
Maintenance of gardens and reserves with respect to plant selection, pest management, irrigation, lawn maintenance and nutrient management	✔	✔(during construction and maintenance period)	✘	~	2.2.7
Maintenance of vehicles, plant and equipment (incl. washing)	✔	✘	✔	✘	2.2.8
Building maintenance (incl. graffiti removal and building washing)	✔	✔	✔	~	2.2.9
Stormwater management on industrial and commercial sites, such as: • Storage of hazardous and dangerous goods, etc. • Housekeeping • Loading/unloading • Waste management • Stormwater management plans • Wastewater management • Emergency management and response • Vehicle and equipment wash-down areas	~	~	✔	~	2.2.10
Education and participation programs					
Building capacity for local government and stormwater management industry professionals	✔	~	~	~	2.3.1
Intensive training of landowners on aspects of stormwater management	✔	✘	✘	✔	2.3.2

	Relevance to the target audiences				
Non-structural control BMPs covered in this manual	**Government stormwater management agencies**	**Developers**	**Commercial or industrial premises managers**	**Individuals, landholders or community groups**	**Section/ chapter referen ce**
Encouraging participation by the community in all aspects of stormwater management	✔	✘	✘	✔	2.3.3 Chapter 8
Education and participation campaigns for commercial and/or industrial premises	✔	✘	✔	~	2.3.4 Chapter 8
Focused stormwater education involving new estates	✔	✔	✘	~	2.3.5
Funding, policy, regulatory and enforcement practices					
Self-sustaining stormwater funding mechanisms	✔	✘	✘	✘	2.4.1
Point source regulation of stormwater discharges and enforcement activities e.g. licensing and inspecting/ auditing industry, enforcement of state or local laws for sources of stormwater pollution	✔	✘	✘	✘	2.4.2
Illicit discharge elimination programs	✔	✘	~	✘	2.4.3
Catchment planning practices					
Use of risk assessments and environmental management systems by local authorities, state government departments and businesses to strategically assess and manage risks to stormwater	✔	~ (major projects)	✔	✘	2.5.1
Integrating the organisational management of stormwater with other aspects of the total water cycle	✔	✔	✔	✘	2.5.2

Key: ✔ = Highly relevant. ~ = Some relevance. ✘ = Not relevant.

1.8 How to select best management practices

The question 'How do I know what BMP to design and use?' is often asked. An overview of the seven steps typically used when undertaking any stormwater and/or groundwater management strategy/plan, whether it is in the context of a new development, catchment or a local government area, is provided below. More detail on the development of stormwater management plans is provided in Chapter 5.

1. Identify relevant water quality-related objectives

For any plan or strategy to succeed, it must have clear objectives. For example, a 'water management plan' for a new development may set quantitative water quality-related design objectives to assist the conceptual design of the stormwater drainage network. These objectives may relate to the quality of stormwater and/or groundwater that may be discharged from the site. Such objectives should be set by or developed in conjunction with regulatory authorities responsible for managing the quality of the area's receiving water bodies.

2. Clearly understand the 'management environment' in which the BMPs will be applied

Those preparing the strategy or plan must clearly understand the resources, constraints and opportunities that are relevant to the project. These may relate to finances, people, skills, timing, politics, land availability, market forces, etc.

3. Undertake a process to select a suitable suite of BMPs

There are many different types of BMPs from which to choose. A process is needed to select a set of BMPs that meet the project's objectives and are compatible with the local physical and 'management environment'. Possible methodologies include:

- undertaking an approach, where a group of experts draw on their knowledge of the study area, available resources and BMPs to quickly develop a suitable suite of BMPs
- undertaking a risk assessment process to screen and prioritise possible BMPs to meet local water management needs and to identify and address pollutant 'hotspots'. An example of such a process is the methodology adapted from the Victoria Stormwater Committee for developing a stormwater management plan in 'Section 3: Stormwater Best Management Practice Guidelines')
- undertaking a 'triple-bottom-line' assessment process using multi-criteria analysis (MCA) to evaluate the economic, social and environmental costs and benefits of possible BMPs. Such a process can be used to highlight which BMPs have greatest overall 'value', and can be linked with public participation processes (e.g. to help determine the weight that should be placed on each criterion in the MCA)
- undertaking pollutant export modelling, where the effect of a suite of BMPs is modelled to determine the approximate reduction of pollutant loads and concentrations in stormwater. Modelling runs are usually undertaken on various conceptual stormwater management designs until the quantitative water quality-related design objectives are achieved. Modelling is still evolving as a stormwater management tool.

Regardless of the chosen assessment methodology, expertise is needed at some point to select a set of possible BMPs that may meet the needs of the study area. People undertaking this role must be broadly familiar with the benefits and constraints of all possible BMPs. As this is a major challenge for one person, a multi-disciplinary team approach is recommended.

More information on the decision-making process for selecting BMPs is provided in Chapter 5, Stormwater Management Plans.

4. Develop a plan or strategy

Once the BMPs have been chosen for the study area, a document should be prepared to set out the characteristics of the BMPs (e.g. location, size, type), the timing of their implementation, who is responsible for their implementation and how they will be monitored and evaluated. For a proposed development, such a document may be a Water Management Plan that is required as part of development approval. For a catchment or local government area, such a document may be part of a Catchment Management Plan that is regularly updated.

5. Design the BMPs

Structural and non-structural BMPs need careful design prior to implementation. For example, if an industrial education and enforcement campaign is to be implemented, careful planning will be needed to ensure that the educational content and strategy is best practice, and that all of the necessary elements are in place for the enforcement component (e.g. regulations, delegated powers, training of enforcement officers, dispute resolution procedures, etc.).

6. Implement the BMPs

This should occur in accordance with the plan or strategy developed in Step 4.

1.9 How to implement non-structural best management practices

The following guidance on using non-structural BMPs is intended to maximise their value and help stormwater managers avoid mistakes.

a) Seek a complementary balance of structural and non-structural controls

All BMPs, whether they are structural or non-structural, or whether they are source controls, in-transit controls or end-of-pipe controls, have potential benefits and limitations. The key is finding the best combination of these measures to suit local circumstances.

A common finding of successful case studies involving stormwater management is that non-structural BMPs often work synergistically with other BMPs, or are needed to deliver structural BMPs. For example, a complementary enforcement and education program may work synergistically to alter people's littering behaviour across a large municipal area. Maintenance of stormwater infrastructure (e.g. sludge removal) will improve the performance of that structural control and of downstream structural controls.

b) Ensure organisational arrangements are conducive to non-structural controls

Delivering a comprehensive stormwater management plan depends on a sound institutional and administrative framework (Taylor and Wong, 2002c). Finnemore and Lynard (1982) emphasised the importance of such frameworks, stating 'the most promising non-structural control measures include institutional control agencies organised to adopt and enforce ordinances, conduct area wide control projects and levy stable and equitable sources of funding' (p.1098). This perspective is supported by Lehner, et al. (1999), who nominated six keys to success based on their review of 100 stormwater management case studies in the US. Three of these keys were administrative (i.e. a dedicated source of funding[4], strong leadership and effective administration). See Section 2.4 for more information.

One of the potential institutional impediments to effective use of non-structural measures in a balanced stormwater management plan/program is that they require a broad range of skills that are not usually found in those sections of traditionally structured organisations that manage stormwater (e.g. traditional 'works

[4] In this context, a dedicated source of funding means a sustainable, secure funding mechanism (such as a local 'environmental levy' or stormwater-related fee on all properties), rather than short-term government grants or year-to-year budget bids.

departments'). Ideally, the section managing the organisation's stormwater program would be in a position to draw upon a wide range of skills to implement the program, including skills in town planning, law, civil engineering, community consultation, marketing, environmental management, psychology and statistics.

There is an increasing trend towards engaging the community via deliberative participation methods to identify issues to be managed, priorities and management strategies. Techniques such as citizen juries are now being used that greatly enhance the community's role in stormwater management. Where new approaches are being used, it is important to ensure that the organisational structure and culture and key staff are amenable to such strategies to increase the chances of success.

Another organisational challenge is to address the fact that some non-structural BMPs have an increased risk of failure compared to more established structural measures. Using the philosophy of 'adaptive environmental management', stormwater managers need to be prepared to engage in responsible risk-taking, leading to improved understanding, program modification and ultimately better outcomes. This philosophy requires a culture of responsible risk-taking within the organisation, which typically requires strong leadership and continual reinforcement.

c) Undertake research and use expertise in their design and evaluation

Non-structural BMPs can be difficult to design and evaluate, primarily because most of these BMPs work by altering people's behaviour. How people will behave in a particular context is difficult to predict because behaviour can be affected by many variables. Similarly, determining with a reasonable level of confidence whether behaviour change has occurred, stormwater quality has improved, or the health of water bodies has improved can be challenging.

When designing a non-structural BMP and/or a plan to evaluate its effectiveness, spend time to undertake research into how effective such BMPs have been in other contexts, how similar BMPs have operated, the features of successful case studies and lessons learnt from other case studies. For example, case studies from similar contexts may demonstrate that it typically takes five years to see on-ground outcomes from new town planning controls for stormwater management. Such knowledge is important, as it may be inconsistent with stakeholder expectations or BMP funding timeframes. The guidelines and references presented in this chapter and a literature review undertaken by the Cooperative Research Centre (CRC) for Catchment Hydrology (Taylor and Wong, 2002c) provide a good starting point for such research.

d) Develop a contingency plan in case of failure to achieve the desired outcome

As explained previously, there are many potential benefits of using non-structural BMPs. However, one disadvantage is that there is often a risk of failure associated with them. This is because of uncertainty regarding their effectiveness and/or their effectiveness is context dependent. Consequently, stormwater managers should develop contingency plans in case evaluation demonstrates that the BMP fails to achieve the desired outcome. For example, a behaviour change campaign may be prepared to encourage residents to minimise the use of fertilisers. If an evaluation finds this campaign is not successful, contingency options could include:

- altering the messages, products, method of delivery, coverage, intensity, etc.
- implementing supporting regulatory measures (e.g. local laws) and enforcing these measures
- implementing supporting economic instruments (e.g. subsidised slow-release fertiliser).

e) Clearly state and document the objectives at the start of the project

It is a common mistake to poorly define the objectives of the BMP, to allow these objectives to evolve as the project is implemented, or define objectives that are impractical to measure. Like all projects that need to demonstrate success (or otherwise), the objectives should be specific, measurable, achievable, relevant and linked to a timeframe.

For example, an education program's objectives could be to implement the program in accordance with the project plan; raise awareness within a target audience; change their values; change their self-reported and actual behaviour; improve stormwater quality (in terms of pollutant loads and/or concentrations); or improve the health of receiving waters. The choice of program objectives has significant implications for the effort required for evaluating the BMP.

f) Be patient and plan for the long-term

Some non-structural BMPs take many years to operate at peak efficiency. For example, it is estimated that it takes approximately a decade for citywide erosion and sediment control programs that have strong, sustained enforcement elements to produce compliance levels of approximately 90 per cent[5] (Taylor and Wong, 2002c).

Two of the consequences of such long timeframes are that:

- the expectations of stakeholders (e.g. local government councillors and community groups) may need to be adjusted, as they may be expecting outcomes within a shorter timeframe
- the organisation’s funding and evaluation arrangements for the BMP may need to be reviewed, so that they can be sustained over the BMP’s entire life cycle.

g) Look for synergies

Non-structural BMPs can be used to add value to structural BMPs. For example, interpretive signage around stormwater management devices in parks can perform a valuable educational role for the local community.

In addition, some non-structural BMPs can help to manage other parts of the ‘total water cycle’[6] (refer to Chapter 2: Understanding the context). For example, town planning controls, educational programs, local laws and/or economic instruments can be used to promote catchment friendly gardening. Resulting benefits may include reduced stormwater and groundwater pollution (e.g. from nutrients), reduced runoff, reduced use of mains water (for irrigation) and ecological benefits from the increased use of native plants.

h) Develop a sound monitoring and evaluation plan at the start of the project

Monitoring and evaluation of non-structural BMPs is often not done, or is done poorly. To better utilise limited funds to improve the state of water bodies, monitoring and evaluation is needed because the effectiveness of many BMPs is either unknown or uncertain.

The CRC for Catchment Hydrology developed monitoring and evaluation guidelines aimed specifically at non-structural measures for stormwater management (Taylor and Wong, 2003). These guidelines outline a conceptual evaluation framework that involves seven possible styles of evaluation to allow stakeholders to choose a style (or styles) that meets their objectives and available resources. These styles involve monitoring:

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[5] That is, about 90% of randomly audited construction sites would be complying with the region's erosion and sediment control requirements.

[6] Total water cycle management recognises that water supply, stormwater, groundwater, surface water and groundwater-dependent ecosystems, and sewage services are interrelated components of catchment systems, and therefore must be dealt with using a holistic water management approach.

1. BMP implementation (i.e. simple evaluation of whether the BMP has been fully implemented and the quality of that implementation)
2. changes in people's awareness and/or knowledge (i.e. evaluation of whether the BMP has increased levels of awareness and/or knowledge of a specific stormwater issue in a segment of the community)
3. changes in people's self-reported attitude (i.e. evaluation of whether the BMP has changed people's attitudes, either towards the goal of the BMP or towards implementing the BMP itself, as indicated through self-reporting).
4. changes in people's self-reported behaviour (i.e. evaluation of whether the BMP has changed people's behaviour, as indicated through self-reporting)
5. changes in people's actual behaviour (i.e. evaluation of whether the BMP has changed people's behaviour, as indicated through direct measurement)
6. changes in stormwater quality (i.e. evaluation of whether the BMP, or set of BMPs, has improved stormwater quality in terms of loads and/or concentrations of pollutants)
7. changes in the health of water bodies (i.e. evaluation of whether the BMP, or set of BMPs, has improved the health of receiving waters).

As a general rule, the results become more meaningful moving from style 1 to 7, but the evaluation becomes increasingly complex and expensive.

Where monitoring and evaluation has been undertaken for non-structural BMPs for stormwater management, an electronic copy of the final report should be sent to the Department of Water and Environmental Regulation, to help disseminate the resulting knowledge to other stakeholders.

i) Report honestly and openly, regardless of success

The failure of a BMP can teach as much and sometimes more than the success of a BMP. Knowledge gained from evaluating non-structural BMPs that have failed to meet their objectives should be communicated within the stormwater industry, so that mistakes can be avoided in future and subsequent funds can be used more wisely. Consequently, any substantial monitoring and evaluation report should be impartial, preferably peer reviewed and communicated to the industry.

j) Recognise that non-structural controls also require maintenance

Concern over the cost of maintaining structural BMPs, such as gross pollutant traps and constructed wetlands, has been one of the drivers for an increased focus on source controls and in particular non-structural BMPs (Taylor, 2000). However, non-structural BMPs also require maintenance.

Common non-structural BMPs such as educational programs, stormwater management plans, town planning controls and enforcement programs all require some work over their life cycle to ensure that they remain effective. Long-term educational programs are perhaps the most difficult to maintain, as messages and strategies need to be regularly refreshed to effectively engage the target audience. In addition, funding may become harder to obtain as the campaign begins to age.

k) Do not get distracted by the 'feel good factor'

Some non-structural BMPs might be perceived to be effective due to support from some sectors of the community. However, if the initial objective of the BMP is to change people's behaviour and/or improve stormwater quality, the level of community support should not be used as the principal measure of success. This is particularly the case for educational programs.

A good example of a BMP where this could occur is the use of stormwater road gully drain stencilling programs. Such programs are commonly used as mechanisms to engage the community, raise awareness of stormwater issues, foster positive attitudes towards stormwater management, help change people's behaviour with respect to stormwater management and reduce stormwater pollution. A literature review by Taylor and Wong (2002c) found that some evaluation exercises have reported a positive correlation between seeing the stencils and levels of stormwater awareness/knowledge but no studies were identified that demonstrated stormwater drain stencilling induces behavioural change. However, if the drain stencilling program includes associated activities such as shopping centre/library displays, postcards/pamphlets in residents' letterboxes and one-on-one discussions, this may increase the possibility of raising awareness levels and changing behaviour.

1.9.1 Additional information

A short set of references is provided at the end of each non-structural BMP addressed in this chapter. In addition, the following general sources of information on non-structural BMPs are recommended:

Australian guidelines (available as a hardcopy only):

- *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victorian Stormwater Committee, 1999)
- *Managing Urban Stormwater – Source Controls* (Draft guidelines prepared for the State Stormwater Coordinating Committee, NSW EPA, 1998).

North American documents (available on the internet):

- *National Menu of Best Management Practices for Storm Water Phase II* (US EPA, 2001)
- *Non-structural Urban BMP Handbook – A Guide to Nonpoint Source Pollution Prevention and Control Through Non-structural Measures* (Northern Virginia Planning District Commission, 1996)
- *Stormwater Strategies: Community Responses to Runoff Pollution* (Numerous American case studies investigated by the Natural Resource Defence Council and reported by Lehner et al., 1999)
- *Guidance Specifying Management Measures for Sources of Nonpoint Source Pollution in Coastal Waters* (US EPA, 1997).

Australian websites:

- *Melbourne Water's Stormwater Management* and *Water Sensitive Urban Design guidelines*: Refer to Melbourne Water's Website. www.melbournewater.com.au/building-and-works/stormwater-management.
- Clearwater: a joint initiative of the Municipal Association of Victoria (MAV) and the Stormwater Victoria (SIAV): www.clearwatervic.com.au/. (Includes an information exchange of case studies, tools, resources, contacts and research.)

American websites:

- The 'Stormwater Manager's Resource Center': www.stormwatercenter.net. (Aimed at local government authorities developing strategic urban stormwater management plans and programs.)
- The American '*National Stormwater Best Management Practices Database'*: www.bmpdatabase.org. (Provides access to BMP performance data in a standardised format for numerous BMP studies conducted over the past 15 years. Currently however, structural BMPs dominate the database.)

1.9.2 Acknowledgment

Several of the introductory sections for this chapter have drawn heavily from Taylor and Wong (2002a & 2002c).

Appendix A - Commonly applied non-structural measures for stormwater management

Non-structural measures	Links and manual reference
Town planning controls	
Stormwater planning controls that promote water sensitive urban design.	WAPC State Planning Policy 2.9 Planning for Water, Planning for Water Guidelines and Liveable Neighbourhoods.
Stormwater planning controls that promote best practice stormwater management on construction sites (including erosion and sediment control).	State Planning Policy 2.9 and Planning for Water Guidelines.
Non-structural, site-based, water sensitive urban design (WSUD) measures for new residential developments: • WSUD applied to public open space networks • WSUD applied to the layout of residential housing lots • WSUD applied to the road layout for residential areas (e.g. narrower residential streets and alternative turnarounds) • WSUD applied to streetscaping layout of residential areas • conservation easements • development density manipulated to minimise inputs of key pollutants • open space design (also known as cluster or conservation development).	WAPC Liveable Neighbourhoods, State Planning Policy Planning for Water Guidelines.
Non-structural, site-based, WSUD measures for new commercial/industrial areas: • WSUD applied to commercial/industrial parking areas (e.g. green parking lot design) • WSUD applied to on-site detention for large commercial/industrial areas.	State Planning Policy 2.9 Planning for Water Guidelines; Detention and infiltration systems in Chapter 9 of this manual.
Strategic planning and institutional controls	
Development of stormwater management plans for a local government area or catchment for the improvement of stormwater quality and protection of aquatic ecosystems.	Chapter 5
Self-sustaining stormwater funding mechanisms.	Section 2.4.1
Use of risk assessments and environmental management systems by local authorities, State government departments and businesses to strategically assess and manage stormwater risks.	Section 2.5.1
Integrating the organisational management of stormwater with other aspects of the total water cycle.	Section 2.5.2
Identifying and fostering champions for stormwater management.	Chapter 11

Non-structural measures	Links and manual reference
Building capacity of elected members, government staff, consultants, developers and residents or the community to improve the management of stormwater.	Section 2.3.1; Chapters 8 and 11
Pollution prevention procedures	
Non-structural, site-based measures for land development and construction sites:	
-drainage controls	-Section 2.1.1
-erosion and sediment controls	-Section 2.1.1
-dust control	-Section 2.1.1
-housekeeping/pollution prevention/waste management controls (e.g. chemical storage and litter prevention)	-Sections 2.1.1 and 2.2.10
-soil amendment undertaken to minimise the export of nutrients.	-Section 2.1.2
Stormwater management addressed in infrastructure/assets maintenance peration s, for example:	
-street cleansing/sweeping	-Section 2.2.1
-stormwater management device maintenance (includes desilting)	-Section 2.2.2
-road/pavement repairs/resurfacing and road runoff	-Section 2.2.5
-maintenance of cemeteries, nurseries, depots, parks/reserves activities and road reserves	-Section 2.2.6
-maintenance of gardens and reserves with respect to plant selection, pest management, watering, bore management, lawn maintenance and the application of fertiliser (includes xeriscaping)	-Section 2.2.7
-vehicle, plant and equipment maintenance (including storage and washing)	-Section 2.2.8
-building maintenance	-Section 2.2.9
-graffiti removal and building wash-down	-Section 2.2.9
-industrial and commercial site practices	-Section 2.2.10
-maintenance of loading and unloading areas	-Section 2.2.10
-storage of hazardous and dangerous goods, food containers etc.	-Section 2.2.10
-sewerage maintenance (including prevention of overflows)	
-management of septic systems	-Department of Health Environmental Health Guide
-management of discharges from swimming pools	
-water main maintenance and construction.	

Non-structural measures	**Links and manual reference**
Waste management practices: • domestic waste and recycling collection	See WA Waste Authority's website, Water Corporation's Waste Wise advice: www.watercorporation.com.au/Waterwise
• manual litter collections and 'clean-up days'	Section 2.2.3
• bin design, positioning and cleaning	Section 2.2.4
• management of pet/animal wastes in public open space	DCBA's Phosphorus Action Group
• management of illegal dumping	Illegal Dumping – refer to Department of Water and Environmental Regulation's website,
• collection programs for hazardous household chemicals, batteries, etc.	Contact the relevant local government authority
Management of wash-waters from: • boats	Victorian Environmental Protection Authority's Cleaner Marinas – EPA Guidelines for Protecting Victoria's Marinas (Oct 1998) www.epa.vic.gov.au/about-epa/publications/624
• mobile industries (e.g. carpet cleaning, dog washing), etc.	SCCP Environmental Management and Cleaner Production Directory for Small and Medium Businesses Section 3.26.
Using/managing stormwater	
Stormwater and shallow groundwater recycling.	Chapter 6; Chapter 9
Urban forestry	Chapter 9
Eliminating kerbs and gutters.	Chapter 6; Chapter 9
Education and participation programs	
Source control measures – education programs (general): • printed material (e.g. posters, pamphlets, etc.) • media campaigns (e.g. radio, tv) • signs (including gully trap stencilling) • community programs • displays (e.g. at major events) • community water quality monitoring programs • launches (e.g. of a new stormwater initiative) • local action committees and groups • consumer programs (e.g. stormwater awareness at the point of sale)	Chapter 8

Non-structural measures	Links and manual reference
• business programs (e.g. surveys, targeted workshops) • school education programs.	
Intensive training on aspects of stormwater management.	Section 2.3.2
Encouraging citizen participation by the community in all aspects of stormwater management.	Section 2.3.4
Regional/citywide stormwater awareness/education programs.	Section 2.3.3; Chapter 8
Education and participation programs involving lawn and garden care practices.	Section 2.3.2
Education campaigns for commercial or industrial premises.	Section 2.3.4
Education and participation campaigns for commercial shopping centres.	Section 2.3.4
Technical education on water sensitive urban design/low- impact development.	Section 2.3.1
Focused stormwater education involving new estates.	Section 2.3.5
Regulatory controls	
Enforcement of state or local laws for point and diffuse sources of stormwater pollution (e.g. for erosion and sediment control).	Section 2.4.2
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry).	Section 2.4.2
Illicit discharge elimination programs.	Section 2.4.3
Vegetated buffer areas.	Chapter 6; Chapter 9

Note:

Where a specific reference has not been given in the above table, consult the general guideline references given in Section 1.10.

2 Guidelines for the use of specific non-structural best management practices

This section contains guidelines for a wide variety of non-structural BMPs.

2.1 Construction practices

2.1.1 Land development and construction sites

Description

These guidelines provide information on management practices that may be applied at construction sites to improve stormwater management and environmental performance. These guidelines may also be applicable to land developments and government agencies that are responsible for land development, such as DevelopmentWA.

Land development and construction sites may be a major source of stormwater pollution. For example, some activities that may allow pollutants to be transported via stormwater management systems to receiving water bodies (e.g. waterways, wetlands, groundwater and marine environments) include:

- litter and waste storage (e.g. litter collection areas that allow litter to be blown by wind or washed away by rainfall)
- washing-down practices (e.g. washing-down concrete mixers and painting tools)
- vehicle tracking of soil from the building site onto roads
- placement and storage of delivery products, particularly sand and soil stockpiles (e.g. if sand is stored where it may be tracked by vehicles onto roads, or blown or washed into roads, and then into stormwater management systems)
- dewatering (e.g. in areas with acid sulfate soils, dewatering activities may cause sulfide minerals in the soil to oxidise and leach acidity, heavy metals and aluminium into groundwater). Contaminated groundwater may then adversely impact on receiving water bodies.

Appendix 1 – Building Activities, Waste Materials and Relevant BMPs outlines the waste materials and relevant BMPs for different trades in the building industry.

Reasons for management of litter, waste and washing-down practices

Contaminants, such as sediment, solvents, paints, adhesives, cement, cement mixer wash-water, lime and litter (e.g. packaging including polystyrene, cardboard and plastic), may be transported via stormwater management systems to receiving water bodies. Where building sites are adjacent to receiving water bodies, contaminants may enter directly from the building site.

These contaminants may harm aquatic ecosystems and cause adverse aesthetic impacts on neighbouring land and receiving water bodies, for example:

- lime and cement, including cement mixer wash-water, may cause changes in pH in receiving waterways and wetlands. This may harm aquatic flora and fauna
- litter (particularly polystyrene, cardboard and plastic) may cause adverse aesthetic impacts, as it may be blown or washed into neighbouring land, stormwater management systems and receiving water bodies. Litter may also harm aquatic fauna, for example plastic may entangle aquatic fauna

- contaminants such as paints and solvents (e.g. turpentine) contain toxic compounds that may harm aquatic flora and fauna. For example, oil-based paints form a thin layer over the surface of the water. This may harm aquatic flora and fauna by preventing sufficient oxygen from entering the water body
- litter and cement may block stormwater management systems, increasing maintenance costs and the risk of localised flooding.

Reasons for erosion and sediment control

Erosion and sediment control is used to prevent or minimise the following:

- sedimentation of receiving water bodies, for example, sediment may smother aquatic plants and filter feeders, encourage weed species and harm aquatic habitats, such as deep pools in waterways
- sedimentation of stormwater management structures and drains. This may increase maintenance costs and the risk of localised flooding. For example, sediment may compromise the capacity of vegetated swales to adequately manage stormwater flows
- increased turbidity in receiving water bodies, which may irritate the gills of fish and reduce photosynthesis in aquatic flora. Reduced photosynthesis may result in deoxygenation of the water and adverse impacts on aquatic flora and fauna, such as fish kills
- environmental harm from pollutants that attach to soil particles (e.g. heavy metals, nutrients and pesticides)
- increased safety risks due to sediment on roads or footpaths
- decreased value of properties due to the loss of topsoil and visual impacts
- increased costs associated with street sweeping and 'downtime' on building sites due to waterlogged conditions or time spent repairing the damage of erosion.

Applicability

The following management practices are applicable to land developments and construction sites in all areas, particularly in catchments or sites with:

- 'traditional' (piped) stormwater management systems
- sensitive receiving water bodies
- steep slopes
- a high proportion of directly connected impervious surfaces (e.g. the roof water from buildings drains directly to the street's drainage system).

These guidelines may be relevant to local governments and State government agencies that coordinate, manage or regulate land development and construction sites, such as:

- land developers (e.g. DevelopmentWA)
- managers of major land development and construction projects (e.g. roads, bridges, drainage works and buildings)
- those who may enforce controls on private sector developments.

The following recommended practices are applicable for all sites:

- litter and waste management (non-hazardous material)
- litter and waste management (hazardous material)
- washing-down practices

- water conservation practices.

Erosion and sediment controls should be based on-site conditions. The ‘Erosion and sediment control practices (relatively flat sites)’ section is applicable for non-constrained sites where there is a low risk of off-site migration of sediment. The ‘Erosion and sediment control practices (constrained sites)’ section is applicable for sites where there is a high risk of off-site migration of sediment, or where there is a sensitive receiving environment.

Recommended practices

See the Additional information section for information sheets on the following recommended practices.

Litter and waste management (non-hazardous material)

The following procedures are recommended for the proper storage and disposal of non-hazardous wastes (e.g. wood, tiles, bricks, metal, soil, dried cement and packaging wastes such as polystyrene, cardboard and plastic) on all construction sites.

✔ Designate a waste collection area on-site that does not receive runoff from upland areas and does not drain directly to a water body or the road. The waste collection area should be placed as far away as practicable from roads and stormwater management systems, water bodies (if applicable) and the lowest point on the site.

✔ Ensure that waste containers have lids so they can be covered before periods of rain, or keep containers in a covered area whenever possible.

✔ Ensure waste containers do not release light-weight material, such as polystyrene, cardboard and paper, during strong winds.

✔ Where bins are emptied on-site by a waste contractor, inspect the area immediately afterwards and undertake ‘dry’ clean-up methods where necessary (e.g. sweeping up spilled litter and debris).

✔ Schedule collection events to prevent waste containers from overfilling.

✔ Clean up spills immediately.

✔ During demolition activities, provide extra containers for waste materials and schedule more frequent collections.

✔ Ensure all wastes are recycled or taken to authorised disposal sites that are appropriate for the types of waste generated from the site. For information about waste acceptance criteria and determination of the appropriate type of landfill for disposal of the collected material, refer to the *Guidelines for Waste categorisation of controlled waste (DWER, 2021) and Landfill Waste Classification and Waste Definitions 1996 (as amended 2019)(DWER, 2019).*

✔ For large building sites, or building businesses that manage many sites, develop a Waste Management Plan to ensure that solid and liquid wastes are minimised and stored correctly to reduce the risk of stormwater contamination. This plan may explore opportunities for waste minimisation (e.g. ensuring the correct amounts of raw materials are purchased to decrease the amount of excess materials that are discarded) and reuse and recycling of wastes and unused materials.

To minimise wastes, the following waste management hierarchy is recommended:

• **Reduce:** Reduce wastes using improved estimation methods and reusable products.

• **Reuse**: Modify procedures so that materials may be reused, for example wood, tiles, formwork, bricks.

• **Recycle**: Builders may work with waste contractors to recycle wood, metals, cardboard, soils, bricks, clay tiles, concrete, mortar, screed, plasterboard and plaster.

Figure 1. Inadequate waste containment and spillage of waste onto the road. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

Figure 2. Site fencing for litter containment and security. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

Litter and waste management (hazardous materials)

The following steps should be undertaken to ensure appropriate disposal of *hazardous* wastes (e.g. paints, adhesives, solvents, contaminated soils, asbestos and Schedule 1 substances) on *all construction sites*:

- ✔ Store materials and equipment that could contaminate stormwater (e.g. fuel, paint, solvents and cement) under covered areas wherever possible and as far away as practicable from roads and stormwater management systems, water bodies (if applicable) and the lowest point on the site. Guidelines for fuel and chemical storage, including Department of Water and Environmental Regulation Water Quality Protection Notes 56 and 65
- ✔ The original product label should never be removed from hazardous wastes in containers (e.g. solvents), as the labels contain important safety information.
- ✔ Design a contingency plan for accidental chemical spills, and clean up spills immediately. Follow clean-up instructions on the package. Use an absorbent material such as sawdust or cat litter to contain the spill where it is safe to do so. Refer to the *Water Quality Protection Note 10: Contaminant spills — emergency response plan* (DWER, 2020) for further advice. Available via Department of Water and Environmental Regulation's website. Further information about emergency response is available via the Department of Water and Environmental Regulation's website.
- ✔ Hazardous wastes should never be mixed during disposal unless specifically recommended by the manufacturer.
- ✔ Local waste management authorities should be consulted about the requirements for disposing of hazardous materials (e.g. contaminated soils, asbestos).
- ✔ If producing controlled wastes, the producer must use a controlled waste carrier to remove that waste. The Department of Water and Environmental Regulation regulates the transportation of these waste through the application of the Environmental Protection (Controlled Waste) Regulations 2004.

- ✔ Staff should be aware of the Environmental Protection (Unauthorised Discharge) Regulations 2004. The regulations include an on-the-spot infringement notice system for minor pollution offences. These powers can be delegated to local government officers. On-the-spot fines carry a penalty of $250 to $500, which increases to up to $5,000 for individuals and $25,000 for companies if the matter proceeds to court. The fines apply to commercial activities including land development and construction premises and cover the discharge of Schedule 1 substances to stormwater or groundwater. These substances include acid with a pH less than 4, alkali with a pH more than 10, hydrocarbons, solvents, degreasers, detergents, dust, engine coolant, pesticides, paint, dyes, sediment and substances containing heavy metals.

Wash-down practices

- ✔ Designate a wash-down area for the site. This area should be located as far away as practicable from roads, stormwater management systems and water bodies (if applicable).
- ✔ Contain wash-water using temporary bunds (e.g. constructed from soil or sand bags), where appropriate, particularly if the wash-down area must be located near roads, stormwater management systems and water bodies.
- ✔ If the bricklayer’s concrete mixers are located near stormwater management systems, water bodies or the lowest point of the site, collect wash-water from the mixer in a wheel barrow and allow the wash-water to soak into the ground in the designated wash-down area (if practicable).
- ✔ Clean equipment before washing (e.g. wipe excess paint from brushes and rollers to remove paint before washing, or brush sand and mud from equipment).

Figure 3. Cement mixer wash-water runoff and sand on the road. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

Figure 4. Contained wash area to collect runoff. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

- ✔ For paint equipment wash-water: Water-based paint wash-water should be diverted into a contained area on-site that is lined with newspaper. When it is dry, place the newspaper containing the paint residue in a solid waste bin. Solvents used for clean-up of oil-based paints should be filtered for reuse or taken to a waste depot that is licensed to accept these wastes. The paint residue left after filtering should be placed in a solid waste bin. Where possible, rather than washing brushes and rollers, seal in an airtight bag for reuse. Unused paint should be kept in the tin or other sealed container and disposed at a waste depot licensed to receive this waste.

- ✔ Ensure that wastewater is discharged to sewer (a Trade Waste Permit is required), or contained and disposed of off-site at an appropriate licensed treatment/disposal facility (for hazardous waste, such as solvents). See 'Litter and waste management (hazardous materials)' section for information on hazardous waste disposal. Further information about connection and discharge of wastewater to sewer is available from the Water Corporation.

Water conservation

Conserve water by turning off taps after use, ensuring water drums are not leaking and minimising the volume of water used during washing-down practices.

Erosion and sediment control practices (relatively flat sites)

The following practices are recommended for land development and construction sites with a low slope and low risk of off-site migration of sediment. Simple Site Management Plans are required for these sites to prevent or minimise sand tracking from vehicles onto footpaths and roads, and to prevent positioning of stockpiles (particularly sand) near roads, where sediment may easily enter stormwater management systems and receiving water bodies.

The site management plan should address the following:

- ✔ Site planning. For example, use a simple map to identify the lowest point on the site, the appropriate location of stockpiles such as sand (e.g. keep sand stockpiles as far from the road and the lowest point of the site as practicable), where to place sediment fences (e.g. on lowest side of the site), and which trees and vegetation will be retained).
- ✔ Minimising the area of disturbance.
- ✔ Dust control and wind erosion.
- ✔ Barriers to trap windblown sediment, sand and litter.
- ✔ Stabilised entry and exit points (i.e. to prevent soil being tracked onto footpaths and roads).
- ✔ Housekeeping practices (e.g. sweeping up and removing any sand tracked by vehicles onto roads, and appropriate disposal of wash-waters to prevent water erosion).
- ✔ Positioning of stockpiles such as sand.
- ✔ In Perth and the South West region, the plan should be guided by the *Erosion and Sediment Control Manual for the Darling Range* (Upper Canning/Southern Wungong Catchment Team, 2001) or any relevant publication current publication specific to the region.
- ✔ For large-scale developments, ensure all on-site staff are trained to understand their responsibilities with respect to stormwater management (including management of litter, liquid wastes, maintenance of erosion and sediment control structures, dust control, subcontractors, etc.). At small-scale (i.e. residential) construction sites, building companies should ensure compliance by providing simple guidelines to subcontractors.

Figure 5. Sand stockpile erosion onto a road. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

Figure 6. Soil stockpile contained by a sediment fence. (Photograph: Clean Site, Keep Australia Beautiful Council WA.)

Erosion and sediment control practices (constrained sites)

Erosion and sediment control practices should be a high priority on sites where:

- there is a significant erosion risk (e.g. land development or construction activities on the Darling Scarp in Perth/the South West in winter)
- there is significant potential for soil to enter stormwater management systems, receiving water bodies, or areas of native vegetation
- receiving water bodies are known to be sensitive to changes in turbidity, sediment loads, litter and/or pollutants; or
- public safety and/or assets could be at risk due to off-site migration of sediment (e.g. sediment on roads, blocking of drains causing localised flooding).

In addition to the practices recommended for erosion and sediment control for relatively flat sites (i.e. sites with low slopes), the following steps should be undertaken when developing an erosion and sediment control plan for constrained sites:

✔ Undertake an evaluation of the site's erosion risk.

✔ Prepare a detailed map of the site that includes information such as property boundaries, contours, area of disturbance, access points, location of all permanent and temporary erosion and sediment control measures (e.g. sediment fences, diversion drains), location of existing vegetation to be retained or removed, location of water bodies and drainage structures, etc.

✔ Provide supporting information, such as a description of the existing site conditions and maintenance strategies (including roles and responsibilities), drawings of erosion and sediment control structures, and design criteria and calculations.

It is essential to plan an approach to managing erosion and sediment control before the site has been disturbed. The erosion and sediment control plan is the primary tool for undertaking and documenting this planning process. The plan should aim to:

✔ Minimise the area disturbed by the development.

✔ Minimise the time disturbed areas are exposed without stabilisation.

✔ Conserve and safely stockpile topsoil for later distribution.

✔ Progressively rehabilitate disturbed areas.

✔ Institute a comprehensive maintenance program for all erosion and sediment control measures.

✔ In Perth and the South West region, these plans should be consistent with the Guidelines for Erosion & Sediment Control at Building Sites in the South West of WA (UWA and South West Catchments Council, 2008) and the Erosion and Sediment Control Manual for the Darling Range (Upper Canning/Southern Wungong Catchment Team, 2001). Refer to the Additional information section for more details.

Figure 7. Silt fence for controlling sediment during land development. (Photograph: André Taylor, Ecological Engineering Pty Ltd.)

Dewatering and acid sulfate soils

Dewatering activities must be approved by the Department of Water and Environmental Regulation or the Department of Biodiversity, Conservation and Attractions. The following conditions apply:

✔ Dewatering operations should be consistent with the Water quality protection note 13: Dewatering of soils at construction sites (DoW 2012).

✔ Disposal of water to stormwater drains that discharge to waterways or wetlands should not be considered, unless other options are not available.

✔ Consult the Department of Water and Environmental Regulation and/or the local government authority to determine suitable water quality criteria for the water being discharged from the site.

✔ A contingency plan is required to manage discharged water (e.g. if the water quality deteriorates during pumping).

✔ Consider the presence of acid sulfate soils. Refer to the Department of Water and Environmental Regulation's website for further information.

Contaminated sites

Extreme care is needed where soils are disturbed or exposed on potential or confirmed 'contaminated sites'. Consult with the Department of Water and Environmental Regulation and the local government authority to determine a suitable stormwater management strategy.

Management systems for government agencies and large-scale operations

The following management arrangements are recommended for State or local government agencies to plan for, and deliver, excellent standards in stormwater management during land development and construction projects. Businesses that regularly undertake large-scale land development or construction activities are also encouraged to adopt these practices.

✔ All operational staff, contractors or sub-contractors should be trained to use appropriate site and waste management procedures and site management plans/erosion and sediment control plans.

✔ Regularly audit compliance with relevant plans, guidelines or procedures for stormwater management on construction sites.

✔ Government agencies and businesses that regularly undertake land development and construction activities are encouraged to develop an EMS. Refer to Section 2.5.1 for further information.

✔ Where contractors undertake construction projects, any contract management arrangements should include provisions for ensuring sound stormwater management. For example:

Clearly specifying stormwater management requirements in the contract.

- Ensure that the tender selection process considers the likely performance of the contractor in managing stormwater during construction.
- If the site management plan/erosion and sediment control plan is prepared by a contractor, allow time and financial resources for evaluation of the plan.
- Allocate a budget for designing and implementing stormwater management practices. The budget should be based on the cost of fully implementing an approved site management plan/erosion and sediment control plan, with a contingency allowance.
- Ensure the site management plan/erosion and sediment control plan is fully implemented and significant consequences to the contractor result from a failure to comply (e.g. financial penalties).

Benefits and effectiveness

These management practices can be expected to:

- reduce loads of pollutants entering stormwater and shallow groundwater (particularly sediment, heavy metals, litter, hydrocarbons, organic matter, paint and solvents), thereby minimising the risk to the health of receiving water bodies
- reduce risk of an isolated discharge from a building site causing an environmental incident (e.g. wastewater from a cement mixer causing a fish kill in a local waterway) or aesthetic impacts (e.g. polystyrene waste being blown by wind into a local wetland)
- reduce risk to public safety and assets
- reduce risk of nuisance to nearby residents
- retain valuable topsoil and building/landscaping materials that may be washed off-site
- reduce risk of localised flooding that is caused by litter/waste or sediment blocking local drains
- improve marketability of the development (particularly for subdivisions where lots are sold prior to construction of buildings)
- have broad educational benefits (e.g. providing examples of best practice stormwater management on construction sites)
- reduce risk of breaching environmental legislation and being subject to prosecution

- reduce risk of public complaints
- reduce costs associated with removing litter and sediment from drainage channels or detention basins downstream of the site; removing litter and sediment from roads and footpaths; collecting windblown litter from around the site; replacing eroded topsoil; re-contouring eroded areas; and 'down time' due to waterlogged conditions on the site impeding workers.

Appropriately designed, implemented and maintained erosion controls on land development and construction sites can be highly efficient and may reduce loads of total suspended solids (TSS) by up to 85–90% (Taylor and Wong, 2002c; Schueler and Holland, 2000; Lehner et al., 1999). Total phosphorus loads may be reduced by up to 80% (Taylor and Wong, 2002c; Lehner et al., 1999).

Well-designed, implemented and maintained sediment controls usually deliver up to 60–70% removal of TSS (US EPA, 1997 and 2001; Schueler and Holland, 2000).

A typical best practice construction site, with a combination of erosion and sediment controls may have a TSS removal efficiency of approximately 60% (i.e. sediment and erosion control measures can trap approximately 60% of the load of suspended sediment in stormwater).

Taylor and Wong (2002c) provide estimates of pollutant removal efficiencies for common erosion control measures (e.g. turfing, seeding, mulching) and sediment control measures (e.g. sediment basins, sediment fences, straw bales).

Challenges

The following challenges may need to be addressed to improve implementation:

- site and equipment considerations, such as space on the site and time needed to perform some maintenance practices (e.g. space for an extra bin for recycling of building materials that would normally be discarded as solid waste)
- procedures and training materials must be regularly updated
- in some areas, local service providers may not be available for hazardous waste and recyclable material removal and processing
- site supervisors need to implement training to address resistance to changes in work practices
- there are safety and localised flooding risks associated with placing geofabric filters over stormwater drain inlets when rainfall is imminent
- it may take time for construction businesses (and associated regulatory personnel), to develop skills and expertise in planning, implementing and maintaining cost-effective Waste Management Plans and Site Management Plans/Erosion and Sediment Control Plans. Technical skills are needed within government agencies, for example those officers assessing a proposed Site Management Plan/erosion and sediment control plan before development
- erosion and sediment control measures may require ongoing maintenance
- a sustained enforcement program is essential for widespread cultural change (Lehner et al., 1999).

Cost^

Generally, the costs associated with these stormwater management practices are minimal, except where large volumes of wastewater need to be treated as 'hazardous waste'.

Erosion and sediment control costs may vary greatly, depending on the characteristics of the site, climate, and type of development. Generic cost estimates (around the year 2001 dollar) for some erosion and sediment control measures are provided in the Table 6 of the Erosion and Sediment Control Manual for the Darling Range, Perth, WA (UCSWCT 2001). Product suppliers and construction contractors are a good source of accurate estimates.

Taylor and Wong (2002c) provide cost estimates for some temporary erosion control measures (e.g. turfing, seeding, mulching) and sediment control measures (e.g. sediment basins, sediment fences, straw bales). However, this information is based on overseas studies.

Costs may be incurred preparing, implementing and auditing a Site Management Plan/erosion and sediment control plan. These costs may vary depending on the type of project and the site conditions.

^ *The costings used in this section are from around 2000. Please adjust the costings for present day*.

Additional information

Other recommended Australian resources include:

- *Keeping Our Stormwater Clean – A guide for building sites* (EPA Victoria and Melbourne Water, undated). Available on the Clearwater Website. www.clearwatervic.com.au/
- The Clearwater Information Exchange (Victoria) website (MAV and SIAV, undated). Available via www.clearwatervic.com.au/

The following WA guideline outlines erosion and sediment control BMPs to manage drainage, erosion, sediment loss and dust, and improve housekeeping practices. They include advice about how to prepare an erosion and sediment control plan, erosion control measures (e.g. diversion drains, drop structures, level spreaders, vegetation stabilisers) and sediment control measures (e.g. stabilised and limited points for site access, sediment traps, straw bales, sediment fences, stormwater inlet filters and vegetated buffers):

- Upper Canning/Southern Wungong Catchment Team (2001). *Erosion and Sediment Control Manual for the Darling Range, Perth, Western Australia*. Edited by B. Lloyd and R. Van Delf, Miscellaneous Publication 17/2001. Agriculture Western Australia, Perth, Western Australia.

The United States Environmental Protection Agency's online *National Menu of Best Management Practices for Storm Water Phase II* has fact sheets on the following practices:

- good housekeeping measures for waste management (e.g. general construction site waste management, such as spill prevention and control plans, vehicle maintenance and washing areas; and education and awareness practices such as contractor certification and inspector training, construction reviewers, BMP inspection and maintenance, and model ordinances or design criteria)
- runoff control measures (e.g. minimising clearing by using land grading, permanent diversions, preserving native vegetation and designing construction entrances; and stabilising drainage ways using check dams, filter berms, grassed lined channels and riprap)
- erosion control measures (e.g. stabilise exposed soils by using chemical stabilisation, mulching, permanent seeding, sodding or turfing and soil roughening; and protecting steep slopes using geotextiles, gradient terraces; soil retention; temporary slope drain; protecting water bodies using temporary stream crossings, vegetated buffers; and phased construction, construction sequencing and dust control)
- sediment control measures (e.g. install perimeter controls using temporary diversion dykes, wind and sand fences, brush barrier, silt/sediment fence; install sediment trapping devices using sediment basins and rock dams, filters, chambers and traps; inlet protection using stormwater management system inlet protection)
- additional fact sheets on turf reinforcement mats, vegetative covers and dust control.

For information on the placement and maintenance of the building's external litter and recycling bins, see the guidelines provided in Section 2.2.4.

For information on developing and maintaining an EMS for a large construction site (or construction company), see the guidelines provided in Section 2.5.1.

Examples/Case studies

Australian case studies are available from:

- Clearwater's website information exchange available via www.clearwatervic.com.au/
- The Housing Industry of Australia's Greensmart® Program website has a list of participating businesses.

Appendix 1. Building activities, waste materials and relevant best management practices

*The relevant BMPs column briefly outlines reasons for some of the BMPs. For further details, please refer to the 'Reasons for management of litter, waste and washing-down practices' and 'Reasons for erosion and sediment control' in the Description part of this Section. Refer to the Recommended practices section for detailed guidance on relevant BMPs.

Waste Authority of Western Australia can provide guidance on resource recovery, recycling and appropriate waste disposal practice. Further information is available via www.wasteauthority.wa.gov.au/%20programs/view/construction-and-demolition-recycling.

Trade/activity	Materials and wastes	Relevant best management practices*
Bricklayers	Bricks, mortar (sand, cement, water, lime, plasticiser, dampcourse additive), wood pallets, chipboard, window and door frames, dampcourse, plastic packaging and strapping, cement bags.	1. Erosion and sediment control. Management of sand stockpiles and preventing/minimising sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly unused lime and cement and cement mixer wash-water disposal (as the pH may harm aquatic flora and fauna) and preventing wind- blown litter (to minimise adverse aesthetic impacts). 3. Resource recovery. Bricks, sand and wood may be recycled. 4. Minimise water use by turning off taps and ensuring water drums are not leaking.
Building supervisors	All materials and wastes. Sediment, food and drink wastes (e.g. paper and plastic), packaging wastes (including polystyrene, cardboard and plastic), paints, lime, cement and cement mixer wash-water, neighbourhood wastes dumped on-site, adhesives, and solvents such as turpentine.	1. Erosion and sediment control. E.g. placement of sand stockpiles and preventing/minimising sand tracking from vehicles onto roads. 2. Litter and waste management. Ensure compliance with recommended practices and relevant legislation. Refer to 'Litter and waste management (non-hazardous and hazardous wastes)' in Recommended practices. For example, unused cement and lime (the pH may harm aquatic flora and fauna) and unused hazardous (Schedule 1) substances such as paint and solvents (these may be toxic to aquatic flora and fauna). Other activities may include preventing windblown litter such as polystyrene, cardboard and plastic (to minimise adverse aesthetic impacts). 3. Washing-down practices. E.g. the pH of cement mix wash-water may harm aquatic flora and fauna. Wash-waters containing paint and solvents from painting tools may be toxic to aquatic flora and fauna. 4. Resource recovery, many building wastes may be recycled.
Carpenters (interior and roof) and cabinet-makers and fitters See also 'Roofs and gutters', if applicable	Wood, packaging (e.g. plastic and cardboard), Laminex, chipboard, adhesives, paints, solvents, sandpaper.	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly disposal of unused paints and solvents (may be toxic to aquatic flora and fauna) and preventing windblown litter (to minimise adverse aesthetic impacts). 3. Washing-down practices. E.g. disposal of wash-waters containing paint and solvents from paintbrushes, rollers and trays. 4. Resource recovery. Wood and cardboard may be recycled.
Ceiling fitter s and flushers	Plasterboard, plaster cornices, ceiling plaster, adhesives, fillers and	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads). 2. Litter and waste management. Particularly

Trade/activity	Materials and wastes	Relevant best management practices*
	sealers, setcoat, putty, cements, sandpaper, packaging (paper and plastic) and corner reinforcing mesh.	preventing windblown litter and disposal of unused adhesives and cement, as these materials may harm aquatic flora and fauna. 3. Washing-down practices. E.g. the pH of cement mixer wash-water may harm aquatic flora and fauna. 4. Resource recovery. Plaster products, i.e. plasterboard, plaster products may be recycled.
Concreters (e.g. pouring concrete building slab)	Concrete, cardboard, wood, polystyrene, black plastic membrane (high-density polyethylene (HDPE)), metal pins/ stakes, steel reinforcing mesh.	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly preventing windblown litter (e.g. polystyrene), management of cement mixer wash-water and concrete disposal practices (as dried cement may block stormwater management systems). 3. Washing-down practices. E.g. the pH of cement mix wash-water may harm aquatic flora and fauna. 4. Resource recovery. Metal, concrete and wood waste may be recycled. Recycled aggregate may be used in concrete to reduce consumption of this resource. 5. Minimise water use.
Deliverers (particularly sand)	Sand, soil, bricks, tiles, timber, waste bins and other relevant products.	Erosion and sediment control. E.g. placement of stockpiles, and preventing sand tracking from vehicles onto roads.
Electricians	Packaging (cardboard and plastic), electrical cables, wooden and plastic electrical cable reels.	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly preventing windblown litter and not burying waste in trenches). 3. Resource recovery. Cardboard wastes may be recycled and electrical cable reels may be returned to distributors/manufacturers for reuse.
Painters (painting and cleaning)	Oil-based paint, water-based paint, solvents (e.g. turpentine), paint tins, sandpaper, polyfiller, masking tape, brushes, rollers, mixers, cardboard, plastic sheets.	1. Erosion and sediment control. E.g. sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly preventing windblown litter and disposal of unused paints and solvents (may be toxic to aquatic flora and fauna). 3. Washing-down practices. E.g. disposal of wash-waters containing paint and solvents from paintbrushes, rollers and trays. 4. Minimise water use by ensuring taps are turned off after use.
Plasterers and renderers	Plaster, sand, screed (render scrapings), cement, water, lime, non-lime	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads). 2. Litter and waste management. Particularly

Trade/activity	Materials and wastes	Relevant best management practices*
	plasticiser.	appropriate disposal of unused cement and lime, as the pH may harm aquatic flora and fauna. 3. Washing-down practices. E.g. disposal of wash-waters containing plaster, cement and lime. 4. Resource recovery. Sand, render and plaster may be recycled. 5. Minimise water use by ensuring taps are turned off after use.
Plumbers and drainers (underground and household).	Polyvinyl chloride (PVC) pipe and fittings, polystyrene, dampcourse, high-density polyethylene (HDPE) plastic, adhesives and solvents (e.g. solvent cement glue), packaging (cardboard and plastic).	1. Erosion and sediment control e.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly appropriate disposal of unused solvents and adhesives (as these materials may be toxic to aquatic flora and fauna), not burying wastes in trenches and preventing windblown litter, such as polystyrene.
Roofs and gutters (roof carpenters, fitters, tilers, trimmers, roof insulation technicians). See also 'Carpenters', if applicable.	Wood, laminated veneer lumber, steel and plastic strapping, metal (e.g. downpipe and gutter off-cuts and zinc/aluminium coated steel sheets), clay or cement tiles, sealers (contain solvents), tile grout, packaging (plastic, metal, wood), roof insulation.	1. Erosion and sediment control e.g. sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly appropriate disposal of sealers (solvents may be toxic to aquatic flora and fauna) and grout (may block stormwater management systems and the pH may harm aquatic flora and fauna) and preventing windblown litter. 3. Resource recovery. Clay tiles, metal, cardboard and wood may be recycled. Note: Copper Chromium Arsenate (CCA) treated timber cannot be recycled.
Site works (earthworks operators, excavators, soakwell/sewer installers, electrician, gas technician, telecommunications technician, Water Corporation technician, retaining wall installers and fence removers/ installers).	Green waste, rubble/excess soil. sand, PVC and HDPE plastic off-cuts, plastic cable reels, cement, fencing sheets, metal, wood, cardboard.	1. Erosion and sediment control. Appropriate placement of stockpiles, particularly sand, and preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly preventing windblown litter and not burying wastes in trenches. 3. Resource recovery. Sand, cardboard and sand/soil may be recycled.
Tilers (interior)	Tiles, adhesive, mortar, grout, silicon, packaging (e.g. metal, cardboard and plastic), damp course products (contain solvents).	1. Erosion and sediment control. E.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management. Particularly appropriate disposal of adhesives (may be toxic to aquatic flora and fauna) and grout (the pH may harm aquatic flora and fauna) and preventing windblown litter. 3. Washing-down practices. E.g. disposal of wash-waters that contain grout. 4. Resource recovery. Metal and cardboard may be recycled.

Trade/activity	Materials and wastes	Relevant best management practices*
Pest controller (e.g. termite control)	Pesticides.	Pesticide use consistent with Department of Health requirements and industry BMPs (not addressed here).
Waste contractors (e.g. hazardous waste collection)	All relevant wastes. Common hazardous wastes include paints (including lead paint, used extensively until 1970), asbestos and solvents.	1. Sediment and erosion control. E.g. preventing sand tracking from vehicles onto roads. 2. Litter and waste management and resource recovery. Ensure all wastes are recycled or taken to authorised disposal sites that are appropriate for the types of wastes generated from the site. Refer to the *Guideline for Waste categorisation of controlled waste* (DWER, 2021). For hazardous wastes (Schedule 1), use BMPs consistent with the Department of Environment's requirements, including the Environmental Protection (Controlled Waste) Regulations, 2004. For further information, refer to the Litter and waste management (hazardous waste) sub- section in the Recommended practices section.

2.1.2 Soil amendment for urban gardens and lawns

Description

Remark: Whilst information in this sub-section (Soil amendment for urban gardens and lawns) is still relevant, for up to date information on; soil amendment in general including its applicability, recommended practices, industrial by-products as soil amendments, benefits and effectiveness and challenges, cost, potential soil amendment agents for the management of phosphorus, relative permeability and Phosphorus Retention Index (PRI) of various substrates, research trials on industrial by-products, Red Mud Gypsum (RMG) and Red Sand Gypsum (RSG), crushed limestone and lime sands, natural clay or loam soils, Synthetic Rutile Production (SRP) wastes, fly ash and lime kiln dust and compost amended soil, contact the Water Science Branch of the Department of Water and Environmental Regulation.

Many areas in WA have sandy soils with low ability to retain moisture, nutrients and trace elements. Urban development may also diminish the capacity of soil to support plant growth, through processes such as the removal of topsoil and soil compaction.

Soil amendment is a technique used to create fertile topsoil by increasing the soil's ability to retain moisture and nutrients, and filter some contaminants, such as heavy metals, before they infiltrate into groundwater.

Soil amendment involves adding an agent to the soil to improve its structure, porosity, water holding capacity and nutrient recycling capacity. Potential amendment agents in an urban environment include compost, organic-rich soils, loam soils, natural clay, crushed limestone and gypsum.

'Soil amendment agents' are generally distinguished from 'fertilisers' by having a lower nutrient content, and a greater ability to retain and recycle both moisture and nutrients.

Applicability

The technique has potential applicability in urban areas where fertilisers are likely to be added (e.g. traditional residential gardens, lawns and parks). However, prior to applying the technique, consideration should be given to potential impact on groundwater-dependent ecosystems (e.g. wetlands). For example, widespread use of soil amendment on sandy soils in Perth may decrease groundwater recharge, reducing the flow of groundwater to ecosystems down-gradient from the site. However, widespread use of soil amendment material may also reduce groundwater abstraction requirements for irrigation due to an increase in the soil's ability to retain water. This may potentially reduce the stress to groundwater-dependent ecosystems caused by lowering of the groundwater table due to water abstraction. Such impacts should be assessed on a site-by-site basis by suitably qualified professionals.

Where soils have the potential to be compacted during development (e.g. Guildford Clays), soil amendment with an organic compost or loam could produce many of the hydrologic and pollutant reduction benefits demonstrated by overseas studies (see Case Studies).

In areas with sandy soils, soil amendment has potential as a way of retaining and recycling nutrients and water in the top 30 cm of soil beneath lawns and gardens.

Recommended practices

The soil amendment process during urban development typically involves the following steps:

- initial soil disturbance
- breaking up of the subsoil
- rock removal (where relevant)
- distribution of imported soil amendment agent
- application of lime and fertiliser (if required after soil analyses have been undertaken and expert advice has been received)
- soil integration (e.g. tilling 10 cm of compost placed on the surface of the soil, to a total depth of 30 cm)
- grading and rolling the site prior to lawn or garden establishment.

Loams with a high organic content and composted green waste are recommended for use as urban soil amendment agents on the Swan Coastal Plain.

Where large-scale application of soil amendment agents is proposed, approval may be required under the Environmental Protection Act 1986. Contact the Department of Water and Environmental Regulation or the Environmental Protection Authority (EPA) for more information.

Industrial by-products as soil amendments

Any soil amendment using industrial by-products should be consistent with the Department of Water's Water Quality Protection Note – Soil Amendment Using Industrial By-Products (DoW, 2015).

Widespread application of industrial by-products (e.g. gypsum-neutralised red mud or red sand (RMG/RSG), fly ash and synthetic rutile production (SRP) wastes, also known as Titanium Dioxide residues) is not currently allowed in urban areas. Special restrictions may also apply in sensitive environments, such as Public Drinking Water Source Areas (i.e. drinking water catchments) and near conservation value wetlands, waterways and native vegetation. Refer to the Water Quality Protection Note for the latest recommendations.

Further information about research trials is available in the Research Trials on Industrial By-Products section.

Benefits and effectiveness

Enhancement of soils with inorganic soil amendment agents (e.g. natural clays) has great potential to increase the amended soil's PRI and reduce the export of phosphorus (P) to stormwater and/or groundwater. For example, the PRI for Bassendean Sands is 0–0.5, while natural clays or loam soils have a PRI of 30–1,000 (WRC, 1998). However, more local research is needed in an urban context, to demonstrate and quantify the effectiveness of soil amendment using a range of amendment agents.

Enhancement of soils with organic soil amendment agents (e.g. compost) will increase the soil's water holding capacity, but does not always reduce nutrient export (see Case Studies). The following benefits of composted amended soils have been reported from overseas studies, where surface water flow dominates the post-development hydrologic regime.

Water quality management benefits include:

- slow passage of potential pollutants so that soil microbes can decompose them
- reduced need for fertilisers and irrigation, as the compost supplies more nutrients, which are slowly released to plants
- increased soil stability, leading to reduced erosion potential
- added protection to groundwater resources, especially from heavy metal contamination
- reduced thermal pollution by detaining surface runoff (LID Centre, 2003).

Water quantity management benefits include:

- more rainwater being held on-site, this attenuates peak flows and decreases runoff
- base flows to local water bodies are maintained (important during dry periods)
- increased groundwater recharge (compared to compacted clays) through better infiltration and by detaining the water on-site longer (LID Centre, 2003)
- increased soil moisture.

Refer to the Examples/Case studies section, below for further information.

When applied to sandy soils, such as those on the Swan Coastal Plain, compost amendment is not likely to produce all the benefits listed above, as the soils already have a very high infiltration capacity. However, when compared to the scenario of highly fertilised non-amended soils (i.e. in European-style residential gardens and lawns), the technique does have the potential to significantly reduce the export of nutrients (particularly phosphorus) to groundwater and reduce the need for irrigation.

Challenges

The following challenges may need to be addressed to improve implementation, where approved soil amendment application is appropriate:

- In urban areas and sensitive environments, such as Public Drinking Water Source Areas, and adjacent to conservation value wetlands, waterways and native vegetation, there may be constraints placed on the *widespread* use of soil amendment agents.
- Determine the phosphorus retention capacity of the amendment agents, as these can vary considerably.
- Amended soils may re-release bound phosphorus if conditions become anaerobic. This limits the use of soil amendment to levels above the groundwater saturation zone.
- There is potential for re-release of phosphorus from amended soils if the pH of the stormwater becomes too acidic (e.g. pH < 5).
- Some areas may be unsuitable for the application of soil amendment agents, such as areas with acidic or alkaline soil (pH that may mobilise metals in the SAM); and areas prone to waterlogging (soil anoxia might cause redox reactions that could mobilise metals in soils) (DoW, 2015).

- Amendment may reduce the permeability of some soils (e.g. sandy soils), and reduce groundwater recharge. Reduced groundwater recharge could adversely affect the health of groundwater-dependent ecosystems that exist nearby. A buffer zone around such ecosystems may be required.
- Amended soils have a finite effective lifespan if nutrients are not recycled by plants and microorganisms.
- Care is needed to prevent the introduction of contaminants in the amendment agents (e.g. heavy metals, poly aromatic hydrocarbons, radio-active materials, pathogens) that may be hazardous to human health, particularly in the context of residential premises where children or animals may ingest soil and vegetables may be grown. Care is required in what material is used and where.

Industrial by-products

There are concerns about the suitability of some industrial by-products (e.g. RMG/RSG, fly ash and SRP wastes) for widespread soil amendment in urban areas. For example, the potential for leachate from RMG/RSG, fly ash and SRP wastes to cause heavy metal contamination.

Refer to the former Department of Water's Soil Amendment Using Industrial By-products Water Quality Protection Note for up-to-date guidance (DoW, 2015). This note currently recommends that industrial by-product soil amendment agents should not be used in urban areas.

Cost^

The technique is relatively inexpensive, with costs including purchase, transportation and application of the amending agents, monitoring the effectiveness of pollutant removal, and replacement of amended soil if its pollutant removal capacity diminishes over time.

Taylor and Wong (2002c), citing Brosnan (2002), estimated the potential cost of soil with a high phosphorus retention capacity in Perth (delivered to sites within the metropolitan region) as approximately \$25–\$30 per m^3.

North American studies of compost amended soils below lawns have concluded that:

- irrigation needs (and therefore costs) may be reduced by up to 60%
- fertilisation requirements and costs also decrease
- mowing and aeration requirements and costs remain the same
- weed control requires monitoring, as composts can contain weed seeds. The spread of weeds may be of significant concern if the development is adjacent to sensitive bushland or wetlands
- routine lawn maintenance and costs are reduced
- overall, the benefits offered by the technique outweigh the installation cost
- for a case study in Seattle, the total estimated amended soil cost was approximately US\$11–US\$33 per m2 (in 1996 dollars), and the payback period was five to six years when compared to traditional topsoil and seeding, and within the first year when compared to traditional topsoil and turfing.

^The costings used in those example are from around 1996 and 2002. Please adjust the costings for present day.

Additional information

Potential soil amendment agents for the management of phosphorus

Possible amendments to retain phosphorus are crushed limestone (applicable to loam soils but may not be necessary on alkaline coastal sands), natural clay, loam soils. For other materials, the optimum ratios should be determined by phosphorus retention and permeability tests.

The following industrial by-products are not approved for use in urban areas. However, field trials have shown they retain phosphorus when used as soil amendments: RMG/RSG, SRP wastes, and alkaline industrial by-products such as fly ash and lime kiln dust.

Relative permeability and PRI of various substrates

The Phosphorus Retention Index (PRI) ranges given in the table below are intended for comparative purposes only. The PRI test was developed to compare the P retention capacities of virgin Western Australian soils, particularly those on the Swan Coastal Plain. When making an assessment of the P retention capacity of industrial by-products, more exhaustive procedures and expert advice must be adopted, as chemical properties such as high pH may affect PRI results (see DoW 2015 for details). The PRI test gives no indication of either the long-term cumulative capacity of amendments, the mechanisms controlling P retention, or the effect of solution P concentration on P retention. After these have been assessed from laboratory or field studies, the PRI test may be useful as part of a monitoring or quality control program for the industrial by-product. For natural soils, a reasonable estimate of P retention capacity from PRI is possible. Table 1 displays the relative permeability and PRI for various substrates.

Table 1. Relative permeability and phosphorus retention index (PRI) for various substrates

Substrate	**Permeability (m/day)**	**PRI**
Bassendean Sands	30+	0 – 0.5
Karrakatta Sands	10+	2 – 4
Cottesloe Sands	10 +	5 – 12
Crushed limestone or lime sands	2–5	5 – 20
Natural clay or loam soils	<0.4	30 – 1,000+
Leached RMG*	May depend on local soil type and blend	170 – 600
Leached RSG*	May depend on local soil type and blend	13 – 54
SRP Wastes*	May depend on local soil type and blend	90 – 1,000++

* = Not currently allowed as a soil amendment agent in urban areas. Primary sources: WRC (1998) and Davidson (1995).

Crushed limestone and lime sands

The adsorptive potential of calcium carbonate from crushed limestone or lime sands has been found to vary considerably between samples from different locations (Ho and Monk, 1988). A potential advantage of using limestone as a substrate amendment is that phosphorus is not released in response to failing redox potentials caused by oxygen stress (McAuliffe and Evangelisti, 1991). Due to inconsistency and uniformity between limestone samples, thorough testing is required to determine the most suitable mix and site from which to obtain limestone.

Natural clay or loam soils

Natural clay or loam soils (e.g. Gingin loam and Marybrook loam) have been used as amendments to increase the phosphorus retention capacity of sands under agricultural production, and for sewage effluent disposal.

Research trials on industrial by-products

Industrial by-products (e.g. RMG/RSG, fly ash, SRP wastes and lime kiln dust) are not currently approved for widespread soil amendment in urban areas. However, this information may help to build a knowledge platform for future trials.

There is a national initiative to develop environmental guidelines for the application of industrial by-products as soil amendments. A draft discussion paper Development of a National Framework for the Reuse and Recycling of Industrial Residues to Land Management Applications has been prepared by the Environment Protection and Heritage Council.

Refer to the Recommended practices section for further information.

RMG and RSG

Gypsum-neutralised bauxite residues have nutrient stripping potential. There are two by-products, red mud and red sand, which have different particle size distributions. When mixed with gypsum to produce RMG and RSG, the alkalinity of the residues is reduced, with the pH buffered at around 8.3 by calcium carbonate (Summers et al., 1988). The high phosphorus retention capacity of RMG is attributed to adsorption of P by high concentrations of iron and aluminium oxides, adsorption and precipitation by calcium carbonate ($CaCO3$), and precipitation of P by soluble calcium (Ca) from gypsum. Leached RSG has a much smaller concentration of iron and aluminium oxides, and consequently its P retention capacity is only about one-fifth of leached RMG. There is also an approximate two-fold range in the P retention capacities of RMG and RSG from different alumina refineries.

Phosphorus adsorption to iron III (ferric) $Fe3+$ in oxidising conditions is a reversible process, so P has the potential to be re-released in anaerobic conditions. It is unclear whether this applies to RMG/RSG because a significant proportion of the P is precipitated with calcium. As the sorption characteristics of RMG are determined by the alkaline pH, nutrients bound to amended soil may be re-released if the calcium carbonate in the amended soil is neutralised by percolating acidic water (McAuliffe & Evangelisti, 1991).

Studies undertaken by Ho et al. (1989) found that the major salts in the leachate of RMG amended sands were by-products of the alkalinity neutralisation process. Salt concentrations in groundwater immediately below soils amended with RMG are expected to rise, but with negligible long-term effects. Background concentrations are expected to return after one to two years.

Alcoa and the former Department of Agriculture trialled the use of RMG/RSG in the Peel-Harvey catchment. The Department of Primary Industries and Regional Development has conducted further studies into the continued effectiveness of these soil amendment practices. See the Summers et al. (2020) in the Reference and Further Reading section of this section.

SRP wastes

There are two by-products of synthetic rutile production from mineral sands, both of which contain high concentrations of iron oxides. One is acidic and the other is alkaline (due to the presence of calcium carbonate). The latter product also contains gypsum and therefore resembles RMG in chemical composition. These by-products have a high capacity to retain P. The permeability of soil mixes is similar to soil mixes with RMG.

Fly ash and lime kiln dust

Fly ash and cement or lime kiln dust (CKD or LKD) have some potential for use as soil amendments. These materials are alkaline due to the presence of very finely divided calcium carbonate or calcium hydroxide and have a similar mode of action in the long-term to very fine limestone.

Fly ash trials have been conducted in WA. For example, in-field trials by the University of WA Turf Research Program, fly ash applied at 150 tonnes per hectare in the top 15 centimetres (cm) of soil significantly increased the amount of water retained (Sports Turf Technology, 2004). Other research is being conducted by Boral Material Technology and Fly Ash Australia.

These industrial by-products require further testing to determine their capacity for pollutant removal and effect on permeability.

Examples/Case studies

Refer to www.lid-stormwater.net for an overview of North American approaches to using soil amendments to reduce the rate of stormwater runoff, and reduce the overall nutrient export load.

Compost amended soil

Compost amended soils usually reduce the net export of nutrients compared to non-amended soils. For example, Harrison *et al.* (1997) reported a relative reduction of:

- 70% of total P load
- 58% of soluble-reactive P load
- 7% of nitrate load.

These load reductions may be associated with a substantial reduction in water flux rates rather than improvements in water quality (i.e. less water may leave the amended soils via stormwater or groundwater). For example, concentrations of nitrate in water draining from the compost amended soils can be higher compared to non-amended soils.

The study by Harrison et al. (1997) found that when compost amended soils were used for lawns, they produced a grass that was uniformly aesthetic, and required little or no fertilisation over the three month trial period. Harrison et al. (1997) concluded that the reduced need for lawn fertilisation may be the biggest environmental benefit of compost amendment. This benefit has been demonstrated in several studies conducted over three to six month trial periods.

The US EPA (1999) evaluated the benefits of compost amended soils for impoverished soils where surface water runoff dominates the hydrologic regime. For example, composted amended soil was found to increase water infiltration (and reduce surface runoff), increase fertility, and significantly enhance the aesthetics of the turf. The need for continuous fertilisation to establish and maintain the turf was reduced or eliminated. The compost also increased the concentrations of many nutrients in the runoff, particularly when the site was newly developed. However, due to increased infiltration, the nutrient mass runoff should be significantly reduced.

Taylor and Wong (2002c) estimated the potential reduction in total phosphorus loads that may be obtained from amendment of sandy soils in the Perth region from the work of Kelsey (2001). In a pollutant export modelling exercise for a proposed development near Perth, Kelsey used the following total phosphorus export rates based upon the best available information:

Residential land use:

- Lateritic soils TP = 0.15 kilograms/hectare/year (kg/ha/yr)
- Sandy soils TP = 1.2 kg/ha/yr Rural land use:
- Lateritic soils TP = 0.11 kg/ha/yr
- Sandy soils TP = 1 kg/ha/yr.

From these rates, Taylor and Wong (2002c) concluded that the use of lateritic top soils to amend sandy soils could have pollutant removal efficiencies of *up to* 87.5% and 89% for stormwater from residential and rural land use, respectively. Actual efficiencies are likely to be lower than these percentages due to the blending process that occurs during soil amendment.

2.2 Maintenance practices

2.2.1 Street sweeping/cleansing

Description

Street sweeping is widely used in urban areas to reduce the accumulation of litter, leaves and coarse sediment from roads, carparks and footpaths. It is undertaken to improve aesthetics, public safety and stormwater quality. It is also the most studied non-structural BMP for the improvement of urban stormwater quality.

Street sweeping as a stormwater quality BMP is an attractive option for many local authorities, as it is already in use (albeit primarily for aesthetic reasons), and roads, carparks and footpaths account for approximately 70% of impervious urban areas (VSC, 1999).

This guideline will focus on street sweeping rather than flushing, as the flushing of pollutants through the stormwater system is not recommended. Street sweeping equipment can collect high portions of sediment, litter and organic matter. Street sweeping also can remove nutrients and heavy metals that are absorbed into sediments.

Improvements in stormwater quality using street sweeping is best achieved by focusing on pollution 'hot spots' rather than routinely sweeping all streets (VSC, 1999). In addition, it is recommended that street sweeping be coordinated with other maintenance activities and events. For example, targeted street sweeping may be undertaken after:

- resurfacing works on a roadway
- unloading of materials in an industrial or commercial area
- a public rally or major sporting event.

Applicability

Street sweeping may be undertaken by owners of commercial and industrial premises, developers during construction activity, the local government authority as part of a well-planned sweeping schedule, or by State government authorities after construction activities.

Although Taylor and Wong (2002c) concluded that while street sweeping appears to have limited benefits as a stormwater quality BMP when applied on a citywide scale using traditional equipment, it has significant benefits when applied in high risk areas and in specific circumstances. For example:

- street sweeping is applicable for large industrial or commercial sites or residential construction sites, where access to pollutants on impervious surfaces can be easily controlled and resources are available for more frequent sweeping and sweeping at particular times
- street sweeping in areas with deciduous trees during autumn. Large volumes of leaf litter can be collected, which would minimise the loading of organic matter on sensitive water bodies
- to collect large volumes of gross pollutants deposited as a result of a specific event in a clearly defined and easily accessible area (e.g. after a ticker tape parade or major sporting event)
- programs that sweep streets, carparks and pavement before 'first-flush' runoff events, to collect accumulated sediment
- the collection of absorbent material commonly used by incident response crews to contain liquids after traffic accidents.

Street sweeping in Perth has several advantages compared to many other parts of Australia. Firstly, there is evidence to suggest that the particle size distribution of sediment in Perth's urban areas generally has a higher percentage of coarser particles, making it more likely to be collected by street sweepers. Secondly, the city's long dry periods over summer provide a good opportunity for material that has accumulated on impervious surfaces (e.g. windblown litter and sediment) to be collected before it is washed into receiving waters. Areas like the lower Canning River catchment upstream of the Kent Street Weir occasionally experience harmful blue green algal blooms shortly after late summer/early autumn rainfall events. These blooms often occur after long, dry periods. Targeted street sweeping in such catchments is beneficial (i.e. targeting areas where nutrients may be associated with sediment and/or organic material that can be collected by a sweeper).

Recommended practices

Recommended practices for street sweeping are summarised below from VSC (1999) and NVPDC (1996):

Planning and monitoring

✔ Ensure that street sweeping resources enable targeting of 'hot spots' to occur.

✔ Identify priority pollutants that could be collected by street sweeping (e.g. leaves from deciduous trees upstream of a lake) and priority locations where these pollutants may accumulate.

✔ Identify the best timing for street sweeping, to maximise capture efficiency while reducing costs.

– Street sweeping should be strongly considered after a long dry period (e.g. mid-summer), when large loads of material have accumulated on impervious surfaces and there is the potential for this material to be flushed into water bodies following the next major storm event (e.g. those in late summer/early autumn). Such storm events can be associated with harmful algal blooms in receiving water bodies.

– Areas with a high percentage of deciduous trees should be swept during/after the autumn leaf fall.

– Sweeping frequency should be increased during the wet season, as rainfall is a significant pollutant vector.

✔ Ensure street sweeping occurs at a time when vehicles do not block access to the kerb because significantly more particulates accumulate along the gutter line/kerb.

✔ Inspect the swept area before sweeping to determine the need and likely effectiveness, and after sweeping to *broadly* determine its value.

✔ Ensure that records are kept of the quantity and composition of collected material, as well as the cost, so that the cost-effectiveness of the sweeping program can be improved over time.

✔ Keep up-to-date with new street sweeping technology and ensure new equipment maximises the capture efficiency for pollutants of concern (e.g. phosphorus adsorbed to fine particles of sediment). Local research to understand the pollutants on impervious surfaces is highly recommended (e.g. understanding the typical particle size distribution of sediments and the association of nutrients and toxicants with sediment particles of varying size).

Coordination with other activities

✔ Undertake a risk assessment to identify activities with stormwater quality impacts that could be minimised through street sweeping. For example, street sweeping would be beneficial prior to the scouring of new water mains or at the end of the day around a construction site where sediment has tracked onto the road.

- ✔ Ensure routine maintenance programs that have a need for street sweeping (such as road repair works) include street sweeping as part of their procedures.
- ✔ Identify infrequent activities that may require street sweeping after the event (e.g. a street market or ticker tape parade).

Community coordination

- ✔ Advise the community of street sweeping schedules and encourage people to remove vehicles from the street so that the sweeper can access the kerb.
- ✔ Install temporary parking restrictions to gain access to the kerb in areas that are heavily trafficked.

Operational restrictions

- ✔ Ensure street sweepers do not discharge any solid or liquid waste to the drainage system. Such wastes should be assessed to determine the correct form of disposal in consultation with operators of liquid and soil waste disposal facilities. For information about waste acceptance criteria and determination of the appropriate type of landfill for disposal of the collected material, refer to the Factsheet–Assessing whether material is waste (DWER, no date) and the Landfill Waste Classification and Waste Definitions (DWER, 1996, as amended 2019)
- ✔ Discourage the washing of footpaths and flushing of kerbs unless necessary for safety reasons. Where flushing is necessary, investigate opportunities to trap the stormwater for subsequent disposal (e.g. to a grassed area) or filter it prior to discharge to stormwater.
- ✔ Where mechanical sweeping equipment has limited access to an area, hand sweeping is recommended.

Benefits and effectiveness

Street sweeping has significant benefits when applied in high risk areas and in specific circumstances, particularly when new technology sweepers are used.

In 1999, Walker and Wong reviewed the street sweeping literature and data from Australian field studies (including WA studies) to evaluate the effectiveness of this BMP for stormwater quality improvement. However, new street sweeping technologies have emerged over time, making much of the research that was undertaken in the 1980s and 1990s obsolete. Therefore, the following conclusions should not be applied to new street sweeping technology. Taylor and Wong (2002c) summarised their principal findings and conclusions as:

- literature from overseas studies indicates traditional street sweeping is relatively ineffective in reducing the load of particles smaller than 125 µm (in diameter) on the street surface
- the typical range of suspended solid particle size in Australian urban stormwater is 1–400 µm (in diameter), with approximately 70% of the particles being smaller than 125 µm (in diameter). As mentioned in the Applicability section, however, areas like Perth may not be 'typical' with respect to particle size distribution due to the higher proportion of coarser particles
- for typical Australian conditions, street sweeping as it was practised in the late 1990s was unlikely to effectively reduce pollutants of concern (i.e. fine suspended particles <125 µm with adsorbed heavy metals and nutrients)

- Australian field studies found significant loads of gross pollutants in stormwater draining from urban areas that had been subject to a daily street sweeping regime. Drawing on the findings of studies on the generation of gross pollutants in Melbourne, Walker and Wong (1999) suggest that loads of gross pollutants in stormwater draining from urban areas depend more on the type of rainfall (i.e. the available energy to mobilise and transport gross pollutants) than reductions to the load of gross pollutants on the street surface (i.e. through street sweeping)
- while newer street sweeping technology[7] more effectively removes the finer fraction of suspended particles under experimental conditions (see Sutherland and Jelen, 1996), 'the effectiveness of street sweeping programs depends more on factors such as land-use activities, the inter-event dry period, street sweeping frequency and timing, access to source areas and sweep operation than the actual street sweeping mechanism' (Walker and Wong, 1999, p. 4).

While street sweeping frequency is a variable that can influence pollutant removal efficiency, Taylor and Wong (2002c) caution that slightly increasing the frequency will not necessarily increase the efficiency of the BMP due to other factors such as the type of rainfall (e.g. its timing). For example, the influence of sweeping frequency on the load of litter entering stormwater from Californian highways was investigated in a US$2.8M Litter Management Pilot Study (Caltrans, 2000). The study found that increasing the frequency of mechanical sweeping from monthly to weekly did not statistically reduce (a = 0.05) the count or weight of litter in stormwater (as measured at stormwater drain outlets) or the total load of litter in the stormwater system (Caltrans, 2000). In addition, statistical analysis between treatment and control areas failed to show a reduced concentration of chemical constituents in stormwater that could be attributed to the increased sweeping frequency.

As discussed in the Recommended practices section, planning the sweeping program will significantly increase its effectiveness.

Highman (2004) concluded that without street sweeping, more pollutants would have reached downstream stormwater treatment systems (e.g. inlet pits) or receiving water bodies. The material collected by street sweepers can also block some stormwater treatment systems, resulting in stormwater bypassing the treatment systems.

For quantitative information on 'sweeper removal efficiencies' and 'reductions in the surface contaminant load' that have been associated with various street sweeping studies, see Taylor and Wong (2002c) and/or Walker and Wong (1999).

Challenges

The following challenges may need to be addressed to improve implementation, as reported by Schueler (2000), US EPA (2001) and Taylor and Wong (2002c):

- determining the optimal sweeping frequency, which is region specific, and needs to draw upon local research (this is the primary limitation)
- determining reliable pollutant removal efficiencies for modern ('high efficiency') street sweepers in a local context (again, additional local research is required in this area)
- overcoming operational problems that diminish street sweeping performance such as speed, parked cars, and the ability to get access to the kerb
- budgeting for the cost of new technology sweepers

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[7] For example the 'small-micron surface sweeper technology' can reportedly remove particles as small as 4 μm (in diameter), and produce a total removal efficiency of approximately 70% for particles smaller than 63 μm (Sutherland and Jelen, 1997). Another technology is the 'regenerative air sweeper' that can reportedly produce a removal efficiency of approximately 32% for particles smaller than 63 μm (Sutherland and Jelen, 1997). For more details, see Taylor and Wong (2002c).

- budgeting for the cost of appropriately disposing of highly contaminated waste that may be classed as hazardous and require special disposal arrangements
- budgeting for the cost of maintaining the street sweepers so that they remain effective
- ensuring street sweepers are maintained and tested regularly so they remain effective. The capability of street sweepers (i.e. their ability to capture a high percentage of fine sediments and associated pollutants), although this limitation is reducing with time
- training sweeper operators
- the inability of sweepers to collect some forms of pollutants (e.g. oils and greases, as well as nutrients in a dissolved form).

Additional information

A wide range of guidelines and research reports are available on this subject (see references below). High quality performance data is also available on the US BMP Database (bmpdatabase.org/).

Examples/Case studies

Calculation of optimal sweeping frequency – Northern Virginia, US

As noted previously, determining the optimum sweeping frequency based on local research is important. In guidelines for local stormwater managers, the Northern Virginia Planning District Commission (NVPDC, 1996) undertook this work, and recommended street sweeping frequencies of at least one sweep per week for residential areas and one to three sweeps per week for commercial and industrial areas, to maximise its effectiveness.

These recommendations represent a significant change to typical street sweeping frequencies in the region, which were based primarily on meeting aesthetic and safety needs (i.e. one sweep every six months for residential areas and one sweep every three months for industrial areas).

Control of parked cars to optimise sweeping effectiveness – Wisconsin, US

Gaining access to the kerb is another limitation of street sweeping, particularly in areas where cars are parked during the day and overnight. Like most limitations to street sweeping, this constraint can be managed if resources are available. A successful example reported by Taylor and Wong (2002c) comes from the City of Madison, Wisconsin. The City of Madison undertook a pilot study that aimed to test whether the surface pollutant removal efficiency of street sweeping could be improved by applying parking restrictions to areas where gaining access to the kerb was often difficult.

The study included a public education, parking enforcement and a street sweeping component. As a result, the total quantity of pollutants collected by street sweeping increased in volume by 118% (from 5.25 to 11.46 cubic metres per kerb kilometre swept). In addition, a public survey found 97% of respondents were aware of the new parking restrictions and the revenue gained from parking enforcement activities enabled the education and enforcement aspects of the program to be self-funding in the long-term (Lehner et al., 1999). No data was gathered on the effect on stormwater quality.

2.2.2 Maintenance of the stormwater network

Description

Maintenance of the stormwater drainage network includes inspection, cleaning and repair of open and piped drains, pits, treatment devices, detention basins and outfall structures (VSC, 1999). This network needs to be regularly cleaned to maintain its performance (US EPA, 2001).

Regular cleaning of the stormwater drainage network provides an opportunity to remove pollutant loads that would otherwise enter receiving water bodies after heavy rainfall. In addition to transporting pollutants, drains with accumulated pollutants may also overflow, leading to localised flooding and erosion, as well as risks to human safety and constructed assets.

This guideline will focus on the maintenance of those elements of the stormwater drainage system that are not specifically designed to trap pollutants (e.g. pits, soak wells, pipes, open channels and detention basins). For structural BMPs that are designed to trap pollutants (see Chapter 9), each device should have a detailed and site-specific maintenance plan. Such plans should be prepared when the BMPs are designed and provide guidance on a suitable inspection regime and maintenance practices (including guidelines on the equipment to be used, health and safety procedures, waste disposal arrangements, etc.).

Most stormwater drainage networks have some capacity to capture and temporarily store pollutants (e.g. coarse sediment and litter). Such pollutants may be temporarily stored in drop inlets, gully pits[8], flat open drains or detention basins and ultimately removed by either large storm events or maintenance by the asset manager (Taylor and Wong, 2002c). This is particularly the case where the stormwater drainage network has infiltration pits/soak wells or detention basins along its length. These features can provide 'hot spots' for accumulation of gross pollutants and contaminated sediments. For example, in the Mills Street drainage catchment in Perth, sediments from open drains and detention basins have been found to contain high concentrations of heavy metals (copper, lead and zinc in particular), hydrocarbons and nutrients (SRT, 2003a).[9] The type of land use and industries upstream of the drainage system should be considered in predicting what types of pollutants are likely to be trapped in the device or sediments. Sediments in open drains and basins may also contain iron monosulphide black oozes (MBOs) (black, organic-rich oozes on the bottom of drains and basins, usually occurring in drains with slow flowing summer water flows). Sediments that contain MBOs will require special removal techniques to prevent oxygenation and subsequent acid release and deoxygenation of the water body. Some sediments can accumulate pyrite between cleaning events that could result in a net release of acid on drying of sediments.

Generally, higher concentrations of metals reside in the uppermost organic-rich layers of the sediments and decrease in concentration with depth in stormwater detention basins. This indicates that the stormwater detention basins can act to prevent significant metal pollution of the underlying aquifer, while still performing their designed function of groundwater recharge from stormwater runoff. The potentially high levels of contaminants such as heavy metals must be considered during the removal and disposal of the top layer of sediments from open drains and basins.

Applicability

This management practice is applicable to all areas with stormwater drainage systems, but is particularly relevant where the system has an increased risk of pollutant accumulation (e.g. due to flat grades or the existence of nodes in enclosed drainage systems where pollutants can accumulate). In general, drainage networks that have a high proportion of open drains and detention basins provide a greater opportunity for the capture of contaminants than equivalent enclosed systems.

'Leaky' drainage systems that are built on sandy soils will need a relatively intensive maintenance regime to inspect and, if necessary, clean out trapped stormwater pollutants at dedicated infiltration points (e.g. gross pollutants and contaminated sediments). However, a gross pollutant and sediment trap installed before the entry of the leaky pipe system can reduce the maintenance requirements to no greater than the requirements of a traditional enclosed drainage system.

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[8] 'Drop inlets', 'gully pits', and 'catchbasins' are all terms for structures in the stormwater drainage network that receive stormwater as it first enters the enclosed, public stormwater drainage system (e.g. from a road surface or commercial property). Designs vary depending upon the locality, but these structures often have the ability to trap small amounts of coarse sediment andgross pollutants (albeit temporarily).

[9] For example, half of the sediment samples analysed from this catchment exceeded 400 mg/kg for total N and 110 mg/kg for total P (SRT,2003a).

These guidelines are primarily intended to assist local government authorities and drainage service providers (such as the Water Corporation). However, they are also relevant to managers of privately owned stormwater drainage assets (e.g. those responsible for stormwater drainage structures on commercial or industrial sites).

Recommended practices

In the Perth region, maintenance of open drains, detention basins and infiltration basins is a significant issue for some stakeholders, as it can affect the export of contaminants from some drainage catchments. Some recommended maintenance practices are provided below for these types of assets.

Inspection and maintenance frequencies

- ✔ Identify pollutant 'hot spots', where relatively large quantities of pollutants of concern regularly accumulate in the drainage system.
- ✔ Focus on those parts of the stormwater drainage network with relatively flat grades or low flows, as pollutants tend to accumulate in these areas.
- ✔ Undertake regular inspections of 'hot spots' to assess whether pollutants are accumulating.
- ✔ Inspect all stormwater drains and detention basins at least once a year, preferably immediately prior to the wet season.
- ✔ Adjust the maintenance frequency of the drainage network to suit pollutant accumulation rates and seasonal conditions (flexibility of the maintenance regime is required given the uncertainty with accumulation rates and rainfall patterns).
- ✔ Prepare an inspection program that assigns inspection tasks, frequencies and responsibilities.

Desilting and pollutant removal operations

Management of desilting operations should aim to minimise movement of low dissolved oxygen and potentially heavy metal rich slugs of water downstream of cleaning operations. A major issue is that removed material may be too wet for landfill disposal, but contain too many solids for disposal to the wastewater system. Management of handling, drying and final disposal of the materials needs to be considered.

- ✔ Use suitable equipment to extract the waste from the drainage system (e.g. for enclosed drains and pits, machinery that operates via suction rather than flushing, where possible).
- ✔ Where flushing must be used, ensure that wastewater is collected and suitably disposed. This wastewater is usually prohibited from being discharged to sewer. Discharge is an offence unless approved by the Water Corporation, and approval is only given in some special circumstances. Contact Water Corporation for further information.
- ✔ For major desilting works involving drainage assets that may be regarded as 'waterways' by members of the community (rather than 'drains'), consult with local residents and relevant community groups before undertaking work.
- ✔ Management precautions when planning cleaning of open drains and basins should include spot testing to determine whether there is a potential soil acidity issue or the presence of iron monosulphide black oozes (MBOs).

✔ For guidance on how to manage acid sulfate soils, see the Department of Water and Environmental Regulation *Acid Sulfate Soils Fact Sheets: Managing urban development in acid sulfate soil areas* (2015) and the WA Planning Commission's Planning Guidelines: *Acid Sulfate Soils* (2008).

✔ Work in dry weather, when the drainage facility is dry or during low flow conditions. This will reduce the volume of material that will require disposal.

✔ Do not disturb the banks of the drain, unless they are eroded and need stabilisation.

✔ If banks need stabilisation, explore physical and vegetative options, rather than scraping contaminated sediment onto the banks where it will erode again. Further information about determining local native plant species and sourcing and planting local native plants is provided in Section 2.2.7. Biodegradable erosion control matting (e.g. jute matting or equivalent) should also be considered for steep slopes that are at a higher risk of erosion until vegetation stabilises these areas. In extreme cases, structural measures may need to be explored (e.g. use of rock lining).

✔ Determine if there are any sensitive flora or fauna in the vicinity of the work site and establish precautions to protect these species when undertaking maintenance works. Records should be kept by maintenance staff of any area that requires special maintenance procedures (e.g. an area where maintenance activities need to be scheduled around months when birds nest in the area).

✔ Remove sediment, litter and weeds from the drainage asset without altering its design invert level. This is particularly important in areas where nutrient-rich base flow enters open drains in summer months and transports these nutrients to sensitive waterways and wetlands. In such locations, all effort should be made to minimise the deepening of open drains and detention basins.

✔ Analyse a representative sample of the sediment before it is removed. In most of the urbanised catchments in the Perth region, removed sediment is likely to contain high levels of nutrients and often contain high levels of heavy metals and hydrocarbons. Analysis will determine if the sediment is suitable for use as a soil amendment, if it can be disposed on-site, or if it is contaminated and requires disposal at a landfill.

✔ When maintaining detention basins, be aware that the highest levels of contaminants are usually found in sediments closest to the outlet

✔ Sediment should not be left alongside the drain or basin where it can erode and re-enter the drainage system.

Figure 8. Sediment excavated from the Harvey Main Drain and stockpiled on the banks. Sediment has buried fringing vegetation and may be washed into the waterway. (Photograph: Department of

Figure 9. Sediment cleared from a stormwater compensation basin and spread on the banks. Mill Street Compensation Basin, Welshpool. (Photograph: Department of Environment.)

- ✔ If the sediment requires disposal in a landfill, refer to the Landfill Waste Classification and Waste Definitions 1996 (as amended 2019) (DWER, 1996) to determine the appropriate landfill type and the waste acceptance criteria. The Department of Water and Environmental Regulations regulates the transportation of wastes that may cause environmental or health risks. It does this through the application of the Environmental Protection (Controlled Waste) Regulations 2004. Controlled waste is generally defined as all liquid waste, and any waste that does not meet the acceptance criteria for a Class I, II or III landfill site. The Guideline: Waste categorisation of controlled waste (DWER, 2021) specifies that a generator is a person whose activities produce, or apparatus result in the production of controlled waste. Generators are required to use a DWER controlled waste licensed carrier to transport the material off-site and be in possession of a controlled waste tracking form.
- ✔ Sediment might require dewatering before removal from the site. This can be done by temporarily stockpiling (in a location where leachate does not flow back into the drainage asset) to allow for evaporation. Leachate should be managed in accordance with the Environmental Protection (Unauthorised Discharge) Regulations 2004. Alternatively, the sediment can be removed as a sludge/slurry and disposed in accordance with the *Landfill Waste Classification and Waster Definitions 1996 (as amended 2019)* (DWER, 1996) and the Environmental Protection (Controlled Waste) Regulations 2004. All loads should be covered when being transported.
- ✔ Before leaving the site, ensure that collected vegetative matter and litter have been removed, sediment has not been 'tracked' onto sealed roads, and the site does not pose a significant erosion risk.
- ✔ Ensure that all staff or contractors are suitably trained to implement these procedures.
- ✔ Enhancement of the drainage asset's ability to trap pollutants should be attempted in accordance with a plan that has been developed by people with suitable expertise using best practice design manuals for structural best management practices (see Chapter 9). This includes the introduction of meanders and riffles to drains, the construction of features to stop short-circuiting in detention basins, enlargement of basins, altering the bathymetry of drainage assets, planting alongside the drainage asset to lower groundwater levels and reduce nutrient concentrations in shallow groundwater, and the planting of bands of native vegetation perpendicular to the flow direction. These works can also be designed to enhance the habitat value of the waterway or basin and create an aesthetic landscape feature. See Chapter 6 for further information about retrofitting existing infrastructure to achieve multiple benefits. For major works, an environmental management plan may also have to be prepared, which details how the construction process will minimise impacts on water quality.

Mowing and other types of mechanical vegetation maintenance

- ✔ Ensure that the proposed work is really necessary. The vegetation may appear unsightly, but may be providing a soil stabilisation role, habitat to valuable fauna and shading of the water column.
- ✔ Under no circumstances should vegetative matter (e.g. grass clippings, removed weeds) enter the water in the drainage asset, or be placed in locations where they could be blown or washed into the drainage asset. It is best to remove vegetative matter and litter from the site. Such material can be taken to an approved disposal site/transfer station where it can be recycled or disposed.
- ✔ When maintaining recreational areas alongside open drainage channels or detention basins, try to maintain a buffer zone of at least 10 metres where no fertilisation of lawns and gardens occurs. This

strip should consist of suitable native plant species. Where possible, bank-side vegetation regimes should be designed to shade water in the drainage asset.

- ✔ Where appropriate, maintain firebreaks along drainage easements in accordance with local government requirements. Dry detention/ retention basins and swales overgrown with grass that dry out in summer can be a potential fire risk.
- ✔ The existence of non-native annual grasses along the top of the banks is a matter of concern to some water quality managers because such vegetation provides little shading and a poor buffer, requires regular mowing, can block drainage inlets and can contaminate the waterway following maintenance (e.g. from cut material entering the water column). Where a grassed landscape is preferred (e.g. for aesthetic reasons), it is recommended that conventional grasses be replaced with native perennial grasses, where practicable.
- ✔ Avoid using machinery that contributes to bank instability.
- ✔ Avoid washing machinery on-site. Ideally, vehicles and machinery should be washed in a sewered wash bay. An Industrial Waste Permit is required to connect and discharge these wastes to sewer. For further information, contact the Water Corporation.
- ✔ When refuelling machinery, ensure that fuel is not spilt on soil, vegetation or water. Ideally, refuelling should occur well away from drains and waterways. See Section 2.2.8 for further information.
- ✔ Report all environmental incidents (e.g. fish kills, oil spills) and the presence of noxious weeds to responsible parties for action as soon as practicable after their identification.

Use of herbicides for weed control

- ✔ Herbicides should only be used after an examination of alternatives (e.g. physical removal of weeds, biological control, planting of native species that can out-compete weeds species, or planting of species that will shade out weed species and help lower the water temperature in the drainage asset). Ideally, a rigorous and scientifically based decision-making process should be used to determine the best methodology (including the type of control agent, method of application and timing of application) for managing weeds on a site-specific basis. Water and Rivers Commission Water Note 22 *Herbicide Use in Wetlands and Chapter 3 of the Department of Biodiversity, Conservation and Attractions' guide to managing and restoring wetlands in Western Australia will* provides guidance on minimising the risk of herbicide use to aquatic ecosystems. Frogs in particular have been found to be sensitive to most herbicides; however, some products have been developed that are far less toxic to frogs.
- ✔ A weed management plan should be prepared for significant hot spots and priority areas. Further information about the types of weeds in wetlands and waterways is provided in Water and Rivers Commission Water Notes 1 and 15. Guidelines for planning and implementing revegetation programs are outlined in the Water and Rivers Commission River Restoration Manual Chapters RR 4, 5 and 8.
- ✔ All practical attempts should be made to avoid herbicides entering water in drainage assets (e.g. avoid spraying in windy conditions).
- ✔ Be careful that weed control activities do not generate an erosion problem (e.g. along the banks of open drains). To minimise this risk, consider planting native species two weeks after spraying the weeds (see Section 2.2.7).

✔ The service provider undertaking spraying activities must have knowledge of the weed species and the best time to spray.

✔ Where large volumes of chemicals are present on-site, ensure that a spill clean-up kit is available and personnel are trained in its use.

✔ Avoid washing equipment on-site.

✔ See Section 2.2.7 for more information on pesticide use.

Benefits and effectiveness

The US EPA (2001) reported that regular cleaning of the stormwater drainage network can increase dissolved oxygen levels in stormwater, reduce levels of bacteria, reduce pollutants entering receiving waters (e.g. sediment, nutrients, litter, organic matter), minimise localised flooding and minimise erosion that is caused by localised flooding.

Quantitative information on pollutants removal efficiencies associated with the maintenance of open drainage channels and detention basins in WA is not available. In regions like Perth, it is likely that accumulated sediments in urban areas are enriched with nutrients, heavy metals and hydrocarbons. The flat grades, high infiltration rates, and relatively low rainfall intensity of the region would help sediments to be deposited in the drainage network rather than being flushed through it. Given these circumstances, it would seem likely that a high-quality drain inspection and maintenance program would be effective at removing considerable quantities of contaminants (including nutrients) from the system, thus preventing these contaminants from entering sensitive water bodies. Maintenance programs could target areas that are most likely to generate contaminated sediments and potentially discharge the sediments to sensitive receiving water bodies (e.g. conservation category wetlands).

Challenges

The following challenges may need to be addressed to improve implementation:

- determining an optimal maintenance regime (e.g. best locations, frequency and timing)
- agreeing among stakeholders what the objectives of drain maintenance should be. For example, should a drainage authority be required to routinely remove non-noxious weeds from open drainage channels if they are not significantly affecting water quality or the drain's hydrology?
- appropriate disposal or reuse of the liquid and/or solid waste, which can be highly contaminated and/or voluminous. For example, sediment removed from open drains and detention basins in Perth is voluminous, usually nutrient-enriched, and potentially contaminated with heavy metals and hydrocarbons (depending upon the location). See the *Landfill Waste Classification and Waste Definitions 1996 (as amended 2019)* (DWER,1996)
- ensuring maintenance teams do not inadvertently change the original bathymetry of open drains and detention basins
- dsigning an efficient maintenance regime that covers stormwater management systems of differing designs
- trapping wastewater that results from flushing enclosed stormwater management systems (i.e. pipes) before it enters receiving waters. The wastewater from flushing enclosed (i.e. piped) stormwater management systems is usually prohibited from being discharged to sewer. Discharge of this wastewater to sewer is an offence unless approved by the Water Corporation, and approval is only given in some special circumstances
- where flushing is used for enclosed (i.e. piped) stormwater management systems, a significant water source is often required.

Additional information

Before flushing is used as a cleaning technique for enclosed drainage, discussions should occur with environmental regulators (e.g. the Department of Water and Environmental Regulation) to determine waste disposal requirements for the resulting wastewater. Trials may be necessary to:

- determine the quality and quantity of wastewater (to enable decisions relating to disposal to be made)
- ensure maintenance equipment and practices effectively collect the wastewater
- test the practicality and effectiveness of on-site treatment options for the wastewater.

Examples/Case studies

Mineart and Singh (2000) reported a study in San Francisco, California, which investigated whether an increased cleaning frequency of stormwater drain inlets could result in increased removal of urban stormwater pollutants. They examined the mass of pollutants captured during monthly, quarterly, semi-annual and annual clean-outs of drop inlets. They concluded that monthly maintenance collected the greatest volume of pollutants in residential, commercial and industrial areas, with a reduction in annual copper loads entering the city’s water bodies of at least 3%–4%, and possibly higher (i.e. 11%–12%), if the monthly maintenance also captured pollutants from illegal dumping activities.

2.2.3 Manual litter collections

Description

The manual collection of gross pollutants (e.g. litter) in locations where it may be blown or washed into the stormwater drainage network or water bodies is a common management practice in urban areas and along main roads. Collections are typically undertaken by:

- staff from government agencies (e.g. in ‘hot spots’, such as along the road corridor in commercial areas)
- volunteers during ‘clean-up days’
- the private sector in relation to their own premises (e.g. around commercial and industrial sites)
- sectors of the community that sponsor an area (e.g. a section of highway).

This management practice is often implemented for aesthetic reasons. However, there is evidence that a regular manual litter collection program can significantly reduce the loads of pollutants entering water bodies via the stormwater drainage network. The practice can, in some circumstances, be used to provide an opportunity to raise the public's awareness of stormwater pollution.

Applicability

This management practice is applicable where gross pollutants (particularly litter) are accumulating in locations that are easily accessed by maintenance teams or volunteers. It is particularly relevant where:

- these pollutants have a high risk of entering the stormwater drainage system or water bodies (e.g. litter in an urbanised catchment with a steep grade and a high percentage of directly connected impervious surfaces
- the receiving water bodies host environmental values that would be threatened by the discharge of litter in stormwater (e.g. swimming beaches and urban wetlands with high aesthetic or conservation values)
- ‘hot spots’ are easily identified (e.g. pockets where windblown litter accumulates).

Recommended practices

The key steps to establishing a manual litter collection program include:

- ✔ Identify 'hot spots' where litter accumulates.
- ✔ Identify areas where there is a high risk of litter entering the stormwater management system or receiving water bodies.
- ✔ Determine a suitable maintenance regime (including collection frequency, collection methods, personnel, health and safety requirements, etc.).
- ✔ Develop a simple monitoring and evaluation plan to determine the effectiveness of the program (for guidance on this issue, see Taylor and Wong, 2002d).

Explore opportunities to raise awareness of stormwater pollution and littering during the clean-up activities. For example, signage can be used to explain the purpose of clean-up activities, and large volumes of collected waste can be used as a graphic reminder of the quantities of litter that are generated in the region. When specific 'clean up days' are organised for volunteers, there are usually many media opportunities (e.g. involvement of high profile public figures, statistics on the tonnage of waste collected and details of unusual items that have been found).

Figure 10. Manual litter collection on the Swan River foreshore. (Photograph: Clean Up Australia.)

Other recommendations include the following:

- ✔ Place a strong emphasis on maintaining safety standards. For example, manual litter collectors may find hazardous substances (e.g. syringes) and volunteers may have limited training. Specialist 'sharps containers' and associated instructions/training should be provided.
- ✔ In areas where the collected litter includes a high percentage of potentially recyclable items (e.g. glass and plastic bottles), the collected waste should be sorted into recyclable and non-recyclable streams. Typically, roadside litter will contain a high proportion of recyclable material.

Benefits and effectiveness

In 2000, the Californian Department of Transportation undertook the three-year Litter Management Pilot Study to assess the efficiency of various litter management practices on major highways (Caltrans, 2000).

The study found that increasing the frequency of manual litter collections along highways from monthly to weekly:

- decreased the litter quantity in stormwater at all stormwater outfalls (a statistically significant finding with $a = 0.05$)
- decreased the average annual litter load in stormwater by 30% (by weight), 41% (by volume) and 33% (by count) compared to control sites (Berger, 2001 as cited in Taylor and Wong 2002c, Caltrans, 2000).

The litter control activities (e.g. bin placement and manual litter collections) can effectively control gross pollutants, especially in areas with a high proportion of directly connected impervious areas.

Challenges

The following challenges may need to be addressed to improve implementation:

- cost, as it is labour-intensive
- occupational health and safety procedures must be addressed, particularly when volunteers are involved
- consideration of how smaller items can be collected, as only medium to large items of litter are typically collected
- determining an optimum maintenance frequency for a given area.

Cost^

A typical roadside manual litter collection program may involve two maintenance staff, a vehicle, and basic health and safety equipment. Two maintenance personnel can cover about 1 km of the road corridor in one hour. Local disposal costs for solid, non-hazardous waste should also be included.

The Californian Department of Transport estimated manual litter collections of medium to large items along highways (i.e. items greater in size than, but not including cigarette butts) cost approximately US$40–US$45 per kilometre (Berger, 2001).

^The costings used in the section are from around 2000. Please adjust the costings for present day.

Additional information

The following websites are recommended resources:

- Clean Up Australia, available via www.cleanup.org.au
- Keep Australia Beautiful Council of Western Australia's A Litter Prevention Strategy For Western Australia 2015-2020 available via www.kabc.wa.gov.au

Examples/Case studies

Main Roads Western Australia (MRWA) conducts road maintenance activity which include litter collection as part of its EMS. It is in partnership with the Keep Australia Beautiful Council to support volunteer groups in regions to clean-up on roads managed by MRWA).

The 'Clean Up Australia' program is an example of a successful national program with activities in Western Australia.

2.2.4 Litter bin design, positioning and cleaning

Description

The design, location and maintenance regimes of public litter bins (and accompanying recycling facilities) is an important source control for litter, particularly in urban areas.

Applicability

This management practice is suitable for public spaces in urban areas and potential litter 'hot spots' in non-urban locations (e.g. roadside rest areas). In remote locations however, the placement of public litter bins may attract illegal dumping of large volumes of waste (e.g. places where people camp).

This management practice is particularly relevant where:

- litter has a high risk of entering the stormwater drainage system or water bodies (e.g. litter in an urbanised catchment with a steep grade and a high percentage of directly connected impervious surfaces)
- the receiving water bodies host environmental values that would be threatened by the discharge of litter in stormwater (e.g. swimming beaches and urban wetlands with high aesthetic or conservation values).

Caution is needed, as this management practice should not be considered in isolation from the local context in which it will be applied or from supporting measures (e.g. signage, public participation and enforcement).

Recommended practices

The following practices for reducing littering in public places are recommended.

✔ Placing litter and recycling bins in locations that are convenient/accessible to the public (i.e. located close to the source of litter, such as fast food outlets, ATMs and exits from large public venues).

✔ Undertaking site assessments to identify those bins that are the most heavily used, particularly near stormwater management systems and water bodies. These bins should be subject to increased levels of inspection (and if necessary, maintenance).

✔ Designing bins that catch the attention of the public and are easily identifiable.

✔ Being consistent to avoid confusion (e.g. making the colours and shape of litter and recycling bins consistent).

✔ When designing bins, the bin opening should be small enough to discourage illegal dumping, yet acceptable for normal litter items.

✔ Decisions made regarding the size of bins should seek to minimise the required emptying frequency while discouraging illegal dumping.

✔ Assessing the need for specialist bins in specific locations (e.g. for cigarette butts, sharps, etc.).

Figure 11. Waste and goods dumped outside charity bins in Perth. (Photograph: Dieter Solonec, Paraquad Association of WA.)

Figure 12. Example of charity bin sticker to discourage dumping. (Sticker source: ParaquadAssociation of WA.)

Figure 13 (right). Make sure bins are emptied regularly – rubbish attracts rubbish! (Photograph: Keep Australia Beautiful Council WA.)

✔ Placement of politely worded signage close to where littering occurs.

✔ Keeping observable litter to a minimum (e.g. through frequent collections) as littering rates are reduced in areas that are regularly cleaned – 'clean equals clean'.

✔ Typically, bins should be emptied before they reach 75–80% full. The service provider that undertakes bin emptying should be responsible for clearing up unconfined litter within a specified radius of the bin (e.g. two metres). The frequency of bin emptying will vary depending on the location; however, a general guide in urbanised areas is that street litter bins will need emptying at least daily; and park litter bins will need emptying at least weekly.

✔ Involving the community in litter management initiatives (e.g. involve users of public areas in the design and placement of bin facilities).

✔ Acting on behaviour (e.g. with rewards and/or sanctions, as appropriate).

✔ Encouraging responsibility (e.g. behaviour change programs to encourage people to take responsibility).

✔ Designing public open space to minimise areas that are hidden from public view.

✔ Integrating programs (e.g. anti-litter educational strategies should be accompanied by the provision of litter bin and recycling infrastructure and sound maintenance regimes).

✔ Demonstrating commitment (e.g. agencies promoting anti-litter messages must lead by example).

In relation to recycling bins, suggested that the following key elements must exist for recycling to work in public places:

✔ The bins should be labelled using appropriate symbols and a recognisable and consistent system of colours.

✔ Bins should be grouped into stations with a litter bin at either end and recycling bins in the middle.

✔ Bins should only be provided for items which patrons easily identify with recycling.

✔ Recycling bins should have locked lids and holes in the lids the size and shape of the materials to be put in them.

✔ Litter bins should have the lids open.

✔ Bins should have overhead signs so that their location can be seen above a crowd.

Benefits and effectiveness

For litter bins to significantly reduce littering rates, they have to be part of an overall management strategy incorporating the recommended practices, outlined above. This view is supported by many local observational studies in Australia involving littering in public places.

Challenges

The following challenges may need to be addressed to improve implementation:

- complementary management measures are required (e.g. signage, enforcement activities, manual litter collections, street sweeping, involvement of the local community in bin design and placement and positive reinforcement of stakeholders that undertake desirable behaviour)
- sound monitoring and evaluation is required as each local circumstance is different (for guidance on this matter, see Taylor and Wong, 2002d)
- if the maintenance regime for clearing the litter and recycling bins is inadequate, the litter loads in stormwater may be worse than if no bins were provided. This is because littered areas promote littering behaviour.

Additional information

- Clean Up Australia, available via www.cleanup.org.au
- Keep Australia Beautiful Council of Western Australia. Useful references are available via www.kabc.wa.gov.au
- Sustainability Victoria, available via www.sustainability.vic.gov.au
- Australian Standards AS 4123.6-2006, Mobile waste containers Health, safety and environment
- Australian Standards AS 41123.7, Mobile waste containers Colours, markings, and designation requirements
- Keep Australia Beautiful, Litter Toolkit: Managing Litter a Local Level. Available via www.kabc.wa.gov.au

2.2.5 Road/pavement repairs/resurfacing and road runoff

Description

Activities to repair potholes and degraded footpaths, as well as road and carpark resurfacing, have the potential to contaminate stormwater. Specific management practices need to be applied to minimise this risk, such as planning maintenance activities, modifying road resurfacing and footpath maintenance practices, managing spills and sweeping.

In addition, substantial amounts of pollutants are generated during daily roadway use, which can threaten the health of local water bodies by contributing heavy metals, hydrocarbons, sediments, gross pollutants and nutrients. Table 1 highlights typical highway runoff constituents and their primary sources.

Table 1. Typical highway runoff constituents and their primary sources

Constituent	Primary sources
Particulates	Pavement wear, vehicles, atmospheric deposition
Nitrogen, phosphorus	Atmospheric deposition, roadside fertiliser application
Lead	Tyre wear
Zinc	Tyre wear, vehicle exhaust, grease
Iron	Vehicle rust, steel highway structures, moving engine parts
Copper	Metal plating, brake lining wear, moving engine parts, bearing and brushing wear, fungicides and insecticides
Cadmium	Tyre wear, insecticides
Chromium	Metal plating, moving engine parts, brake lining wear
Nickel	Diesel fuel and petrol, lubricating oil, brake lining wear, metal plating, asphalt paving
Manganese	Moving engine parts
Sulfate	Fuel
Petroleum/hydrocarbons	Spills, leaks of motor lubricants, hydraulic fluids, asphalt surface leachate

Source: US EPA (1997).

Potential risks to stormwater quality from roads, carparks and footpaths include:

- discharge of sediments, heavy metals and hydrocarbons from the wear and tear of the road surface, vehicle tyres and vehicle brake linings
- discharge of hydrocarbons during road and carpark resurfacing work (e.g. during a spill or unexpected rainfall event)
- discharge of bitumen overspray during road and carpark resurfacing activities
- discharge of alkaline slurry from concrete cutting activities
- discharge of wastewater from the washing of machinery and tools (e.g. cement mixers and pumps).

Applicability

This management practice is applicable to all areas with roads, carparks and footpaths, and includes sealed and unsealed surfaces. It is particularly relevant in steeply sloping catchments with a high proportion of directly connected impervious surfaces and sensitive receiving waters.

Improving the quality of stormwater runoff from road surfaces is usually a priority in urban areas, given the significant load of stormwater pollutants that can be generated from road runoff, and the efficiency of traditional drainage systems in transporting this load to receiving waters. While the potential for environmental harm from road runoff is often significant, there is a high degree of variability in the quality of this runoff. For example, the US EPA (2001) noted that the level of pollutants found in road runoff is determined by many site-specific factors such as:

- traffic volume
- traffic movement (e.g. areas where vehicle braking and acceleration is frequent)
- climate

- maintenance regime, including incident response procedures (e.g. to manage vehicle accidents and spills)
- surrounding land use
- design of the road and associated drainage network
- presence of roadside vegetation (and the use of herbicides or insecticides on this vegetation)
- frequency and type of accidents and spills that can discharge a variety of hazardous substances to stormwater.

Recommended practices

Management practices recommended by VSC (1999) and US EPA (2001) are summarised below. Ideally, these management practices would be part of an EMS (see Section 2.5.1) that includes regular training, auditing/risk assessments, performance reporting mechanisms, etc.

Site preparation and planning

✔ Where there is the threat of material entering side entry pits during maintenance activities (e.g. road base, aggregate, or bitumen), install temporary inlet filters (e.g. using geofabric).

✔ Ensure stockpiled materials are kept away from drainage paths. Cover loose stockpiled material that can be transported during rain events to prevent erosion.

✔ Ensure that procedures and training exist so that resurfacing activities do not occur when rainfall is imminent or occurring. This guideline also applies to cement stabilisation activities.

✔ Pavement should be repaired in sections to reduce the spillage of paving materials during the repair of potholes and worn pavement.

✔ Ensure spill clean-up kits are available and site staff are trained in their use. These kits may be needed to trap hydrocarbons spills from machinery/plant or from runoff following an unexpected rainfall event during resurfacing.

Bitumen/resurfacing work

✔ Do not carry out bitumen spraying in windy conditions.

✔ Place only the required amount of screenings on the bitumen.

✔ Ensure loose aggregate is swept up at the completion of works.

✔ Use pollution prevention techniques such as drip pans and absorbent materials for all paving machines to limit leaks and spills of paving materials.

✔ Consider the use of porous asphalt when replacing surfaces, to reduce the volume of stormwater runoff and associated pollutant loads.

Concrete work

✔ Undertake concrete mixing and clean-up operations in a designated area that is capable of containing wastewater. Small amounts of wastewater can be allowed to evaporate or infiltrate into the soil.

- ✔ Ensure a contingency measure is in place to prevent any spilt material from entering the drainage network when using concrete pumps.
- ✔ Allow concrete waste and slurry to set before disposal off-site.
- ✔ Prevent wastewater from concrete cutting, brick cutting, or grinding activities from entering the stormwater system. Where it is not practical to trap this wastewater, or direct it to a permeable area for infiltration, the wastewater should at least be filtered through a geofabric material. However, filtering will not affect the pH of this wastewater, which can be very high for wastewaters involving concrete.
- ✔ Remove any cover material and formwork from the site once concrete has cured.

‘Housekeeping’ practices

- ✔ Remove all excess material from the work site before leaving, including all waste concrete, packing material and soil. Loose material should be swept from hard surfaces, not flushed.
- ✔ If equipment/plant needs to be washed on-site, ensure that it is undertaken in an area where stormwater will not be contaminated (e.g. on a well-grassed area). Ideally, equipment/plant should be washed in a sewered wash bay. An Industrial Waste Permit is required to connect and discharge these wastes to sewer. Further information is available from the Water Corporation. Section 2.2.8 provides further best practice guidelines for maintenance and washing of vehicles and equipment.

Related maintenance practices

- ✔ Regularly sweep roads, carparks and paths that are identified as ‘hot spots’ for sediments and gross pollutants (see Section 2.2.1 for more details).
- ✔ Regularly remove accumulated pollutants (e.g. sediments and gross pollutants) from nodes in the stormwater network that may accumulate pollutants, such as pits and infiltration sumps (see Section 2.2.2 and Chapter 9 for more details).
- ✔ Where roadside vegetation exists (e.g. along highways), ensure that it operates as an effective filter strip to improve the quality of road runoff and to promote infiltration. In addition, restrict the use of herbicides and insecticides on roadside vegetation, and ensure maintenance staff use appropriate handling and application procedures for these materials. See Section 2.2.7 for more information on vegetation maintenance practices. See Chapter 9 for more information on swales and vegetated filter strips.
- ✔ Use indigenous vegetation along roadsides, paths and in swales, as recommended in Section 2.2.7 and Chapter 9.

Benefits and effectiveness

The US EPA (2001) reported that limited data is available on the effectiveness of road maintenance practices in removing pollutants from stormwater runoff (e.g. see the limited data in the table below). However, preventative maintenance and strategic planning are recognised as cost-effective methods to minimise contamination of stormwater runoff and reduce the risk of environmental harm to the receiving environment.

Table 2. Road maintenance management practices: indicative effectiveness and cost

Management practice	Effectiveness (% removal*)	Indicative cost (in 1993 US dollars)
Maintaining roadside vegetation (as a filter strip)	Sediment control: 90% average. Phosphorus and nitrogen: 40% average. Chemical oxygen demand (COD), lead and zinc: 50% average. Total suspended solids (TSS): 60% average.	Natural succession of vegetation allowed to occur: • average = US$100/acre/year; and • range = US$50–$200/acre/year
Street sweeping (see Section 2.2.1 for more information)	Smooth street, frequent cleaning: • TSS = 20% • COD = 5% • Lead = 25% Smooth street, infrequent cleaning: • TSS = N/A • COD = N/A • Lead = 5%	Average = US$20/kerb mile. Range = US$10–$30/kerb/mile. (See Section 2.2.1 for Australian costing data)
Litter control	N/A	Accepted as economical practices to control or prevent stormwater impacts
General maintenance	N/A	Accepted as economical practices to control or prevent stormwater impacts

* Assumed to be either the approximate per cent reduction in the stormwater's average annual loads or event mean concentrations.

^The costings used in this table are from around 1993. Please adjust the costings for present day.

Challenges

The following challenges may need to be addressed to improve implementation:

- budgeting for the cost and effort associated with implementing new procedures, additional equipment and staff training
- budgeting for the cost associated with delaying maintenance work (e.g. waiting to undertake resurfacing activities until rainfall is unlikely to occur)
- overcoming the difficulty in trapping and/or effectively treating wastewaters on hard surfaces (e.g. wastewater from concrete cutting equipment, where there is no opportunity to direct this wastewater to an infiltration area)
- it relies upon staff fully implementing procedures, as well as the continual improvement of procedures and practices. An EMS can provide the framework to minimise this risk (see Section 2.5.1 for more details).

Cost

The primary costs associated with introducing improved stormwater management practices during road/pavement maintenance involve the purchase of new equipment, the time associated with implementing new procedures, the time associated with staff training and the cost of accessing specialist expertise. Some indicative cost information from the US is provided in Table 2. Employing good maintenance practices is an efficient and low-cost BMP to eliminate or reduce the impacts of pollutants associated with road systems.

Additional Information

Further information about roadside swales and vegetated filter systems is provided in Chapter 9. For more information on planning, construction and maintenance of roads, see the former Department of Water's *Roads near in Sensitive Water Resources* Water Quality Protection Note (DoW, 2006).

Also see the *Handbook of Environmental Practice for Road Construction And Maintenance Works* published by the Roadside Conservation Committee, Main Roads and WALGA.

2.2.6 Maintenance of premises typically operated by local government

Description

This guideline will briefly address key stormwater management practices that are often required on premises that may be operated by local government. These premises include cemeteries, parks, sports fields, nurseries, depots, buildings and road reserves. These premises have the potential to contaminate stormwater and/or generate large volumes of stormwater due to a high percentage of impervious surfaces. Note that Section 2.2.7 specifically addresses stormwater management on gardens and reserves.

To identify, assess, manage, monitor and continually improve the management of stormwater-related risks from these premises, it is recommended that operators undertake a risk assessment and develop a plan to address those risks, or implement an environmental management system (EMS).

As explained more fully in Section 2.5.1, an EMS provides a management framework, which is documented as an international standard, to help set objectives/policy, undertake site-specific risk assessments, develop specific management strategies (e.g. procedures), undertake regular audits to check performance, report on performance and continually improve performance. Typically, a specialist environmental manager will be engaged to establish and/or maintain an EMS. In some situations, the system will also be subject to periodic assessment and certification by an independent auditor. Alternatively, a stormwater management system could be developed. See Section 2.5.1. for more information.

Applicability

These management practices are applicable to the types of premises typically operated by local government. However, this is a generic stormwater guideline that may need to be supplemented with site-specific practices. A risk assessment that identifies and evaluates the potential stormwater-related risks is strongly recommended prior to the application of new management practices. The guideline presented here provides a basis for undertaking the assessment and developing a tailored, site-specific stormwater management plan/procedure.

Recommended practices

The following management practices are typically applicable to premises operated by local government.

Depots

- ✔ Identify sources of potential stormwater contamination and seek to remove the risk of stormwater contamination by covering storage areas, bunding storage areas, or removing unnecessary materials/equipment from the site (see Section 2.2.10).
- ✔ Keep stormwater that is likely to be relatively 'clean' separate from potentially contaminated stormwater.

- ✔ Seek to minimise the percentage of the site that has directly connected impervious surfaces. See Chapters 6 and 9 for the types of structural controls that can reduce the amount of directly connected impervious surfaces.
- ✔ Undertake washing of vehicles, equipment and plant in a sewered wash bay (see Section 2.2.8). A trade waste permit is required to connect and discharge these wastes to sewer. Further information is available from the Water Corporation.
- ✔ Ensure materials that are potentially erodible are covered (preferred solution), stored out of the way of drainage paths, and/or subject to downstream sediment controls.
- ✔ Ensure spill clean-up kits are available, where necessary, and staff are familiar with their use (see Section 2.2.10, Stormwater management on industrial and commercial sites).
- ✔ Sweep up loose materials (e.g. sediment) as soon as possible after the material has accumulated on hard surfaces, rather than flushing it to stormwater (see Section 2.2.10, Stormwater management on industrial and commercial sites).
- ✔ Ensure staff using the depot are familiar with the site's stormwater-related risks, requirements (e.g. procedures), and consequences for failing to comply with these requirements.
- ✔ Seek expert advice on the installation of structural stormwater management devices (e.g. oil-water separators, devices that trap sediment and hydrocarbons), and install these devices where necessary. The installation of structural stormwater management devices should be an option of last resort. Where devices are installed, a sound maintenance regime will need to be developed and implemented (see Chapter 9).
- ✔ Stabilise any exposed soil on the site through erosion control methods (see Section 2.1.1), particularly where there is a risk that the soils may be contaminated due to historic site activities.
- ✔ Investigate opportunities to reuse stormwater and/or shallow groundwater on the site (e.g. for vehicle washing or toilet flushing).

Buildings

- ✔ Investigate opportunities to reuse stormwater (roof water) and/or shallow groundwater in the building (e.g. for toilet flushing) or on the surrounding garden (e.g. for irrigation). Reuse should occur via water efficient devices both within the building and around the garden.
- ✔ During construction activities, ensure that sound erosion and sediment control practices are undertaken, as well as best practice housekeeping practices for construction activities (see Section 2.1.1).
- ✔ Minimise the percentage of the site's area that contains directly connected impervious surfaces (e.g. promote opportunities for filtration and infiltration of stormwater). See Chapter 9 for further information.
- ✔ Install structural stormwater management devices (e.g. rain gardens, bioretention systems), where necessary (see Chapter 9). Where devices are installed, a sound maintenance regime will need to be developed and implemented.
- ✔ Where stormwater is allowed to infiltrate into the groundwater, assess the risk of groundwater contamination and, where necessary, undertake pre-treatment of stormwater and/or recycling of shallow groundwater.

- ✔ Ensure the building's maintenance practices include regular sweeping of loose litter, sediment or leaves from hard surfaces, the provision of appropriate litter and recycling bins (with signage), and the emptying of these bins before they are 75% full (see Sections 2.2.3 and 2.2.4).
- ✔ Ensure that flaking paint on roofs does not contaminate stormwater.
- ✔ If a building is washed, contaminated wastewater should be prevented from entering stormwater (e.g. by directing wastewater to an infiltration area, or through the use of absorbent material). For more information on building maintenance practices, see Section 2.2.9.

Planning and coordination of activities in parks, gardens and sports fields (from VSC, 1999)

- ✔ Monitor key pollution indicators for each park and garden (e.g. the number of people using the area, types of pollutants, proximity to water bodies, etc.).
- ✔ Determine appropriate work practices to minimise pollution risks, based on park activities. Determine where specialist maintenance methods and equipment may be required and, where necessary, implement structural controls to trap stormwater pollutants.
- ✔ For more information on designing and maintaining gardens and reserves, see Section 2.2.7.

Nurseries

- ✔ Most of the management practices recommended for depots also apply to nurseries. However, there is a focus on minimising the discharge of stormwater from nurseries as there is a high risk that this stormwater could be contaminated by nutrients and pesticides.
- ✔ Seek to minimise the export of stormwater from the site by capturing stormwater for reuse as irrigation water, and capturing and reusing shallow groundwater that may be contaminated from on-site activities.
- ✔ Use slow-release fertilisers, where possible.
- ✔ Manage the nursery's watering regime to minimise runoff.
- ✔ Consider the use of soil amendment for sites with sandy soils that are not paved, to minimise the potential for contaminants to easily enter shallow groundwater (see Section 2.1.2).
- ✔ Minimise the use of insecticides through 'integrated pest management' practices.
- ✔ See Section 2.2.7 for more information on maintenance of plants/gardens.
- ✔ Refer to the *Nurseries and Garden Centres* Water Quality Protection Note 32 (DWER, 2018) for further guidance on managing stormwater on nursery premises.

Highly maintained open space and sports fields (including golf courses)

- ✔ See Section 2.2.7.

Road reserves

✔ Undertake erosion and sediment control on road reserves to minimise the export of sediment to stormwater (see Section 2.1.1). This is particularly important during maintenance activities involving re-grading the road shoulder and associated table drains.

✔ Undertake manual litter collections (see Section 2.2.3.).

✔ Maintain a healthy grass/vegetation cover to help filter and infiltrate stormwater.

✔ Minimise the use of herbicides and pesticides during the maintenance of road reserves (see Section 2.2.7).

✔ Further information about roadside swales and vegetated filter systems is provided in Chapter 9.

Cemeteries

✔ Most of the management practices recommended for general park maintenance (see Section 2.2.7) and depots also apply to cemeteries.

✔ Seek to adopt the principles of water sensitive urban design along interior roadways (see Wong *et al*., 2000, for guidance on this issue).

✔ Seek to minimise the export of stormwater from the site by capturing stormwater for reuse as irrigation water and/or capturing and reusing shallow groundwater that may be contaminated from on-site activities.

✔ Use slow-release fertilisers and integrated pest management practices where possible (see Section 2.2.7).

✔ Undertake basic erosion and sediment control measures on areas with disturbed soils (see Section 2.1.1).

✔ Where soils are poor at retaining moisture and nutrients, consider the use of soil amendment to minimise the potential for contaminants (e.g. nutrients from gardens) to easily enter shallow groundwater or stormwater (see Section 2.1.2.). Soil amendment in this circumstance will also reduce the need for fertilisation and watering of lawns.

✔ Implement a water efficient irrigation scheme to minimise runoff during watering periods (e.g. an automated system that uses sensors to detect soil moisture).

Benefits and effectiveness

The benefits and effectiveness of the practices outlined in this guideline are only discussed in general terms.

Sound stormwater management on the types of premises covered by this guideline should result in:

- reduced loads of pollutants entering stormwater and/or shallow groundwater, thereby minimising the risk to the health of receiving waters
- reduced potential for organisations managing these premises to be subject to complaints from stakeholders or enforcement by environmental regulators
- reduced need for scheme/mains water because of stormwater and/or groundwater reuse

- reduced need for downstream, end-of-pipe, stormwater treatment devices (as the practices in this guideline are all *source* controls)
- reduced need for the application of fertilisers, herbicides and/or pesticides
- in some cases, reduced volumes of stormwater discharge (e.g. because of stormwater reuse and/or infiltration).

Challenges

The main challenge for implementing these management practices is the cost and effort required to undertake a risk assessment at the premises, develop site-specific management practices (using this guideline), implement these practices (including training staff) and monitor their implementation. However, it is suggested that this barrier should be overcome, particularly if the organisation is a government agency that should lead by example.

Cost

Meaningful cost information cannot be provided due to the generic content in this guideline.

Additional information

The Department of Water and Environmental Regulation's Water Quality Protection Note Series provides advice for a range of different industries and land uses. For a full list of the series content visit the department's website at www.water.wa.gov.au/__data/assets/pdf_file/0009/5958/WQPNs-available-by-name-web-version-12.5.15.pdf

Some useful Notes include:

- WQPN 52, Stormwater management at industrial sites
- WQPN 93, Light industry near sensitive waters
- WQPN 32, Nurseries and garden centres

Examples/Case studies

Examples of cleaner site management practices are provided in Section 2.2.10 and of parks and gardens maintenance are provided in 2.2.7.

2.2.7 Maintenance of gardens and reserves

Description

This guideline focuses on the following management practices that can be applied at parks, gardens, road/drainage reserves and turfed sports fields/venues:

- plant selection and landscaping design
- nutrient management
- irrigation management
- pest management
- lawn mowing, top-dressing and pruning.

The maintenance practices applied to grassed areas and gardens can have a significant potential impact on stormwater and groundwater quality. Potential pollutants include nutrients, sediment, pesticides, wastewater from washing machinery (e.g. mowers), and organic matter (e.g. grass clippings). Possible impacts include eutrophication and elevated levels of turbidity in receiving waters, leading to a variety of adverse impacts on aquatic flora and fauna.

As detailed guidelines are currently available for these practices, including several comprehensive Western Australian guidelines (see Additional Information), this section will:

- reference these guidelines
- briefly summarise key aspects that relate to stormwater management.

Note: Xeriscaping and zeroscaping are terms used in various places in the world. Xeriscaping is derived from the Greek word ‘xeros’, which means ‘dry’. Thus, xeriscaping can be simply translated as meaning ‘dry landscaping’. The primary goal of xeriscaping is to create a visually attractive landscape that uses plants selected for their water efficiency. Zeroscaping is sometimes used in relation to landscaping with a focus on water conservation but is not equivalent to xeriscaping. Zeroscaping creates a harsher and less diverse landscape, primarily using rocks and drought-tolerant plants species such as cacti. In contrast, xeriscaping can produce a cool and lush landscape, using a wide variety of water efficient plants.

Applicability

The following management practices are applicable to all areas where maintenance is undertaken on parks, gardens, road/drainage reserves and turfed sports fields/venues (e.g. ovals, golf courses and bowling greens). However, they are particularly relevant to areas of open space that:

- drain to sensitive receiving waters (e.g. conservation category wetlands, or the Swan-Canning estuary system that is under stress from nutrient inputs)
- are close to water bodies (e.g. river-side parks)
- have soils with poor moisture and nutrient retention capabilities (e.g. sandy soils on the Swan Coastal Plain)
- are subject to erosion (e.g. areas on steep slopes)
- are subject to intense rainfall events that may generate surface runoff
- are subject to intensive maintenance practices (e.g. highly maintained golf courses).

Recommended practices

Landscape design

✔ Minimise the amount of grassed/lawn areas.

✔ Minimise the extent of water-consuming planting.

✔ Apply the basic principles of hydro-zoning (grouping plants on the basis of having similar water requirements) to planting design.

✔ Match the plants to the soil type.

✔ Maximise the use of water conserving elements and techniques, such as using mulches, ground covers and porous paving instead of lawn.

Nutrient management

✔ For turf and grassed areas, use the guidelines provided by SRT (2014) to determine each area’s fertilisation requirements. This process involves visual inspection of the turf; regular analysis of leaf tissue, soil and water; consideration of the grass species, turf and grass use, weather patterns, ground temperatures, air temperatures, water availability, sunlight intensity and soil conditions; the use of catalysts (where necessary) to convert soil nutrients to a form that can be utilised by plants; synchronising the application of fertiliser with the needs of the plant; and adopting the principle of frequently applying small amounts of fertiliser. SRT (2014) also provides guidance on calculating fertiliser application rates, and specific factors that should be considered when determining nitrogen and phosphorus application rates.

✔ When applying nitrogen to sandy soils on the Swan Coastal Plain, the quantity of nitrogen applied in any one application should not exceed 40 kg/ha (SRT, 2014).

✔ Where phosphorus is being applied, special consideration must be given to the level of available phosphorus in the soil; the Phosphorus Retention Index (PRI); and the results of leaf tissue analysis. See SRT (2014) for fertilisation recommendations for soils with various PRI ranges and see the Phosphorus Action Group's *Fertilise Wise Guides* (see the Additional Information section).

✔ When determining a suitable fertilisation regime, recognise that reducing the amount of water used on gardens and lawns will also reduce the need for fertilisation (WAWC, 2021).

✔ Where 'fertigation' is used to supply plants with soluble nutrients in irrigation water, care is needed to frequently apply very small amounts of nutrients to the plants at a rate at which the roots can take up most, if not all, of the nutrients. This is necessary to minimise the percentage of nutrients that move past the root zone and enter shallow groundwater, as well as the cost of fertilisation. SRT (2014) suggest that fertigation 'is ideally suited for the soils of the Swan Coastal Plain that have a poor capacity to retain nutrients. It has the advantage that the fertilisers are only applied when water is required (not in winter) but it has the disadvantage that it requires accurate irrigation systems to avoid areas of over and under application of nutrients'.

✔ Use slow-release fertilisers where possible. Avoid using fertilisers in areas where runoff can result in the fertiliser entering the drainage system or water bodies.

✔ If fertiliser is required, apply in spring or early autumn (September, October, November, March and April). Apply the fertilisers often and in small amounts during the spring and early autumn period.

✔ Applying organic matter or soil amendment to the upper 15 cm of sandy soils can produce multiple benefits. These include the slow release of nutrients, and the retention and recycling of soil moisture and nutrients. For more information on soil amendment, see Section 2.1.2.

✔ While fertilisers are usually applied immediately before watering, extreme care must be taken to ensure that this watering does not generate runoff or leachate to shallow groundwater.

✔ Where possible, establish a buffer zone at least 50 metres wide between fertilised areas and water bodies.

✔ Where drainage channels flow through fertilised areas (e.g. golf courses), apply the principles of water sensitive design to establish a 'treatment train' within the drainage corridor (e.g. by using controls such as unfertilised buffer zones, swales, wetlands, ponds, stormwater recycling, etc.).

✔ On intensive horticultural sites that are using high amounts of fertilisers and have sandy soils and shallow groundwater, construct leachate barriers that drain nutrient-rich groundwater to collection basins for reuse. Alternatively, establish shallow groundwater bores down-gradient from the fertilised area to recycle leached nutrients via irrigation systems.

Irrigation management

Detailed guidance on water conserving irrigation practices is available in SRT (2014) and on the Water Corporation's website. The following management practices are highlighted as being important with respect to stormwater:

- ✔ Ensure that the irrigation system is water efficient (e.g. drip or trickle systems, sprinklers that produce large droplets, sprinklers with matched precipitation rates[10], high quality controllers that have the ability to run separate watering programs for lawn and garden areas, and rain sensors that can be used to prevent irrigation after summer rain storms).
- ✔ Ensure the design, sensors and settings used for automated irrigation systems do not produce surface runoff from the area being watered or from adjacent impervious surfaces.
- ✔ The necessary amount of irrigation should be determined with due consideration of grass growth rate, soil type, daily evaporation rate, wind effects, soil temperature and available soil moisture (SRT, 2014). This can be achieved with modern soil moisture and air sensing devices such as tensiometers, soil moisture sensors, relative humidity measuring devices and wind velocity detectors.
- ✔ Seek to recycle nutrient-rich shallow groundwater and/or stormwater from the site.
- ✔ Visually check irrigation systems every week to identify maintenance needs (e.g. the repair of leaks), or, for major irrigation systems, install an automated warning system to identify malfunctions.
- ✔ Apply mulch to garden beds to improve water retention, smother weeds and prevent erosion.
- ✔ Where required, apply soil wetting agents to overcome hydrophobic soil conditions and enhance infiltration of irrigation water. See SRT (2014)for details of recommended application rates for these agents.
- ✔ Use soil amendments to improve the water retention capacities of soils, where appropriate. For more information on soil amendment, see Section 2.1.2.
- ✔ Where nutrient-rich wastewater is used as a source of irrigation water, it is particularly important to control application rates so that surface runoff and shallow groundwater contamination does not occur. A comprehensive monitoring and evaluation program should be established to ensure that this objective is achieved.

Pest management

Integrated pest management (IPM) is a holistic approach to unwanted plant (weed) and insect control that examines the interrelationships between soil, water, air, nutrients, insects, diseases, landscape design, weeds, animals, weather and cultural practices to select an appropriate pest management plan (US EPA, 2001). The goal of an IPM program is to manage pests to an acceptable level while avoiding disruptions to the environment. It incorporates preventative practices in combination with chemical and non-chemical pest control methods to minimise the use of traditional pesticides (i.e. insecticides and herbicides) and promote natural control of pest species.

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[10] A sprinkler array with 'matched precipitation rates' means the nozzles provide the necessary water to the plants without any plants being over-watered.

Three different non-chemical pest control practices are used to limit the need for chemical pesticides:

• Biological (e.g. predation of pest species by other organisms).

• Cultural (e.g. weeding, handpicking of pests, removal of plants with diseases).

• Mechanical (e.g. pruning, altering the mowing regime, slashing, covering weeds with black plastic or jute matting).

The most effective pest control methods are often a combination of non-chemical and chemical control methods (SRT, 2014). Where chemical pest control methods need to be used, less hazardous products or target-specific chemicals should be used for control of nuisance/disease vector insects, rather than pesticides that are a greater threat to aquatic systems, such as diazinon and chlorpyrifos. The less hazardous chemical pesticides must still be used with the best practice precautions applied to other chemical pesticides.

Methods to reduce the risks from pesticides include:

✔ Apply according to the label's recommended rate.

✔ Do not apply pesticides when rain is occurring or imminent.

✔ Do not spray pesticides on windy days.

✔ Where possible, wipe or inject pesticides to avoid spray drift (Water and Rivers Commission, 2001).

✔ If possible, spray when surface water levels are low (Water and Rivers Commission, 2001).

✔ Do not apply pesticides when there is a high risk of impact to vulnerable stages of fauna development. For example, avoid the period from egg lay to dispersal of junior frogs into the surrounding area – this period varies, but is generally between late autumn and early spring (Water and Rivers Commission, 2001). Mix in a coloured dye so that you can see which areas have been sprayed.

✔ Avoid using surfactants in the pesticides, as frogs are particularly sensitive to surfactants (Water and Rivers Commission, 2001).

✔ Detailed guidance on pesticide selection and application, mixing and diluting pesticides, disposal of pesticide concentrates and containers, and pesticides storage can be obtained from the *Western Australian environmental guidelines for the establishment and maintenance of turf grass areas* (SRT, 2014).

✔ The Department of Primary Industries and Regional Development website has various articles on the safe, responsible and effective use of agricultural and veterinary chemicals. Issues covered include duty of care, choice and purchase of chemicals, transport, storage, occupational safety and health, environmental protection, management and minimisation of spray drift, minimising residues in agricultural produce, record keeping and responsibilities for owners.

✔Pesticides must be stored in a covered, bunded and secured area. If disposal of unwanted pesticides and/or pesticide containers needs to be undertaken, consultation should occur with operators of local waste disposal/treatment facilities to identify options for reuse or disposal.

Lawn mowing, top-dressing and pruning

✔ Remove litter and debris before mowing.

✔ Close cropping during mowing is not recommended, as it provides an opportunity for accelerated erosion and increases the area's irrigation requirements. As a general rule, no more than 33% of the grass leaf area should be removed during one mowing event (SRT, 2014).

✔ Where possible and where there is not a risk of cuttings entering adjacent water bodies, grass cuttings should be left on the lawn after mowing. Where grass cuttings are collected, they should be composted and reused as fertiliser. Compost should be stored in areas where stormwater and/or groundwater will not be contaminated.

✔ Grass cuttings should not be 'thrown' from the mower blades onto hard surfaces (e.g. roads) or into adjacent water bodies. If some cuttings are inadvertently deposited on roads or footpaths, they should be collected by 'dry' methods (e.g. sweeping) at the completion of mowing activities. Cuttings should not be blown or swept onto the road or into water bodies or the stormwater system.

Figure 14. Remove grass cuttings from roads and paths to ensure they do not enter the stormwatersystem. (Photograph: South East Regional Centre for Urban Landcare.)

✔ In areas adjacent to roads with a kerb and channel, coordinate activities such as mowing or pruning with street cleaning operations (VSC, 1999).

✔ Mowing equipment is commonly hosed down after use at a particular location to prevent the transfer of weeds between mowing sites. Where this is done, the rinse water can be infiltrated into the soil. Under no circumstances should this rinse water be directed to the stormwater system.

✔ Only use top-dressing to even out bumps and hollows in the lawn, and then only use special top-dressing mixes which contain organic matter. A vegetated buffer should be maintained between the top-dressed area and stormwater drains or water bodies. In addition, top- dressing should not occur when intense and/or prolonged rainfall is likely.

Benefits and effectiveness

Collectively, these management practices seek to:

- reduce pollutant loads to stormwater and shallow groundwater (particularly nutrients, sediment, pesticides and organic matter)
- reduce the use of mains water for irrigation
- reduce the volume of surface water runoff
- where possible, save time and money on maintenance practices
- reduce health and safety risks associated with the use of chemical pesticides.

Integrated pest management

Integrated Pest management (IPM) has been studied in Maryland, where it was used for managing street trees within a residential suburb (Taylor and Wong, 2002c). As a result, pesticide use was reduced by 79%–87% due to spot application techniques and average annual costs were reduced by 22% (US EPA, 1997).

The US EPA (1997) also documented reports from a US lawn management company (the Natural Lawn Company) that it reduced its herbicide use by 85%–90% by switching from blanket applications to spot application. Cost reductions of a similar magnitude were anticipated (Taylor and Wong, 2002c).

Taylor and Wong (2002c) reported that the cumulative performance of IPM and associated non-fertilised buffer strips at the Rosewood Lakes golf course in Reno, Nevada, was measured by long-term water quality monitoring in downstream wetlands. After eight years of water quality monitoring, pesticides were not detected in the wetlands and nutrient concentrations did not show seasonal fluctuations, despite seasonal applications of fertiliser on the course and the potential for surface runoff (Lehner et al., 1999).

The US EPA (2001) highlighted the adverse impacts from water-soluble pesticides, such as diazinon, as a good example of why IPM practices are recommended. A study in the San Francisco Bay region found that diazinon contamination of urban streams resulted from application of this pesticide at a small number of sites in the catchment. Source controls are needed (i.e. the application of IPM practices by government authorities, businesses and homeowners) as structural controls cannot significantly reduce pesticide levels once they have entered the stormwater management system.

Challenges

The following challenges may need to be addressed to improve implementation:

- resources (e.g. time, money and effort) should be invested for maintenance staff to learn and adopt new practices and management plans should be documented, regularly audited and updated
- reducing the popularity of green lawns, lush gardens and exotic plant species, as these are an impediment to the widespread adoption of waterwise and fertilise wise gardens and reserves, particularly the adoption of local native plants
- for integrated pest management, the perception that there is no alternative to pesticide use is a significant barrier to overcome (US EPA, 2001)
- the cost of slow-release fertilisers, soil testing, installing water efficient irrigation systems, irrigation sensor systems and applying fertilisers frequently but sparingly are potential barriers to the adoption of these management practices. However, rebates are offered for many catchment friendly (‘waterwise’) gardening practices/systems.

Additional information

Resources for catchment friendly gardening are available from the following:

- Western Australian environmental guidelines for the establishment and maintenance of turf grass areas (SRT, 2014)
- Sports Turf Technology (2004) TurfSustain – A guide to turf management in Western Australia. Available for purchase via www.sportsturf.net.au/about-turf-technology/
- free gardening workshops – Swan River Trust. These feature information and guidance on fertilise wise and sustainable gardening practices. Fertilise Wise Guides – The Phosphorus Action Group’s Fertilise Wise Guides advise gardeners on appropriate fertiliser types and application rates for soils in the Perth region. You may access fertilise wise information via the South East Regional Centre for Urban Landcare website www.sercul.org.au

- to select Perth plants suitable for your soil type, go to the APACE WA website www.apacewa.org.au/
- *Wildflower Society of Western Australia* – The Society provides a range of resources (e.g. books) and advice regarding planting local native plants. See their website www.wildflowersocietywa.org.au/
- *Free Gardening* Advisory *Service* –Botanic Gardens and Parks Authority (BGPA) www.bgpa.wa.gov.au. The BGPA's website provide a free advice for home gardeners.
- *Waterwise* – Waterwise gardening information on the following topics is provided on the Water Corporation website (www.watercorporation.com.au/waterwise): common plants, catch cup instructions, irrigation, lawns, new gardens, new lawns, waterwise garden centres, waterwise garden designs and waterwise garden irrigators.

Examples/Case studies

Mowing

The Victorian Stormwater Committee (1999) documented a simple contract clause from the City of Manningham to reduce the effect of mowing activities on stormwater quality. This clause has two parts and is provided below:

'Prior to grass cutting all loose litter, rubbish or debris is to be cleared from the mowing area.' (Performance criteria: absence of litter, rubbish or debris).

'All grass clippings and other debris is to be swept or cleared from adjoining paths, gutters, paved surfaces and garden areas.' (Performance criteria: no clippings or other debris after cutting operations)

Integrated pest management

IPM was successfully applied at the 178 ha US National Arboretum in north-west Washington in the District of Columbia. As a result, pesticide use declined by 75%, resulting in an 80% reduction in costs (Lehner et al., 1999). The program included:

- setting thresholds for pest-related plant damage (i.e. the arboretum had a higher tolerance for pest infection);
- catching pests early;
- using beneficial insects which are natural predators of the insects that harm the arboretum's vegetation;
- handpicking insects off infected plants;
- reduced mowing of lawns;
- using biorational oils (i.e. natural soaps and oils)
- using alternative growing methods.

2.2.8 Maintenance of vehicles, plant and equipment including washing

Description

The storage and maintenance of vehicles, plant and equipment can contaminate stormwater with pollutants such as petrol, diesel, kerosene, coolants, solvents, brake fluid, motor oils, lubricating grease, sediment and heavy metals. The washing of vehicles, plant and equipment can also produce highly contaminated wastewater that should not be directed to stormwater or groundwater.

Applicability

The following management practices are applicable to maintenance activities undertaken by government agencies, construction and maintenance companies, operators of automotive workshops and residents that maintain their own vehicles.

The US EPA (2001) highlighted the automotive repair industry as a significant generator of hazardous waste. Common activities at these premises include cleaning of engine parts, changing of vehicle fluids and replacement and repair of equipment.

These maintenance activities are undertaken in urban and regional areas; however, in high-density urban areas, the potential environmental impacts are more pronounced due to the greater concentration of vehicles and higher proportion of impervious surfaces (US EPA, 2001).

Recommended practices

The Motor Trade Association of WA's Green Stamp Program and the Centre of Excellence in Cleaner Production can provide training, support and further information. Refer to the Additional Information and Examples/Case studies sections.

The following management practices are recommended by VSC (1999), US EPA (2001) and Motor Trade Association (MTA) of WA environmental guidelines (October 2004).

Storage

- ✔ Store vehicles, plant and equipment in secure, bunded and undercover areas where possible.
- ✔ Schedule and record the results of regular plant inspections.
- ✔ Designate parking areas for each vehicle to facilitate leak tracing.
- ✔ Develop procedures for identifying, reporting, repairing and cleaning up leakages.

Cleaning plant and equipment

- ✔ See the MTAWA's Environmental Guidelines Cleaning Vehicles, Cleaning Up Spills, Degreasers and Detergents, Mobile Mechanical Repairers, Oil Separators, Parts Washers and Purchasing Spill Kits for more information.
- ✔ Clean plant and equipment regularly and routinely.
- ✔ Install suitable signage, identifying the use of specific areas and prohibiting the disposal of liquid wastes to the stormwater system. Stencilling around all stormwater drains/inlets is also recommended (e.g. 'Rainwater only – flows to the river').
- ✔ Stormwater must be separated from wastewater. Ensure that all 'wash-down' activities are conducted in a dedicated wash bay. Wash bays should be covered and bunded where appropriate. Wash bays that are connected to sewer and have an area greater than 20 m^2 must be covered.
- ✔ A trade waste permit is required to connect and discharge wastewater to sewer. Further information is available from the Water Corporation.
- ✔ Wastewater from wash bays may require pre-treatment, such as silt traps and oil separation systems, prior to being discharged into wastewater systems (e.g. sewer or septics). For example, wastewater from degreasing operations must pass through an approved oil separation system before being discharged to sewer.

Figure 15. Green Stamp automotive premises, Balcatta. Undercover, bunded, wash-down area,with parts washer, wastewater treatment equipment and drums for recyclable materials. (Photograph: Department of Environment.)

Figure 16. Green Stamp automotive premises, Balcatta. Vehicle wash-down area, with collection drain for wastewater treatment. (Photograph: Department of Environment.)

- ✔ Use grassed areas where infrequent on-site cleaning of mildly soiled vehicles is required and a wash bay is not easily accessible. No degreasing or parts cleaning should occur outside of designated cleaning areas. Mobile services should not degrease engines, unless the wastewater can either be captured for approved disposal by a licensed waste contractor or can be collected and pre- treated via an oil separation system before approved disposal to sewer (in accordance with an approved trade waste permit) or septic.
- ✔ The wash bay's water supply may be supplemented with stormwater (e.g. rain water from roofs).
- ✔ Design a contingency plan for accidental chemical spills, and clean up spills immediately. Refer to MTA WA's guideline, *Cleaning Up Spills*. For large spills, contact the Department of Water and Environmental Emergency Pollution Response Unit on1300 784 782. Further information is available via www.der.wa.gov.au/your-environment/reporting-pollution. If a spill is life threatening call 000 and the Department of Fire and Emergency Services will call out to DWER.

Refuelling areas

- ✔ Use concrete paved areas because bitumen deteriorates as a result of fuel or oil spillage. The area's design should contain all spills and ensure spillages cannot enter the stormwater system. See the MTAWA's Environmental Guidelines *Bunds and Bunding*, *Cleaning Up Spills*, *Oil Separators*, *Preventing Oil Pollution* and *Purchasing Spill Kits* for more information.
- ✔ Design a contingency plan for chemical spills and train staff in the correct use of spill absorbents and clean up procedures. For large spills, contact the Department of Water and Environmental Regulation's Emergency Pollution Response Unit on 1300 784 782(08) 9222 7123 (after hours 1800 018 800). Further information is available via www.der.wa.gov.au/your-environment/reporting-pollution. If a spill is life threatening call 000 and the Department of Fire and Emergency Services will call out DWER.
- ✔ Clean up spills using 'dry' methods. Maintain kits containing dry clean up material (e.g. absorbents) and directions for its use adjacent to, or within, refuelling areas. Post signs to instruct operators not to 'top off' or overfill fuel tanks.
- ✔ Inspect fuel areas daily to identify any leakages.

- ✔ Ensure underground fuel tanks are subject to regular testing for leakages (e.g. pressure testing).
- ✔ Do not hose the refuelling area during cleaning activities, unless the resultant wastewater can be directed towards an oil separation system.

Vehicle maintenance

- ✔ Where possible, perform vehicle maintenance indoors.
- ✔ If maintenance work is performed outdoors, designate a specific area, keep it clean at all times and use 'dry' clean-up practices.
- ✔ Update the facility's schematics to accurately reflect all plumbing connections.
- ✔ Floor drains should be sealed off during maintenance activities.
- ✔ Keep drip trays or containers under the vehicles at all times during maintenance. The captured liquids should be disposed of through an approved system and/or recycled.
- ✔ Train staff in the correct use of spill absorbents and clean-up procedures. Spills should be cleaned up immediately. For large spills, contact the Department of Water and Environmental Regulation's Emergency Pollution Response Unit on 1300 784 782(08) 9222 7123 (after hours 1800 018 800). Further information is available via www.der.wa.gov.au/your-environment/reporting-pollution. If a spill is life threatening call 000 and the Department of Fire and Emergency Services will call out to DWER.
- ✔ Rags or absorbent cloths should be used to clean up small spills, dry absorbent material for larger spills, and a mop for general cleaning (i.e. not to clean up any spills). Mop water can be disposed of via the sink or toilet.
- ✔ Reinforce proper waste disposal practices by undertaking employee training. Ideally, training (as well as risk assessments, procedures, audits, reporting, etc.) would be undertaken as part of an EMS for the site (see Section 2.5.1).
- ✔ Promptly transfer used fluids to drums or hazardous waste containers for recycling or disposal by a licensed waste contractor.
- ✔ Do not pour liquid waste down the floor drains, sinks or outdoor stormwater drains/inlets.
- ✔ Drain all fluids from any end-of-life vehicles being kept on-site for scrap metal and/or parts.
- ✔ All cleaning activities should be conducted in a centralised area to facilitate the capture, treatment and/or disposal of wastewater and other hazardous liquids.
- ✔ Replace chlorinated organic solvents with non-chlorinated ones like kerosene or mineral spirits or water-based products.
- ✔ A licensed waste contractor should be used to remove used solvents from site either for recycling or approved disposal. Alternatively, solvent thinner recycling systems can be used on the premises, reducing purchase and disposal costs.
- ✔ Store all new and used batteries on sealed ground, in bunded undercover areas.
- ✔ When degreasing and cleaning parts, use water-based cleaning agents in preference to those that are solvent-based. Steam cleaning and pressure washing may also be used instead of cleaning agents.

✔ See the following MTA WA's Environmental Guidelines for more information: Bunds and Bunding, Cleaning Up Spills, Coolant Management, Degreasers and Detergents, Managing Body Repairer Wastewater, Mobile Mechanical Repairers, Oil Separators, Parts Washers, Preventing Oil Pollution, Purchasing Spill Kits and Solvent Thinner Recycling Systems.

Benefits and effectiveness

The US EPA (2001) noted in relation to vehicle maintenance that 'fluid spills and improper disposal of materials result in pollutants, heavy metals and toxic materials entering ground and surface water supplies, creating public health and environmental risks. Alteration of practices involving the clean-up and storage of automotive fluids and cleaning of vehicles and vehicle parts can help reduce the influence of automotive maintenance practices on stormwater runoff and local water supplies' (p. 10).

Specifically, pollution prevention practices and good 'housekeeping' practices for the maintenance of vehicles, plant and equipment as addressed in this guideline should result in:

- reduced loads of pollutants entering stormwater and shallow groundwater (particularly fuels, oils, solvents, sediment and heavy metals), thereby minimising the risk to the health of receiving waters
- reduced potential for organisations managing these premises to be subject to complaints from stakeholders or enforcement by environmental regulators
- reduced need for scheme/mains water because of stormwater reuse (e.g. at wash bays)
- reduced need for downstream, end-of-pipe, stormwater treatment devices (as the practices in this guideline are all source controls).

Challenges

The following challenges may need to be addressed to improve implementation:

- the facilities and time needed to perform maintenance work indoors may make this practice impractical or unappealing
- it may be difficult to contain spills from vehicles that are brought on-site after working hours.
- procedures and training materials for employees must be continually updated
- installation and maintenance of structural controls for pre-treatment of wastewater discharges and stormwater discharges can be expensive
- there could be some reluctance to invest in fixed infrastructure (e.g. wash bays) when operating out of leased premises
- some facilities can be limited by the lack of local service providers with respect to hazardous waste removal, maintenance of wastewater treatment infrastructure, or provision of equipment to recycle hazardous substances.

Cost

Given the numerous management practices covered by this guideline and the need to select and tailor these practices for each site, meaningful cost information cannot be provided.

Additional information

Refer to Section 2.2.10 for stormwater management on commercial and industrial premises. Refer to Section 2.3.4 for information about education and participation campaigns for commercial and industrial premises. For information on stormwater management at work depots, see Section 2.2.6.

The Examples/Case studies part of Section 2.3.4 has information about the South East Regional Centre for Urban Landcare's (SERCUL's) Clean Drains – River Gains campaign to reduce nutrients and other contaminants in receiving water bodies. For further information, contact the SERCUL, 19 Horley Road, Beckenham WA 6107, via www.sercul.org.au.

The MTA of WA's Green Stamp program provides environmental assessments, training and support, including simple environmental management plans, case studies and environmental guidelines for automotive businesses and practices. Resources include the Environmental Products and Services Directory and guidelines such as Asbestos Use and Disposal, Building New Premises, Bunds and Bunding, Cleaning up Spills, Cleaning Vehicles, Coolant Management, Degreasers and Detergents, Environmental Policy, Mobile Mechanics, New Environmental Laws, Oil Separators, Parts Washers, Preventing Oil Pollution, Purchasing Spill Kits, Solvent Thinner Recycling Systems, Wastewater Management for Body Repairers, Environmental Assessments for Body Repairers and Environmental Assessments for Mechanical Repairers. Refer to the Examples/Case studies section, below. Further information is available via www.mtawa.com.au/oshgreenstamp-audits/green-stamp/.

Refer to relevant Water Quality Protection Notes, available from the Department of Water and Environmental Regulation via www.dwer.wa.gov.au/ or email drinkingwater@dwer.wa.gov.au. For example:

- WQPN 28, Mechanical Servicing and Workshops (DOW, 2013)
- WQPN 29, Mobile Mechanical and Cleaning Services (DOW, 2013)
- WQPN 68, Mechanical Equipment Washdown (DOW, 2013)
- WQPN 93, Light industry near sensitive waters (DOW, 2009)
- WQPN 52, Stormwater management at industrial sites (DOW, 2010)
- WQPN 10, Contaminant Spills – Emergency Response Plan (DWER, 2020)
- WQPN 52, Stormwater Management at Industrial Sites (DOW, 2010)
- WQPN 65, Toxic and Hazardous Substances (DOW,2015).

Examples/Case studies

Green Stamp Program – Motor Trade Association of WA

The Green Stamp Program was developed by the MTA of WA and the WA former Department of Environment, with funding assistance from the Waste Management and Recycling Fund. It originated in 1997 after the then Department of Environmental Protection released a set of Codes of Practice for three sectors of the automotive retail industry. The Department found that this approach had little or no impact on changing behaviour and believed that an industry-based approach may be more successful. The MTA of WA in conjunction with the Department developed a range of sector-specific environmental resources and initiatives. As the program developed, so too did the concept of developing an accreditation system for the industry to promote those businesses demonstrating industry best practice. The program currently consists of one full-time coordinator that manages the program's broad range of activities, including site assessments, environmental seminars, distribution of environmental guidance notes and directories, certification and promotion of Green Stamp Accredited businesses.

The program has identified and focused on several key areas considered essential to reducing the environmental impact of the automotive industry. These areas are:

- storage practices associated with chemicals and other hazardous substances
- pre-treatment of wastewater from the workshop prior to approved disposal
- spill management to prevent pollution of ground and stormwater systems
- correct disposal of waste products (preferably to recycling or reuse)

- air quality management
- energy and resource conservation
- the development and implementation of environmental management plans.

Solvent recovery system, Western Australia

A WA panel and paint repair workshop that repairs about 160 vehicles per month invested in a solvent recovery system in the mid-1980s. The system produces recycled solvent suitable for use in gunwash (for cleaning spray equipment), metal primers and polyester resins. The purchase of new solvents for gunwash has been reduced from approximately 200 L per month to approximately 20 L per month. This has resulted in reduced on-site pollution risk due to the storage of smaller volumes of solvents on the premises. The recycling system has also reduced the volume of waste solvent requiring disposal to zero. The savings from reduced new solvent purchases and zero waste disposal costs have resulted in an annual saving of $3,792. More information can be obtained from the MTA of WA's Green Stamp website, under Eco-efficiency Case Studies: Solvent Recycling (www.mtawa.com.au/oshgreenstamp-audits/).

Vehicle maintenance facilities in California

The Clean Bay Business Program in Palo Alto, California, regulated vehicle service facilities via licensing, education, inspections and the provision of incentives for good performance (Lehner et al., 1999). When premises were first inspected under the program in 1992, only 4% of 318 facilities complied with regulations relating to discharges to stormwater and sewer. By the end of 1992, this percentage had risen to 41% and by 1998 it had risen to 94%. In addition, violations of regulations that specifically protect stormwater drains fell by 90% between 1992 and 1995. The program also found and eliminated 78 direct discharges to stormwater (e.g. wash-water discharges).

Other case studies

Australian and international case studies are also available from:

- The Centre of Excellence in Cleaner Production, Curtin University, Western Australia. curtinedu.academia.edu/Departments/Centre_of_Excellence_in_Cleaner_Production/Documents

2.2.9 Building maintenance

Description

Buildings and their immediate surroundings can be the source of stormwater pollution during:

- building maintenance practices (e.g. removal of graffiti, washing of buildings and paved surfaces, sandblasting, painting, rendering, etc.)
- the post-construction phase (e.g. contaminated runoff from roofed areas and paved surfaces may enter stormwater after every rainfall event).

Building maintenance practices can produce contaminated wastewater, which can:

- be acutely toxic to aquatic biota in the immediate vicinity (e.g. solvents or chlorinated wastewater from these maintenance activities may drain to receiving waters via the stormwater drainage system)
- lead to long-term chronic impacts on the health of aquatic biota (e.g. lead-based paint flakes from these maintenance activities may be washed into receiving waters via the stormwater drainage system)
- cause aesthetic impacts (e.g. paint flakes from these maintenance activities may be washed into receiving waters via the stormwater drainage system).

Pollutants may enter stormwater from a building's roof (e.g. from flaking paint containing heavy metals, or atmospheric deposition of nitrogen), paved surfaces (e.g. litter from the building's footpaths, or hydrocarbons and heavy metals from the building's roadways and carparks), and during intense rainfall, from pervious areas (e.g. runoff from fertilised lawns and garden beds).

Management practices can be applied during building maintenance and post-construction stages to minimise the risk of stormwater and groundwater pollution and, to a lesser extent, minimise the volume of stormwater discharge.

Applicability

These management practices are applicable to building maintenance in all areas, particularly in catchments with:

- a high proportion of directly connected impervious surfaces (e.g. carparks draining directly to the street's drainage system)
- steep slopes
- 'traditional' (piped or constructed channel) stormwater management systems; or
- sensitive receiving water bodies.

Recommended practices

Building maintenance activities (e.g. painting, sandblasting and graffiti removal)

✔ A 'waste management hierarchy' should be adopted when undertaking building maintenance activities. For example, first explore options that do not generate wastewater (e.g. painting over graffiti rather than removing it); then 'dry' methods (e.g. paint scraping with debris being swept up); then methods that involve little risk of stormwater discharge (e.g. spot application of solvents to remove graffiti using an absorbent ground sheet); then options that generate large amounts of relatively innocuous wastewater (e.g. high-pressure hoses that wash a building but do not remove paints). Options that generate large amounts of relatively hazardous wastewater (e.g. chlorinated wash-waters from washing buildings with moulds) should be used only when other options are not available.

✔ These types of maintenance activities should not be used in wet weather or when rainfall is imminent.

✔ Used solvents and excess paint should be managed as 'hazardous waste'. Accordingly, liaise with local waste management firms and the operators of local waste management disposal/treatment facilities to identify opportunities for recycling and appropriate disposal options. For information about waste acceptance criteria and determination of the appropriate type of landfill for disposal of waste material, refer to the Factsheet – Assessing whether material is waste (DWER, Undated) and the Guideline for waste categorisation of controlled waste (DWER, 2021).

✔ Where washing is necessary and wastewater contains only non-hazardous contaminants in particulate form, direct wastewater to an infiltration area. Where infiltration of wastewater is not possible, remove the suspended material by allowing sedimentation (e.g. building 'check dams' along the roadside channel using sandbags) and/or filtration (e.g. using filters made of geofabric on drainage inlets). Another filtration option is to build several 'socks' approximately 50 centimetres long, which are made of geofabric filled with crushed aggregate. These can be placed on hard surfaces between the source of the wastewater and the drainage inlet.

- ✔ Ensure spill clean-up kits are available and used for spills of solvents or paint. Site personnel should also be trained in their use.

The following maintenance practices are recommended *for painting activities:*

- ✔ Store materials undercover or in contained areas.
- ✔ Clean the work site daily. Use 'dry' methods for clean-up, where possible.
- ✔ Ensure paint or solvent leakages cannot enter the stormwater system. Treat a paint spill in the same manner as a 'chemical spill'.
- ✔ Use a ground cloth/sheet to collect dust and paint residue during scraping, sanding and painting activities.
- ✔ Clean water-based paint equipment where residue cannot enter the stormwater system.
- ✔ Clean oil-based paint equipment where the liquid waste material can be collected and disposed of as hazardous waste.
- ✔ Avoid spray painting outdoors on windy days.

Sandblasting is sometimes undertaken to remove paint and dirt. A waste is produced from this process that consists of the blasting sand, paint and dirt. In some cases, these wastes can be hazardous, due to the presence of heavy metals from older types of paints. Such wastes should be contained, and it is recommended that a licensed waste management firm be engaged to test, transport and dispose of the material.

The following basic maintenance practices are recommended for *graffiti removal*:

- ✔ Ensure wastewater does not enter the stormwater system.
- ✔ Fit temporary geofabric filters on stormwater inlets, where required, to prevent pollutant entry.
- ✔ Sweep up the site immediately after works and dispose of waste materials appropriately.
- ✔ Use temporary bunding to contain potential pollutants.
- ✔ Undertake sound waste handling and disposal practices.
- ✔ For graffiti removal using wet sand blasting methods and where lead-based paint is not likely to be present in the wastewater, minimise the amount of water used. Then direct wastewater to landscaped areas where possible. If this is not possible, filter the wastewater to remove coarse sediment particles prior to its discharge to stormwater.
- ✔ For graffiti removal using high-pressure washing and cleaning compounds, direct wastewater to landscaped areas where possible[11], or pump the wastewater to sewer, (in accordance with an approved trade waste permit). Note that pre-treatment of wastewater may be necessary before its disposal to sewer if some types of cleaners have been used.

Guidelines for surface cleaning activities include:

- ✔ If wastewater should be connected and discharged to sewer, a trade waste permit is required. Further information is available from the Water Corporation.

[11] This guideline is not recommended in areas where cleaning compounds are used and groundwater contamination is likely (e.g. sandy soils on the Swan Coastal Plain).

- ✔ Where painted buildings are being washed and there is the likelihood of lead or mercury additives in the paint, wastewater should be directed to sewer (in accordance with an approved trade waste permit) or taken to a hazardous waste treatment facility by a licensed contractor.
- ✔ Where an acid wash is being used to remove mineral deposits on masonry, rinse the treated area with an alkaline soap to neutralise the acid residue. Direct rinse water to a landscaped area. Collect the acidic wastewater, neutralise the pH to between 6 and 11, and pump the wastewater to sewer (in accordance with an approved trade waste permit).
- ✔ Where washing building walls with soap, either discharge wastewater to a landscaped area, to sewer (in accordance with an approved trade waste permit), or to a waste treatment facility via a licensed waste transport contractor.
- ✔ Where washing building walls without soap and where lead-based paint is not likely to be present in the wastewater, direct wastewater to landscaped areas where possible, or if this is not possible, filter the wastewater to remove coarse sediment particles prior to its discharge to stormwater. Dispose of collected solids as non-hazardous solid waste.

Maintenance of gardens, carparks and paving

- ✔ Regularly sweep up contaminants from paved/carpark surfaces.
- ✔ Identify 'hot spots' where contaminants such as litter, leaves and sediment regularly accumulate. Program regular inspections and removal of these materials using 'dry' clean-up methods to minimise the potential for stormwater pollution.
- ✔ Provide suitable litter and recycling bins around the building, and ensure that an adequate inspection and maintenance program is in place for these bins, where appropriate. For more details on this practice, refer to Section 2.2.4.
- ✔ Ensure vehicles that are parked on-site do not leak fluids (e.g. oils). Undertake regular inspections, provide drip pans where necessary, and immediately clean up any identified leaks/spills.
- ✔ Seek to reduce the amount of impervious surfaces directly connected to the stormwater system by promoting infiltration and filtration, where site conditions are suitable.
- ✔ Implement opportunities to reuse roof water and other forms of stormwater from the site (e.g. for toilet flushing and garden irrigation).
- ✔ Implement water conservation and integrated pest management practices and reduce fertiliser use on lawn and garden areas. Refer to Section 2.2.7 for further information.
- ✔ Minimise the use of inorganic fertilisers on lawn and garden areas (e.g. via soil amendment practices and use of organic fertilisers). Refer to Section 2.2.7 for further information.
- ✔ Seek to ensure permeable areas (e.g. lawns and gardens) have features that promote infiltration of stormwater (e.g. uncompacted soils, contouring that causes temporary ponding during heavy rain and use of mulch on garden beds).
- ✔ Seek to implement permeable paving as an alternative to traditional paving, where practical and where site conditions are suitable (e.g. areas with permeable soils and where groundwater tables are not high). Refer to Chapter 9 for more information on permeable paving.

Maintenance of the building's stormwater-related structures

✔ Regularly inspect and maintain all structural stormwater treatment, retention or infiltration devices. A maintenance and repair plan should be developed that clearly outlines inspection and maintenance frequencies, procedures for the disposal of wastes, equipment requirements, health and safety requirements. See Chapter 9 for more information.

✔ Inspect and, where necessary, maintain the site's in-ground stormwater network (at least annually).

✔ Inspect and, where necessary, maintain the building's drain inlets, spouting and downpipes (at least twice per year).

Benefits and effectiveness

These measures are generally simple, low-cost pollution prevention and minimisation practices with a low risk of failure. They can be applied at the source of pollution, and are likely to be more cost-effective than trying to achieve the same stormwater management benefits at a point downstream, using alternative methods (e.g. regional stormwater treatment devices).

These management practices may:

- minimise risks to the health of receiving water bodies by reducing loads of pollutants entering stormwater and shallow groundwater (particularly sediment, heavy metals, litter, hydrocarbons, organic matter, paint and solvents)
- reduce aesthetic impacts (e.g. coloured paint flakes being washed from a building's roof under high pressure into the stormwater system and into a local wetland)
- reduce the pressure on downstream, end-of-pipe, stormwater treatment devices.

Challenges

The following challenges may need to be addressed to improve implementation:

- procedures and training materials must be regularly updated
- maintenance of a building's structural stormwater management devices may be limited by the absence of suitable maintenance plans that should have been developed when the devices were designed and installed
- in some areas, local service providers may not be available for hazardous waste and recyclable material removal and processing
- implement training to address resistance to changes in work practices
- safety and localised flooding risks associated with placing geofabric filters over stormwater drain inlets when rainfall is imminent.

Cost

Generally the costs associated with management practices outlined in these guidelines are minimal, except where large volumes of wastewater need to be treated as 'hazardous waste'.

Additional information

For information on maintenance of the site's drainage system, refer to the guidelines provided in Section 2.2.2.

For information on the placement and maintenance of the building's external litter and recycling bins, refer to the guidelines provided in Section 2.2.4.

This guideline has been developed assuming that maintenance is required. Taking a ‘pollution prevention’ approach, the need for maintenance may be reduced or eliminated through measures such as:

- incorporating maintenance considerations into the *design* of buildings
- multi-dimensional programs to minimise the occurrence of graffiti (e.g. ensuring quick removal of graffiti, installing sensor lighting in high risk areas, avoiding the creation of large surfaces that create a ‘canvas’ for graffiti attacks, creating partnerships with the community, providing areas where ‘street art’ is encouraged, using landscaping to make sites less accessible, etc).

Examples/Case studies

No documented case studies were identified.

2.2.10 Stormwater management on industrial and commercial sites

Description

Industrial and commercial premises have significant potential to pollute stormwater. For example:

- commercial areas are known to generate large loads of litter
- industrial premises can contaminate stormwater through poor control of industrial processes or the transport, handling and storage of goods and wastes
- food preparation businesses may have poor facilities for waste handling and disposal.

In 2014, the Auditor General of WA stated that small to medium-sized industrial premises still represented a risk to the health of water resources in Perth (AGWA, 2014). Improving practices that potentially impact on stormwater and groundwater at these premises is a priority for water resource protection.

As several detailed guidelines are currently available that provide guidance on this topic, including several comprehensive WA guidelines (see Additional Information), this section will:

- reference these guidelines
- briefly summarise key aspects that relate to stormwater management.

Applicability

Pollution prevention and other management activities for stormwater management are applicable to most commercial and industrial sites. Site-specific risks should be identified and appropriate management practices should be designed for the site. Attending suitable training, and the industry-specific seminars and workshops provided by the Green Stamp Program, can help people gain the skills necessary to undertake this process.

Recommended practices

The Green Stamp Program can provide training, support, case studies and further information.

Preparing the workplace

✔ Identify and assess stormwater-related risks on the site (e.g. activities that may contaminate stormwater). Various checklists and surveys have been developed to help people identify these risks (e.g. see Motor Trade Association of WA’s self-assessment guides; VSC, 1999). In some circumstances, a survey or checklist can also be used to raise awareness among staff of the potential for contamination of stormwater (VSC, 1999). Staff who may undertake risk assessments should receive training to ensure they have the necessary skills.

- ✔ Develop management plans or procedures to manage the identified risks (e.g. a Stormwater Management Plan, Waste Management Plan, Emergency Response Plan, etc.). Again, professional training is recommended to help those people developing these documents to access necessary skills and resources. For guidance on the content of a 'Stormwater Management Plan' for larger industrial or commercial sites, see Chapter 5 of this manual.
- ✔ Train all staff to be aware of stormwater pollution, to undertake their roles in related management plans/procedures, report incidents and safely manage incidents.
- ✔ All stormwater-related actions in relevant plans or procedures should be subject to regular audits to ensure they are occurring. These may result in recommendations for improvement (e.g. modified procedures, new training, new equipment, etc.).
- ✔ For large sites with many potential sources of stormwater pollution or sites with significant risks to stormwater, it is recommended that an environmental management system (EMS) be developed, implemented and maintained. See Section 2.5.1 for guidance on this issue.
- ✔ Look for opportunities to recycle stormwater/roof water on-site as a way of minimising the use of scheme water and the export of stormwater and stormwater pollutants from the site. This water may be used for irrigation, vehicle washing, toilet flushing or industrial processes. A cost saving may be generated from this activity if the consumption of mains water is reduced.
- ✔ Develop and implement a Waste Management Plan to ensure that solid and liquid wastes are minimised and stored correctly to reduce the risk of stormwater contamination. This plan would explore opportunities for waste minimisation (e.g. ensuring the correct amounts of raw materials are purchased to decrease the amount of excess materials that are discarded) and the reuse of wastes (either on the site or within the region). For information about waste acceptance criteria and determination of the appropriate type of landfill for disposal of waste material, refer to the *Factsheet – Assessing whether material is waste (DWER, undated) and the guideline for Waste categorisation of controlled waste (DWER, 2021)*. The Department of Water and Environmental Regulation regulates the transportation of wastes that may cause environmental or health risks. It does so through the application of the Environmental Protection (Controlled Waste) Regulations 2004. Controlled waste is generally defined as all liquid waste, and any waste that does not meet the acceptance criteria for a Class I, II or III landfill site. The *Waste categorisation of controlled waste (DWER, 2021)* specifies that a generator is a person whose activities produce, or apparatus result in the production of controlled waste. Staff should be aware of the Environmental Protection (Unauthorised Discharge) Regulations 2004. The regulations include an on-the-spot infringement notice system for minor pollution offences. These powers can be delegated to local government officers. On-the-spot fines carry a penalty of $250 to $500, which increases to up to $5,000 for individuals and $25,000 for companies if the matter proceeds to court. The fines apply to commercial activities including land development and construction premises and cover the discharge of Schedule 1 substances to stormwater or groundwater. These substances include acid with a pH less than 4, alkali with a pH more than 10, hydrocarbons, solvents, degreasers, detergents, dust, engine coolant, pesticides, paint, dyes, sediment and substances containing heavy metals.

Figure 17. Green Stamp automotive premises, Balcatta. Correct storage of fuel and other chemicals in a bunded area. (Photograph: Department of Water and Environmental Regulation.)

✔ Ensure all containers holding wastes or hazardous materials are designed to minimise the risk of stormwater contamination. This includes having lids on solid waste containers to prevent windblown litter, covering storage areas, using bunds around areas where liquid materials are stored, etc. Waste containers should be stored in bunded, undercover areas, on an impermeable surface and away from stormwater drains.

✔ *Large quantities* of potentially hazardous material should be stored within a bunded compound that is impervious to infiltration, able to safely contain at least 110% of the volume of the largest container in the bund and 25% of the combined volume of all other liquids held within the compound. If located outside, the storage area should be roofed to prevent the collection of rainwater inside the bunded area.

✔ For storage of chemicals, all floor areas should be sealed to prevent infiltration and assist with the clean-up of spills.

✔ In areas where accidental spills may occur (e.g. loading/unloading areas), ensure that appropriate spill response equipment is available and readily accessible at all times.

✔ Designated material handling areas need to be kerbed and graded to contain spills, stormwater and the liquid generated from at least one hour of typical fire-fighting activities. Speed humps or irregular surfaces that may cause accidents with containers should not be permitted in handling areas.

✔ Ensure stormwater from relatively clean areas (e.g. roofs) is kept separate from stormwater from potentially contaminated areas (e.g. uncovered work areas of industrial sites) to minimise the volume of stormwater that requires a high level of treatment.

✔ Prevent contaminated wastewater from floors and covered work areas from entering stormwater systems by using surface grades, bunds, or diversion drains to an impervious sump or wastewater treatment system.

✔ Wash-down pads should be designed to collect all water and residue in impervious collection sumps and have impervious bunds. The captured wastewater should be discharged to wastewater treatment facilities or removed by licensed waste contractors.

✔ Ensure suitable structural stormwater treatment devices are in place, and are regularly inspected and maintained in accordance with a maintenance plan. See Chapter 9 for information on structural controls.

- ✔ Obtain specialist advice on whether stormwater from various locations around the site needs to be treated and whether the stormwater can be discharged to the stormwater system (e.g. drains), soakwells, a hazardous waste treatment facility (via a licensed waste transport contractor) or sewer (approved in some rare circumstances only). This advice should be confirmed in writing from the Department of Water and Environmental Regulation and the local government and then documented in the site's stormwater management plan.
- ✔ Consider the quality and quantity of stormwater discharges from the site during the design of new buildings and surrounding areas. Apply water sensitive design features where possible.
- ✔ Look for opportunities to re-engineer or redesign processes to take advantage of newer, cleaner and more efficient equipment that has a reduced risk of stormwater contamination.
- ✔ Use alternative materials for cleaning, coating, lubrication, and other production processes to prevent the generation of hazardous wastes and minimise the risk of stormwater being contaminated by these wastes.
- ✔ Stormwater drains within and around the site should be stencilled with messages to alert all staff that they drain to watercourses or wetlands (e.g. 'Rainwater only – flows to the Swan River'). See Section 2.3.4 for information about education/participation campaigns for industrial and commercial sites.

Keeping the workplace clean

- ✔ Ensure surfaces that drain to stormwater are regularly cleaned using 'dry' methods.
- ✔ Only undertake washing, degreasing and cleaning activities in dedicated wash-down bays where the wastewater can be collected and prevented from mixing with stormwater. This includes vehicle washing using biodegradable detergents.
- ✔ Maintain machinery/vehicles to minimise the risk of leaks and store such machinery in cleaned areas so that regular inspections can quickly identify any discharges.
- ✔ Use spill trays under work areas where spills could occur.
- ✔ Control airborne sprays so those surfaces that generate or convey stormwater are not contaminated.
- ✔ Where possible, loading and unloading should take place in a covered area away from the vicinity of stormwater drains. Stormwater should be directed away from loading and unloading areas.
- ✔ For more information, see Section 2.2.8 Maintenance of vehicles, plant and equipment (including washing).

Minimising the risk of accident/incident

- ✔ Ensure staff training includes safe material handling and storage procedures to minimise the risk of a spill. For large spills, contact the Department of Water and Environmental Regulation's Emergency Pollution Response Unit on 1300 784 782(08) 9222 7123 (after hours 1800 018 800). Further information is available via https://www.der.wa.gov.au/your-environment/reporting-pollution/117 reporting-pollution-to-land-including-waste-and-litter -pollution. If a spill is life threatening call 000 and the Department of Fire and Emergency Services will contact DWER.

✓ In consultation with staff, develop and communicate an Emergency Response Plan to manage spills. One of the primary objectives of this plan is to ensure that spills do not leave the site via stormwater drains.

✓ Ensure the site is equipped with suitable emergency spill equipment and absorbents and train staff on their use. Spill materials vary according to the nature of the work being undertaken, the location of the business (e.g. next to water bodies) and the types of liquids being handled. At a minimum, spill kits should include gloves and/or other protective clothing, suitable absorbent pads/powders/granules, shovels, brooms and dust pans.

✓ Clean-up of spills should be immediate, automatic and routine in industrial premises, no matter how small. Under no circumstances should spills be washed away with water or buried on-site.

Benefits and effectiveness

Benefits associated with implementing these management practices may include:

- reduced risks to, and impacts on, stormwater and groundwater quality
- improved workplace health and safety
- reduced risk of breaching environmental legislation and being prosecuted under this legislation
- cost savings as a result of cleaner production techniques
- reduced risk of complaints from stakeholders (e.g. neighbours, environmental groups)
- enhanced corporate citizenry and public image
- reduced legal and financial liability with respect to issues such as site contamination.

In terms of the effectiveness of these practices, it is widely recognised that source control, cleaner production and pollution prevention techniques are cost-effective strategies for managing pollution on commercial and industrial premises. However, pollutant removal efficiency data for specific practices covered by this guideline are not available.

Challenges

The following challenges may need to be addressed to improve implementation:

- the development of a Site Management Plan with a focus on pollution prevention for commercial industrial sites will require an initial investment of time and money, which could be recouped over time through more efficient business practices
- a low level of environment regulation or enforcement (particularly for small to medium-sized enterprises) creates little to no incentive to comply with environmental legislation
- there are a limited number of positive incentives for commercial or industrial premises to improve their stormwater-related environmental performance (e.g. opportunities for the company to gain positive publicity, reduced licence fees, grants for environmental works, subsidies and rebates)
- few commercial benefits with customers that do not consider a business' environmental practices in their purchasing decision
- implementing training to address resistance to changes in work practices
- lack of expertise and/or knowledge of how to address the issues
- planning restrictions and restrictive lease arrangements.

Cost

The cost required to identify, assess and manage stormwater-related risks will vary greatly depending on the activities being undertaken, the characteristics of the site, and the extent to which the stormwater-related management plans are implemented.

Additional information

The guidelines provided in Sections 2.4.2 and 2.5.1 are relevant to commercial and industrial premises. Section 2.4.2 explains how regulation (with enforcement of these regulations) can provide an effective incentive for improved stormwater management on commercial and industrial premises, while Section/2.5.1 explains the benefits of environmental management systems.

Section 2.2.8 is relevant for maintenance of vehicles and equipment (including washing).

Section 2.3.4 has information about education and participation campaigns for industrial and commercial premises.

The following resources provide guidance on undertaking sound environmental management on commercial and industrial sites, including cleaner production techniques and stormwater management practices: Green Stamp is an industry-specific environmental accreditation and education program that assists small to medium businesses to implement environmental BMPs. The program provides environmental assessments, training and support, including simple environmental management plans and industry-specific case studies and environmental guidelines. Green Stamp Programs are currently available through the following industry associations:

- MTA of WA. Resources include the Environmental Products and Services Directory and environmental guidelines such as Asbestos Use and Disposal, Building New Premises, Bunds and Bunding, Cleaning up Spills, Cleaning Vehicles, Coolant Management, Degreasers and Detergents, Environmental Policy, Mobile Mechanics, New Environmental Laws, Oil Separators, Parts Washers, Preventing Oil Pollution, Purchasing Spill Kits, Solvent Thinner Recycling Systems, Wastewater Management for Body Repairers, Environmental Assessments for Body Repairers and Environmental Assessments for Mechanical Repairers. Refer to the Examples/Case studies section, below. Further information is available by telephoning the Automotive Industry Green Stamp Officer on (08) 9233 9800 or via www.mtawa.com.au/oshgreenstamp-audits/green-stamp/
- The Print and Visual Communication Association. Resources include Managing and Monitoring Environmental Impacts – A Simple Environmental Management Plan for Printing Businesses, Accreditation Criteria for Printing Businesses, Baseline Audit for Printing Businesses and information sheets on Chemical and Ink Management, Environmental Law, Protecting Stormwater Drains, Solid Waste Management and Wastewater Management. These resources are available by telephoning the Printing Industry Green Stamp Coordinator on 1800 227 425. Further information is available via www.pvca.org.au/sustainable-green-print/green-stamp-western-australia/
- Building Service Contractors Association of Australia LTD. The Building Service Contractor's Association Green Stamp Coordinator is available by telephoning 1800 312 970 for further information.

Refer to relevant Water Quality Protection Notes, available from the Department of Water and Environmental Regulation or by telephoning (08) 6364 7000.

For example:

- WQPN 28, Mechanical Servicing and Workshops (DOW, 2013)

- WQPN 29, Mobile Mechanical and Cleaning Services (DOW, 2013)
- WQPN 68, Mechanical Equipment Washdown (DOW, 2013)
- WQPN 93, Light industry near sensitive waters (DOW, 2009)
- WQPN 52, Stormwater management at industrial sites (DOW, 2010)
- WQPN 10, Contaminant Spills – Emergency Response Plan (DWER, 2020)
- WQPN 52, Stormwater Management at Industrial Sites (DOW, 2010)
- WQPN 65, Toxic and Hazardous Substances (DOW, 2015).
- WA Department of Mines, Industry Regulation and Safety – Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 Guide. These guidelines and further information about dangerous goods storage, handling and transport, relevant legislation and accredited training providers and consultants are available at www.dmp.wa.gov.au/ Dangerous-Goods/Dangerous-goods-safety-guidance-6510.aspx

Examples/Case studies

Refer to the Green Stamp Program, outlined in the Additional information Section and Section 2.3.4.

The case study provided in Section 2.4.2 is relevant to this management practice, as it demonstrates the stormwater-related outcomes that can be achieved at vehicle service facilities where there is a strong incentive to improve. In the case study provided, positive and negative incentives were used by a regulator to promote behavioural change.

2.3 Educational and participatory practices

2.3.1 Capacity building programs for local government and stormwater management industry professionals

Description

Capacity building is a 'holistic approach to knowledge building and transfer, identifying issues of relevance and benefit to foster professional skill development, competency, innovation, creativity, confidence, certainty and clarity. Capacity building is also a means to facilitate network building, linkages and training for continuous improvement'.

Stormwater-related capacity building programs can be run at a variety of scales, from a program that covers a small local government area to one that covers an entire state.

Providing people with the information and contacts they need to make better decisions is an essential part of promoting best practice stormwater management.

Applicability

These programs are applicable to local government authorities, metropolitan regional councils and stormwater management industry associations.

Refer to the Recommended practices section for the potential target audiences, who should be involved in the scoping stage of the program.

Recommended practices

The Clearwater program in Victoria and the New WAter Ways in WA are good examples of stormwater management capacity building programs (refer to the Examples/Case studies section for further information).

Recommended steps for a stormwater-related capacity building program

✔ Scoping the program by identifying the capacity building requirements for the target audience. For example, specialist market researchers may be engaged to survey the target audience (through methods such as focus groups, workshops and phone surveys) to identify current levels of stormwater knowledge and awareness, training and development needs, barriers to change, potential education and networking opportunities, including existing communication networks.

✔ Using the information from the scoping step to identify key project areas.

✔ Developing project plans for each of the key project areas. These plans detail how major projects will be delivered (e.g. training events, information registers, websites and guidelines), including details such as the target audience, objectives, expected outputs, expected outcomes, method of evaluation, timing and responsibilities.

✔ Implementing these project plans.

✔ Communicating with stakeholders *throughout* this process. Opportunities for communication include newsletters (paper and electronic), websites, workshops and travelling 'road shows', where stakeholders are introduced to the capacity building program, new projects are advertised (e.g. upcoming training events or guidelines), and new products are explained.

✔ Evaluating the program. An approach to monitoring and evaluation should be planned at the beginning of the program's development and executed throughout its delivery. For advice on designing a suitable monitoring and evaluation plan, see Taylor and Wong (2002d).

The following potential target audiences should be involved in the initial scoping exercise (i.e. step number one above):

• elected members (particularly in small to medium-sized local government)

• senior managers in local government, State government and relevant water service providers

• town planners, engineers, ecologists, architects, landscape architects and staff responsible for the maintenance of stormwater assets

• the construction and stormwater management industries (both in government and the private sector)

• local catchment groups, industry associations and other existing communication networks, where applicable.

In large urban areas covering several local government districts, there are potential benefits associated with combining available resources to form a major regional capacity building program (e.g. jointly funded by State and local government).

Benefits and effectiveness

The potential benefits of a capacity building program include:

- increased rate of uptake of stormwater best practices by the public and private sector
- increased understanding of the need for stormwater management initiatives (e.g. strict town planning controls and stable funding mechanisms), particularly by senior managers and elected officials
- widely communicated results of other successful projects
- enhanced communication networks amongst stakeholders that will exist long after the capacity building program has officially finished

- identification of common needs (e.g. a specific guideline or training module) and the facilitation of a cost-effective, high quality regional project that most organisations could not fund on their own.

Best practice stormwater-related capacity building programs may be highly effective if designed, delivered and evaluated in accordance with the steps highlighted in this guideline.

Challenges

The primary challenge for running a capacity building program is cost. Some of these costs could be recovered by charging participants to attend specific training events and to access products, although this option is rarely chosen.

Stakeholder needs may change over time. For example, in the early stages of a program, stakeholders may require basic information and knowledge. As stakeholders become more experienced, other issues, such as funding and the regulatory framework, may become more prominent. Bold initiatives like strict town planning controls, enforcement programs, new funding arrangements and new organisational structures may not be implemented unless senior managers, elected officials and the broader community understand the need for these measures. A capacity building program can help to ensure this base level of knowledge is obtained, particularly within professional stakeholder groups.

Additional information

For further guidance about how to undertake specific educational events (e.g. training programs), see Sections 2.3.2 to 2.3.5 in the Educational and Participatory Practices section of this chapter. Chapter 8: Education and awareness for stormwater management provides additional case studies and guidance on how to design a community education and awareness program.

For information on the effectiveness of educational and participatory approaches to stormwater management, see Taylor and Wong (2002c).

For more information about capacity building, see the Implementation chapter of this manual. The following behaviour change resources are recommended when designing the program:

- Community Change (Victoria, Australia) via www.communitychange.com.au
- Community-Based Social Marketing (Canada) via www.cbsm.com
- Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing (McKenzie- Mohr & Smith, 1999). Further information is available from Community-Based Social Marketing via www.cbsm.com
- The Facilitation Toolkit: A practical guide for working more effectively with people and groups (Keating, 2003) is a recommended resource to use when facilitating workshops, seminars or group meetings

Examples/Case studies

The New WAter Ways capacity building program WA

New WAter Ways was formed in 2006 to enable excellence in integrated water cycle management and build capacity of government and industry practitioners. It was incorporated under the Incorporated Associations Act 1987 in 2014. The members of New WAter Ways Inc provide oversight of the program. They are Department of Planning, Lands and Heritage; Department of Water and Environmental Regulation; Department of Biodiversity, Conservation and Attractions; Western Australian Local Government Association; Urban Development Institute of Australia (WA); and Water Corporation.

The New WAter Ways program commits for partnerships, collaboration and consultation; demonstration of best practices, policy and processes; and providing leadership and supporting champions, in order to showcase the wide range of total water cycle solutions available, building capacity in the achievement of better urban water management outcomes across the state. The program's objectives are to deliver outcomes in the areas of knowledge sharing; education, science and training; advocacy and leadership; and partnerships and bridging including to:

- provide easy access to best practice and supporting WSUD information including trusted science, technical tools, current policy and existing programs
- make WSUD "normal practice" by facilitating the upskilling of WSUD practitioners to deliver best practice for WA based on trusted and reliable science
- provide leadership and advocacy for the adoption of best management and planning practices for WSUD in WA
- promote effective partnerships by acting as a bridging organisation for the WA water sector.

The Victorian Clearwater Capacity Building Program and Information Exchange

The Clearwater capacity building program is a statewide targeted education and training program to support local government and industry professionals in the sustainable management of urban stormwater. It is a joint initiative of the Municipal Association of Victoria (MAV) and the Stormwater Industry Association of Victoria (SIAV), made possible through the Victorian Stormwater Action Program (Clearwater, 2002 and 2003). In 2006, Melbourne Water became a major funding partner and host of the program and additional special funding has been provided from the Department of Environment, Land, Water and Planning (previously DSE), Municipal Association of Victoria and Environment Protection Authority. The Clearwater program partnerships promote industry sharing and collaboration. Clearwater has valuable connections with local, state and national government bodies, research institutions and commercial organisations. These partnerships enable to bring the latest technical and scientific knowledge, behavioural research and policy development from the forefront of sustainable urban water management thinking.

The Clearwater program conducts regular program evaluation using rigorous market research to ensure they remain relevant and responsive to industry needs.

The program offers services such as public training, guided technical tours, tailored and specialised training workshops (available in-house and on-request), knowledge sharing as well as network building events.

The program's training and events are informed by the latest research and delivered by recognised industry leaders. The courses combine both theory and practice and promote relevant best practice in sustainable urban water management. And the training courses are widely recognised for continuing professional development.

This series of workshops helped to develop a program of education and training events. Key project areas include WSUD, town planning tools, regulation and enforcement, leadership and commitment. Specific project plans are being developed for each of these four areas.

To respond to the needs of surveyed stakeholders, a 'stormwater information exchange' was established and a travelling 'road show' was delivered at four areas around Victoria, to showcase work being done through the program.

The Clearwater information exchange is a web-based database for urban stormwater management initiatives, available via www.clearwatervic.com.au/. It aims to provide up-to-date and relevant information on topics including tools and resources; research; reports; case studies (including contact details for further information); interstate programs and resources; partnership projects; contacts; and relevant websites.

The HIA GreenSmart® Program

The HIA GreenSmart® Program is a national, industry-based capacity building program run by the Housing Industry Association of Australia within each state, in cooperation with the Australian Government, Greening Australia and industry groups. The program aims to promote environmentally responsible land development and building practices. The program focuses on energy efficiency, water efficiency, waste management and stormwater management. It involves training, accreditation of professionals (builders), demonstration sites and promotional activities (e.g. annual awards).

2.3.2 Intensive training of landowners on aspects of stormwater management

Description

This BMP typically involves a series of free intensive training workshops for volunteer residents involving lawn and garden care activities. The aim is to promote alternative lawn and garden care practices to minimise stormwater pollution.

Home gardens can have a significant adverse impact on stormwater and groundwater quality. Potential pollutants include nutrients, pesticides, sediments and organic matter (e.g. manure and grass clippings).

Intensive training programs may focus on water conservation, plant selection, fertiliser use, weed and pest management, irrigation practices, stormwater and shallow groundwater reuse, composting and soil amendment.

The Swan River Trust gardening workshops and the Living Smart sustainable living workshops are successful WA examples. Other examples include the Master Gardener Program in the US. Refer to the Examples/Case studies section for further information.

Applicability

These programs are applicable to all areas, however they are particularly applicable in the following situations:

- areas with sandy soils that have low nutrient and moisture retention capabilities
- areas draining to sensitive water bodies (e.g. wetlands and waterways with conservation values, or catchments that are under stress from nutrient inputs, such as the Peel-Harvey and Swan-Canning)
- drinking water catchments
- areas where gardens are close to water bodies
- areas with large gardens and lawns
- areas subject to erosion (e.g. due to steep slopes).

Recommended practices

Use proven behaviour change techniques, such as commitments/goal setting, prompts (to address forgetting), develop social norms and consider incentives. These techniques, particularly commitments/goal setting, have been used successfully in the Living Smart workshops in Western Australia and the Master Gardeners program in the US. Refer to the Additional information section for a list of recommended behaviour change resources.

For example, the Master Gardener program approach is outlined below:

Attendees who demonstrate an interest in environment-sensitive lawn and garden care can enrol their property as ‘volunteer gardens’ to demonstrate best practice techniques.

Participating landowners may sign an agreement to implement a variety of best management practices and keep a log of their activities over a full year.

Each volunteer may be assigned a personal Master Gardener, who is also a volunteer but has received prior training in alternative lawn and garden care techniques. The Master Gardener visits the landowner and sets aside regular times to discuss their progress.

Participants who successfully complete a year in the program can earn the title of 'demonstration garden', where they place a sign on the property to highlight that an alternative approach is being used. Participants are also encouraged to network within their local residential community to promote the practices they have learned and adopted. Participants may also undergo additional intensive training to become Master Gardeners themselves.

Changes in the knowledge and self-reported behaviour of participants are evaluated through regular surveys and through the logs kept by volunteers.

The training may also extend to water conservation, waste management practices and integrated pest management, where the application of insecticides and herbicides is minimised through alternative garden and lawn management techniques.

To engage the community, it may be advantageous for the program to address a range of sustainable living issues, e.g. stormwater management, water conservation, water sensitive gardening, waste minimisation and energy efficiency. Examples of sustainable living programs are provided in the Examples/Case studies section.

Benefits and effectiveness

These programs can specifically target key sources of pollution, audiences and landowners from geographic areas. The program can also evolve as new pollutant priorities and management practices emerge. The programs can be applied in established areas and are relatively cost-effective to run. Unlike the equivalent structural measures, they are not associated with a maintenance requirement for several decades (although maintenance of the training program is needed over time).

Supporting earlier work by Schueler (2000), the US EPA (2001) reviewed the effectiveness of nonpoint source education programs and concluded 'from evaluations of several market surveys, it appears that media campaigns and intensive training can each produce up to a 10 to 20% (self-reported) improvement in selected behaviours. A combination of both outreach techniques is probably needed in most watersheds, as each complements the other' (p. 29).

Taylor and Wong (2002c) reviewed a number of US case studies and reported that intensive training programs involving lawn and garden care practices can produce:

- 26%–41% increase in knowledge[12]
- 17% increase in desirable attitudes
- 10%–75% (with the range 20%–40% being common and an average of the most reliable data around 29%) increase in the number of people undertaking a specific desirable behaviour (based on self- reported data)
- 40% increase in the number of desirable practices adopted (based on self-reported data)
- For lawn care training, total nitrogen and pesticide loads applied to lawns can be reduced by to lawns can be reduced by approximately 40% and 25%, respectively.

[12] That is, 26% – 41% of the surveyed population increased their knowledge in a certain area (e.g. they knew the best season and weather conditions to apply fertiliser).

Taylor and Wong (2002c) also reported that combined awareness and training programs (e.g. catchment-wide awareness and intensive lawn care training initiatives) are capable of producing:

- a 20%–29% increase in the number of participants undertaking a desirable behaviour (again based on self-reported data)
- event mean concentrations of common lawn herbicides in stormwater may be reduced by 56%–86% over several years.

Taylor and Wong (2002c) concluded that there is strong evidence that intensive and interactive training is a superior method for changing lawn and garden care behaviour compared with seminars and publications. For example, an independent investigation was undertaken on the effectiveness of these three extension methods as part of the Florida Yards and Neighbourhoods Program. Intensive training involving interactive workshops and mentoring (e.g. consistent with the Master Gardener program) increased the number of desirable lawn care practices adopted by participants by approximately 36%, compared to 24% for seminars and 15% for publications. The relative difference between the effects of these three methods is unlikely to be distorted by any bias associated with self-reported behavioural change.

The Examples/Case studies section outlines the benefits and effectiveness of particular programs.

Challenges

The primary challenge with this BMP is that it is a voluntary measure, relying upon individuals to volunteer their time to participate in the program. Significant effort would be required to communicate the needs for participation in such a program (e.g. why nutrient management on residential properties is an issue on the Swan Coastal Plain), and the benefits of doing so, both in terms of the broader community and the individual.

The programs should be delivered free of charge to attract a significant number of participants, so funding must be sourced from government agencies (i.e. rather than a 'polluter pays' arrangement).

Additional information

Chapter 8: *Education and awareness for stormwater management* provides additional case studies and guidance on how to design a community education and awareness program.

The following *behaviour change* resources are recommended when designing the program:

- Community-Based Social Marketing (Canada) via www.cbsm.com
- *Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing* (McKenzie- Mohr & Smith, 1999). Further information is available from Community-Based Social Marketing via www.cbsm.com
- The *Facilitation Toolkit: A practical guide for working more effectively with people and groups* (Keating, 2003) is a recommended resource about facilitating workshops, seminars or group meetings.

Refer to Section 2.2.7 for further information about recommended BMPs for gardens. The following guidelines, programs and sources of information are some of the recommended resources:

- free gardening workshops – The Department of Biodiversity, Conservation and Attractions' (DBCA) supported 'River Guardians program' and the Water Corporation's 'Waterwise program', run a number of workshops that showcase the latest ideas in environmentally-friendly gardening and provide participants with the practical information needed to get the best results from their garden. Further information available from www.riverguardians.com/
- Fertilise Wise Guides – The Phosphorus Action Group's Fertilise Wise Guides advise gardeners on appropriate fertiliser types and application rates for soils in the Perth region. (08) 9458 5664.

You may access fertilise wise information via the SERCUL website www.sercul.org.au/our-projects/fertilise-wise/

- guidelines on various aspects of saving water when designing and maintaining lawns and gardens posted on the Waterwise page of the WA Water Corporation's website www.watercorporation.com.au/waterwise

Growing local plants may protect water resources, as they require minimal water, pesticides and fertilisers. Further information is available from the following resources:

- to select Perth plants suitable for your soil type, go to the APACE WA website https://www.apacewa.org.au/ or telephone APACE on (08) 9336 1262
- Wildflower Society of Western Australia – The Society provides a range of resources (e.g. books) and advice about planting local native plants www.wildflowersocietywa.org.au
- Free Gardening Advisory Service – Botanic Gardens and Parks Authority (08) 9480 3672 www.bgpa.wa.gov.au. Section 2.3.4 has useful information about the benefits of community participation programs versus traditional education programs.

Examples/Case studies

Gardening Workshops in Western Australia

The DBCA-supported River Guardians program and the Water Corporation's Waterwise program run a number of workshops that showcase the latest ideas in environmentally-friendly gardening and provide participants with the practical information needed to get the best results from their garden. Other examples of community gardening workshops include City of Vincent-run ones through the North Perth Community Garden and Kings Park.

Figure 18. A display garden is set up at each Great Gardens workshop to promote local native plants. (Photograph: Garry Heady, Heady Enterprises.)

Figure 19. The mayor of South Perth opening a Great Gardens workshop. Local governments host all Great Gardens workshops to maximise local ownership. (Photograph: Garry Heady, Heady Enterprises.)

Sustainable living programs in Western Australia

Examples of sustainable living programs in WA include: the Living Smart Program developed by The Meeting Place Community Centre, City of Fremantle, Murdoch University and Southern Metropolitan Regional Council (SMRC) the Creating Communities program ; and the Green Houses Program (energy and water conservation only) by SMRC and Murdoch University.

The Living Smart and Green Houses programs use proven goal-setting techniques and recognise that information alone is not enough to achieve sustained behaviour change. For example, as a result of attending the Living Smart pilot program:

- participants significantly increased their environmental knowledge and the number and frequency of sustainable behaviours
- 63% of participants said it was very important for them to reach their goal and the majority thought setting goals increased their motivation and made them more likely to act
- in all topics (including Simple Smart Lifestyles, Goal-Setting, Waste Smart, Smart Gardens, Power Smart, Water Smart, Health Smart, Move Smart and Take Action), participants increased their effort towards sustainable practices by 17-22%
- 68% said that the program changed the way they think about lifestyle and environmental issues.

Sustainable living programs provide additional benefits for communities. For example, as a result of attending the Living Smart pilot program, 91% of participants felt more a part of the community, 95% increased their knowledge of community resources and services and 82% increased their sense of wellbeing (Sheehy, 2004).

The Living Smart Program kept operating until 2011 when it became an independently incorporated, non-profit organisation. The program provides training courses in WA , South Australia and New South Wales. More information can be found on their website livingsmart.org.au/

Communication techniques include workshops, self-paced learning via booklets, ongoing dialogue (newsletters and meetings) and/or websites.

Chesapeake Bay residential watershed program (US)

The Chesapeake Bay Residential Watershed Water Quality Management Program was an intensive training program that involved recruitment of residents from selected neighbourhoods, lawn care seminars by trained extension agents, home visits and data collection by trained Master Gardener volunteers, and demonstration lawns. The program included pre- and post- participation surveys to assess changes in people's attitudes, knowledge and self-reported behaviour.

From 1990 to 2001, approximately 3,600 residents participated in the program in 18 counties and cities in Virginia, with an estimated area of lawn managed through the program in 2001 of 158 hectares.

Results reported by Virginia Cooperative Extension (2001) and Aveni (2002) included:

- soil testing by participants increased from 25% to almost 100% following participation in the program
- composting grass clippings increased from 22%–54% to 50%–71% following participation
- the proportion of people who knew how much fertiliser they applied to their lawn each year increased from 25% to 66% following participation
- the proportion of people fertilising their lawn during autumn (as promoted) increased from 55% to 77% following participation
- the proportion of people who aerated their lawns increased from 12%–50% to 75%–100% following participation
- estimates derived from self-reported behavioural change data indicated that the load of total nitrogen and total phosphorus applied to residential lawns was reduced by approximately 49–98 kg/ha/year as a result of participation in the program.

2.3.3 Encouraging participation by the community in stormwater management

Description

Stormwater-related community participation programs seek to:

- engage the community so they understand the problem, and can participate in the development and implementation of solutions
- treat community members as people who, given support and time, can quickly build knowledge and positively contribute to the formulation of new and sustainable approaches to stormwater management
- foster ownership of the stormwater-related problem by the local community.

This section recommends an increased focus on public participation in urban stormwater management (e.g. involving the community in deliberative decision-making processes), as opposed to traditional community education approaches (e.g. distribution of education materials).

Traditional community educational approaches may be considered 'top-down', i.e. consultative rather than participatory, delivered by experts from outside the site of intervention. Public participation is 'bottom-up', concerned with spreading control and ownership as widely as possible throughout the community and 'developing a partnered or shared analysis of both the problem and the solution' (Ryan and Brown, 2000).

Ryan and Brown (2000) promote public participation and consensus as 'the key vehicles for improving the management of urban stormwater through social action'.

Applicability

This technique is widely applicable to stormwater-related activities that seek to alter people's behaviour. Advocates of the participatory approach challenge the effectiveness of traditional 'top-down' education methods in changing people's behaviour, and urge people to consider moving towards a more participatory approach.

Figure 20. Clean Drains – River Gains drain stenciling at Blue Gum Lake, Booragoon. (Photograph: South East Regional Centre for Urban Landcare.)

The technique can be applied to common stormwater- related activities such as:

- the development of management plans
- education and participation programs (e.g. programs within a catchment to protect the health of a local waterway or wetland and anti-litter campaigns within a commercial district)
- specific activities such as stormwater drain stencilling and clean-up activities.

Recommended practices

The development of a stormwater management plan in a catchment or local government area could adopt a participatory approach. For example, awareness could be raised in the community then volunteers could be sought to participate in development of the plan. Participation techniques such as citizen juries can be used to:

- select a group of citizens that is representative of the community
- deliberate and agree on priority issues to be managed
- jointly develop sustainable solutions.

'Expert witnesses' can also be used to provide technical information and advice to community members as needed. Involvement of sections of the community should also be sought during implementation of the plan.

Resources for planning public participation in decision-making and designing behaviour change programs are provided in the Additional information section.

Benefits and effectiveness

Participation programs produce environmental benefits (e.g. waterway health) and social benefits (e.g. through building the capacity of individuals and groups).

Taylor and Wong (2002c) found that participation programs which promote widespread ownership of the stormwater pollution issue, and encourage community participation to develop and implement a solution, are more effective at changing behaviour than programs that rely on traditional forms of education. However, the success of a participatory approach depends on the capacity of the community to develop and implement the solutions. This is supported by other research, for example, 'a comprehensive review of the literature finds very little evidence of the success of traditional ('top-down') community education activities…' (Ryan and Brown, 2000).

In a literature review on *littering* behaviours and intervention strategies, Reeve *et al.* (2000) also stress the importance of a participatory approach, stating 'there is ample evidence from the literature that community participation in the design and management of public space, together with the coupling of local litter education with community involvement strategies, is still one of the best ways to obtain the sense of local ownership and relevance that enables social norms against littering to be effective' (p. 30).

Challenges

Taylor and Wong (2002c) report that genuine participation programs for stormwater management are still relatively rare in Australia, with the exception of stormwater drain stencilling. One of the likely reasons for this is that increased resources (especially time) are often required to shift the emphasis from traditional educational approaches to ones with extensive community involvement. Participatory programs require partnerships between agencies and community members/groups, which take time to build and require a significant investment of enthusiasm, time and trust.

In most cases, community participation requires capacity building, which involves a transfer (or flow between) of knowledge, skills and resources from agencies to the community. An agency should ensure the community is well informed of the issues if they become involved in the decision-making processes. This type of process is initially time consuming and resource intensive. Also, a change in representation from the community can result in a loss of knowledge (and leadership), often requiring a re-education of new community members.

Adopting a participatory approach to effect behavioural change represents a significant change of direction for many urban stormwater managers in Australia, who frequently rely on traditional education methods such as pamphlets, advertisements, fact sheets and newsletters. It also shifts the focus of control for urban stormwater management away from professional technical managers (e.g. engineers in a local government) towards the community. This shift in control may be unsettling for some individuals and organisational cultures.

Cost

The cost of adopting a participatory approach will vary depending upon the project and the degree of participation. Costs would however be expected to be greater than those associated with traditional forms of stormwater-related education.

Additional information

Chapter 8: Education and awareness for stormwater management provides additional case studies and guidance on how to design a community education and awareness program.

Recommended resources for community participation in decision-making include:

- Community-Based Social Marketing (Canada) via www.cbsm.com
- Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing (McKenzie- Mohr & Smith, 1999). Further information is available from Community-Based Social Marketing via www.cbsm.com
- The Facilitation Toolkit: A practical guide for working more effectively with people and groups (Keating, 2003) is a recommended resource to use when facilitating workshops, seminars or group meetings.

Refer to the Examples/Case studies provided in Section 2.3.2, as these intensive training programs use proven goal-setting techniques and recognise that information alone is not enough to achieve sustained behaviour change. Communication techniques include workshops, self-paced learning via booklets, on-going dialogue (newsletters and meetings) and/or websites.

For focused participation programs involving new estates, refer to Section 2.3.5.

Examples/Case studies

Bronte Catchment Project (NSW)

The Bronte Catchment Project in Waverley, Sydney, is a good example of how a 'bottom-up', participatory and deliberative approach to urban water management can produce enhanced results. This was a local stormwater management project involving community development activities, deliberative decision-making processes (e.g. a citizen jury and citizens' Telepoll) and a review of the local government's activities and processes. The project:

- used social research, community development and active learning techniques to profile community barriers to participation
- strengthened environmental education initiatives with participatory strategies
- tested new deliberative decision-making processes in environmental management
- built democratic and environmental capacity across the catchment
- demonstrated the critical importance of council and community commitment to participation in environmental management (Elton Consulting, undated).

The project involved three primary components:

- the development, implementation and evaluation of targeted stormwater education campaigns
- installation of gross pollutant control devices
- physical and observational monitoring of pollutants and behaviours within the catchments.

The project delivered positive changes in people's stormwater-related environmental attitudes and values, knowledge about urban stormwater pollution, and self-reported behaviour (Elton Consulting, undated).

The elected leaders of Waverley Council (e.g. the Mayor) and its officers have publicly spoken about the success of the project and have even created an ongoing consultative role for the citizens involved in the participatory process.

Clean Drains – River Gains (WA)

Clean Drains – River Gains is a campaign by the South East Regional Centre for Urban Landcare (SERCUL) to reduce nutrients and other contaminants in receiving water bodies. The campaign aims to raise awareness about the link between stormwater drains and natural waterways, as well as providing information on positive behavioural changes that will reduce stormwater pollution. The campaign delivers its message through activities such as stormwater drain stencilling with the Clean Drains – River Gains slogan, letterbox drops in residential, commercial and industrial areas, displays at community events, shopping centres and libraries, and through products including posters, postcards, pamphlets, a website, reusable shopping bags and stencils. Businesses, local governments and community groups are encouraged to hire the stencils for stormwater drain stencilling in their area.

For further information, contact the SERCUL.

2.3.4 Education and participation on campaigns for commercial and industrial premises

Description

Education and participation campaigns for commercial and industrial premises should be tailored for each target audience. Planning should include development of the procedures for surveying the target audience, designing (involving the target audience where possible) and delivering the campaign (incorporating site assessments and incentives/disincentives), and evaluation.

The campaigns may focus on pollutants, behaviours, and best practice techniques and technologies that are most important for the area within which the campaign is operating.

The Green Stamp Program is a good example of successful education and participation programs for commercial and industrial premises in WA. For further information about these programs, including the training and support available, refer to the Examples/Case studies section.

Industrial and commercial premises can pose significant risks to stormwater and shallow groundwater due to the activities they undertake and the types of materials being handled and stored on-site. Promoting sound management practices and technologies, and ensuring a high degree of compliance (either through education, incentives or regulation) should be a high priority in any urban stormwater management program.

Applicability

These campaigns or programs are applicable to all commercial and industrial areas, however they are particularly applicable in the following situations:

- areas with sandy soils that have low nutrient and moisture retention capabilities
- areas draining to sensitive water bodies (e.g. conservation category wetlands, or catchments that are under stress from nutrient inputs, such as the Peel-Harvey and Swan-Canning)

- drinking water catchments
- areas where premises are close to water bodies
- areas that are not sewered (e.g. parts of the Canning catchment). This may elevate the risks of adverse impacts from illegal discharges of wastes to stormwater or shallow groundwater.

Recommended practices

Use proven behaviour change techniques, such as commitments/goal setting, prompts (to address forgetting), develop social norms and consider incentives. Refer to the Additional information section for a list of recommended behaviour change resources.

Targeted education and participation programs should be applied on a priority basis. An investigation should be undertaken to determine those premises that pose the greatest risk to the health of water bodies. For example, this has been undertaken for industrial premises on the Swan Coastal Plain (see Water and Rivers Commission, 2000b).

Campaigns should specifically tailor messages to a particular target audience (i.e. based on the type of business or industry sector). To maximise the impact of the campaign, consider complementary use of site assessments, incentives (e.g. positive recognition, assistance) and disincentives (e.g. penalties).

The design of the campaign should draw upon knowledge gained from executing similar campaigns (e.g. those involving similar target audiences, promoting similar forms of behaviour, and involving similar timeframes and budgets). Similar case studies should be carefully studied at the beginning of a new project. Leading stormwater managers in other Australian States and research institutions should be briefly consulted to identify the existence of similar case studies.

It is important to understand the knowledge and attitudes of the target audience, as well as the context in which they conduct their work. Typically, social scientists will survey the target audience to answer these questions prior to the campaign being designed. This survey can also act as a baseline monitoring event, to help evaluate the overall effectiveness of the campaign.

Such surveys can identify critical pieces of information, such as the need to develop education materials in several languages, the need to address specific knowledge gaps or attitudes, and the need to deliver educational messages in a form that is compatible with the work environment of the target audience.

Ideally, such campaigns will take a ‘participatory approach’ and seek to involve the target audience in the design and delivery of the campaign. Campaigns that are able to enhance the participatory element of the program are generally more successful than those that rely upon traditional forms of education.

Educational materials designed for commercial and industrial premises may include posters, flyers, checklists, brochures, fact sheets, guidelines, magnets, calendars, caps, T-shirts, drain stencils, procedures, training materials (e.g. videos), signs, etc.

Figure 21. Industrial site drain stencil. (Photograph: Colin Ceresa, ARRIX.)

Educational events may also be used, such as training sessions, trade displays and field days (to highlight BMPs and technologies), and free lunches or barbecues (where educational messages are communicated).

Incentives to change behaviour could include promotional give-aways (e.g. spill clean-up kits, signs, T-shirts), free educational events (as described above), recognition in the local media, awards schemes with associated publicity, cash grants, assistance from environmental specialists (e.g. to conduct site assessments and recommend solutions to identified problems), listing in a 'green business directory', licence fee reductions and free waste disposal.

Due to the specific needs of commercial and industrial businesses, education campaigns will often include a site assessment. Free site assessments are undertaken by suitably qualified specialists to highlight to the business owner where improvements may or should be made. Typically, an amnesty from prosecution under environmental law is provided to participating businesses for a given period (e.g. three months).

Working through the relevant industry associations is highly recommended. For example, this approach has been successful for the Green Stamp Program, where the relevant industry associations are directly involved in designing the program and promoting active involvement by members.

Refer to the Examples/Case studies Section. These examples highlight the different approaches that may be taken.

Benefits and effectiveness

Businesses that are more aware of environmental issues as a result of an educational campaign may be willing to partner with local governments, catchment groups and water service providers, and sponsor waterway health-related programs and activities that reach a wider audience in the community (e.g. broad awareness campaigns, clean-up events, waterway rehabilitation projects). Businesses may receive positive publicity in return for the donation of money, materials, personnel or use of their facilities (US EPA, 2001).

Taylor and Wong (2002c) reviewed a number of education and behaviour change programs for industrial and commercial premises (e.g. campaigns involving media, site assessments and one-to-one discussions) and concluded that they can deliver:

- 5%–15% increase in environmental knowledge/awareness
- 58% increase in the number of people undertaking at least one desirable behaviour (e.g. storage of materials, waste disposal practices, staff training and/or environmental management systems)

- 26%–40% increase in the number of people undertaking a specific desirable behaviour (e.g. 40% of respondents reported changes to the storage of materials, 34% of respondents reported changes to waste disposal practices, 29% of respondents reported changes to environmental management systems and 26% of respondents reported changes to staff training).

Challenges

If the proposed education campaign is purely voluntary and promotes behavioural change that is difficult or costly to implement, its effectiveness may be limited. The campaign should try to create an environment where environmental compliance is promoted through incentive mechanisms and then regulatory enforcement approaches if necessary. For example, an anti-litter education campaign focusing on the waste behaviours of traders in a small commercial shopping centre may discover during its pre- campaign survey of traders that the public litter bin infrastructure is inadequate, as are the waste receptacles the traders use to store their solid waste. Fixing these infrastructure problems as a part of the campaign may be necessary to facilitate behavioural change in the centre (in addition to the promotion of desired waste management behaviours).

The willingness of businesses to participate is important to the success of the campaign, so planning should include consideration of the resources and interests of participants. Where a campaign is followed up by a regulatory approach, ensure businesses have enough time to implement new initiatives.

These types of campaigns are typically government funded. Acquiring the funds to run the campaign may be a significant challenge.

Cost

The cost associated with developing an educational campaign for commercial or industrial premises depends greatly upon the type and quantities of materials produced, the human resource demands and the scope of the campaign. Where campaigns include surveys of the target audience, site assessments of premises, and one-to-one discussions with business owners, the time demands on staff running the campaign can be considerable.

Some indicative costs are given for the New South Wales and South Australian case studies, below.

Additional information

Refer to Section 2.2.10 for recommended BMPs related to commercial and industrial premises. Section 2.2.8 is relevant for maintenance of vehicles, plant and equipment (including washing).

Chapter 8: Education and awareness for stormwater management provides guidance on how to design an education and awareness program, including programs for commercial and industrial premises.

The following behaviour change resources are recommended when designing the program:

- Community-Based Social Marketing (Canada) via www.cbsm.com
- *Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing* (McKenzie- Mohr & Smith, 1999). Further information is available from Community-Based Social Marketing via www.cbsm.com
- The *Facilitation Toolkit: A practical guide for working more effectively with people and groups* (Keating, 2003) is a recommended resource to use when facilitating workshops, seminars or group meetings.

Refer to relevant Water Quality Protection Notes, available from the Department of Water and Environmental Regulation via www.water.wa.gov.au/__data/assets/pdf_file/0009/5958/WQPNs-available-by-name-web-version-12.5.15.pdf or by telephoning (08) 6364 7000.

For example:

- WQPN 28, Mechanical Servicing and Workshops (DOW, 2013)
- WQPN 29, Mobile Mechanical and Cleaning Services (DOW, 2013)
- WQPN 68, Mechanical Equipment Washdown (DOW, 2013)
- WQPN 93, Light industry near sensitive waters (DOW, 2009)
- WQPN 52, Stormwater management at industrial sites (DOW, 2010)
- WQPN 10, Contaminant Spills – Emergency Response Plan (DWER, 2020)
- WQPN 52, Stormwater Management at Industrial Sites (DOW, 2010)
- WQPN 65, Toxic and Hazardous Substances (DOW, 2015).

Section 2.3.3 is designed for the general community, rather than industrial and commercial premises. However, this section has useful information about the benefits of participation programs versus traditional education programs.

Examples/Case studies

The Green Stamp Programs, Western Australia

Green Stamp is an industry-specific environmental accreditation and education program that assists small to medium businesses to implement environmental BMPs. The program provides environmental assessments, training and support, including simple environmental management plans and industry-specific case studies and environmental guidelines. Green Stamp Programs are currently available through the following industry associations:

- Motor Trade Association (MTA) of Western Australia. Resources include the Environmental Products and Services Directory and guidelines such as Asbestos Use and Disposal, Building New Premises, Bunds and Bunding, Cleaning up Spills, Cleaning Vehicles, Coolant Management, Degreasers and Detergents, Environmental Policy, Mobile Mechanics, New Environmental Laws, Oil Separators, Parts Washers, Preventing Oil Pollution, Purchasing Spill Kits, Solvent Thinner Recycling Systems, Wastewater Management for Body Repairers, Environmental Assessments for Body Repairers and Environmental Assessments for Mechanical Repairers. Further information is available by telephoning the Automotive Industry Green Stamp Officer on (08) 9233 9800 or via www.mtawa.com.au/oshgreenstamp-audits/green-stamp/. Their office is at MTA House, 253 Balcatta Road, Balcatta WA 6914. Further information about the MTA of WA's Green Stamp Program is available in Chapter 8: Education and awareness for stormwater management
- The Print & Visual Communication Association. Resources include Managing and Monitoring Environmental Impacts – A Simple Environmental Management Plan for Printing Businesses, Accreditation Criteria for Printing Businesses, Baseline Audit for Printing Businesses and information sheets on Chemical and Ink Management, Environmental Law, Protecting Stormwater Drains, Solid Waste Management and Wastewater Management. Further information is available via www.pvca.org.au/job-dashboard/
- Building Service Contractors Association (formerly the Master Cleaners Guild). Further information is available via bscaa.com/wa/

The Green Stamp Program was originally developed by the former Department of Environment and the MTA of WA to encourage automotive businesses to comply with environmental laws and to reward those going beyond their legislative requirements.

Drains – River Gains, WA

Clean Drains – River Gains is a campaign by the South East Regional Centre for Urban Landcare (SERCUL) to reduce nutrients and other contaminants in receiving water bodies. For more information, see Section 2.3.3.

Manly, New South Wales – 'The Great Estate' Stormwater Environmental Education Program

Taylor and Wong (2002c) reported preliminary results from Smith (2002a and 2002b) involving a study of the small (11.2 ha) Balgowlah industrial estate in Manly, Sydney. The study included an evaluation of the effectiveness of industry education and auditing as non-structural BMPs to promote improved housekeeping practices and reduce stormwater pollution.

The Great Estate Stormwater Environmental Education Program involved face-to-face discussions with operators of premises within the industrial estate, audits and promotion of improved housekeeping practices such as material handling and stockpiling. An Education Officer was appointed for 12 months to undertake this work from March 2001 to March 2002.

Substantial opportunities were taken by the occupants of the estate to improve the management of material storage. For example, in one of the estate's three sub-catchments, 1,260 m2 (or 21% of the total area) used for stockpiling was converted from an uncovered area to a roofed area.

Reductions in annual pollutant loads that could potentially be attributed to education, auditing and better industrial housekeeping were approximately 8% (TSS), 40% (total nitrogen), 49% (total phosphorus), 42% (copper), 72% (lead) and 83% (zinc).

Other

Chapter 8: Education and awareness for stormwater management provides guidance on how to design an education and awareness program, including case studies that may be relevant to commercial and industrial premises. Other case studies can be identified through publications such as Taylor and Wong (2002c), Lehner et al. (1999) and US EPA (2001).

2.3.5 Focused stormwater education involving new estates

Description

This BMP involves engagement of a temporary Stormwater Management/Environmental Officer for a large residential estate land development. The officer may be employed on a part or full-time basis (depending on the size of the estate) and may play a role in:

- ensuring stormwater quality during construction/building (e.g. helping to maintain the integrity of structural controls such as infiltration systems, educating builders and subcontractors while they are on-site, monitoring erosion and sediment controls, and monitoring construction practices)
- promoting water sensitive gardening practices, as new landowners begin to landscape their properties
- educating new landowners about sustainable practices for washing cars, car maintenance (e.g. changing oil), composting, disposing of animal wastes, disposal of swimming pool discharges, bin washing, and how to keep materials such as lawn clippings and sediment out of the stormwater management system
- undertaking manual litter collections in areas such as parks (as psychological studies indicate that if you keep a public place clean it promotes reduced rates of littering)
- promoting positive stormwater initiatives that occur on the estate via local media (i.e. provide positive feedback to reinforce desired forms of behaviour)

- educating mobile businesses about stormwater management when they are on-site (e.g. dog washing franchises, external house and roof cleaners and car servicing businesses)
- explaining to new landowners about the purpose of, and how to look after, permanent WSUD features in the estate (e.g. not driving on grassed swales).

Applicability

This practice is suitable for large residential estates/land developments, particularly in the following situations:

- areas with sandy soils that have low nutrient and moisture retention capabilities;
- areas draining to sensitive water bodies (e.g. conservation category wetlands, or catchments that are under stress from nutrient inputs, such as the Peel-Harvey and Swan-Canning)
- drinking water catchments
- areas where gardens are close to water bodies
- areas subject to erosion (e.g. due to steep slopes)
- areas with large gardens and lawns.

The role could be valuable in protecting infiltration systems during construction and educating residents on water sensitive management practices at the building stage, when there is the greatest potential to adopt measures such as waterwise and fertilise wise gardening, and the reuse of shallow groundwater or roof water.

Recommended practices

Use proven *behaviour change* techniques, such as commitments/goal setting, prompts (to address forgetting), develop social norms and consider incentives. Refer to the Additional information section for a list of recommended behaviour change resources.

This role could be undertaken by a local environmental group (e.g. staff from the group may be funded by the developer and/or local government), which would help to build expertise and skills in the region. Developer funding may be applicable if the Stormwater Management/Environmental Officer is exclusively engaged for a particular development. However, funding or employment by local government or a catchment management authority may be advantageous, so that the officer could be engaged over a much larger area.

The role would start immediately prior to construction and continue for at least six months after the development has effectively finished (i.e. the vast majority of potential residents are living in the estate).

A specific 'role description' should be developed for the position by the developer and local government as part of a site-based stormwater management plan. The role description would be specifically worded so that an enforcement officer could easily check that each element of the role had been delivered.

To engage the community, it may be advantageous for the officer to address a range of *sustainable living* issues, e.g. stormwater management, water conservation, water sensitive gardening, waste minimisation and energy efficiency. Examples of sustainable living programs are provided in the Examples/Case studies section.

Benefits and effectiveness

The officer may provide valuable marketing benefits to the developer and help to build human and social capital by:

- welcoming new residents to the estate
- fostering a positive sense of community (e.g. psychological studies show that if you can foster a positive sense of community it promotes reduced rates of littering)
- running basic education and participation events (e.g. stormwater-related training courses like the DBCA's River Guardians gardening workshop program in WA and the Master Gardener Program in the United States), activities for children, clean-up events and drain stencilling)
- helping to establish an *ongoing* environmental group for the catchment area (i.e. to keep the momentum going after the officer's tenure expires).

In terms of potential pollutant removal efficiencies, the effectiveness of this BMP is currently unknown. A conservative estimate of the post-construction 'pollutant removal efficiency' is approximately 20% for typical stormwater pollutants in a residential development[13].

Challenges

This BMP is difficult to evaluate and success is largely dependent on the skills and commitment of the Stormwater Management/Environmental Officer.

The program would operate for a limited period only. After this time, continuing education should be undertaken via local or State government initiatives.

Cost

The cost should be determined on a case-by-case basis. However, it is relatively easy to estimate. Principal costs include the officer's time, transport, and consumables (e.g. educational products, advertisements).

When the many potential benefits are compared to costs on a 'life cycle cost basis' and compared to structural alternatives, this BMP represents an attractive option particularly for large greenfield estates.

Additional information

Enforcement would need to occur to ensure the BMP was *fully* implemented. This could occur via the development's approval conditions and through regular site inspections by local government officers.

Refer to Section 2.1.1 for further information about BMPs on construction sites. Refer to Section 2.2.7 for further information about BMPs for gardens.

Section 2.3.2 addresses intensive training of landowners on aspects of stormwater management and Section 2.3.3 has information about encouraging participation by the community in stormwater management. Refer to Section 2.3.4 for useful information about the benefits of community participation programs versus traditional education programs.

The Examples/Case studies part of Section 2.3.3 has information about the SERCUL's Clean Drains–River Gains campaign to reduce nutrients and other contaminants in receiving water bodies. For further advice, contact the South East Regional Centre for Urban Landcare (SERCUL).

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[13] That is, the BMP can be expected to reduce the event mean concentration of typical pollutants in stormwater by approximately 20% during the post-construction stage of the development.

Chapter 8: *Education and awareness for stormwater management* provides guidance on how to design an education and awareness program.

The following *behaviour change* resources are recommended when designing the program:

- Community Change (Victoria, Australia) via www.communitychange.com.au
- Community-Based Social Marketing (Canada) via www.cbsm.com
- Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing (McKenzie- Mohr & Smith, 1999). Further information is available from Community-Based Social Marketing via www.cbsm.com
- The Facilitation Toolkit: A practical guide for working more effectively with people and groups (Keating, 2003) is a recommended resource to use when facilitating workshops, seminars or group meetings.

Examples/Case studies

No detailed case studies are available for residential estates. However, the initiative has been applied in the US. A similar initiative has been successfully applied in an industrial estate in Manly, NSW (Taylor and Wong, 2002c). Refer to the Examples/Case studies part of Section 2.3.4

These programs use proven goal-setting techniques and recognise that information alone is not enough to achieve sustained behaviour change. For example, as a result of attending the Living Smart pilot program:

- participants significantly increased their environmental knowledge and the number and frequency of sustainable behaviours
- 63% of participants said it was very important for them to reach their goal and the majority thought setting goals increased their motivation and made them more likely to act
- in all topics, participants increased their effort towards sustainable practices by 17-22%
- 68% said that the program changed the way they think about lifestyle and environmental issues.

Sustainable living programs provide additional benefits for communities. For example, as a result of attending the Living Smart pilot program, 91% of participants felt more a part of the community, 95% increased their knowledge of community resources and services and 82% increased their sense of wellbeing (Sheehy, 2004).

Communication techniques include workshops, self-paced learning via booklets, ongoing dialogue (newsletters and meetings) and/or websites.

2.4 Funding, policy, regulatory and enforcement practices

2.4.1 Funding programs for stormwater management

Description

Effective stormwater management requires substantial resources. In Australia, resources are typically obtained from:

- short-term grants
- consolidated revenue or general rates (e.g. a local government may fund stormwater management initiatives through its general rate base)
- environmental levies (e.g. a local government may charge a separate levy as part of its rates, to fund specific environmental initiatives)

- stormwater-related fees (e.g. a local government or regional stormwater authority may charge properties a fee to use downstream stormwater drainage infrastructure).

There is compelling evidence from case studies, particularly from North America, that establishing a dedicated and stable source of funding for stormwater management ensures long-term viability of programs and public support. For example, Lehner et al. (1999) surveyed 100 stormwater case studies in the US and concluded that there were six 'foundations of success' in relation to stormwater management projects:

1. Focusing on pollution prevention (e.g. using non-structural and structural source controls)
2. Preserving and utilising natural features and processes (e.g. using vegetated buffers, 'cluster development' principles)
3. Providing strong incentives, routine monitoring and consistent enforcement to establish accountability
4. Establishing a dedicated source of funding to ensure long-term viability of programs and public support
5. Providing strong leadership to provide a catalyst for success
6. Providing effective administration.

In areas of Australia where major stormwater-related grants programs have been in existence for several years and then removed, local government authorities are increasingly establishing their own dedicated funding mechanisms. These often take the form of an environmental levy or a property-based stormwater fee (known as a 'stormwater utility' in the US).

The US Centre for Watershed Protection (2000) describes a 'stormwater utility' as a method of stormwater financing, where property owners are charged a modest fee for using the stormwater drainage network. The revenue gained from these fees is used to finance capital and operating expenses that are needed for local stormwater quality and quantity management.

The US Centre for Watershed Protection (2000) also reported that the American Public Works Association considers stormwater utilities as the 'most dependable and equitable approach available to local government to finance stormwater management'. Such funding arrangements were rare in the early 1990s, but are now an important revenue raising mechanism in several hundred cities and counties across the US.

Applicability

A stable and dedicated funding mechanism for urban stormwater management is needed in all urban areas, particularly those experiencing rising stormwater costs and community expectations.

Exploration of funding options should occur early in the development of a region's stormwater management program (e.g. as a critical management action in the region's stormwater management plan). As mentioned below, awareness of stormwater-related issues within the community would need to be significantly raised before a funding mechanism can be established. In this context, 'community' includes all key stakeholders (e.g. elected officials, environmental groups, ratepayer associations, etc.).

Recommended practices

One method of creating secure and stable funding for stormwater management is through the establishment of an environmental levy or a property-based stormwater fee (known as a 'stormwater utility' in the US). The US Centre for Watershed Protection (2000) provides the following five-step plan for successfully creating a 'stormwater utility'.

✔ Accurately estimate revenue requirements.

- ✔ Determine an administrative structure for stormwater management (e.g. determine the scope of activities needed to manage stormwater and identify the administrative units best suited to perform each task).
- ✔ Devise a fee structure and a billing system. For example, a fee schedule may be structured according to the amount of directly connected impervious area on the property.
- ✔ Implement a public information program. Public involvement during and after the establishment of the stormwater utility is believed to be essential for its successful implementation. Through participation processes, the community could also be involved in designing the stormwater utility.
- ✔ Adopt stormwater utility ordinances. This step ensures that the utility has a statutory basis, if challenged.

Benefits and effectiveness

Funding is obviously essential for sound urban stormwater management. However, the type of funding arrangement is also important.

For example, there is persuasive anecdotal evidence around Australia that short-term funding programs have led to poor outcomes in some cases. This evidence includes gross pollutant traps that were hastily built with grant funds, but never maintained due to a lack of ongoing funding. In this situation, gross pollutant traps may exacerbate the pollution problem, by converting nutrients in an organic form to a bioavailable form in the anoxic environment of an unmaintained trap.

A good example of a funding system is the use of economic incentives that can operate under a property-based stormwater fee/utility. For example, such a funding mechanism can be structured so that properties with a large amount of directly connected impervious area (e.g. a traditional carpark) pay a relatively high fee, while properties with a small amount of directly connected impervious area (e.g. a carpark with bioretention systems) pay a relatively low fee. Such an arrangement provides a strong, ongoing economic incentive for WSUD for both developing areas and existing areas. It is also consistent with the 'polluter pays' and 'user pays' principles. This approach may be particularly attractive in developed areas where stormwater quality and quantity needs to be managed but there is little room downstream for stormwater detention and treatment structures.

Challenges

A potential challenge to establishing stable, dedicated funding arrangements is resistance from existing ratepayers. However, such resistance is often minimal where the need for stormwater funding is clearly communicated to the local community, mechanisms are established to ensure stormwater-related fees/levies are used for stormwater-related projects only, and the community is involved in the design of the funding mechanism (e.g. through citizen juries or focus groups).

Another potential challenge is the amount of work required to establish the funding mechanism, particularly where a property-based stormwater fee is structured in relation to each property's directly connected impervious area.

Another potential challenge is where jurisdiction for stormwater management is controversial or complex. In such circumstances, an organisation like a local government authority may be reluctant to invest resources in establishing a new stormwater funding mechanism. Also, the legal validity of the mechanism may be uncertain. Responsibilities (e.g. of State government agencies and local government authorities) must be clearly established before new funding mechanisms can be introduced.

Additional information

The US Centre for Watershed Protection (2000) stressed the importance of involving the public before and after the implementation of a stormwater-related funding mechanism. They concluded that the experience of communities that have successfully implemented stormwater utilities underscores the importance of public education and involvement. It should initially be assumed that the general public is unaware of the impact of stormwater runoff, or the role it plays in maintaining watershed quality. However, it assumes that once educated, the public will be discriminating in the services and programs they expect to be delivered from a new stormwater utility (p. 408).

Examples/Case studies

Black and Veatch (1996) conducted a survey of 97 stormwater management agencies across 20 states in North America that had implemented a property-based stormwater management fee to address stormwater quality and quantity (i.e. a 'stormwater utility'). Some of the trends they observed are provided below as an indicator of typical experiences:

- 61% of respondents felt public information/education was essential to the success of the funding mechanism and only 1% considered it unnecessary
- 55% of respondents used the percentage of impervious cover as the basis for the fee
- 74% of respondents billed on a monthly basis
- 57% of respondents provided some form of credit if on-site detention/retention practices exist
- 81% of respondents reported that the stormwater utility helps to fund capital as well as operating and maintenance costs
- 82% of respondents reported that the stormwater utility revenue meets 'most needs' or at least 'most urgent needs'
- 11% of respondents reported that the stormwater utility revenues were adequate for 'all stormwater needs'.

2.4.2 Point source regulation of stormwater discharges and enforcement activities

Description

Point source regulation

Regulation of specific commercial and industrial premises (e.g. automotive industries, nurseries, landfills, waste recycling facilities, etc.) is a widely used technique to minimise stormwater and groundwater pollution. Such premises are typically licensed by a government agency, with their activities controlled through legally enforceable licence conditions that are regularly checked by enforcement officers who audit the premises. These officers also provide guidance, training and, if necessary, perform an enforcement role.

Control of point sources of stormwater pollution is generally easier than controlling diffuse sources (e.g. runoff from roads and rural land uses), and more rewarding on a cost-benefit basis. A well-managed point source regulation program should be a priority of agencies that are responsible for managing stormwater and groundwater quality.

Enforcement activities

Enforcement is another cost-effective regulatory tool for the management of stormwater and groundwater quality. This BMP uses enforcement of state legislation or local laws to modify behaviour that has the potential to pollute stormwater or groundwater. Legislation is often passed and enforced to address specific forms of pollution (e.g. cigarette butts) or control high risk activities (e.g. specific industrial facilities). Consequences of enforcement activities to a polluter can include the payment of a fine, the payment of clean-up costs, being unable to legally operate a business, and, in extreme cases, imprisonment. Enforcement is primarily an economic disincentive that is designed to influence people's behaviour.

Applicability

Point source regulation

Point source regulation is a BMP that is highly applicable to all urban areas in WA where:

- the basic regulatory framework is provided under the *Environmental Protection Act 1986*. However, licensing/registration under the *Environmental Protection Act* is for large industry/prescribed premises only. Currently there are no provisions under local law to register or license small to medium-sized enterprises
- there is a clear need for improved environmental management of small to medium-sized commercial and industrial premises (SRT, 1999). For example, the Swan-Canning Industry Survey Report (WRC, 2000) undertook a survey and risk assessment of light industrial premises in the Swan-Canning region in 1997 and 1998. It involved more than 550 premises. These were effectively unregulated premises, as about 95% of the 2,000 – 2,500 industrial premises in Perth are not regulated by a licensing/registration instrument that aims to implement environmental controls. Accordingly, they are not routinely inspected by government regulators, nor are they subject to specific licence conditions with respect to environmental management. The overall conclusion of the Swan-Canning Industry Survey Report was 'because of the large number of premises and generally poor environmental management practices, light industry also presents a significant pollution risk. This arises from the cumulative impact of small discharges and the potential for accidents to cause serious pollution'.

The Swan-Canning Industry Survey Report (WRC, 2000) gives an indication of which small to medium-sized industrial premises pose a risk to the health of the Swan-Canning system. The survey identified the following proportion of premises as being of 'medium risk' to the Swan-Canning: 29% of audited pool suppliers, 30% of automotive industries, 36% of vehicle depots, 19% of engineering/manufacturing type industries and 17% of recyclers. The equivalent figures for 'high risk' were: 14% of audited vehicle depots, 3% of automotive industries, and 1% of chemical/pesticide premises.

In 2014, the WA Auditor General stated that without direct control over catchment land uses and discharges, drainage managers have a difficult task to treat the symptoms of poor water quality. Collaboration between state and local governments remains essential to manage water quality within the urban drainage system. Some local governments in WA have expressed an interest in using delegated powers under the Environmental Protection Act 1986 to regulate small to medium-sized industry in their region (i.e. undertake training, audits and enforcement activities) in response to rising expectations from their ratepayers that these premises should improve their environmental performance. Regulations under this Act (gazetted on 12 March 2004) provide local authorities with the regulatory tools they need to fully undertake a point source regulation program that targets small to medium-sized industry. In addition, discussions are occurring between local and State government authorities to determine the best way to fund such programs.

The Healthy Rivers Action Plan was prepared by the former Swan River Trust (now Department of Biodiversity, Conservation and Attractions) to improve water quality in the Swan and Canning rivers. Building on the achievements and outcomes of the Swan-Canning Cleanup Program Action Plan (1999), it represents a significantly new approach for government, industry and the community to work together for the long-term benefits of the Swan-Canning River system.

Enforcement activities

Enforcement of relevant legislation is also an option that is widely applicable to WA. However, enforcement programs typically follow major educational initiatives. For example, an 'on-the-spot fine' enforcement program that targets littering in the central business district of Perth would normally follow an intensive education exercise, and an evaluation process that demonstrates levels of people's awareness are high but significant behavioural change has not occurred.

Areas of stormwater and groundwater quality management where enforcement has the most potential include:

- littering
- illegal dumping of wastes in locations where water bodies may be affected
- stormwater management on building sites
- car washing on the street
- feeding of birds in water bodies where eutrophication is a problem
- liquid and solid waste discharges from vessels
- discharges to stormwater or groundwater from commercial and industrial premises.

For enforcement strategies to work in this context, the regulatory instruments must be simple to use (e.g. on-the-spot fines, where court proceedings only occur if fines are challenged by the recipients) and the magnitude of the fines must be suitable deterrents.

The Unauthorised Discharge Regulations 2004 have been enacted under the Environmental Protection Act 1986 in WA. These regulations include an on-the-spot infringement notice system for minor pollution offences. These powers can be delegated to local government officers. The new on-the-spot fines carry a penalty of $250 to $500, which increases to up to $5,000 for individuals and $25,000 for companies if the matter proceeds to court. The fines apply to commercial activities including land development and construction premises and cover the discharge of Schedule 1 substances to stormwater or groundwater. These substances include acid with a pH less than 4, alkali with a pH more than 10, hydrocarbons, solvents, degreasers, detergents, dust, engine coolant, pesticides, paint, dyes, sediment and substances containing heavy metals.

Recommended practices

Point source regulation

In some jurisdictions, several tiers of licensing are used (e.g. 'licences' for high risk premises and 'permits' for low risk premises). The tiers are distinguished by the cost of annual licence/permit fees, the frequency of inspections/audits, and the tailoring of licence/permit conditions. In addition, financial incentives are often provided for premises that exceed the minimum stormwater management requirements as set out in the licence/permit (e.g. a 'green licensing system' that allows businesses with excellent environmental performance to pay a reduced annual licence fee and gain positive publicity).

Determining which premises should be regulated via a licence/permit should involve a risk assessment that considers current environmental management practices of various premises types, potential risks to stormwater and groundwater quality, and potential risks to the health of water bodies.

Ideally, costs of running a best practice point source regulation program should be recovered on a 'polluter pays basis'. That is, the program should be cost neutral to the regulator, with all revenue being raised through licence/permit application fees, annual licence/permit fees and prosecutions for breaches of environmental regulations.

Enforcement activities

Common examples of laws to prevent or minimise specific forms of stormwater pollution include those that:

• encourage builders to minimise the discharge of sediment, litter and wash-waters from building sites

• discourage illegal dumping of wastes (e.g. waste oil, domestic solid waste)

• encourage pet owners in public areas to correctly dispose of their pets' waste

• discourage the illegal connection of sewage and other wastewaters to the stormwater drainage network

• discourage littering in public places

• discourage the discharge of commercial or industrial wastes to stormwater (or groundwater).

Figure 22. Former Department of Environment, Pollution Response Unit testing of an industrial site.(Photograph: former Department of Environment.)

Some less common examples reported by Taylor and Wong (2002c) include laws that aim to:

• Encourage xeriscaping. For example, the City of Albuquerque in New Mexico, US, has a Water Conservation Ordinance that requires xeriscaping on new developments and works in partnership with a rebate system to encourage the conversion of existing turfed areas to resource sensitive alternatives (Lehner et al., 1999).

• Discourage the feeding of birds in and around water bodies. For example, the Hopatcong Borough in New Jersey prohibits the feeding of geese in and around their lake systems as a measure to improve water quality (Lehner et al., 1999).

Enforcement of environmental management standards on premises that are regulated by a licensing instrument typically occurs via state legislation (e.g. the *Environmental Protection Act 1986)*, although the power to enforce this legislation may be delegated to trained and authorised local government officers.

Benefits and effectiveness

Point source regulation

The primary benefits of running a point source regulatory program are:

- the ability to prevent or minimise pollution at the source
- the ability to run the program on a polluter pays basis (i.e. at no cost to the wider community)
- the ability to provide economic incentives for those premises whose performance exceeds minimum regulatory standards
- the ability to easily identify and remove major sources of pollution (e.g. wastewater from industrial plants being illegally discharged to stormwater or groundwater)

- the opportunity to build a constructive partnership between the regulator and the operators through regular education, auditing, the development of site-specific licence conditions, and performance reporting
- the requirements set out in licence/permit conditions are not voluntary (i.e. a breach of conditions may be followed by enforcement)
- new environmental management technology, new knowledge about risks to the receiving environment and new management/political priorities can be incorporated in the program (e.g. newly identified risks can be addressed via modified audit checklists, amended licence/permit conditions, updated industry guidelines, new training materials, etc.).

While the licensing of industrial and commercial premises is a common form of environmental management in urban areas, Taylor and Wong (2000c) report that few agencies have evaluated and reported the effectiveness of the approach for stormwater quality improvement (e.g. reductions in pollutant loads due to regulation).

Some case studies give an indication of the potential of the BMP. The Clean Bay Business Program in Palo Alto, California, is a good example of a program where impressive outcomes were achieved in terms of behavioural change (see the Examples/Case studies section below for details).

In a literature review involving non-structural measures for stormwater quality improvement, Taylor and Wong (2002c) concluded that a best practice, small industry licensing program that includes regular inspections, education, incentives and disincentives should be able to deliver levels of compliance with stormwater-related requirements of approximately 90%–95%. They also concluded that such licensing programs could be some of the most effective non-structural BMPs for improving stormwater quality and the health of water bodies.

Enforcement activities

The primary benefits associated with using enforcement measures to influence behaviour include that it:

- sends a strong message that government is serious about minimising stormwater and groundwater pollution
- can be a powerful educational instrument
- uses an economic driver to promote behavioural change
- implements the ‘polluter pays’ principle
- is flexible, in that enforcement strategies can be quickly adjusted to respond to new issues and priorities.

The potential effectiveness of enforcement campaigns is perhaps best demonstrated by studies involving erosion and sediment control programs. There is strong evidence to suggest a well-designed, strict and sustained enforcement program that complements an educational campaign is essential in order to substantially increase the performance of erosion and sediment control on construction sites (Taylor and Wong, 2002c). For example: Lehner et al. (1999) concluded from a review of 100 stormwater-related case studies in the US that ‘communities reiterate the need to develop the financial resources and authority necessary to enforce standards and maintenance of stormwater controls before a problem or violation occurs’ (p. 5-7) and ‘programs with high accountability [e.g. enforcement elements] often reduce pollutant loadings by 50% or greater’ (p. 1-2).

- Lehner *et al.* (1999) also concluded in relation to erosion and sediment control programs that ‘whatever the education program however, they have not proven successful without the accompanying teeth of enforcement’ (p. 5-13).

- Findings from case studies reported in Taylor and Wong (2002c) indicate that citywide erosion and sediment control programs with strong and *sustained* educational and enforcement elements may represent the best performing non-structural BMP for the control of stormwater pollution from industry. Lehner *et al.* (1999) also concluded 'from the [100 US] case studies, it appears that, even more than with respect to other industries, education and enforcement can achieve measurable stormwater pollution reduction' (p. 5-13).

Achieving and maintaining high levels of compliance with erosion and sediment control requirements on a citywide basis is difficult. Based on Australian and overseas data, Taylor and Wong (2002c) estimate that best practice erosion and sediment control programs should be able to achieve a 20%–30% increase in compliance levels in the first few years (based on a typical baseline compliance level of 20%–30%), and achieve a 60%–70% increase from baseline levels over a decade. In addition, compliant sites can be expected to reduce the average load of total suspended solids (TSS) in stormwater during the construction phase by approximately 60% on average.

Consequently, the overall TSS pollutant removal efficiency of citywide erosion and sediment control programs that include strong town planning, enforcement and educational elements is approximately 12%-14% in the short-term (e.g. one to three years) and 36%–42% over a decade. These percentages represent an approximate reduction in the average load of TSS in stormwater leaving construction/building sites over the life span of the construction phase (see Taylor and Wong, 2002c for more details).

Erosion and sediment control case study information summarised in Taylor and Wong (2002c) highlights the need for sustained levels of enforcement (as compliance levels can quickly drop after a short-term enforcement campaign has finished) and programs that seek improvement over the long-term (e.g. a decade). An important consequence of this finding is that program managers in Australia should ensure that erosion and sediment control programs are self-funding or have a secure funding base.

Challenges

The primary challenge associated with using point source regulation is the difficulty that may be encountered when first establishing the regulatory framework (i.e. the necessary delegations under the Environmental Protection Act 1986 and practical regulatory tools such as the on-the-spot fining provisions of the Unauthorised Discharge Regulations 2004) and funding mechanism. Local government agencies may be cautious about accepting delegations to regulate small to medium-sized industry, unless it can be done on a cost-neutral basis. Some local authorities may not wish to undertake such a program, as they might consider it to be a State government responsibility.

The primary challenge associated with enforcement activities is the risk of a negative reaction from some stakeholders when an enforcement program begins, particularly if there are some 'teething troubles' during the beginning of the campaign (e.g. inconsistent interpretation of the law by enforcement officers, enforcement agencies not leading by example). During this early period, strong managerial and political commitment is often needed to ensure the program proceeds and becomes successful.

Another challenge with the use of enforcement is the magnitude of penalties (e.g. on-the-spot fines issued under the Unauthorised Discharge Regulations 2004). The size of the penalty must be proportional to the offence and the cost of compliance, yet not be perceived as a 'revenue raising exercise'. A careful balance must be achieved – a balance that will subtly change over time. In some cases, the enforcement agency may have limited power to alter the magnitude of the fines (e.g. where powers are delegated to local government by the state).

Cost^

Point source regulation

In a literature review involving non-structural measures for stormwater quality improvement, Taylor and Wong (2002c) concluded that point source regulatory programs involving small to medium-sized businesses may cost $287–$1,204 per premises per year to run, with a typical Australian local government-managed program costing in the order of $480 per premises per year.

However, these programs can be structured to be cost-neutral to the regulatory agency. That is, the revenue from licences, prosecutions and cost-recovery following incidents should cover the regulator's expenses. In some cases, additional expenditure is incurred by regulatory agencies, particularly when the magnitude of licence fees is set by another tier of government. For example, as a local government regulator, the Brisbane City Council in Queensland administers devolved provisions of state environmental legislation and regulates approximately 2,600–3,000 potentially polluting small to medium-sized premises (Taylor, 2002). In 2002, the council collected about $1.2 million in environmental licence fees but spent about $1.44 million (20% more) on these regulatory activities to deliver a standard of service that meets the expectations of the community (Taylor, 2002).

Indicative costing information is also available from the Auckland Regional Council in New Zealand, which has run an Industrial Pollution Prevention Program since 1998. The program includes regulation, education and auditing components and cost approximately NZ$350,000 to run in 2000-01. This level of funding enabled more than 400 premises to be audited (Sturrock, 2002).

Enforcement activities

In terms of enforcement, the primary costs to the enforcement agency include:

- staff time by enforcement officers (e.g. enforcement officers need to be trained, maintain a presence in the field, resolve disputes, process warnings/infringement notices, collect evidence for major prosecutions, etc.)
- legal costs (e.g. to manage hearings or prosecutions that are resolved in court)
- associated educational initiatives (e.g. the provision of information to ensure that the target audience know how to comply with regulations and avoid enforcement action).

Costing figures are also available for regional or citywide erosion and sediment control programs with a strong enforcement element (see Taylor and Wong, 2002c). The cost of running such programs in Australia ranges from $0.19–$0.51 per capita per year, and averages $0.32 per capita per year (where 'per capita' refers to the residential population of the area affected by the program).

^The costings used in this section are from around 2000. Please adjust the costings for present day.

Additional information

When planning to implement a point source regulation program at the local government level, it is recommended that consultation occur with the Department of Water and Environment Regulation to gain the latest information on these initiatives.

Once a best practice point source regulation program is in operation, regulatory agencies may wish to consider an advanced water quality management technique, namely to implement a pollutant trading scheme for a given receiving water. These systems operate by:

- setting a sustainable load of pollutants for the receiving waters based on scientific studies (e.g. average annual loads for TN and TP)

- setting discharge standards on regulated industry to reflect the receiving water's sustainable pollutant loads
- allowing regulated industries that can reduce their pollutant discharge loads below minimum standards to gain an economic advantage by selling their 'excess discharge credits'. For example, these credits may be bought by a new industry that wants to start discharging some pollutants into the receiving waters, or an industry that finds it more economical to buy these credits than upgrade its own on-site stormwater treatment technology to reduce its discharge loads by similar amounts to meet licence conditions.

Such pollutant trading schemes operate for all sources of water pollution, whether they are stormwater or wastewater.

Enforcement of regulations is usually considered an option of last resort, although experience around the world has demonstrated that it is often needed and is highly effective at managing stormwater-related behaviour in some contexts. If an enforcement program is to be used, the regulatory agency should demonstrate that less litigious alternatives (e.g. education) have been attempted but found to be insufficient. Agencies need to have a sound monitoring and evaluation program to monitor the effectiveness of education programs. For guidelines on how to plan and undertake an evaluation process, see Taylor and Wong (2002d).

Examples/Case studies

Point Source Regulation – Clean Bay Business Program, Palo Alto, California

A good overseas case study involves the Clean Bay Business Program in Palo Alto, California (Lehner et al., 1999). Vehicle service facilities (e.g. petrol stations) were regulated through licensing, education, inspections and the provision of incentives for good performance (e.g. attaining the status of a Clean Bay Business, which allowed businesses to access free advertising).

When premises were first inspected under the program in 1992, only 4% of 318 facilities complied with regulations relating to discharges to stormwater and sewer. By the end of 1992, this percentage had risen to 41% and by 1998 it had risen to 94%. In addition, violations of regulations that specifically protect stormwater drains fell by 90% between 1992 and 1995. The program also found and eliminated 78 direct discharges to stormwater (e.g. wash-water discharges).

2.4.3 Illicit discharge elimination programs

Description

Illicit connections are defined as 'illegal or improper connections to storm [water] drainage systems and receiving waters' (CWP, 1998). Illicit discharge elimination programs seek to identify and remove illegal or inappropriate waste streams entering the stormwater network. The most obvious of these waste streams include trade wastes from commercial and industrial premises and wastewater from domestic premises.

Illicit connections to stormwater can be surprisingly common. For example, a 1986 US study found 38% of businesses surveyed in Washtenaw County (Michigan) had illicit connections, mostly in automobile-related and manufacturing businesses (Schmidt and Spencer, 1986).

These connections can also represent a major source of pollution. For example, the Clean Charles 2005 Initiative in Boston (Massachusetts) found one connection that contributed approximately 327,000 litres of sewage to stormwater per day (Lehner et al., 1999).

Applicability

This BMP is applicable to all urban areas, but has increased value in commercial and industrial areas, older areas where several generations of plumbing may have occurred, and unsewered areas. Case studies indicate that this BMP can result in major reductions in pollutants being discharged to the stormwater network, and therefore it should be a priority in any urban stormwater quality management program.

For new developments, preventative practices such as the thorough inspection and verification of drainage and sewerage arrangements during the construction phase can avoid the need for more extensive detection techniques and subsequent disconnection (US EPA, 2001). For existing developments, illicit connections are detected using the techniques briefly described below.

Recommended practices

The US EPA (2001) recommends that illicit discharge elimination programs should have four principal components:

- procedures for locating priority areas that are likely to have illicit discharges
- procedures for tracing the source of an illicit discharge
- procedures for removing the source of the discharge
- procedures for program evaluation.

Illicit discharge education initiatives are also needed, which may include stormwater drain stencilling, a program to encourage public reporting of illicit connections or discharges to stormwater/water bodies and the distribution of educational materials to businesses, tradespersons (e.g. plumbers) and residents.

Other features of illicit discharge elimination programs are the mapping of the region's stormwater drainage network, targeted education campaigns, plans to detect and remove non-stormwater discharges, and regulatory mechanisms that:

- prohibit non-stormwater discharges from entering the stormwater network
- allow inspectors to access private property to investigate potential illicit discharges
- allow regulatory action to be taken to eliminate the discharge and prosecute offenders (where appropriate).

See Section 2.4.2 for more discussion on point source regulation and enforcement activities. In particular, the Unauthorised Discharge Regulations 2004 have been enacted under the *Environmental Protection Act 1986* in WA. These regulations include an on-the-spot infringement notice system for minor pollution offences. These powers can be delegated to local government officers. The new on-the-spot fines carry a penalty of $250 to $500, which increases to up to $5,000 for individuals and $25,000 for companies if the matter proceeds to court. The fines apply to commercial activities including land development and construction premises and cover the discharge of Schedule 1 substances to stormwater or groundwater. These substances include acid with a pH less than 4, alkali with a pH more than 10, hydrocarbons, solvents, degreasers, detergents, dust, engine coolant, pesticides, paint, dyes, sediment and substances containing heavy metals.

Typically, illicit discharge elimination programs focus on identifying and removing direct connections of wastewater to the stormwater network (e.g. from domestic, commercial or industrial premises). To identify such illicit discharges, the programs may include techniques such as:

- field testing of dry weather discharges in the stormwater drainage network
- visual inspections by closed circuit cameras

• undertaking a review of architectural plans and plumbing details to identify potential sites where improper connections may have occurred

• conducting field tests of selected pollutants in stormwater

• smoke testing

• dye testing.

Figure 23. Testing of an industrial site stormwater drain for illicit discharges. (Photograph: former Department of Environment.)

Following identification of an illicit discharge, an inspection of the discharging premises occurs, followed by elimination of the discharge and, potentially, prosecution of those responsible for the discharge.

Note: A Trade Waste Permit is required to connect and discharge wastewater to sewer.

Further information is available from the Water Corporation by telephoning the Customer Service Centre on 13 13 75 or via www.watercorporation.com.au/Help-and-advice

In some jurisdictions, community volunteers are engaged to help identify dry weather discharges to the stormwater system and minimise the cost of the program. For example, the Department of Environmental Protection in Montgomery County (Maryland) has an illicit discharge detection and elimination initiative called 'Pipe Detectives'. Under this initiative, community volunteers undertake dry weather inspections and report suspicious findings to a community hotline (MCDEP, 1997).

Benefits and effectiveness

Taylor and Wong (2002c) report that illicit discharge elimination programs can be a highly effective non-structural BMP for the improvement of stormwater quality and waterway health. They found evidence from several case studies that receiving water quality can be improved (particularly for faecal coliform levels and dissolved oxygen concentrations), large volumes of liquid wastes can be prevented from entering stormwater and significant loads of stormwater pollutants can be reduced over several years. For example, one study reported that an illicit discharge elimination program was responsible for a 75% decrease in faecal coliform levels in a receiving water, over three years. Another program prevented 999 litres/km^2/day of raw sewage entering receiving waters, while another eliminated 4,321 litres/km^2/day of liquid waste discharges (Taylor and Wong, 2002c).

Such evidence prompted Lehner et al. (1999) to conclude that, in the US, 'local governments have found that identifying and eliminating illicit connections and discharges is a remarkably simple and cost-effective way to eliminate some of the worst pollution from stormwater and to improve water quality' d(p. 5–15).

Challenges

Illicit discharge elimination programs are publicly funded, and despite attempts to involve volunteers in the detection and reporting process, they are often labour-intensive and require a substantial commitment of funds to carry out the detection tasks. In addition, jurisdictional disputes may arise in some areas about whether such programs should be funded and/or delivered by the agency that owns the sewerage network or by the affected stormwater drainage network.

Another challenge is the issue of gaining access to private property for inspection purposes. A regulatory instrument that ensures right of entry is critical in locating potential illicit discharges (US EPA, 2001).

In areas with highly permeable soils, such as much of the Swan Coastal Plain, illicit discharges to groundwater can be harder to detect than those discharges entering an impermeable drainage network. Detection techniques in this context may include inspection of 'high risk' premises (e.g. unlicensed premises that typically generate liquid trade wastes), dry weather water quality monitoring in drains and waterways (such programs may indicate the approximate location of a plume of contaminated groundwater), and groundwater quality monitoring. Similarly, in areas where the stormwater drainage network is discontinuous (i.e. where infiltration of stormwater is encouraged), illicit discharges may quickly drain to groundwater and be hard to detect using simple methods such as dry weather inspections.

Cost

Based on four successful US programs, Taylor and Wong (2002c) report that the cost of running an illicit discharge elimination program is approximately AUD$0.23–AUD$14.23/km^2 per annum[14] (averaging AUD$3.77/km^2 p.a.), when the total program costs are spread over the entire city area. Another cost estimate based on US programs is AUD$935–AUD$1,241/km^2, where the entire area is tested for illicit discharges to stormwater. Equivalent costs for Australian programs are not currently available.

Additional information

The *National Menu of Best Management Practices for Storm Water Phase II* (US EPA, 2001) contains excellent online guidelines that contain a number of useful references and fact sheets on key aspects of illicit discharge elimination programs, such as:

- identifying illicit connections
- industrial/business connections
- recreational sewage
- sewer overflows
- wastewater connections to the stormwater drainage system
- failing septic systems
- illegal dumping
- non-stormwater water discharges.

Examples/Case studies

Tulsa, Oklahoma

Taylor and Wong (2002c) report that the City of Tulsa, Oklahoma, started an illicit discharge elimination program in 1994, in cooperation with state agencies. The program included inspection of premises (using

[14] Based on a 2003 currency conversion rate of US$1 = AUD$1.92.

remote camera and smoke inspection techniques), dry weather field screening, industrial surveys, enforcement activities, repairs to sewerage infrastructure, as well as community education and involvement. The number of inspections and enforcement actions in the 1997-98 reporting year was 164 and 20, respectively. The program covered a region with a population of approximately 367,000 and an area of 471 km2 (Lehner et al., 1999), and cost about US$3.5 million per annum (Van Loo, 2002).

Changes to the quality of the City of Tulsa's stormwater before and after the program were measured and analysed using event mean concentrations averaged over four year intervals. The results include a 13%, 17% and 18% reduction in event mean concentrations for TSS, total phosphorus and total kjeldahl nitrogen, respectively (US EPA, 2001; Lehner et al., 1999). Taylor and Wong (2002c) report that the bulk of this improvement may be attributable to the City's illicit discharge elimination program (including its educational elements).

New York City, New York state

The New York City Department of Environmental Protection began a Shoreline Survey Program in 1989 to detect and eliminate illegal dry weather discharges to the city's stormwater and estuaries. The region over which the program operated was approximately 2,939 km^2, with a population of approximately 8.5 million (Lehner et al., 1999). The approximate cost of the program was US$475,000 p.a. (Lehner et al., 1999).

It is estimated that from 1989 to 1998, the Shoreline Survey Program eliminated approximately 12.7 million litres per day of illicit discharges. The department also reported that overall water quality conditions in the city's receiving waters from 1991 to 1995 improved on pre-1990 conditions. Levels of faecal coliforms and dissolved oxygen concentrations, in particular, continually improved throughout the 1990s (Lehner et al., 1999).

^The costings used in this section (Cost & Case Studies) are from around 2000. Please adjust the costings for present day.

2.5 Catchment planning practices

2.5.1 Risk assessments and environmental management systems

Description

Managing stormwater at the catchment or citywide scale is a challenging task, as there are typically many sources of pollution and limited resources to manage them. Each of these sources poses a different level of risk to the health of receiving waters. One way of identifying stormwater management risks, assessing them, prioritising them, and allocating resources to manage them is to use 'risk assessments' and associated 'environmental management systems'.

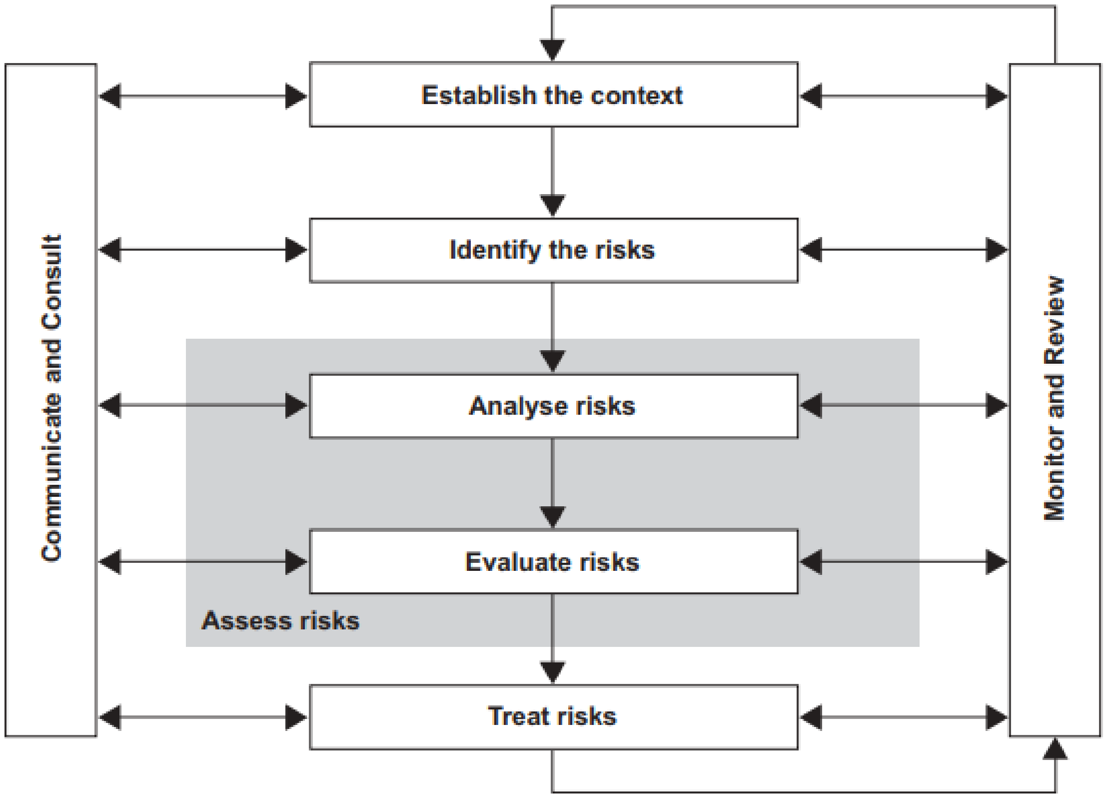

Figure 24. The process of risk assessment (Standards Australia, 1999)

For stormwater management in Australia, the process tools are commonly used in the following contexts:

- when a local authority is developing a stormwater management plan for a catchment or region, they may use a risk assessment process to help prioritise management actions
- when a local authority, state government department or business is reviewing their own operations and premises to ensure all reasonable and practicable steps are being taken to prevent or minimise stormwater pollution, they may undertake a risk assessment (often within the framework provided by an environmental management system)
- a risk assessment process may be used during the identification of priority areas within a city or shire that require:
  - strengthened town planning controls to ensure new development adopts a level of WSUD that matches the sensitivity of the environmental values of downstream water bodies; or
  - the application of structural stormwater management measures in developed areas (e.g. gross pollutant traps, Living Streams and constructed wetlands)
- an erosion hazard/risk assessment may be used on major construction sites to identify the need for erosion and sediment controls (see Section 2.1.1).

This guideline will focus on the first two of these applications.

The use of risk assessments and EMSs as tools for managing stormwater is highly applicable to local government authorities, government departments, industry and business.

Applicability

A risk assessment process is suggested as being essential to develop a focused and practical stormwater management plan for a local government area or catchment, given the multitude of sources of stormwater pollution and limited funds for management.

EMSs are recommended as a highly valuable organisational tool to systematically identify, assess and manage stormwater, particularly for organisations that have many activities or premises that may pollute stormwater.

Both of these tools are applicable to any geographic region.

Benefits and effectiveness

The primary benefit of undertaking risk assessments is to prioritise the allocation of limited resources to maximise the outcomes to the community and environment. The process of undertaking risk assessment may also identify serious breaches of environmental legislation, activities that are having significant impacts on the health of water bodies, and legal risks to the organisation (and individuals), and may help educate staff about best practice stormwater management.

Benefits of implementing an EMS include it:

- provides a systematic framework for rigorously identifying, assessing and managing risks, minimising the chance that the organisation's activities will adversely affect water body health
- potentially provides a 'due diligence defence' to environmental prosecutions (i.e. providing protection to staff and the organisation)
- provides a 'paper trail', that minimises the loss of corporate knowledge when key staff leave the organisation
- can identify savings to the organisation (e.g. waste recycling opportunities, water minimisation and reuse initiatives)
- provides senior management and stakeholders (e.g. community groups, shareholders) with a mechanism to quickly identify whether environmental management is being adequately undertaken within the organisation (particularly if the system has independent certification).

In terms of the effectiveness of these tools, the methodology is widely used, well accepted and has been documented as Australian Standards (e.g. AS/NZS 4360:1999 and AS/NZS ISO 14001:1996). However, no system is perfect. A well-designed and maintained EMS should minimise the risk of stormwater-related environmental impacts.

Challenges

The following challenges may need to be addressed to improve implementation:

- their effectiveness primarily depends upon the skills of those people implementing various elements (e.g. risk assessments, audits, developing policy). This is particularly the case during the risk assessment stage, when hazards/threats are easily missed and when there is often a subjective element to the assessment that relies heavily on expertise
- some risk assessment processes and environmental management systems can be cumbersome to run (e.g. risk assessments that incorporate a quantitative assessment or environmental management systems with frequent auditing and reporting requirements). These tools should be based on the financial and human resources of an organisation. A trial project or period is highly recommended to ensure this occurs. In the case of environmental management systems, it is also recommended that a paper-based system be successfully implemented for at least 12 months before moving to an electronic system (e.g. where all of the EMS's documentation is online).

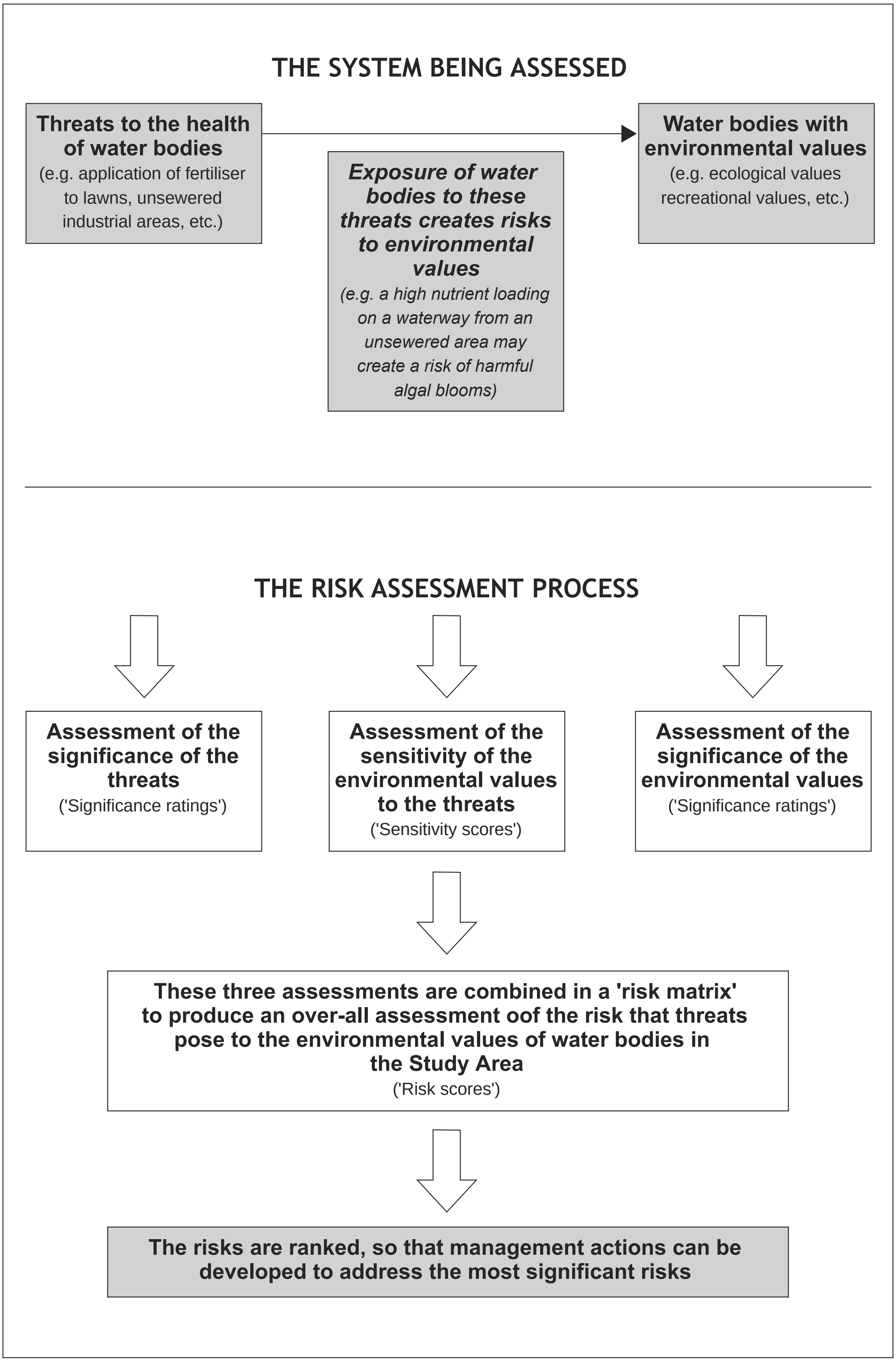

Figure 25. A risk assessment process used to develop a stormwater quality management plan (Parsons Brinckerhoff and Ecological Engineering, 2003)

Cost^

The cost of running these processes and systems will vary greatly depending upon their design and context.

As a general guideline, a medium-sized local government authority (say with 50,000 people) would require one full-time environmental engineer/scientist (say at a salary of $50,000 p.a. and on-costs) to coordinate the development and maintenance of an environmental management system. This person would also need:

- input from operational staff during risk assessments, procedure development, audits and reporting
- an expenses budget (say $50,000 in the first year and then $20,000 p.a. thereafter) to acquire specific expertise (e.g. specialist auditors, environmental monitoring specialists, trainers and analysis of samples).

^The costings used in this section (Cost & Case Studies) are from around 2000. Please adjust the costings for present day.

Additional information

Potential synergies emerge when an organisation combines environmental management systems with equivalent systems for managing health and safety, quality, and other forms of risk (e.g. legal, political). The philosophy and steps in these systems are similar. Some organisations reduce costs by combining several staff roles. For example, a medium-sized business may hire one professional who is trained in environmental management and health and safety, to operate an integrated environmental, health and safety management system.

There are a number of Australian and international standards that relate to environmental management systems, risk assessment and auditing. The two primary Australian Standards that are relevant to this guideline are listed in the reference section below. Additional references can be obtained from these standards.

Examples/Case studies

Stormwater self-management system – City of Greater Shepparton, Victoria

In 2003, the City of Greater Shepparton developed a simple form of environmental management system that focused on stormwater quality (Clearwater, 2003). The stormwater self-management system (SMS) was developed to achieve successful and sustainable implementation of stormwater best practice with respect to local government activities (e.g. street sweeping and construction). It is an interactive tool involving input from all departments within the organisation to monitor compliance with best practice standards. The system has also been developed as a software package.

The SMS process is as follows:

- stormwater management tasks are assigned to council personnel (i.e. these are management actions to address previously identified risks to stormwater quality)
- audits are carried out using a checklist
- findings from the audits are entered into a database (i.e. necessary actions)
- necessary actions are electronically sent to the responsible department
- actions that are delegated or completed are electronically entered back into the database
- segular checks are undertaken of compliance.

The SMS's checklist was obtained from the Victorian Urban Stormwater Best Practice Environmental Management Guidelines (VSC, 1999).

2.5.2 Managing the total water cycle

Description

Please refer to the *Decision process for stormwater management in Western Australia November 2017*, a component of chapter 4 of this manual for further information on managing the total water cycle.

Applicability

Resolving the organisational impediments to promote an integrated approach to urban water cycle management is relevant to all regions, but particularly for those that:

- are facing pressure to improve the management of more than one part of the water cycle, and seeking to harness the synergies that are available from an integrated approach
- where responsibilities for parts of the water cycle are fragmented, and the interests of the relevant organisational units are not clearly aligned.

Recommended practices

To help overcome these organisational impediments to promoting an integrated approach to urban water management, the following actions are suggested as essential:

✔ Ensure there is a clear and consistent vision (or policy) for total water cycle management that is shared by all agencies in the region with a role in water management.

✔ Ensure measurable targets are developed that relate to the management of stormwater quality, stormwater quantity, water supply and wastewater/effluent (including reuse).

✔ Ensure there is strong managerial and political commitment to the vision and targets.

✔ Ensure that all organisational units that manage parts of the urban water cycle are committed to the same vision and their interests are aligned. For example, if an organisational unit's performance is judged on narrow objectives (e.g. 'how much water is sold', 'how much wastewater is reused'), it may constrain an integrated approach to projects where collaboration occurs between all units whose water-related interests may be affected. Such collaboration is required to maximise the probability of finding an optimal outcome for the community in terms of *total* water cycle management.

✔ Ensure responsibilities for managing all parts of the urban water cycle are clear and agreed (e.g. the responsibilities of local government, State government departments and water service providers).

✔ Ensure public reporting mechanisms foster accountability within all agencies responsible for urban water management. The development of measurable targets can assist this process.

✔ Ensure that the total water cycle management philosophy permeates all water-related decisions and projects, such as:

– the design and construction of new government assets (e.g. roads, buildings)

– development assessment decisions

– decisions relating to regional stormwater treatment devices, sewage treatment plants, reuse schemes, rainwater tank subsidies, grant programs, etc.

– town planning instruments

– state and local government policies

– development control plans/strategies

– catchment-based water management plans.

Benefits and effectiveness

From case study information, the following quantitative benefits can result from an integrated approach to urban water cycle management:

- reduction of scheme water consumption by approximately 25 to 30% per cent is possible in a typical household, through the adoption of water efficient appliances and practices. This figure could rise to 65% in the long-term through the use of alternative sources of water, as well as demand reduction strategies (Institution of Engineers Australia, 2006)
- average annual pollutant loads in stormwater can be substantially reduced (e.g. 80% reduction in typical urban TSS loads and 45% reduction in TP and TN loads are objectives that can be met in most circumstances within Australia). For more information, see Institution of Engineers Australia (2003) or Taylor and Wong (2002c)
- in the long-term, 100% reuse of treated wastewater effluent is possible within large individual developments or within the region (Institution of Engineers Australia, 2006)
- n terms of hydrological performance, WSUD can often ensure the peak stormwater discharge is maintained at pre-development levels, while pre-development runoff volumes are also maintained (Institution of Engineers Australia, 2006).

Challenges

The move towards an integrated approach to urban water management has been limited in some regions because of factors such as:

- organisational fragmentation, cultures, inertia and unaligned interests (as highlighted above)
- concerns over post-development operation and maintenance costs (e.g. for structures such as aquifer storage and recovery systems)
- increased complexity in decision-making
- the lack of an effective regulatory and operating environment at the state or local government level
- limited quantitative data on the long-term performance of BMPs
- the current skills within some local governments and water service providers do not yet support the changes required for the assessment, approval, construction and maintenance of development schemes based on WSUD principles
- lack of guidance on the life cycle costs of BMPs (including a lack of guidelines on how to undertake such analyses, especially where externalities are included)
- uncertainties regarding the market acceptance of residential properties with WSUD features. (Modified from Lloyd *et al.*, 2002.)

Cost

Information from case studies on the cost of development using an integrated approach to water management is available in Lloyd et al. (2002) and Taylor and Wong (2002c).

The cost of successfully overcoming organisational impediments to integrated urban water cycle management cannot be estimated, due the large number of unknown variables.

Additional information

In summarising key environmental issues for the Australian water industry, the objectives of a more sustainable urban water system should be defined by the total urban water cycle, specifically:

- reduced diversions of freshwater from the environment to service growing urban populations
- reduced environmental impacts of pollutants from point and nonpoint sources such as nutrients and sediment
- reduced potential for pathogens to adversely impact human health
- lower energy consumption
- reduced net emissions of greenhouse gases.
- increased resilience to manage variability in demands and unexpected events
- increased cost-effectiveness.

Despite the strength of the arguments for integrated water resource management, it should not be considered to be the 'correct' problem-solving model that will automatically produce sustainable and cost-effective urban water systems. In reality, the approach to managing water resources in urban areas will evolve over time as new ideas, information, drivers for change and technologies emerge. This approach is sometimes called 'adaptive environmental management'.

Examples/Case studies

Several leading WSUD case studies for specific developments in Australia are described in Engineers Australia (2006).

In terms of organisational case studies, the greater Melbourne region provides an example of how jurisdictional fragmentation was managed to achieve positive results. In Melbourne, responsibility for stormwater management is split between Melbourne Water (which manages the trunk drainage network), numerous local government authorities (which manage the minor drainage network), and the Victorian Environmental Protection Authority (which is the lead agent for environmental protection). To help clarify roles and responsibilities with respect to stormwater and to ensure that all organisational units were coordinated, a 'Partnership Agreement' was jointly developed and signed on 26 November 2002 (Clearwater, 2002). This was seen as a major step forward towards improved management of stormwater in the greater Melbourne region.

Another organisational example is Brisbane City Council. Brisbane City Council manages virtually the entire urban water cycle in Brisbane. In 2002, the policy (or 'purchaser') units of Council that were responsible for stormwater quality, stormwater quantity, catchment management, water supply and wastewater were combined to form one branch (the Water Resources Branch). Other initiatives included:

- the development of a citywide Water Management Strategy as a vehicle to define an agreed vision for 2020, and the major projects that will be delivered to achieve this vision
- the use of multi-disciplinary project teams to ensure all aspects of the water cycle are considered during major projects.

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