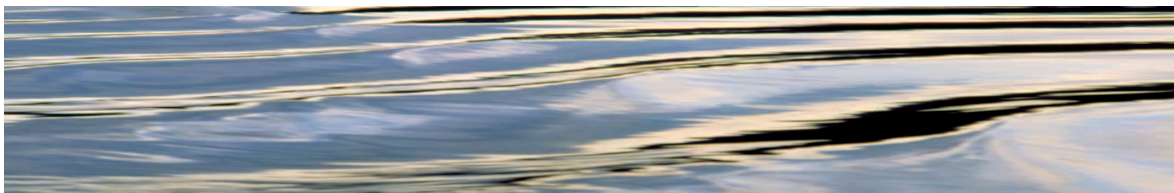# NON-STRUCTURAL STORMWATER QUALITY BEST MANAGEMENT PRACTICES - A SURVEY INVESTIGATING THEIR USE AND VALUE

TECHNICAL REPORT
Report 02/12
December 2002

André Taylor / Tony Wong

Taylor, A. C., 1969-

Non-structural stormwater quality best management practices - a survey investigating their use and value

Keywords

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Non-structural Stormwater Quality Best Management Practices - A Survey Investigating Their Use and Value

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Preface

In 2001 the Cooperative Research Centre for Catchment Hydrology formed a partnership with the Victorian Environment Protection Authority to undertake research into the use, value, cost and evaluation of non-structural best management practices to improve urban stormwater quality (non-structural BMPs). Such BMPs include town planning controls, strategic planning and institutional controls, pollution prevention procedures, education and participation programs, and regulatory controls.

The primary aim of this research project was to produce monitoring protocols that could be used by local government authorities to measure the value and life-cycle cost of non-structural BMPs that improve urban stormwater quality.

Secondary objectives of this research project were to help local government authorities manage urban stormwater quality by providing:

* Quantitative information from the literature and case studies on the value of non-structural BMPs.

* Information on how structural and non-structural BMPs for urban stormwater quality improvement are being used (e.g. the extent to which 70 specific BMPs are being used around Australia, New Zealand and the United States of America).

* Funding profiles for several leading urban stormwater quality management authorities in Australia and overseas, that can be used as benchmarks when developing urban stormwater management programs.

* Information on the views of Australian and overseas urban stormwater quality managers on the effectiveness, efficiency and practicality of 41 non-structural BMPs.

* A short-list of non-structural BMPs deemed to be of most value in terms of effectiveness, efficiency, practicality, acceptance and potential for future use (based on the findings of a literature review and survey of Australian and overseas stormwater managers).

* Recommended references relating to the design of non-structural BMPs.

- A new evaluation framework that can be used for any type of non-structural BMP that aims to improve urban stormwater quality.

Four reports have been produced to communicate this work to stakeholders:

- CRC for Catchment Hydrology Report 02/11 (No. 1 in the series) is an **overview report** that describes the project's aims, background, methodology, and presents key findings in a condensed form.

- CRC for Catchment Hydrology Report 02/12 (No. 2 in the series) is this technical report on the findings of a detailed **survey** of 36 urban stormwater managers.

- CRC for Catchment Hydrology Report 02/13 (No. 3 in the series) is a technical report that presents the findings of a **literature review** on the value and life-cycle costs of non-structural BMPs to improve urban stormwater quality.

- The fourth report in the series investigates **monitoring and evaluating non-structural BMPs** for urban stormwater quality improvement. A draft version of this report has been released as a working document (CRC for Catchment Hydrology Working Document 02/6). The report presents guidelines and a new evaluation framework for measuring the value and life-cycle costs of non-structural BMPs. This framework defines seven different styles of evaluation to suit the needs and budgets of a variety of stakeholders involved with stormwater management. In addition, monitoring protocols and data recording sheets have been developed to support each style of evaluation.

    This work will be published as a final CRC technical report during 2003.

Tim Fletcher
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1. Introduction

1.1 What are non-structural stormwater quality best management practices?

Non-structural stormwater quality best management practices (non-structural BMPs) are pollution-prevention practices designed to prevent or minimise pollutants from entering stormwater run-off 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), persuasion, economic instruments and/or institutional arrangements (e.g. funding programs and specialist government agencies).

Examples of non-structural BMPs for managing urban stormwater quality include:

- town planning controls (e.g. using town planning instruments to promote Water Sensitive Urban Design [WSUD] principles in new developments, such as decreasing the area of impervious surfaces);

- city-wide stormwater management planning (e.g. local authorities developing and implementing strategic management plans to improve stormwater quality throughout a catchment or city);

- controls involving construction and maintenance activities (e.g. maintenance activities such as regular inspection and clean-out of structural BMPs and litter collections);

- education and participation programs (e.g. focused campaigns that aim to change those aspects of behaviour that may be damaging the health of local waterways, such as over-applying garden fertiliser);

- enforcement campaigns (e.g. the use of enforcement and education to improve erosion and sediment control on construction sites);

- economic controls (e.g. financial incentives to encourage the conversion of lawns and gardens that require large amounts of fertilisation and watering to more resource-sensitive alternatives);

- regulation and inspection activities involving industrial and commercial premises (e.g. auditing programs for small commercial and industrial premises); and

- programs to identify and eliminate illicit discharges of pollutants to stormwater (e.g. programs to minimise illegal connections of sewerage to stormwater)

2. Background

A detailed background on the nature of non-structural BMPs for urban stormwater quality improvement is presented in the overview report of this series CRC for Catchment Hydrology Technical Report 02/11, and will not be repeated in full here. The background section of the overview report contains information on:

- Terminology used in all four reports.
- Types of non-structural BMPs.
- Broad trends on the use of non-structural BMPs.
- The status of attempts to evaluate non-structural BMPs.
- Impediments to the evaluation of non-structural BMPs.
- Sources of information (i.e. web sites and on-line documents) that are recommended for the design of non-structural BMPs for urban stormwater quality improvement in Australia.

It is recommended that the overview report be read before the technical reports, where possible.

2.1 Terminology

The following definitions - modified from Strecker *et al.* (2001) and ASCE & US EPA (2002) - are used in this report:

- Best management practice (BMP) - a device, practice or method for removing, reducing, retarding or preventing targeted stormwater run-off constituents, pollutants and contaminants from reaching receiving waters. Within the context of this report, BMPs primarily seek to manage stormwater *quality*.
- BMP System - the BMP and any related stormwater the BMP is unable to manage.[1]
- Performance - a measure of how well a BMP meets its goals for the stormwater it is designed to improve.
- Effectiveness - a measure of how well a BMP system meets its goals for all stormwater flows reaching the area of coverage by the BMP.

- Efficiency - a measure of how well a BMP or BMP system removes or controls pollutants. Although 'percent removal' is the most common form of expressing BMP efficiency, recent US work on structural BMP evaluation (ASCE & US EPA, 2002) argues that 'percent removal' (when used alone) is a poor measure of BMP efficiency compared with alternatives such as the 'effluent probability method'.[2]

The term 'value' is used in this report as a collective description of the benefits of non-structural BMPs, encompassing attributes such as their:

- ability to raise people's awareness, change their attitudes and/or change their behaviour;
- performance, effectiveness and efficiency with respect to stormwater quality improvement (as defined above); and
- ability to improve waterway health.

The term 'life-cycle cost' describes the total cost of the design, implementation, operation and maintenance of the BMP over its life span.

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[1] Additional information is provided in the Glossary (Section 7).

[2] For a discussion on this issue see ASCE & US EPA (2002).

3. Methodology

3.1 BMP use and funding profiles of urban stormwater management agencies

To gather information on the use of, and funding allocated to, non-structural and structural BMPs, we designed a detailed three-part survey for urban stormwater managers, which included:

1. A section asking stormwater managers to indicate for 41 non-structural BMPs and 29 structural BMPs:

    •   the degree to which the BMPs were being used in their regions (using a 1 - 5 rating system); and

    •   whether the use of the BMPs was increasing, decreasing or remaining static.[3]

2. A section asking stormwater managers to consider 41 non-structural BMPs and then:

    •   rank the BMPs in terms of their effectiveness, efficiency and practicality (using a 1 - 5 rating system);

    •   indicate the most promising BMPs for future use in their region;

    •   state whether the effects and life-cycle cost of the BMPs had been reliably monitored in their region and, if so, the nature of the monitoring indicators and whether monitoring protocols had been developed; and

    •   provide contact details for further information on monitoring.

3. A section on public funding for urban stormwater quality management, asking stormwater managers to indicate:

    •   the primary function of their organisation (six generic categories were provided); and

    •   the approximate annual expenditure by their organisation in 11 categories of management activities (e.g. capital/construction costs for structural BMPs, planning and regulatory mechanisms, education programs, enforcement programs, etc.).

The survey form was sent to stormwater managers around Australia, NZ and the US.

We contacted the Australian stormwater managers by phone, forwarding the survey electronically to those who agreed to participate. We invited managers in 32 agencies from Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Western Australia, to participate. All agreed to be involved (100%) and 25 completed surveys were received by the deadline (a return rate of 78%).

For overseas stormwater managers, specific people and agencies were targeted based on their reputation as leaders and/or highly experienced in the management of urban stormwater quality. Twenty-four (24) agencies were invited via email to participate, of which 15 agreed (63%), with 11 surveys being received by the deadline (a return rate of 73%).

Stormwater management agencies that participated in the survey are listed in Table 3.1. Those who completed the survey are acknowledged in the Acknowledgments Section of this report (Appendix D).

The survey form sent to Australian stormwater managers is included in Appendix A. The overseas survey contained minor alterations (e.g. modification of terms).

The survey data are presented in a table in Appendix B. These data were analysed to present the findings outlined in Sections 4 and 5.

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[3] The majority of these BMPs were named, listed and arranged in the same manner as the Victorian Urban Stormwater Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999).

Table 3.1   Stormwater Management Agencies that Responded to the Survey

AUSTRALIAN	OVERSEAS
Blacktown City Council, Sydney, New South Wales.	Auckland Regional Council, New Zealand.
Brisbane City Council, Brisbane, Queensland.	City of Austin, Texas.
Caboolture Shire Council, Caboolture, Queensland.	City of Olympia Public Works, Washington.
City of Canning, Perth, Western Australia.	City of Orlando, Florida.
City of Kingston, Melbourne, Victoria.	Department of Environment, Delaware.
City of Port Adelaide Enfield, Port Adelaide, South Australia.	Maryland Department of the Environment, Maryland.
City of Port Phillip, Melbourne, Victoria.	New Jersey Department of Environmental Protection, New Jersey.
City of Salisbury, Salisbury, South Australia.	North Central Texas Council of Governments, Texas.
City of Unley, Unley, South Australia.	North Shore City Council, New Zealand.
Water and Rivers Commission, Perth,Western Australia.	Pennsylvania Department of Environmental Protection, Pennsylvania.
Department of Planning and Land Management, Canberra, Australian Capital Territory.	Waitakere City Council, New Zealand.
Department of Urban Services, Canberra, Australian Capital Territory.	
Eastern Metropolitan Regional Council, Perth, Western Australia.	
Gold Coast City Council, Gold Coast, Queensland (Two branches with different roles responded separately).	
Hornsby Shire Council, Sydney, New South Wales.	
Kogarah City Council, Kogarah, New South Wales.	
Melbourne Water, Melbourne, Victoria.	
New South Wales Environment Protection Authority, New South Wales.	
Patawalonga Catchment Water Management Board, South Australia.	
South Australian Environmental Protection Agency, South Australia.	
Swan River Trust, Perth, Western Australia.	
Sydney Water, Sydney, New South Wales.	
Upper Parramatta River Catchment Trust, Sydney, New South Wales.	
Victorian Environmental Protection Agency, Victoria.	

NB: Although discrete data sets were collected for 70 different types of structural and non-structural BMPs via the survey, it was not practical to analyse and discuss all the data in this report. Our discussion centres around key findings and the non-structural BMPs deemed to be of most value to urban stormwater managers.

During the literature review and survey components of this project, particular stormwater management agencies were recognised as being leaders in the field as a result of their:

- experience (e.g. the City of Orlando in Florida has been implementing and monitoring stormwater quality BMPs for over 20 years);

- achievements (e.g. the impressive research and management activities of agencies in the catchment of Chesapeake Bay in Maryland and Virginia to reduce the load of nutrients entering the Bay); and

- ability to lead other stormwater management agencies in terms of policy (e.g. agencies such as the Brisbane and Blacktown City Councils in Australia, which have strong stormwater quality provisions in their local planning instruments).

As indicated above, we asked surveyed agencies to provide details of their approximate annual expenditure on core elements of urban stormwater quality management. All agencies approached in Australia participated in this component of the survey. Only some of the overseas agencies agreed to participate, but enough information was gathered to allow simple benchmarking.

To enable a useful comparison between funding profiles of leading stormwater management agencies and ones seeking guidance, organisational function and size should be similar. This creates an unavoidable element of complexity, as stormwater management functions can vary enormously. For example, in Australia local governments may be responsible for just the minor stormwater drainage, all of the minor and part of the trunk/main drainage, or all the drainage.

To overcome this complexity:

- details of the function and size of leading stormwater management agencies was gathered and has been presented along with their funding profiles in Section 4.3; and

- where funding-related comparisons are made between agencies, these comparisons only involve agencies with similar functions.

3.2 Relative value of non-structural BMPs

Information gathered by the survey is an expression of the collective knowledge and practical experience of many stormwater managers and was used as one measure to describe the relative value of non-structural BMPs for urban stormwater quality management. In Report No. 3 of this series, CRC for Catchment Hydrology Report 02/13, information obtained from the literature and case studies was used as another source of such information. Collectively this information is valuable to help:

- guide the use of non-structural BMPs in the absence of high-quality, locally-derived data on their life-cycle cost and value; and

- prioritise those non-structural BMPs that should be more thoroughly monitored and evaluated.

To assess relative value, we obtained information from the survey of Australian, US and NZ urban stormwater managers on four key attributes, namely their:

1. Perceptions of the overall effectiveness, efficiency and practicality of 41 non-structural BMPs.

2. Views on the degree to which specific non-structural BMPs were being used in their region.

3. Views on trends in the use of these non-structural BMPs in their region.

4. Views on specific non-structural BMPs showing promise for future use in their region.

We also developed a Value Utility Function (see next page) that converts equivalent scores for each of the above four attributes into an overall Value Score for each non-structural BMP. We used weightings to reflect the relative importance of each attribute.

Value Score (for a non-structural BMP)

$$= [(D \times Wd) + (T \times Wt) + (E \times We) + (P \times Wp)] \div 20$$

Where:

- The Value Score is a score out of 100, with a high score representing a high relative value.

- D = Current degree of BMP use (%, converted from 1 - 5 rating scores obtained via the survey).

- Wd = Weighting for attribute D (a number from 0 to 10).

- T = Current trend of increasing BMP use (% of survey respondents reporting an increase in use).

- Wt = Weighting for attribute T (a number from 0 to 10).

- E = Perceived effectiveness, efficiency and practicality of BMP (%, converted from 1 - 5 rating scores obtained via the survey).

- We = Weighting for attribute E (a number from 0 to 10).

- P = Degree of promise for future use of BMP (%, converted from the number of survey respondents to the survey who indicated promise).

- Wp = Weighting for attribute P (a number from 0 to 10).[4]

The adopted weightings were:

- Perceptions of the effectiveness, efficiency and practicality of 41 non-structural BMPs = 10/10 (highest weighting).

- Views on the most promising non-structural BMPs for the surveyed stormwater managers' regions = 5/10.

- Views on the trends in the use of these non-structural BMPs in the surveyed stormwater managers' regions = 3/10.

- Views on the degree to which these non-structural BMPs were being used in the surveyed stormwater managers' regions = 2/10.

Appendix B lists the Value Scores for the 41 non-structural BMPs. Note that Value Scores were calculated separately from the data sets obtained by surveying Australian and overseas stormwater managers.

We undertook a basic form of sensitivity analysis for the Value Utility Function, by evaluating the effect of four different, but plausible, sets of weightings on the top 10 rankings of non-structural BMPs with the highest Value Score (see Appendix C for details). This analysis found that the top five ranked BMPs derived from using the preferred set of weightings (i.e. those above) were also:

- In the top five ranked BMPs derived from recalculating the Value Scores using data just from Australian stormwater managers and *all three* alternative sets of weightings.

- In the top 10 ranked BMPs derived from recalculating the Value Scores using data just from overseas stormwater managers and *all three* alternative sets of weightings.

Based on this analysis, we concluded the proposed Value Score was not overly sensitive to changes in the weightings.

Finally, information gathered from the survey was combined with information from the literature review (Report No. 3 in this series, CRC for Catchment Hydrology Report 02/13) which focused on attempts to quantitatively monitor and evaluate the effects of non-structural BMPs. This review gathered information from published literature, the internet, case studies and unpublished reports. Unpublished information obtained directly from stormwater management agencies was particularly valuable, as few attempts at quantitatively monitoring and evaluating the effects of non-structural BMPs have been published.

The survey and literature review information enabled us to develop a short-list of non-structural BMPs deemed most valuable. We developed this short-list because:

- Given the large number of non-structural BMPs, it is logical to develop monitoring tools and undertake evaluation trials on those BMPs likely to be of most value to urban stormwater managers.

- The desk-top evaluation of non-structural BMP value is a useful outcome of this project in itself. This information could help stormwater managers seeking an optimal mix of BMPs for their region. To the best of the Author's knowledge, this type of desk-top evaluation of relative non-structural BMP value has not been attempted before.

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[4] See Appendix B for the survey data and the formulas used to convert average scores from the survey (e.g. 1 - 5 ratings) into percentages.

4. Results - BMP Use for Urban Stormwater Management

4.1 BMP use in Australia

Structural and non-structural BMP use in Australia was evaluated via a survey involving 25 urban stormwater managers from agencies in Queensland, New South Wales, the Australian Capital Territory, Western Australia, South Australia and Victoria. The survey gathered data on:

• the degree of current BMP use in the region for which the surveyed stormwater managers had knowledge; and

• the current trend in BMP use (i.e. increasing, decreasing or remaining static).

These data were gathered for 41 non-structural and 29 structural BMPs (see Appendix A) and used to calculate average ratings for each BMP, representing their typical use in Australia (as of 2001-02).

Based on the Australian survey data:

• Figure 4.1 highlights the top 11 non-structural BMPs most widely used in Australia.

• Figure 4.2 highlights the top 11 structural BMPs most widely used in Australia.

• Figure 4.3 highlights the top 11 non-structural and structural BMPs associated with the most widespread trend of increasing use within Australia.
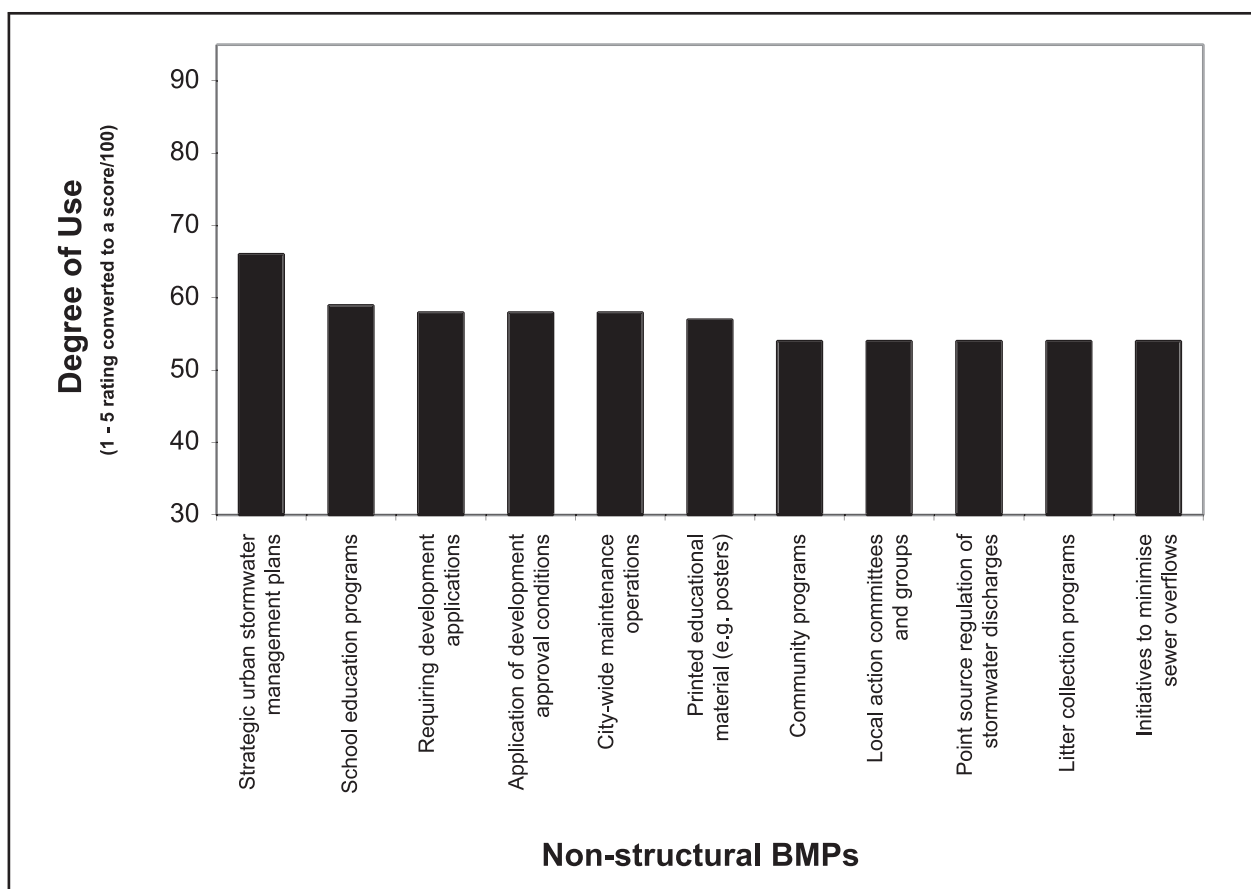

Figure 4.1   Most Frequently Used Non-structural BMPs in Australia

Notes:

• For the 'degree of use' scale: 0 = Not used, 25 = Low degree of use, 50 = Low-medium degree of use, 75 = Medium-high degree of use, 100 = High degree of use.

• Only the top 10 BMPs (and those with an equal score to the tenth highest ranked BMP) have been presented in this graph. For information on the remaining BMPs, see the data presented in Appendix B.

Figure 4.2   Most Frequently Used Structural BMPs in Australia

Notes:

• For the 'degree of use' scale: 0 = Not used, 25 = Low degree of use, 50 = Low-medium degree of use, 75 = Medium-high degree of use, 100 = High degree of use.

• Only the top 10 BMPs (and those with an equal score to the tenth highest ranked BMP) have been presented in this graph. For information on the remaining BMPs, see the data presented in Appendix B.
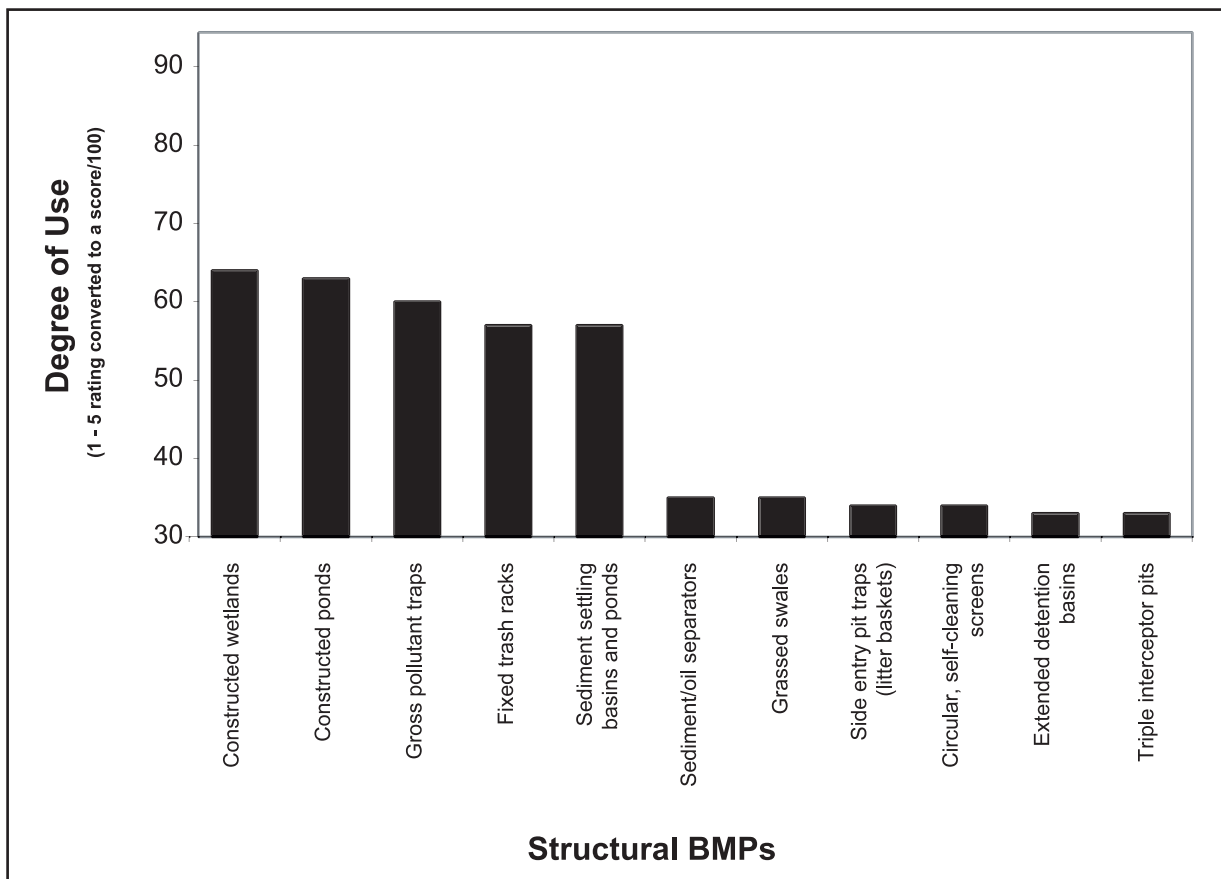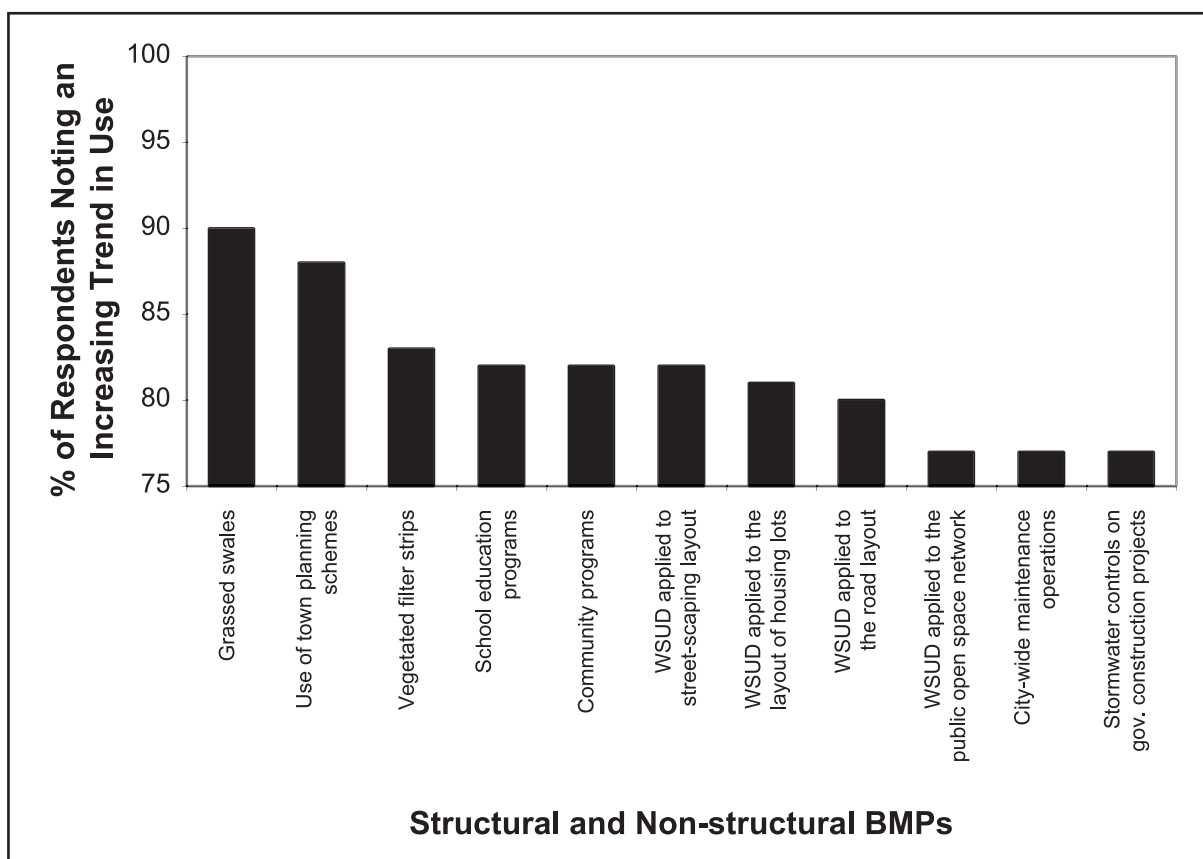
Figure 4.3   BMPs That Are Most Widely Increasing in Use Within Australia

From these figures it is evident that:

- Three of the top four most frequently used non-structural BMPs are related to planning (i.e. strategic, city-wide planning of stormwater management, and the use of town planning controls).

- Four of the top eight most frequently used non-structural BMPs are related to education and participation programs.

- Five structural BMPs are used significantly more than the other 29 structural BMPs included in the survey: constructed wetlands, constructed ponds, gross pollutant traps, fixed trash racks and sediment settling basins/ponds. This may represent the legacy of a decade where the installation of large regional, structural BMPs was the focus for many stormwater quality management agencies.

- Of the top 11 BMPs associated with the most widespread trend of increasing use in Australia:

  - nine were 'non-structural' as defined in this report;

  - seven were closely related to the philosophy of site-based WSUD[5];

  - one was related to city-wide planning (i.e. the use of town planning controls ranked second); and

  - two of the top five BMPs related to education and participation programs (i.e. school education programs and community programs).

In addition, the data in Appendix B indicate the majority of BMPs included in the survey were associated with an increasing trend in use, particularly the non-structural variety. For example, the majority of respondents (>50%) reported an increasing trend in use for:

- 76% of the 41 non-structural BMPs included in the survey (e.g. the use of town planning schemes and school education programs); and

- 34% of the 29 structural BMPs included in the survey (e.g. grassed swales and vegetated filter strips).

4.2 BMP use in the US and NZ

Based on the US and NZ data gathered through the survey of 11 stormwater managers:

- Figure 4.4 highlights the top 11 non-structural BMPs most widely used in the US and NZ.

- Figure 4.5 highlights the top 10 structural BMPs most widely used in the US and NZ.

- Figure 4.6 highlights the top 13 non-structural and structural BMPs associated with the most widespread trend of increasing use within the US and NZ.

From these figures it is evident that:

- Four of the top 11 most commonly used non-structural BMPs relate to planning controls, while three relate to municipal operations (e.g. maintenance activities) and three relate to regulation.

- Compared to Australian data on current degree of use, there appears to be:

  - A more widespread trend of increasing use of stormwater BMPs, particularly the non-structural variety. For example, the majority of overseas respondents (>50%) reported an increasing trend in use for:

    - 90% of the 41 non-structural BMPs included in the survey (e.g. the use of strategic urban stormwater management plans and city-wide maintenance operations); and

    - 38% of the 29 structural BMPs included in the survey (e.g. hydrodynamic/vortex separators and porous pavements).

  - an increased use of non-structural BMPs in the US and NZ that relate to regulation; and

  - a much higher degree of use of non-structural BMPs in general (e.g. even the tenth most commonly used non-structural BMP in the US and NZ has a significantly higher degree of use than the most commonly used non-structural BMP in Australia).

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[5] For example: use of town planning controls, use of grassed swales and vegetated filter strips, and applying the WSUD philosophy to street scapes, public open space, etc.

- The top two most commonly used structural BMPs in the US and NZ (i.e. sediment settling basins/ ponds and constructed ponds) are used more commonly than any structural BMP in Australia.

- Four of the top five most commonly used structural BMPs in Australia also rank in the top 10 most commonly used structural BMPs in the US and NZ (i.e. sediment settling basins/ ponds, constructed ponds, fixed trash racks and constructed wetlands).

- The degree of use of structural BMPs in the US and NZ declines quite rapidly over the top 10 most commonly used BMPs.

- Eleven out of the top 13 BMPs associated with the most widespread trend of increasing use within the US and NZ are non-structural as defined in this report. In addition:

  - five of the top 13 BMPs are closely related to the philosophy of site-based WSUD (also known as 'low impact development');

  - three of the top five BMPs relate to municipal operations;

  - two of the top seven BMPs are related to city-wide planning, with the use of city-wide strategic management plans ranking first; and

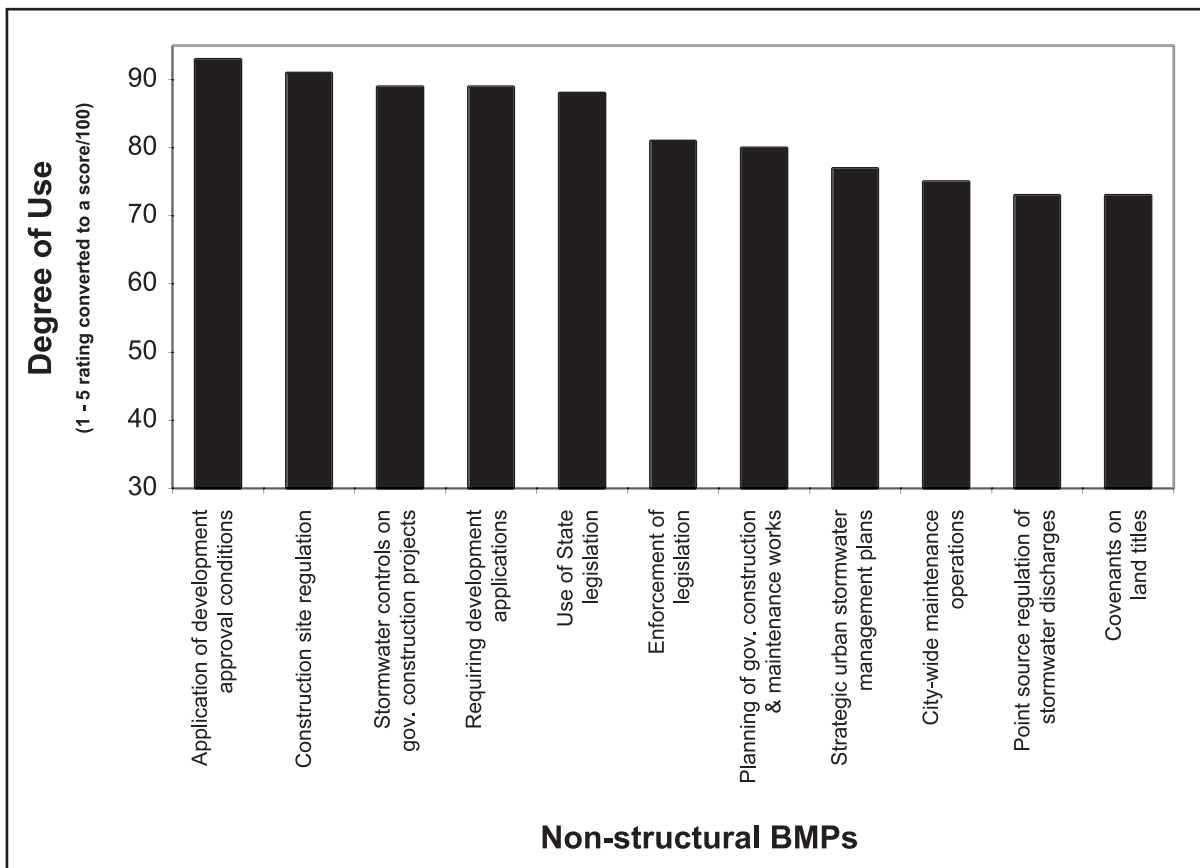 - two of the top eight BMPs relate to education and participation programs.

Figure 4.4   Most Frequently Used Non-structural BMPs in the US and NZ

Notes:
- For the 'degree of use' scale: 0 = Not used, 25 = Low degree of use, 50 = Low-medium degree of use, 75 = Medium-high degree of use, 100 = High degree of use.
- Only the top 10 BMPs (and those with an equal score to the tenth highest ranked BMP) have been presented in this graph. For information on the remaining BMPs, see the data presented in Appendix B.
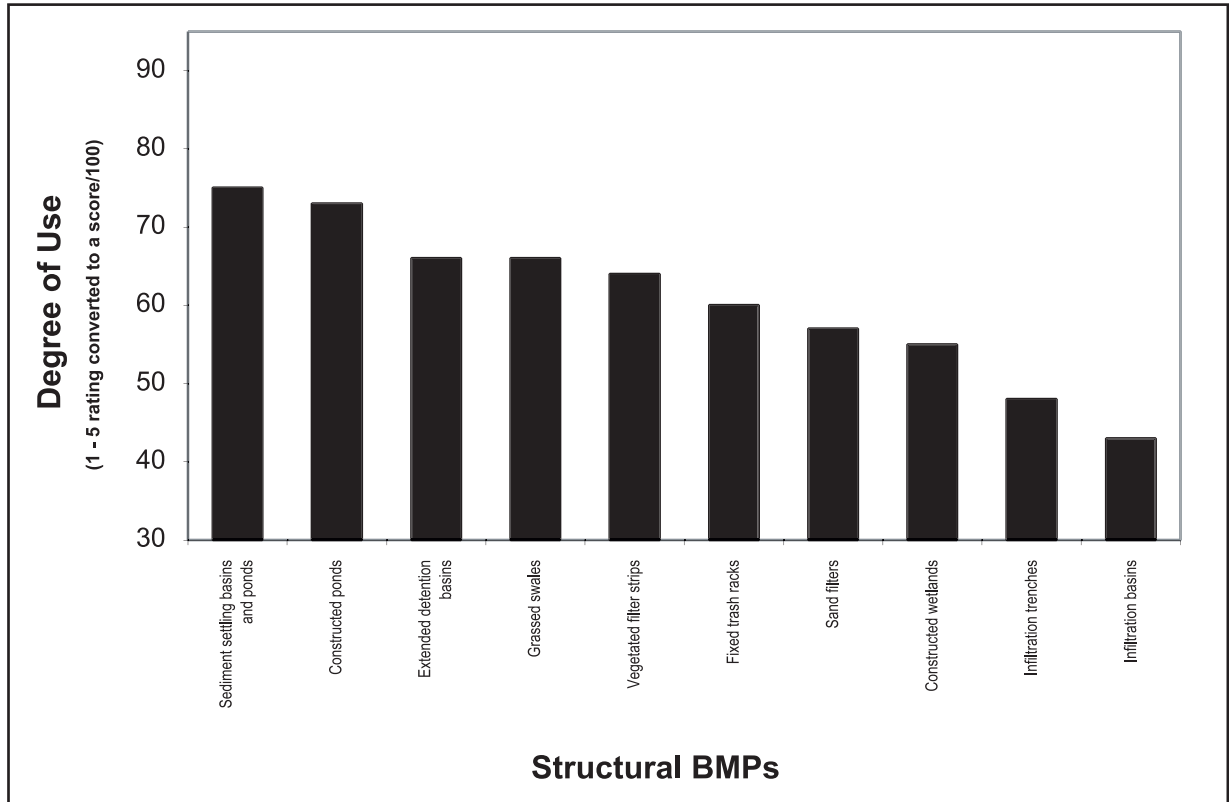
Figure 4.5   Most Frequently Used Structural BMPs in the US and NZ

Notes:

• Only the top 10 BMPs have been presented in this graph. For information on the remaining BMPs, see the data presented in Appendix B.

• For the 'degree of use' scale: 0 = Not used, 25 = Low degree of use, 50 = Low-medium degree of use, 75 = Medium-high degree of use, 100 = High degree of use.
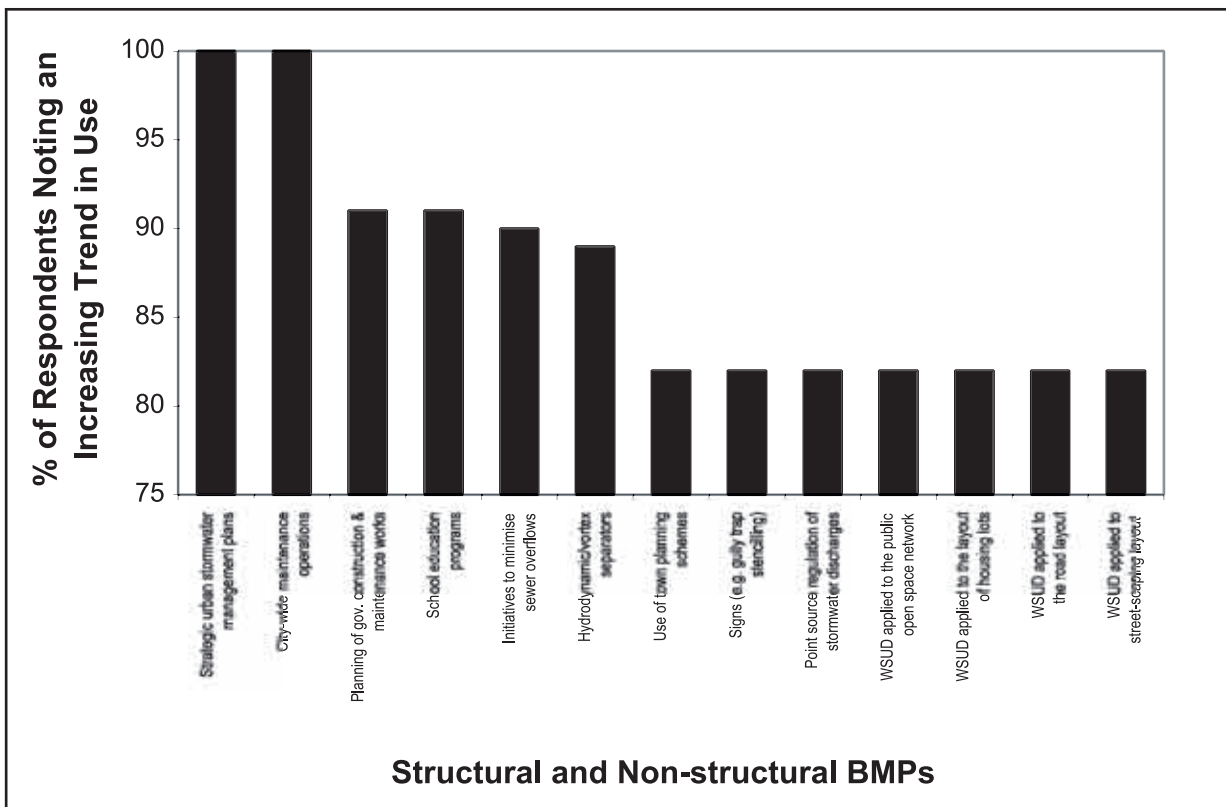

Figure 4.6   BMPs That Are Most Widely Increasing in Use Within the US and NZ

Some information is also available from the literature on BMP use by municipalities (local government). For example, Lehner *et al.* (1999) reported on two 1998 studies that examined the use of stormwater BMPs by US municipalities. One study involved coastal communities in the US, while the other involved municipalities in the New York and Connecticut region. The data from these findings are presented in Figure 4.7.

From the data in Figure 4.7, it is apparent that:

- Of the seven BMPs reported as being used by both surveys, four relate to municipal pollution prevention procedures (e.g. municipal employee training, street sweeping, used oil collections, septic system maintenance) and two relate to education programs (e.g. public education on stormwater management and stormwater drain stencilling).
- There is little consistency in the findings of the two surveys (e.g. of the 15 BMPs listed only seven are recorded as being used by municipalities in both of the surveys). This may however, be a consequence of the survey design.

4.3 Funding profiles of leading stormwater management agencies

Perhaps the most challenging and fundamental question facing urban stormwater quality managers in government agencies is: "How should I spend the City's stormwater quality budget to maximise the positive outcomes for the community and the region's waterways?"

Gaps exist in our understanding of the value of various BMPs, especially in relation to their pollutant removal efficiencies and life-cycle costs. While research is being undertaken to fill some of these gaps, the above question must be answered in a climate of uncertainty.

One useful source of information for urban stormwater quality managers is the experience of stormwater management agencies with relatively high levels of success in this area. The way such agencies structure their urban stormwater quality management programs and allocate funding can be used as a guide to current best practice.

This section summarises how a variety of leading stormwater management agencies allocate funds to core elements of their stormwater quality management programs. It includes information from overseas and Australian agencies.

Tables 4.1 and 4.2 provide funding profiles for nine leading Australian and overseas agencies (including details of their function and size), which can be used for benchmarking purposes. Funding information for Australian and overseas agencies has been provided because:

- The leading Australian agencies provide a benchmark that is perhaps more relevant in the short-medium term for Australian agencies starting to establish strategic and on-going urban stormwater quality management programs. In addition, some of the work being conducted by Australian stormwater quality agencies is world's best practice.

- The leading US stormwater quality management agencies operate within a regulatory framework that sets, in the opinion of the Author, standards that are higher than any regulatory regime in Australia and significantly higher than five of the six Australian States. One could argue such a standard of environmental protection is not currently justified for urban stormwater management in Australia, given the other issues competing for public funds. Given this argument, information on the relative distribution of funds across program elements is likely to be of more value to Australian agencies than the absolute quantum of funding.

The typical *relative* distribution of stormwater quality management funds spent on various activities (e.g. structural BMP maintenance, stormwater quality monitoring) are presented in Table 4.3 for six leading stormwater management agencies with similar functions. The most significant finding from these data is that Australian stormwater management agencies managing minor and major/trunk stormwater drainage spend proportionally more on *constructing* structural BMPs compared to US agencies with similar roles. For example, Brisbane City Council, Blacktown City Council, Hornsby Shire Council and the City of Salisbury spend on average 30.6% of their
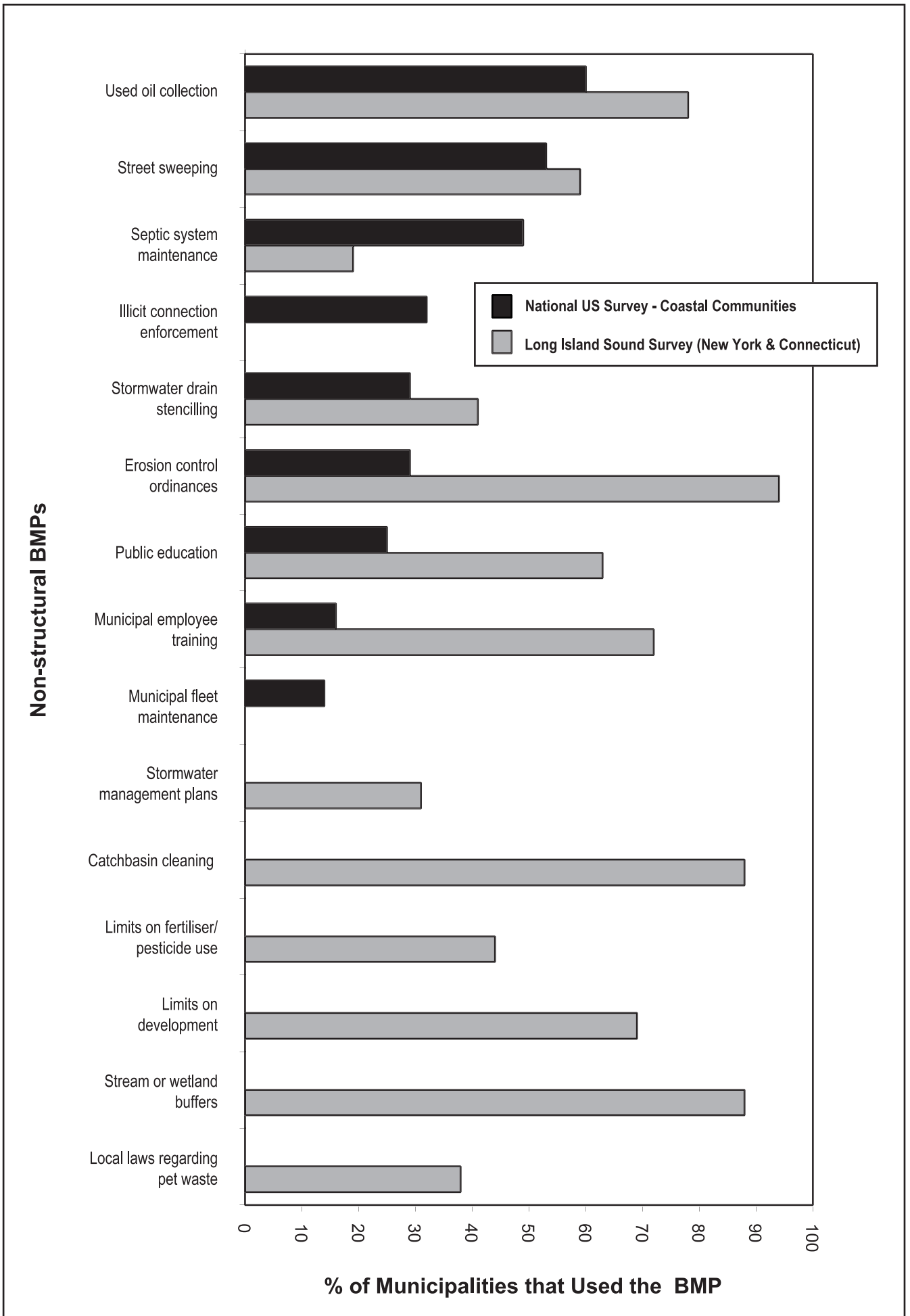
Figure 4.7   Stormwater Management BMPs Used by US Municipalities (two 1998 surveys reported in Lehner *et al.,* 1999)

Table 4.1   Funding Profiles for Leading Australian Stormwater Quality Management Agencies

		ESTIMATED EXPENDITURE PER ANNUM (AUD$)					
		MELBOURNE WATER, VICTORIA	**NSW EPA, NEW SOUTH WALES***	**BRISBANE CITY COUNCIL, QUEENSLAND**	**BLACKTOWN CITY COUNCIL, NEW SOUTH WALES**	**HORNSBY SHIRE COUNCIL, NEW SOUTH WALES**	**CITY OF SALISBURY, SOUTH AUSTRALIA**
TYPE OF AGENCY		Agency responsible for city-wide trunk/ main urban stormwater drainage	Agency responsible for State-wide stormwater quality policy	Large local authority responsible for minor and trunk/ main urban stormwater drainage in a city	Medium sized local authority responsible for minor and trunk/ main urban stormwater drainage in a city (except for one area of trunk drainage)	Medium sized local authority responsible for minor and trunk/main urban stormwater drainage in a city	Medium sized local authority responsible for minor and trunk/ main urban stormwater drainage in a city
POPULATION FOR WHICH THE FUNDING APPLIES		3.14M (metropolitan Melbourne)	4.88M (metropolitan Sydney and the urbanised coastal areas of NSW)	864,000	240,000	140,000	108,000
CATEGORIES OF URBAN STORMWATER QUALITY MANAGEMENT ACTIVITIES	Structural measures (gross pollutant traps, wetlands, ponds, etc.) - capital/ construction costs	$3M	11.3M (includes staffing costs)	$2M	$180,000	$1.47M	$1.5M
	Structural measures - recurrent maintenance costs	$80,000	Not applicable	$415,000	$160,000	$150,000	$250,000
	Stormwater quality related monitoring, evaluation and research	$120,000	$51,000	$400,000	$90,000	$90,000	$70,000
	Non-structural measures:						
	• Work on planning and regulatory mechanisms	$70,000	Minimal	$140,000	$80,000	$480,000	Minimal
	• Work on promoting the 'water sensitive urban design/low impact development philosophy'	$180,000	$1.34M (includes staffing costs)	$70,000	$15,000	Minimal	$30,000
	• Stormwater management activities associated with construction and maintenance works (incl. street sweeping, drain desilting, collection of waste and litter from public areas, erosion and sediment control)	$600,000	$206,000 (includes staffing costs)	$2.07M	$600,000	$1.766M	$1M
	• Education programs and campaigns	$1M	$4.22M (includes staffing costs)	$35,000	$60,000	Minimal	$30,000
	• Point source regulation (e.g. licensing and inspecting small-medium industry)	Not applicable	$515,000 (includes staffing costs)	$70,000	$120,000	$390,000	$30,000
	• Enforcement programs	Not applicable	Included in the 'Point source regulation' figure	$350,000	$80,000	$80,000	Not applicable
	• Technical training and guideline development	$40,000	Minimal	$35,000	$20,000	Included in 'education' above	Not applicable
	• Initiatives to minimise sewer overflows (separate stormwater and sewerage networks)	$4M	Not applicable (managed by Sydney Water)	$2.21M	$5,000 (managed by Sydney Water)	Not applicable (managed by Sydney Water)	Not applicable
	Other major items of expenditure:	Emergency response = $250,000	-	-	-	Support for community projects = $21,000	-
TOTAL (approximate only)		**$9.34M (approx $2.98/person)**	**$17.63M (approx $3.62/person)**	**$7.80M (approx $9.03/person)**	**$1.41M (approx $5.89/person)**	**$4.53M (approx $32.34/person)**	**$2.91M (approx $26.83/person)**

Note:
• Figures from Phase 1 of the NSW EPA's Stormwater Trust funding (circa 1998-99). Current expenditure (on later phases) shows a relative increase in funding research and non-structural elements (Barter, 2002; Taylor and McManus, 2002).

Table 4.2   Funding Profiles for Some Leading Overseas Stormwater Quality Management Agencies

CATEGORIES OF URBAN STORMWATER QUALITY MANAGEMENT ACTIVITIES	ESTIMATED EXPENDITURE PER ANNUM		
	CITY OF ORLANDO, FLORIDA	CITY OF AUSTIN, TEXAS	AUCKLAND REGIONAL COUNCIL, NEW ZEALAND
TYPE OF AGENCY	Medium sized agency responsible for minor and trunk/main urban stormwater drainage in a city	Large agency responsible for minor and trunk/main urban stormwater drainage in a city	A large regional authority responsible for stormwater quality management initiatives such as regulation and education, but not responsible for asset management
POPULATION FOR WHICH THE FUNDING APPLIES	185,915	656,562	1.2M
Structural measures (gross pollutant traps, wetlands, ponds, etc.) - capital/construction costs	US$2M	US$850,000	NZ$0 (the Auckland Regional Council is a regulator)
Structural measures - recurrent maintenance costs	US$3.3M	US$400,000	NZ$0
Stormwater quality related monitoring, evaluation and research	US$150,000	US$1.7M	NZ$800,000
Non-structural measures:			
• Work on planning and regulatory mechanisms	US$150,000	US$250,000	NZ$235,000
• Work on promoting the 'water sensitive urban design/low impact development philosophy'	US$150,000	US$0	NZ$50,000
• Stormwater management activities associated with construction and maintenance works (incl. street sweeping, drain desilting, collection of waste and litter from public areas, erosion and sediment control)	US$2.3M	US$5.25M	Minor
• Education programs and campaigns	US$250,000	US$400,000	NZ$120,000
• Point source regulation (e.g. licensing and inspecting small-medium industry)	US$50,000	US$500,000	NZ$2M
• Enforcement programs	US$310,000	US$6.9M	NZ$190,000
• Technical training and guideline development	US$25,000	US$100,000	NZ$65,000
• Initiatives to minimise sewer overflows (separate stormwater and sewerage networks)	Not applicable	Data not available.	NZ$500,000
Other major items of expenditure:	-	Water pollution detection, tracking and forecasting = US$850,000	-
TOTAL (approximate only)	**US$8.59M (approx AUD$16.46M, or AUD$88.51/person)***	**US$17.2M (approx AUD$33.52M, or AUD$51.06/person)***	**NZ$3.96M (approx AUD$5.43M, or AUD$4.53/person)***

Note:

* Exchange rates at 18 February 2002 were used to convert currency (i.e. AUD$1 = US$0.522 or NZ$1.3755).

Source: Information supplied by the listed agencies as part of this project's survey.

annual stormwater quality management budgets on constructing structural BMPs (e.g. regional wetlands and gross pollutant traps). The equivalent figure for the City of Orlando and the City of Austin is 14.1% (i.e. less than half of that spent by Australian agencies).

Although the surveyed US agencies appear to spend a smaller portion of their budget on capital works, they spend a larger portion on maintenance of structural BMPs (on average), and spend approximately the same percentage on city-wide non-structural BMPs.[6] The increased maintenance burden for the City of Orlando is especially noticeable as it is 38% of their total stormwater quality budget. This is likely to reflect the longevity of Orlando's program (i.e. over 20 years old) compared to those in Australia.

Table 4.3   Relative Distribution of Stormwater Quality Management Funds by Leading Stormwater Management Agencies

CATEGORIES OF URBAN STORMWATER QUALITY MANAGEMENT ACTIVITIES	PERCENTAGE OF TYPICAL ANNUAL STORMWATER QUALITY MANAGEMENT EXPENDITURE (%)					
	BRISBANE CITY COUNCIL, QUEENSLAND	BLACKTOWN CITY COUNCIL, NEW SOUTH WALES	HORNSBY SHIRE COUNCIL, NEW SOUTH WALES	CITY OF SALISBURY, SOUTH AUSTRALIA	CITY OF ORLANDO, FLORIDA	CITY OF AUSTIN, TEXAS
Structural measures (gross pollutant traps, wetlands, ponds, etc.) - capital/construction costs	25.6	12.8	32.5	51.5	23.3	4.9
Structural measures - recurrent maintenance costs	5.3	11.3	3.3	8.6	38.4	2.3
Stormwater quality related monitoring, evaluation and research	5.1	6.4	2.0	2.4	1.8	9.9
Non-structural measures:						
• Work on planning and regulatory mechanisms	1.8	5.7	10.6	Minimal	1.8	1.5
• Work on promoting the 'water sensitive urban design/low impact development philosophy'	0.9	1.1	Minimal	1.0	1.8	0.0
• Stormwater management activities associated with construction and maintenance works (incl. street sweeping, drain desilting, collection of waste and litter from public areas, erosion and sediment control)	26.5	42.6	39.0	34.4	26.8	30.5
• Education programs and campaigns	0.4	4.2	Minimal	1.0	2.9	2.3
• Point source regulation (e.g. licensing and inspecting small-medium industry)	0.9	8.5	8.6	1.0	0.5	2.9
• Enforcement programs	4.5	5.7	1.8	Not applicable	3.6	40.0
• Technical training and guideline development	0.4	1.4	Included in 'education'	Not applicable	0.3	0.6
• Initiatives to minimise sewer overflows (separate stormwater and sewerage networks)	28.3	0.4	Not applicable	Not applicable	Not applicable	Not applicable

Note:

* These six agencies are responsible for all minor and major/trunk stormwater drainage (with the exception of Blacktown City Council, where one area of the City's trunk drainage is managed by Sydney Water).

Source: Information supplied by the listed agencies as part of this project's survey.

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[6]   For comments relating to funding profiles in this report, the 'non-structural budget' of stormwater quality management agencies does not include costs associated with construction or maintenance of structural BMPs. While *manipulation* of structural BMP maintenance regimes can be classed as a non-structural BMP, maintenance costs associated with structural BMPs have been excluded from the 'non-structural' budget as they are an integral part of the life-cycle cost of structural BMPs.

In terms of *absolute* funding allocated to stormwater quality management, the data in Tables 4.1 and 4.2 broadly indicate that for stormwater management agencies managing minor and major/trunk drainage:

• total expenditure (AUD$ per capita per year) for four leading Australian agencies ranges from $5.89 to $32.34 and averages $18.52;

• non-structural expenditure (AUD$ per capita per year) for four leading Australian agencies ranges from $4.46 to $20.19 and averages $10.41 (56% of the average total);

• total expenditure (AUD$ per capita per year) for two leading overseas agencies[7] ranges from $51.06 to $88.51 and averages $69.79[8]; and

• non-structural expenditure (AUD$ per capita per year) for two leading overseas agencies ranges from $34.89 to $46.54 and averages $40.72 (58% of the average total).[9]

These figures can be compared with US estimates by Reese (2000) on the costs associated with typical city-wide urban stormwater quality programs (as discussed in Technical Report No. 3 in this series, CRC for Catchment Hydrology Report 02/13). These estimates:

• did not include costs associated with publicly funded structural BMPs; and

• ranged from US$1 to US$11 per capita per year for towns with a population of 10,000 to 50,000 (approximately AUD$1.92 to AUD$21.07).

The average expenditure of four leading Australian agencies on non-structural elements of their stormwater quality programs (i.e. AUD$10.41 per capita per year) is within the range reported in the literature by Reese (2000). However, the average expenditure of two leading US agencies on non-structural elements of their stormwater quality programs (i.e. AUD$40.72 per capita per year) is well above this range. This may reflect their status as leading agencies, that is, they dedicate substantially more resources (per capita) to this issue than most agencies in the US.

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[7] Only two of the three leading overseas agencies were included in this analysis, as the Auckland Regional Council is primarily a regulator rather than a management agency for minor and/or major trunk drainage.

[8] A currency conversion rate of US$1 = AUD$0.522 was adopted.

[9] Note that costs associated with construction and maintenance of structural BMPs have been excluded from the non-structural budget.

5.   Results - The Relative Value of Non-structural BMPs

Finnemore and Lynard (1982) suggested that, as the effectiveness of non-structural BMPs for stormwater quality management is not well documented, their value can be "best determined by intuitive judgment" (p. 108). Using this approach, we gathered information on the *perceived* value of non-structural BMPs from 36 urban stormwater management agencies in Australia and overseas as a part of our survey. The resulting data reflects the surveyed managers' intuitive judgment and draws on a large amount of collective knowledge and experience.

Surveyed stormwater managers from Australia, the US and NZ were asked to score the "perceived effectiveness, efficiency and practicality" of 41 non-structural BMPs from 1 ("low") to 5 ("high"). Table 5.1 separately lists the 10 highest scoring non-structural BMPs from the Australian and overseas survey data. Equivalent scores for all 41 non-structural BMPs included in the survey are provided in Appendix B.

The data in Table 5.1 indicates that:

*   Eight BMPs are common to the 'top 10 lists' for Australian and overseas stormwater managers:

    1. **Planning and regulatory measures:** requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality.

    2. **Planning and regulatory measures:** development of urban stormwater management plans for the city, shire, or catchment for improved urban stormwater quality and protection of urban aquatic ecosystems.

    3. **Source control measures - construction and maintenance:** stormwater quality management addressed in construction activities undertaken by municipalities or State agencies.

    4. **Source control measures - construction and maintenance:** stormwater quality addressed in a wide variety of maintenance operations.

    5. **Planning and regulatory measures:** implementing stormwater quality improvement policy in town/city planning schemes.

    6. **Planning and regulatory measures:** application of development approval/permit conditions.

    7. **Source control measures - construction and maintenance:** stormwater quality addressed in the planning of government-managed construction and maintenance works.

    8. **Source control measures - enforcement:** point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry).[10]

*   Collectively, the surveyed overseas stormwater managers more strongly emphasised the value of BMPs involving enforcement, regulation and improved construction and maintenance practices, compared to their Australian counterparts.

*   Collectively, the surveyed Australian stormwater managers more strongly emphasised the value of BMPs involving planning controls and site-based WSUD elements, compared to their overseas counterparts.

It is suggested that the main differences between the views of the Australian and overseas stormwater managers can be explained by the relative maturity of their programs. For example, embryonic erosion and sediment control programs typically focus on education and basic town planning controls, but as they mature, they usually develop stronger regulatory and enforcement elements.

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[10] These BMPs are listed in accordance with the average rankings of surveyed Australian stormwater managers, with the first BMP being the highest ranked.

Table 5.1   Perceived Effectiveness, Efficiency and Practicality of Non-structural BMPs

RANKING	AUSTRALIAN STORMWATER MANAGERS		OVERSEAS STORMWATER MANAGERS	
	NON-STRUCTURAL BMP	AVE SCORE (1 - 5)	NON-STRUCTURAL BMP	AVE SCORE (1 - 5)
1 (highest score)	**Planning and regulatory measures** Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	4.24	**Source control measures - construction and maintenance** Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies	4.88
2	**Planning and regulatory measures** Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems [equal]	4	**Source control measures - construction and maintenance** Stormwater quality addressed in the planning of government-managed construction and maintenance works [equal]	4.75
	Source control measures - construction and maintenance Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies [equal]	4	**Source control measures - construction and maintenance** Stormwater quality addressed in a wide variety of maintenance operations [equal]	4.75
	Source control measures - construction and maintenance Stormwater quality addressed in a wide variety of maintenance operations [equal]	4		
3	**Planning and regulatory measures** Implementing stormwater quality improvement policy in town/city planning schemes	3.95	**Planning and regulatory measures** Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	4.7
4	**Source control measures - miscellaneous** Stormwater quality management addressed in staff training for government and private sector staff	3.86	**Source control measures - enforcement** Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	4.67
5	**Planning and regulatory measures** Application of development approval/ permit conditions	3.85	**Source control measures - construction and maintenance** Stormwater quality management addressed in construction activities regulated by municipalities or State agencies	4.56
6	**Water sensitive urban design (WSUD) measures for new development** WSUD applied to public open space networks	3.71	**Planning and regulatory measures** Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	4.4
7	**WSUD measures for new development** WSUD applied to the road layout for residential areas [equal]	3.68	**Planning and regulatory measures** Application of development approval/permit conditions [equal]	4.33
	Source control measures - construction and maintenance Stormwater quality addressed in the planning of government-managed construction and maintenance works [equal]	3.68	**Source control measures - enforcement** Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry) [equal]	4.33
	Source control measures - education programs Media campaigns (e.g. radio, TV) [equal]	3.68		
8	**Source control measures - enforcement** Point source regulation of stormwater discharges (e.g. licensing and inspecting/ auditing industry)	3.67	**Source control measures - miscellaneous** Initiatives to minimise sewer overflows (where the sewerage and stormwater drainage are separated)	4.29
9	**WSUD measures for new development** WSUD applied to street-scaping layout of residential areas	3.57	**Source control measures - miscellaneous** Emergency response activities	4.22
10	**WSUD measures for new development** WSUD applied to on-site detention for large commercial/industrial areas [equal]	3.55	**Planning and regulatory measures** Implementing stormwater quality improvement policy in Town/City planning schemes	4.2
	WSUD measures for new development Stormwater (and/or shallow groundwater) recycling undertaken* [equal]	3.55		

Notes:
• *Could be considered a structural BMP.
• See Appendix B for average scores for all 41 non-structural BMPs that were listed in the survey.

Source: Stormwater managers surveyed as part of this project.

We short-listed the non-structural BMPs most worthy of thorough evaluation in field trials. To do this, we gathered information from Australian and overseas stormwater managers on:

1. Perceptions of the effectiveness, efficiency and practicality of 41 non-structural BMPs (i.e. the data described above).

2. Views on the most promising non-structural BMPs for future use in their region.

3. Views on the degree to which these non-structural BMPs were being used in their regions.

4. Views on trends in the use of these non-structural BMPs in their regions (e.g. whether they were increasing in use).

These four attributes were considered appropriate, as BMP performance evaluation should *ideally* focus on the BMPs likely to be the most efficient, cost-effective and practical, and those:

• currently being widely used;

• likely to be used in future (given the management environment in which they would have to operate); and

• increasing in use.

As explained in Section 3.2, a Value Utility Function was developed to combine the above attributes into a relative Value Score for each non-structural BMP. Appendix B lists the Value Scores for each of the 41 non-structural BMPs included in the survey.

Using the derived Value Scores, we short-listed the top 10 non-structural BMPs considered most worthy of detailed field evaluation based on the data provided by Australian and overseas stormwater managers. The short-list is provided in Table 5.2.

The BMPs rankings presented in Table 5.2 indicate that four non-structural BMPs rank highly regardless of whether the scores are calculated using data from Australian or overseas stormwater quality managers. They were:

1. **Planning and regulatory measures:** requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality. (Ranked the highest when the Value Scores derived separately from the Australian and overseas data are added).

2. **Source control measures - construction and maintenance:** stormwater quality addressed in a wide variety of maintenance operations (e.g. stormwater drain maintenance, maintenance regimes for structural BMPs, street sweeping, etc.).

3. **Planning and regulatory measures:** development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems.

4. **Planning and regulatory measures:** implementing stormwater quality improvement policy in town/city planning schemes (closely related to the highest ranked BMP).

Three of these BMPs relate to planning. One is a strategic planning control (i.e. the use of city-wide stormwater management plans), while the other two relate to town planning controls on development.

Added to Table 5.2 is a ranking of those non-structural BMPs deemed most worthy of evaluation based on the Author's opinion after undertaking a major international literature review involving approximately 200 references (see Technical Report No. 3 in this series, CRC for Catchment Hydrology Report 02/13). This opinion also draws on practical experience as a former stormwater quality manager for Australia's largest local government authority. Of the four top-ranked BMPs listed above (based on Australian or overseas data), the three planning-related BMPs were ranked by the Author as being of the highest value.

Table 5.2   A Short-list of Those Non-structural BMPs Deemed to be Most Worthy of Evaluation in Field Trials

NON-STRUCTURAL BEST MANAGEMENT PRACTICES (BMPs)	RANKING OF TOP 10 BMPs[1] [VALUE SCORE GIVEN IN SQUARE BRACKETS]		
	AUSTRALIAN SURVEY DATA[2]	US AND NZ SURVEY DATA[2]	AUTHOR'S VIEW (1 - 10 RANKING ONLY)
Planning and regulatory measures: Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	1 [83]	2 (equal) [88]	1 (equal)
Planning and regulatory measures: Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	4 [73]	1 [90]	2
Planning and regulatory measures: Implementing stormwater quality improvement policy in town/city planning schemes	3 [75]	4 (equal) [81]	1 (equal)
Source control measures: construction and maintenance Stormwater quality addressed in a wide variety of maintenance operations (e.g. structural BMP, drain and road maintenance)	2 [76]	2 (equal) [88]	8
Source control measures: construction and maintenanceStormwater quality management addressed in construction activities undertaken by municipalities or State agencies	6 [71]	6 (equal) [77]	9
Planning and regulatory measures: Application of development approval/permit conditions	8 [63]	6 (equal) [77]	6
Source control measures: construction and maintenanceStormwater quality management addressed in construction activities regulated by municipalities or State agencies	9 [65]	7 [74]	4 (equal)
Source control measures: enforcement Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	-	4 (equal) [81]	5
Source control measures: miscellaneous Initiatives to minimise sewer overflows (assuming the sewerage and stormwater drainage are separated) - includes illegal discharge elimination programs.	-	5 [80]	3
Source control measures: education programs Media campaigns (e.g. radio, TV)	10 [60]	-	-
Source control measures: construction and maintenance Stormwater quality addressed in the planning of government-managed construction and maintenance works	-	3 [87]	-
Source control measures: enforcement Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	-	-	4 (equal)
Source control measures: miscellaneous Stormwater quality management addressed in staff training for government and private sector staff	5 [72]	-	-
Water sensitive urban design (WSUD) measures for new development: WSUD applied to public open space networks	7 [69]	-	-
Source control measures: education programs Community programs (e.g. the US 'Master Gardeners' programs)	-	-	7
Source control measures: education programs School education programs	-	8 [72]	-
Water sensitive urban design (WSUD) measures for new development: WSUD applied to the layout of residential housing lots	-	9 [71]	-
Source control measures: education programs Business/ industry programs	-	-	10
Source control measures: miscellaneous Emergency response activities	-	10 [70]	-

Notes:

1.   '1' is the highest ranking (i.e. the BMP deemed most worthy of evaluation).

2.   The Value Utility function used for ranking data from the survey of Australian, US and NZ stormwater quality managers is explained in Section 3.2.

•   '-' = not ranked in the top 10.

•   Value Scores for all 41 non-structural BMPs are given in Appendix B.

6. Summary and Conclusions

This technical report presents information obtained primarily from a survey of 36 managers from around Australia, NZ and the US who are responsible for the improvement of urban stormwater quality. It is part of a series of four reports from a project that focuses on the use, value, life-cycle cost and evaluation of non-structural best management practices (BMPs) for improved urban stormwater quality and waterway health.

This technical report seeks to assist urban stormwater managers by providing:

- The results of the survey of stormwater managers, including information on:
    - the extent of BMP use and trends in BMP use for 70 practices (41 of which were non-structural); and
    - how leading stormwater management agencies allocate their funds to various aspects of urban stormwater quality management (e.g. capital works, maintenance, training, planning controls, etc.).
- A relative evaluation of the value of non-structural BMPs for stormwater quality improvement drawing upon information gathered from the:
    - survey of 25 Australian stormwater managers;
    - survey of 11 overseas stormwater managers; and
    - a literature review undertaken as part of our research project involving non-structural BMPs (see Technical Report No. 3, CRC for Catchment Hydrology Report 02/13).

The outcomes of this technical report should assist urban stormwater managers immediately. For example, stormwater managers can now use:

- the survey and literature review findings on the value and cost of non-structural BMPs to guide their decisions on the use of non-structural BMPs; and

- information on funding profiles of leading stormwater management agencies as benchmarks when developing or fine-tuning their urban stormwater management programs.

In the longer term, stormwater managers will also be able to use information gathered from well-designed monitoring and evaluation programs using the newly-developed evaluation framework and monitoring tools (see Report No. 4 in this series, CRC for Catchment Hydrology Working Document 02/6). The accumulation of reliable, high quality data sets on the benefits and cost of non-structural BMPs will enable a greater degree of analysis when considering urban stormwater management options and confidence in the resulting strategies.

Key findings from the survey of urban stormwater quality managers included:

Australian BMP use

Data from the survey of 25 stormwater managers from Australian agencies within five States and one Territory indicated that:

- The majority of BMPs included in the survey were associated with an increasing trend in use, particularly the non-structural variety. For example, the majority of respondents (>50%) reported an increasing trend in use for:
    - 76% of the 41 non-structural BMPs included in the survey (e.g. the use of town planning schemes and school education programs); and
    - 34% of the 29 structural BMPs included in the survey (e.g. grassed swales and vegetated filter strips).
- Three of the top four most frequently used non-structural BMPs are related to planning (i.e. strategic, city-wide planning of stormwater management and the use of town planning controls).
- Nine out of the top 11 BMPs associated with the most widespread trend of increasing use in Australia are non-structural. In addition, seven of the top 11 BMPs are closely related to the philosophy of site-based water sensitive urban design (WSUD).

Overseas BMP use

Data from the survey of 11 stormwater managers from agencies within the US and NZ indicated that:

- Compared to Australian data on current degree of use, there appears to be:

  - A more widespread trend of increasing use of stormwater BMPs, particularly the non-structural variety. For example, the majority of overseas respondents (>50%) reported an increasing trend in use for:

    - 90% of the 41 non-structural BMPs included in the survey (e.g. the use of strategic urban stormwater management plans and city-wide maintenance operations); and

    - 38% of the 29 structural BMPs included in the survey (e.g. hydrodynamic/vortex separators and porous pavements).

  - An increased use of non-structural BMPs in the US and NZ that relate to regulation.

  - A much higher degree of use of non-structural BMPs in general. For example, even the tenth most commonly used non-structural BMP in the US and NZ has a significantly higher degree of use than the most commonly used non-structural BMP in Australia.

- Eleven (11) out of the top 13 BMPs associated with the most widespread trend of increasing use within the US and NZ are non-structural. In addition:

  - Five of the top 13 BMPs are closely related to the philosophy of site-based WSUD (known as 'low impact development' overseas).

  - Three of the top five BMPs relate to operations carried out by local governments/municipalities.

Funding profiles for leading stormwater quality management agencies

We analysed the typical relative distribution of funding for various stormwater quality management activities and found that Australian stormwater management agencies responsible for minor and major/trunk drainage spend a far greater percentage of their total stormwater quality management budget on structural elements than their US counterparts (i.e. approximately 31% compared to 14%).

Although leading US stormwater management agencies appear to spend a smaller portion of their stormwater quality budget on capital works compared with their Australian counterparts, they spend a larger portion on maintenance of structural BMPs (on average) and spend approximately the same percentage on city-wide non-structural BMPs.

On average, leading Australian stormwater management agencies responsible for minor and major/trunk drainage spend approximately 56% of their total stormwater quality management budget on non-structural measures (i.e. AUD$10.56 of AUD$18.52 per person per year, on average).

In terms of absolute funding allocated to stormwater quality management in agencies responsible for minor and major/trunk drainage, compared to equivalent Australian agencies leading US agencies that were surveyed spend approximately:

- 3.8 times as much (per capita) on stormwater quality management (in total); and

- 3.9 times as much (per capita) on the non-structural elements of their programs.

The relative value of non-structural BMPs

To determine those non-structural BMPs most worthy of use in the short-term and thorough evaluation in field trials, we assessed and ranked the relative value of 41 non-structural BMPs by:

1. Using data from the survey of 36 stormwater managers within Australia, NZ and the US on their perceptions of each BMP's "effectiveness, efficiency and practicality", drawing upon an impressive resource of collective knowledge and experience in a wide variety of contexts.

2. Using a Value Utility Function that assigns a relative Value Score to each BMP, drawing on data collected via the survey of stormwater managers. The Value Utility Function incorporates four attributes (i.e. the current degree of BMP use, the trends in use, the degree of promise for future use and perceptions of effectiveness, efficiency, and

practicality), and incorporates weightings for each attribute. Also, we performed a sensitivity analysis to ensure the final ranking of BMPs was not overly sensitive to the chosen set of weightings.

3. The Author's opinion following a major international literature review on the beneficial effects and costs of non-structural BMPs for stormwater quality improvement, involving approximately 200 references (see Technical Report No. 3, CRC for Catchment Hydrology Report 02/13 for a summary of the findings of this review). This opinion also draws on practical experience as a former stormwater quality manager for Australia's largest local government authority.

Principal findings from these assessments were:

• The use of the three value assessment methods listed above produced five ranked sets of non-structural BMPs. Six BMPs were represented in the top 10 rankings of all five sets. These were:

  - Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality.

  - Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems.

  - Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies.

  - Stormwater quality addressed in a wide variety of maintenance operations.

  - Implementing stormwater quality improvement policy in town/city planning schemes.

  - Application of development approval/permit conditions.

• Collectively, the overseas stormwater managers emphasised the value of non-structural BMPs involving enforcement, regulation, and improved construction and maintenance practices, compared to their Australian counterparts.

• Collectively, the Australian stormwater managers emphasised the value of non-structural BMPs involving planning controls and site-based WSUD elements, compared to their overseas counterparts.

In conclusion, the survey has provided a snapshot of the use of BMPs for stormwater quality management in Australia in 2001-02 and how funding is allocated to core elements of major urban stormwater quality management programs. Similar data from a selected group of experienced urban stormwater managers from the US and NZ provides a useful indication of trends in BMP use and the allocation of funding that occurs as urban stormwater quality programs mature. Based on these results we conclude that non-structural stormwater quality BMPs are already playing a major role in urban stormwater quality improvement in Australia, are increasing in use, and will continue to do so if Australian programs mature in a similar way to those developed overseas.

Given these conclusions we suggest that urban stormwater management agencies in Australia should review the appropriateness of the relatively small amount of funding current allocated for undertaking high-quality research into the beneficial effects of non-structural BMPs for stormwater quality improvement.

7. Glossary of Key Terms and Acronyms

Bioretention System

A grassed or landscaped swale or basin promoting infiltration into the underlying medium. A perforated pipe collects the infiltrated water and conveys it downstream.

BMP

Best management practice - A device, practice or method for removing, reducing, retarding or preventing targeted stormwater run-off constituents, pollutants and contaminants from reaching receiving waters. Within the context of this report, BMPs primarily seek to manage stormwater quality to minimise impacts on waterway health.

BMP system

The BMP and any related stormwater the BMP is unable to manage. For example, a 'BMP system' may be a residential suburb over which a lawn fertilisation education program (BMP) is operating. The stormwater draining from this suburb may include some that is less polluted as a result of the BMP (e.g. runoff from lawns) and some that is not affected by the BMP (e.g. runoff from roads). A monitoring program may attempt to measure changes in stormwater quality as a result of the BMP. Such a program would be monitoring a 'BMP system'.

CRCCH

Cooperative Research Centre for Catchment Hydrology (Australia).

Effectiveness

In the context of non-structural BMP monitoring, effectiveness is a measure of how well a BMP system meets its goals for all stormwater flows reaching the area of coverage by the BMP.

Efficiency

In the context of non-structural BMP monitoring, efficiency is a measure of how well a BMP or BMP system removes or controls pollutants.

Evaluation

The final assessment of whether the non-structural BMP has achieved its pre-defined objectives and is usually based on some form of monitoring. However, unlike monitoring, evaluation involves an assessment of the project's success or failure.

Life-cycle cost

The total cost of the design, implementation, operation and maintenance of the BMP over its life span.

Low impact development (LID)

See water sensitive urban design (WSUD).

Monitoring

The gathering of information about a non-structural BMP over time and/or space. Monitoring may involve measuring or observing change and is often the raw material or data for evaluation.

Non-structural BMP

A range of pollution prevention practices that are designed to prevent or minimise pollutants from entering stormwater run-off and/or reduce the volume of stormwater requiring management. Unlike structural BMPs, they do not involve fixed, 'permanent' facilities, and they usually work by changing people's behaviour through government regulation (e.g. planning and environmental laws), persuasion, economic instruments and/or institutional arrangements (e.g. funding programs and specialist government agencies).

NSW EPA

New South Wales Environmental Protection Authority.

NZ

New Zealand.

Performance

In the context of non-structural BMP monitoring, performance is a measure of how well a BMP meets its goals for the stormwater it is designed to improve.

Stormwater utility

A utility established to generate a dedicated source of funding for stormwater pollution prevention activities where users pay a fee based on the land use and contribution of run-off to the stormwater system.

Structural BMP

Engineered devices implemented to control, treat, or prevent stormwater run-off pollution.

US

United States of America.

US EPA

United States Environment Protection Agency.

Value

The term 'value' is used in this report as a collective description of the benefits of non-structural BMPs, encompassing attributes such as their:

• ability to raise people's awareness, change their attitudes and/or change their behaviour;

• performance, effectiveness and efficiency with respect to stormwater quality improvement (as defined above); and

• ability to improve waterway health.

Value Score

A score (from 0 - 100) for the relative value of a non-structural BMP that is calculated using a Value Utility Function (see below) and a set of weightings for each of the four attributes included in the Function.

Value Utility Function

A simple mathematical function that uses data from a survey of stormwater managers to calculate a relative Value Score for non-structural BMPs. Specifically, the Value Utility Function incorporates four attributes (i.e. the current degree of BMP use, the trends in use, the degree of promise for future use, and perceptions of effectiveness, efficiency and practicality). In addition, the Function incorporates weightings for each of these four attributes to reflect their relative importance. The resulting scores are then normalised so that they range from 0 - 100. For the actual mathematic equation, see Section 3.2.

Water sensitive urban design (WSUD)

Water Sensitive Urban Design (also known as low impact development) - WSUD aims to minimise the impact of urbanisation on the natural water cycle. Its five key objectives for water management are:

• Protect natural systems.

• Integrate stormwater treatment into the landscape.

• Protect water quality.

• Reduce runoff and peak flows.

• Add value while minimising development costs.

8. References

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APPENDIX A
  Survey form used to obtain information
  from Australian urban stormwater quality managers

SURVEY OF URBAN STORMWATER QUALITY MANAGERS - AUSTRALIA

Introduction to the project

The Cooperative Research Centre for Catchment Hydrology has recently begun a project to evaluate the effectiveness of non-structural measures to improve urban stormwater quality (e.g. planning controls, education, enforcement of laws, etc.).

A component of the project is the development of monitoring protocols and an evaluation methodology for non-structural stormwater management measures. This component of the project is being is funded by the Victorian EPA and involves a *benchmarking study* of leading Australian and overseas stormwater managers to determine:

- Those stormwater management measures currently being used in urban areas (both non-structural and structural).
- Those non-structural stormwater quality management measures that are currently considered to be the most effective, efficient and practical, as well as those that are promising in this respect.
- Whether any attempts have been made to measure the performance and life-cycle costs of non-structural stormwater management measures.
- The approximate distribution of public funding to various stormwater management measures (in relative and absolute terms).

Please note that all findings of the project will be published, so that all stakeholders involved in the project will have the opportunity to use the results in future stormwater management activities.

Your assistance in completing the three (3) attached forms and returning them to myself within the timeframe provided would be *greatly* appreciated. My contact details are given below.

André Taylor
Research Fellow – Program 4
Cooperative Research Centre for Catchment Hydrology

November 2001

Contact details:
e-mail: andretaylor@iprimus.com.au
ph/fax: 08 9386 7565
Mail: PO Box 1151, West Perth BC, WA, 6872

FORM 1
Measures Used for Urban Stormwater Management in Your Area

Name of person completing the form: . . . .

Position held by person completing the form: . . . .

Geographic area for which you have knowledge: . . . .

Urban Stormwater Quality Management Measures	Are they currently being used in your region? (1 = not at all, 5 = widely used)						Is use increasing (!), decreasing (↓), or static (-)?		
	n/a	1	2	3	4	5	!	↓	-
Scoring / marking system	*Place a tick (✔) next to those you favour*						*Place a tick (✔) next to those you favour*		
NON-STRUCTURAL MEASURES									
Planning and regulatory measures									
Implementing stormwater quality improvement policy in town/city planning schemes	❑	❑	❑	❑	❑	❑	❑	❑	❑
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	❑	❑	❑	❑	❑	❑	❑	❑	❑
Application of development approval/permit conditions	❑	❑	❑	❑	❑	❑	❑	❑	❑
Using covenants on land titles to manage stormwater (e.g. for maintenance of on-site controls)	❑	❑	❑	❑	❑	❑	❑	❑	❑
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	❑	❑	❑	❑	❑	❑	❑	❑	❑
Implementation of State legislation setting out requirements for urban stormwater management	❑	❑	❑	❑	❑	❑	❑	❑	❑
Water sensitive urban design* (WSUD) measures for new development									
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	❑	❑	❑	❑	❑	❑	❑	❑	❑
WSUD applied to street scaping layout of residential areas	❑	❑	❑	❑	❑	❑	❑	❑	❑
WSUD applied to commercial/industrial parking areas	❑	❑	❑	❑	❑	❑	❑	❑	❑
WSUD applied to on-site detention for large commercial/industrial areas	❑	❑	❑	❑	❑	❑	❑	❑	❑
Stormwater (and/or shallow groundwater) recycling undertaken	❑	❑	❑	❑	❑	❑	❑	❑	❑
Development density manipulated to minimise inputs of key pollutants	❑	❑	❑	❑	❑	❑	❑	❑	❑
Soil amendment undertaken to minimise the export of nutrients	❑	❑	❑	❑	❑	❑	❑	❑	❑
Source control measures - construction and maintenance									
Stormwater management addressed in the planning of government-managed construction and maintenance works	❑	❑	❑	❑	❑	❑	❑	❑	❑
Stormwater management addressed in maintenance operations, for example: ▪ Street cleansing/sweeping ▪ Stormwater drain maintenance (incl. desilting) ▪ Domestic waste and recycling collection ▪ Council bin design, positioning and cleaning ▪ Road pavement repairs/resurfacing ▪ Unsealed road maintenance ▪ Maintenance of parks, reserves, golf courses, cemeteries, sports fields nurseries depots, road reserves, etc. ▪ Material storage ▪ Plant and equipment maintenance ▪ Maintenance of unloading and loading areas ▪ Building maintenance and construction ▪ Graffiti removal ▪ Swimming pool maintenance (incl. filter backwashing) ▪ Water main maintenance and construction ▪ Sewerage maintenance ▪ Bridge maintenance ▪ Maintenance of street lines/line marking ▪ Footpath maintenance	❑	❑	❑	❑	❑	❑	❑	❑	❑

Urban Stormwater Quality Management Measures	Are they currently being used in your region? (1 = not at all, 5 = widely used)						Is use increasing (!), decreasing (↓), or static (-)?		
	n/a	1	2	3	4	5	!	↓	-
Stormwater quality management addressed in construction activities *undertaken* by municipalities or State agencies, for example: ▪ Site planning ▪ Drainage, erosion and sediment control ▪ Inspection and maintenance of controls ▪ Management of building, storage and washing activities	❏	❏	❏	❏	❏	❏	❏	❏	❏
Stormwater quality management addressed in construction activities *regulated* by municipalities or State agencies, for example: ▪ Site planning ▪ Drainage, erosion and sediment control ▪ Inspection and maintenance of controls ▪ Management of building, storage and washing activities	❏	❏	❏	❏	❏	❏	❏	❏	❏
Source control measures - education programs									
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)	❏	❏	❏	❏	❏	❏	❏	❏	❏
Business programs (e.g. surveys, targeted workshops)	❏	❏	❏	❏	❏	❏	❏	❏	❏
School education programs	❏	❏	❏	❏	❏	❏	❏	❏	❏
Source control measures – point source regulation									
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	❏	❏	❏	❏	❏	❏	❏	❏	❏
Source control measures – enforcement									
Enforcement of State or local laws for point and diffuse sources of stormwater pollution	❏	❏	❏	❏	❏	❏	❏	❏	❏
Source control measures - miscellaneous									
Stormwater management addressed in staff training for local government, State government and private sector staff	❏	❏	❏	❏	❏	❏	❏	❏	❏
Management of pet/animal wastes in public open space	❏	❏	❏	❏	❏	❏	❏	❏	❏
Management of herbicide and pesticide usage	❏	❏	❏	❏	❏	❏	❏	❏	❏
Management of illegal dumping	❏	❏	❏	❏	❏	❏	❏	❏	❏
Emergency response activities	❏	❏	❏	❏	❏	❏	❏	❏	❏
Promoting the use of native plants (requiring little fertilisation)	❏	❏	❏	❏	❏	❏	❏	❏	❏
Management of washwaters from cars, boats, mobile industries, etc.	❏	❏	❏	❏	❏	❏	❏	❏	❏
Litter collection programs (e.g. litter collection boats, clean-up days)	❏	❏	❏	❏	❏	❏	❏	❏	❏
Initiatives to minimise sewer overflows	❏	❏	❏	❏	❏	❏	❏	❏	❏
STRUCTURAL MEASURES*									
Primary stormwater treatment									
Drainage entrance treatments:									
▪ Grate entrance systems on stormwater drains	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Side entry pit traps (i.e. litter baskets)	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Baffled pits (trapped street gullies)	❏	❏	❏	❏	❏	❏	❏	❏	❏
In-line methods:									
▪ Litter collection baskets	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Boom diversion systems	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Release nets	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Fixed trash racks	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Gross pollution traps (open or enclosed)	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Return flow litter baskets	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Hydraulically operated trash racks	❏	❏	❏	❏	❏	❏	❏	❏	❏

Urban Stormwater Quality Management Measures	Are they currently being used in your region? (1 = not at all, 5 = widely used)						Is use increasing (↑), decreasing (↓), or static (-)?		
	n/a	1	2	3	4	5	↑	↓	-
Self-cleaning screens:									
▪ Circular screens	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Downwardly inclined screens	❏	❏	❏	❏	❏	❏	❏	❏	❏
Floating traps:									
▪ Flexible floating booms	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Floating debris traps/trash racks	❏	❏	❏	❏	❏	❏	❏	❏	❏
Sediment traps:									
▪ Sediment settling basins and ponds	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Hydrodynamic separators (vortex separators)	❏	❏	❏	❏	❏	❏	❏	❏	❏
Sediment and oil separators:									
▪ Circular/cylindrical settling tanks	❏	❏	❏	❏	❏	❏	❏	❏	❏
Secondary stormwater treatment									
Pre-entrance treatments:									
▪ Filter strips	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Grass swales	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Triple interceptor pits (oil-grit separators)	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Porous pavements	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Infiltration trenches	❏	❏	❏	❏	❏	❏	❏	❏	❏
In-transit treatments:									
▪ Infiltration basins (promoting sedimentation)	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Extended detention basins	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Sand filters	❏	❏	❏	❏	❏	❏	❏	❏	❏
Tertiary stormwater treatment									
▪ Constructed wetlands	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Bioretention systems (infiltration systems with media to promote biofilms)	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Constructed ponds	❏	❏	❏	❏	❏	❏	❏	❏	❏
▪ Sand filters with an absorption capacity	❏	❏	❏	❏	❏	❏	❏	❏	❏

Note:
* For a description of water sensitive urban design and structural measures, see: Victorian Stormwater Committee (1999). *Urban Stormwater: Best Practice Environmental Management Guidelines*. CSIRO, Melbourne. Or ring André Taylor, ph. 08 9386 7565.

FORM 2
Non-structural Stormwater Quality Management Measures in Your Area

Name of person completing the form: ....

Non-structural measures	How would you rank these measures in terms of effectiveness, efficiency and practicality? (1 = low, 5 = high)						Which measures do you think have the most promise for future use in your area?	Has the performance and life-cycle cost of these measures been reliably determined in your area?	If monitoring has occurred, what were the indicators that were measured?	If monitoring has occurred, were monitoring protocols/ procedures developed?	Contacts for further information on monitoring
Scoring / marking system	?	1	2	3	4	5	*Place a tick (✓) next to those you favour*	*Place a tick (✓) next to the relevant measure*	*Note the indicators*	*Place a tick (✓) next to the relevant measure*	*Name, ph no./ e-mail*
Planning and regulatory measures											
Implementing stormwater quality improvement policy in town/city planning schemes	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Application of development approval/permit conditions	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Using covenants on land titles to manage stormwater (e.g. for maintenance of on-site controls)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Implementation of State legislation setting out requirements for urban stormwater management	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Water sensitive urban design (WSUD) measures for new development											
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	☐	☐	☐	☐	☐	☐	☐	☐		☐	
WSUD applied to street scaping layout of residential areas	☐	☐	☐	☐	☐	☐	☐	☐		☐	
WSUD applied to commercial/industrial parking areas	☐	☐	☐	☐	☐	☐	☐	☐		☐	
WSUD applied to on-site detention for large commercial/industrial areas	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Stormwater (and/or shallow groundwater) recycling undertaken	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Development density manipulated to minimise inputs of key pollutants	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Soil amendment undertaken to minimise the export of nutrients	☐	☐	☐	☐	☐	☐	☐	☐		☐	

Non-structural measures	How would you rank these measures in terms of effectiveness, efficiency and practicality? (1 = low, 5 = high)						Which measures do you think have the most promise for future use in your area?	Has the performance and life-cycle cost of these measures been reliably determined in your area?	If monitoring has occurred, what were the indicators that were measured?	If monitoring has occurred, were monitoring protocols/ procedures developed?	Contacts for further information on monitoring
Scoring / marking system	*?*	*1*	*2*	*3*	*4*	*5*	*Place a tick (✓) next to those you favour*	*Place a tick (✓) next to the relevant measure*	*Note the indicators*	*Place a tick (✓) next to the relevant measure*	*Name, ph no./ e-mail*
Source control measures - construction and maintenance											
Stormwater management addressed in the planning of government-managed construction and maintenance works	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Stormwater management addressed in maintenance operations, for example: ▪ Street cleansing/sweeping ▪ Stormwater drain maintenance (incl. desilting) ▪ Domestic waste and recycling collection ▪ Council bin design, positioning and cleaning ▪ Road pavement repairs/resurfacing ▪ Unsealed road maintenance ▪ Maintenance of parks, reserves, golf courses, cemeteries, sports fields nurseries depots, road reserves, etc. ▪ Material storage ▪ Plant and equipment maintenance ▪ Maintenance of unloading and loading areas ▪ Building maintenance and construction ▪ Graffiti removal ▪ Swimming pool maintenance (incl. filter backwashing) ▪ Water main maintenance and construction ▪ Sewerage maintenance ▪ Bridge maintenance ▪ Maintenance of street lines/line marking ▪ Footpath maintenance	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Stormwater quality management addressed in construction activities *undertaken* by municipalities or State agencies, for example: ▪ Site planning ▪ Drainage, erosion and sediment control ▪ Inspection and maintenance of controls ▪ Management of building, storage and washing activities	☐	☐	☐	☐	☐	☐	☐	☐			
Stormwater quality management addressed in construction activities *regulated* by municipalities or State agencies, for example: ▪ Site planning ▪ Drainage, erosion and sediment control ▪ Inspection and maintenance of controls ▪ Management of building, storage and washing activities	☐	☐	☐	☐	☐	☐	☐	☐			

Non-structural measures	How would you rank these measures in terms of effectiveness, efficiency and practicality? (1 = low, 5 = high)						Which measures do you think have the most promise for future use in your area?	Has the performance and life-cycle cost of these measures been reliably determined in your area?	If monitoring has occurred, what were the indicators that were measured?	If monitoring has occurred, were monitoring protocols/procedures developed?	Contacts for further information on monitoring
Scoring / marking system	?	1	2	3	4	5	Place a tick (✓) next to those you favour	Place a tick (✓) next to the relevant measure	Note the indicators	Place a tick (✓) next to the relevant measure	Name, ph no./e-mail
Source control measures - education programs											
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)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Business programs (e.g. surveys, targeted workshops)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
School education programs	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Source control measures – point source regulation											
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Source control measures – enforcement											
Enforcement of State or local laws for point and diffuse sources of stormwater pollution	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Source control measures - miscellaneous											
Stormwater management addressed in staff training for local government, State government and private sector staff	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Management of pet/animal wastes in public open space	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Management of herbicide and pesticide usage	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Management of illegal dumping	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Emergency response activities	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Promoting the use of native plants (requiring little fertilisation)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Management of washwaters from cars, boats, mobile industries, etc.	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Litter collection programs (e.g. litter collection boats, clean-up days)	☐	☐	☐	☐	☐	☐	☐	☐		☐	
Initiatives to minimise sewer overflows	☐	☐	☐	☐	☐	☐	☐	☐		☐	

FORM 3
Distribution of Public Funds Towards Urban Stormwater Management in Your Area

Name of person completing the form:. . . . .

The geographic region for which the funding applies:. . . . .

Population of the region for which the funding applies: ❒ <100,000.   ❒ >100,000 and <250,000.   ❒ >250,000.

Which of the categories below best describes your organisation?

❑   Local authority responsible only for minor urban stormwater drainage.
❑   Local authority responsible for minor and trunk/major urban stormwater drainage.
❑   Agency responsible for city-wide trunk/main urban stormwater drainage.
❑   Trust or regional authority responsible for stormwater quality management initiatives.
❑   Agency responsible for State-wide stormwater quality policy.

Categories of Urban Stormwater Quality Management Activities	Estimated expenditure per annum ($) by your organisation*
Structural measures (trash racks, GPTs, wetlands, etc.) – capital	
Structural measures – maintenance costs	
Stormwater quality related monitoring, evaluation and research	
Non-structural measures:	
▪ Work on planning and regulatory mechanisms	
▪ Work on promoting the 'water sensitive urban design philosophy'	
▪ Stormwater management activities associated with construction & maintenance (incl. street sweeping, drain desilting, collection of waste & litter from public areas, erosion & sediment control)	
▪ Education programs and campaigns	
▪ Point source regulation (e.g. licensing & inspecting small-medium industry)	
▪ Enforcement programs	
▪ Technical training and guideline development	
▪ Initiatives to minimise sewer overflows	
Other major items of expenditure (please add if necessary):	

Please return all completed forms to: André Taylor, andretaylor@iprimus.com.au, ph/fax. 08 9386 7565,
PO Box 1151, West Perth BC, WA, 6872.

APPENDIX B
Data collected from Australian and overseas urban stormwater quality managers via a survey

Best Management Practice (BMP) Australian Data	Degree of use in Australia (Ave. of 1 - 5 scale rating)	Degree of use in Australia (converted to a %)	Increasing trend in BMP use in Australia (% respondents)	Decreasing trend in BMP use in Australia (% respondents)	No trend in BMP use in Australia (% respondents)	Perceived effectiveness, efficiency and practicality in Australia (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practical-ity in Australia (converted to a %)	Degree of promise for future BMP use in Australia (No. of respondents)	Degree of promise for future BMP use in Australia (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
	A	B	C	D	E	F	G	H	I	J
		Formula: B = (A-1) x 25					Formula: G = (F-1) x 25		Formula: I = H / 18 (i.e. the highest score)*100	Formula: J = [(B*2)+(C*3)+(G*10)+H(*5)]/20. Where 2, 3, 10, and 5 are weightings (out of 10) of perceived importance for the attributes in the utility function. The highest possible score is 100.
NON-STRUCTURAL BMPs										
Planning and regulatory measures										
Implementing stormwater quality improvement policy in town/city planning schemes	2.63	41	88	0	12	3.95	74	15	83	75
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	3.33	58	75	0	25	4.24	81	18	100	83
Application of development approval/permit conditions	3.33	58	58	4	38	3.85	71	12	67	67
Using covenants on land titles to manage stormwater quality (e.g. for maintenance of on-site controls)	1.85	21	46	0	54	2.7	43	5	28	37
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	3.65	66	65	0	35	4	75	14	78	73
Implementation of State legislation setting out requirements for urban stormwater management	2.48	37	46	0	54	2.95	49	8	44	46
Water sensitive urban design (WSUD) measures for new development										
WSUD applied to public open space networks	2.77	44	77	0	23	3.71	68	14	78	69
WSUD applied to the layout of residential housing lots	2.09	27	81	0	19	3.45	61	7	39	55
WSUD applied to the road layout for residential areas	2.00	25	80	0	20	3.68	67	10	56	62
WSUD applied to street scaping layout of residential areas	2.17	29	82	0	18	3.57	64	11	61	63
WSUD applied to commercial/industrial parking areas	1.79	20	73	0	27	3.48	62	11	61	59
WSUD applied to on-site detention for large commercial/industrial areas	2.18	30	76	5	19	3.55	64	10	56	60
Stormwater (and/or shallow groundwater) recycling undertaken (could be considered as a 'structural' measure)	1.65	16	65	0	35	3.55	64	12	67	60

Best Management Practice (BMP) **Australian Data**	Degree of use in Australia (Ave. of 1 - 5 scale rating)	Degree of use in Australia (converted to a %)	Increasing trend in BMP use in Australia (% respondents)	Decreasing trend in BMP use in Australia (% respondents)	No trend in BMP use in Australia (% respondents)	Perceived effectiveness, efficiency and practicality in Australia (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practicality in Australia (converted to a %)	Degree of promise for future BMP use in Australia (No. of respondents)	Degree of promise for future BMP use in Australia (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
Development density manipulated to minimise inputs of key pollutants	1.58	15	35	5	60	2.5	38	3	17	30
Soil amendment undertaken to minimise the export of nutrients (could be considered as a 'structural' measure)	1.25	6	37	0	63	2.28	32	3	17	26
Source control measures - construction and maintenance										
Stormwater quality addressed in the planning of government-managed construction and maintenance works	3.04	51	68	5	27	3.68	67	11	61	64
Stormwater quality addressed in maintenance operations, for example: • Street cleansing/sweeping • Stormwater drain maintenance (incl. desilting) • Domestic waste and recycling collection • Litter bin design, positioning and cleaning • Road pavement repairs/resurfacing • Unsealed road maintenance • Maintenance of parks, reserves, golf courses, etc. • Material storage • Plant and equipment maintenance • Maintenance of unloading and loading areas • Building maintenance and construction • Graffiti removal • Swimming pool maintenance (incl. filter backwashing) • Water main maintenance and construction • Sewerage maintenance • Bridge maintenance • Maintenance of street lines/line marking • Footpath maintenance	3.30	58	77	0	23	4	75	15	83	76
Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	3.00	50	77	0	23	4	75	12	67	71

Best Management Practice (BMP) Australian Data	Degree of use in Australia (Ave. of 1-5 scale rating)	Degree of use in Australia (converted to a %)	Increasing trend in BMP use in Australia (% respondents)	Decreasing trend in BMP use in Australia (% respondents)	No trend in BMP use in Australia (% respondents)	Perceived effectiveness, efficiency and practicality in Australia (Ave. of 1-5 scale rating)	Perceived effectiveness, efficiency and practical-ity in Australia (converted to a %)	Degree of promise for future BMP use in Australia (No. of respondents)	Degree of promise for future BMP use in Australia (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
Stormwater quality management addressed in construction activities regulated by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	2.96	49	73	0	27	3.53	63	13	72	66
Source control measures - education programs										
Printed material (e.g. posters, pamphlets, etc.)	3.29	57	71	0	29	2.89	47	7	39	50
Media campaigns (e.g. radio, TV)	2.55	39	38	0	62	3.68	67	12	67	60
Signs (including gully trap stencilling)	2.81	45	62	10	28	2.58	40	5	28	41
Community programs	3.14	54	82	0	18	3.11	53	7	39	54
Displays (e.g. at major events)	2.95	49	65	0	35	2.58	40	3	17	39
Community water quality monitoring programs	3.47	62	58	0	42	2.84	46	9	50	50
Launches (e.g. of a new stormwater initiative)	2.86	47	50	0	50	2.39	35	2	11	32
Local action committees and groups	3.14	54	58	0	42	3.05	51	7	39	49
Consumer programs (e.g. stormwater awareness at the point of sale)	1.74	19	37	0	63	2.78	45	2	11	32
Business programs (e.g. surveys, targeted workshops)	2.65	41	70	0	30	3.17	54	9	50	54
School education programs	3.36	59	82	0	18	3.35	59	12	67	64
Source control measures – point source regulation										
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	3.14	54	42	0	58	3.67	67	12	67	62
Source control measures – enforcement										
Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	2.82	46	68	5	27	3.45	61	12	67	62
Source control measures - miscellaneous										
Stormwater quality management addressed in staff training for government and private sector staff	2.32	33	68	0	32	3.86	72	16	89	72
Management of pet/animal wastes in public open space (parks)	3.09	52	64	0	36	2.37	34	4	22	37
Management of herbicide and pesticide usage	2.81	45	55	10	35	3.25	56	11	61	56
Management of illegal dumping	2.95	49	47	11	42	2.68	42	6	33	41
Emergency response activities	3.05	51	40	0	60	3.5	63	5	28	49
Promoting the use of plants that require little fertilisation	2.75	44	71	0	29	2.84	46	5	28	45

Best Management Practice (BMP) Australian Data	Degree of use in Australia (Ave. of 1 - 5 scale rating)	Degree of use in Australia (converted to a %)	Increasing trend in BMP use in Australia (% respondents)	Decreasing trend in BMP use in Australia (% respondents)	No trend in BMP use in Australia (% respondents)	Perceived effectiveness, efficiency and practicality in Australia (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practical-ity in Australia (converted to a %)	Degree of promise for future BMP use in Australia (No. of respondents)	Degree of promise for future BMP use in Australia (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
Management of washwaters from cars, boats, mobile industries, etc.	2.67	42	71	0	29	2.9	48	8	44	50
Litter collection programs (e.g. litter collection boats, 'clean-up days')	3.14	54	57	0	43	2.47	37	4	22	38
Initiatives to minimise sewer overflows (assuming the sewerage and stormwater drainage are separated)	3.15	54	65	5	30	3.16	54	9	50	55
STRUCTURAL BMPs										
Primary stormwater treatment										
Drainage entrance treatments:										
• Grate entrance systems on stormwater drains	2.24	31	33	5	62					
• Side entry pit traps (i.e. litter baskets)	2.34	34	50	0	50					
• Baffled pits (trapped street gullies)	1.70	18	15	0	85					
In-line methods:										
• Litter collection baskets	2.14	29	43	0	57					
• Boom diversion systems	1.76	19	14	10	76					
• Release nets	1.95	24	23	9	68					
• Fixed trash racks	3.26	57	43	14	43					
• Gross pollution traps (open or enclosed)	3.39	60	55	5	40					
• Return flow litter baskets	1.44	11	17	6	77					
• Hydraulically operated trash racks	1.60	15	13	0	87					
Self-cleaning screens:										
• Circular screens	2.35	34	28	6	66					
• Downwardly inclined screens	1.75	19	6	0	94					
Floating traps:										
• Flexible floating booms	1.83	21	5	11	84					
• Floating debris traps/trash racks	1.71	18	7	7	86					
Sediment traps:										
• Sediment settling basins and ponds	3.29	57	57	0	43					
• Hydrodynamic separators (vortex separators)	2.10	28	29	10	61					
Sediment and oil separators:										
• Circular/cylindrical settling tanks	2.40	35	40	5	55					
Secondary stormwater treatment										
Pre-entrance treatments:										
• Filter strips	2.06	27	83	6	11					
• Grass swales	2.40	35	90	0	10					
• Triple interceptor pits (oil-grit separators)	2.32	33	50	17	33					
• Porous pavements	1.53	13	68	0	32					
• Infiltration trenches	2.15	29	65	5	30					

Best Management Practice (BMP) **Australian Data**	Degree of use in Australia (Ave. of 1 - 5 scale rating)	Degree of use in Australia (converted to a %)	Increasing trend in BMP use in Australia (% respondents)	Decreasing trend in BMP use in Australia (% respondents)	No trend in BMP use in Australia (% respondents)	Perceived effectiveness, efficiency and practicality in Australia (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practical-ity in Australia (converted to a %)	Degree of promise for future BMP use in Australia (No. of respondents)	Degree of promise for future BMP use in Australia (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
In-transit treatments:										
• Infiltration basins (promoting sedimentation)	2.15	29	55	5	40					
• Extended detention basins	2.30	33	65	5	30					
• Sand filters	1.63	16	37	5	58					
Tertiary stormwater treatment										
• Constructed wetlands	3.55	64	75	0	25					
• Bio-retention systems (infiltration systems with media to promote biofilms)	1.76	19	39	6	55					
• Constructed ponds	3.53	63	68	11	21					
• Sand filters with an adsorption capacity	1.56	14	17	6	77					

Best Management Practice (BMP) NZ and US Data	Degree of use in the US and NZ (Ave. of 1 - 5 scale rating)	Degree of use in the US and NZ (converted to a %)	Increasing trend in the US and NZ (% respondents)	Decreasing trend in BMP use in the US and NZ (% respondents)	No trend in BMP use in the US and NZ (% respondents)	Perceived effectiveness, efficiency and practicality in the US and NZ (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practicality in the US and NZ (converted to a %)	Degree of promise for future BMP use in the US and NZ (No. of respondents)	Degree of promise for future BMP use in the US and NZ (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
	A	B	C	D	E	F	G	H	I	J
		Formula: B = (A-1) x 25					Formula: G = (F-1) x 25		Formula: I = H / 8 (i.e. the highest score)*100	Formula: J = [(B*2)+(C*3)+(G*10) +(I*5)]/20 Where 2, 3, 10, and 5 are weightings (out of 10) of perceived importance for the attributes in the utility function. The highest possible score is 100.
NON-STRUCTURAL BMPs										
Planning and regulatory measures										
Implementing stormwater quality improvement policy in town/city planning schemes	3.73	68	82	0	18	4.2	80	7	88	81
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	4.55	89	73	0	27	4.7	93	7	88	88
Application of development approval/ permit conditions	4.7	93	70	0	30	4.33	83	5	63	77
Using covenants on land titles to manage stormwater quality (e.g. for maintenance of on-site controls)	3.91	73	70	10	20	3.5	63	5	63	65
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	4.08	77	100	0	0	4.4	85	8	100	90
Implementation of State legislation setting out requirements for urban stormwater management	4.5	88	56	0	44	3.67	67	6	75	69
Water sensitive urban design (WSUD) measures for new development										
WSUD applied to public open space networks	2.82	46	82	0	18	3.7	68	5	63	66
WSUD applied to the layout of residential housing lots	3	50	82	0	18	3.8	70	6	75	71
WSUD applied to the road layout for residential areas	3	50	82	0	18	3.8	70	5	63	68
WSUD applied to street scaping layout of residential areas	2.91	48	82	0	18	3.36	59	4	50	59
WSUD applied to commercial/industrial areas	3.09	52	73	0	27	3.6	65	4	50	61
WSUD applied to on-site detention for large commercial/industrial areas	3.18	55	73	0	27	3.89	72	4	50	65
Stormwater (and/or shallow groundwater) recycling undertaken (could be considered as a 'structural' measure)	2.78	45	80	0	20	3.33	58	6	75	64
Development density manipulated to minimise inputs of key pollutants	2.7	43	64	0	36	2.78	45	2	25	42
Soil amendment undertaken to minimise the export of nutrients (could be considered as a 'structural' measure)	1.67	17	63	0	37	2.13	28	0	0	25

Best Management Practice (BMP) NZ and US Data	Degree of use in the US and NZ (Ave. of 1 - 5 scale rating)	Degree of use in the US and NZ (converted to a %)	Increasing trend in the US and NZ (% respondents)	Decreasing trend in BMP use in the US and NZ (% respondents)	No trend in BMP use in the US and NZ (% respondents)	Perceived effectiveness, efficiency and practicality in the US and NZ (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practicality in the US and NZ (converted to a %)	Degree of promise for future BMP use in the US and NZ (No. of respondents)	Degree of promise for future BMP use in the US and NZ (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
Source control measures - construction and maintenance										
Stormwater quality addressed in the planning of government-managed construction and maintenance works	4.18	80	91	9	0	4.75	94	6	75	87
Stormwater quality addressed in maintenance operations, for example: • Street cleansing/sweeping • Stormwater drain maintenance (incl. desilting) • Domestic waste and recycling collection • Litter bin design, positioning and cleaning • Road pavement repairs/resurfacing • Unsealed road maintenance • Maintenance of parks, reserves, golf courses, etc. • Material storage • Plant and equipment maintenance • Maintenance of unloading and loading areas • Building maintenance and construction • Graffiti removal • Swimming pool maintenance (incl. filter backwashing) • Water main maintenance and construction • Sewerage maintenance • Bridge maintenance • Maintenance of street lines/line marking • Footpath maintenance	4	75	100	0	0	4.75	94	6	75	88
Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	4.55	89	73	0	27	4.88	97	6	33	77
Stormwater quality management addressed in construction activities regulated by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	4.64	91	73	0	27	4.56	89	7	39	74
Source control measures - education programs										
Printed material (e.g. posters, pamphlets, etc.)	3.18	55	73	0	27	3.44	61	3	17	51
Media campaigns (e.g. radio, TV)	2.18	30	45	9	36	3.33	58	6	33	47
Signs (including gully trap stencilling)	3.6	65	82	0	18	3.56	64	5	28	58
Community programs	2.91	48	81	0	9	3.89	72	8	44	64

Best Management Practice (BMP) NZ and US Data	Degree of use in the US and NZ (Ave. of 1 - 5 scale rating)	Degree of use in the US and NZ (converted to a %)	Increasing trend in the US and NZ (% respondents)	Decreasing trend in BMP use in the US and NZ (% respondents)	No trend in BMP use in the US and NZ (% respondents)	Perceived effectiveness, efficiency and practicality in the US and NZ (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practicality in the US and NZ (converted to a %)	Degree of promise for future BMP use in the US and NZ (No. of respondents)	Degree of promise for future BMP use in the US and NZ (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
Displays (e.g. at major events)	3	50	60	0	40	3.4	60	5	28	51
Community water quality monitoring programs	3.8	70	80	10	10	3.56	64	6	33	59
Launches (e.g. of a new stormwater initiative)	2.64	41	55	18	27	3.11	53	2	11	42
Local action committees and groups	2.92	48	67	8	25	3.78	70	4	22	55
Consumer programs (e.g. stormwater awareness at the point of sale)	1.7	18	36	0	64	3.33	58	4	22	42
Business programs (e.g. surveys, targeted workshops)	2.3	33	46	0	54	3.67	67	5	28	51
School education programs	3.64	66	91	0	9	4.11	78	9	50	72
Source control measures – point source regulation										
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	3.91	73	82	0	18	4.33	83	5	28	68
Source control measures – enforcement										
Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	4.22	81	56	0	44	4.67	92	6	75	81
Source control measures - miscellaneous										
Stormwater quality management addressed in staff training for government and private sector staff	3.27	57	55	0	45	3.89	72	5	63	66
Management of pet/animal wastes in public open space (parks)	2.64	41	55	0	45	3	50	4	50	50
Management of herbicide and pesticide usage	2.45	36	55	0	45	3.44	61	4	50	55
Management of illegal dumping	3.36	59	45	0	55	3.44	61	5	63	59
Emergency response activities	3.36	59	55	0	45	4.22	81	5	63	70
Promoting the use of plants that require little fertilisation	2.27	32	64	0	36	3.29	57	3	38	51
Management of washwaters from cars, boats, mobile industries, etc.	3.08	52	58	0	42	3.22	56	2	25	48
Litter collection programs (e.g. litter collection boats, 'clean-up days')	3.36	59	64	0	36	3.44	61	4	50	59
Initiatives to minimise sewer overflows (assuming the sewerage and stormwater drainage are separated)	3.7	68	90	0	10	4.29	82	6	75	80

Best Management Practice (BMP) NZ and US Data	Degree of use in the US and NZ (Ave. of 1 - 5 scale rating)	Degree of use in the US and NZ (converted to a %)	Increasing trend in the US and NZ (% respondents)	Decreasing trend in BMP use in the US and NZ (% respondents)	No trend in BMP use in the US and NZ (% respondents)	Perceived effectiveness, efficiency and practicality in the US and NZ (Ave. of 1 - 5 scale rating)	Perceived effectiveness, efficiency and practicality in the US and NZ (converted to a %)	Degree of promise for future BMP use in the US and NZ (No. of respondents)	Degree of promise for future BMP use in the US and NZ (converted to a %)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs (out of 100)
STRUCTURAL BMPs										
Primary stormwater treatment										
Drainage entrance treatments:										
• Grate entrance systems on stormwater drains	2.3	33	40	0	60					
• Side entry pit traps (i.e. litter baskets)	1.89	22	44	0	56					
• Baffled pits (trapped street gullies)	2.43	36	29	0	71					
In-line methods:										
• Litter collection baskets	1.83	21	33	0	67					
• Boom diversion systems	2.4	35	40	0	60					
• Release nets	1.6	15	0	0	100					
• Fixed trash racks	3.38	60	38	0	62					
• Gross pollution traps (open or enclosed)	1.89	22	71	0	29					
• Return flow litter baskets	1.83	21	40	0	60					
• Hydraulically operated trash racks	1.67	17	25	0	75					
Self-cleaning screens:										
• Circular screens	2	25	33	0	67					
• Downwardly inclined screens	2	25	20	0	80					
Floating traps:										
• Flexible floating booms	2.33	33	50	0	50					
• Floating debris traps/trash racks	2.38	35	43	0	57					
Sediment traps:										
• Sediment settling basins and ponds	4	75	67	0	33					
• Hydrodynamic separators (vortex separators)	2.6	40	89	0	11					
Sediment and oil separators:										
• Circular/cylindrical settling tanks	2.44	36	63	0	37					
Secondary stormwater treatment										
Pre-entrance treatments:										
• Filter strips	3.55	64	70	0	30					
• Grass swales	3.64	66	60	0	40					
• Triple interceptor pits (oil-grit separators)	2.18	30	30	10	60					
• Porous pavements	2.18	30	80	10	10					
• Infiltration trenches	2.91	48	70	0	30					
In-transit treatments:										
• Infiltration basins (promoting sedimentation)	2.73	43	30	0	70					
• Extended detention basins	3.64	66	60	10	30					
• Sand filters	3.27	57	50	20	30					
Tertiary stormwater treatment										
• Constructed wetlands	3.18	55	60	10	30					
• Bio-retention systems (infiltration systems with media to promote biofilms)	2.27	32	70	0	30					
• Constructed ponds	3.91	73	50	0	50					
• Sand filters with an adsorption capacity	1.88	22	50	13	37					

APPENDIX C
Sensitivity analysis of the Utility Value Function
(used to short-list those non-structural BMPs most worthy of evaluation)

Best Management Practice (BMP) **Australian Data**	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Case 1 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Formula: Value = [(Current use %*Weighting 1)+(Positive trend in use %*Weighting 2)+(Perceived effectiveness, efficiency and practicality %*Weighting 3)+(Degree of promise for future use %*Weighting 4)]/(sum of all 4 weightings). The highest possible score is 100.	Weighting 1 = 2. Weighting 2 = 3. Weighting 3 = 10. Weighting 4 = 5.		Weighting 1 = 0. Weighting 2 = 0. Weighting 3 = 10. Weighting 4 = 7.		Weighting 1 = 5. Weighting 2 = 5. Weighting 3 = 5. Weighting 4 = 5.		Weighting 1 = 0. Weighting 2 = 0. Weighting 3 = 10. Weighting 4 = 0.	
NON-STRUCTURAL BMPs								
Planning and regulatory measures								
Implementing stormwater quality improvement policy in town/city planning schemes	75	3	78	3 (equal)	71	3 (equal)	74	3
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	83	1	89	1	79	1	81	1
Application of development approval/permit conditions	67	8	69	6	64	6 (equal)	71	5
Using covenants on land titles to manage stormwater quality (e.g. for maintenance of on-site controls)	37		36		34		43	
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	73	4	76	4	71	3 (equal)	75	2 (equal)
Implementation of State legislation setting out requirements for urban stormwater management	46		47		44		49	
Water sensitive urban design (WSUD) measures for new development								
WSUD applied to public open space networks	69	7	72	5 (equal)	67	4 (equal)	68	6
WSUD applied to the layout of residential housing lots	55		52		52		61	
WSUD applied to the road layout for residential areas	62		62	10 (equal)	57	10 (equal)	67	7 (equal)
WSUD applied to street scaping layout of residential areas	63		63	9 (equal)	59	9	64	8 (equal)
WSUD applied to commercial/industrial parking areas	59		62	10 (equal)	54		62	10
WSUD applied to on-site detention for large commercial/industrial areas	60		60		56		64	8 (equal)
Stormwater (and/or shallow groundwater) recycling undertaken (could be considered as a 'structural' measure)	60		65	8 (equal)	53		64	8 (equal)
Development density manipulated to minimise inputs of key pollutants	30		29		26		38	
Soil amendment undertaken to minimise the export of nutrients (could be considered as a 'structural' measure)	26		26		23		32	

Best Management Practice (BMP) — Australian Data	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Case 1 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Source control measures - construction and maintenance								
Stormwater quality addressed in the planning of government-managed construction and maintenance works	64		65	8 (equal)	62	7	67	7 (equal)
Stormwater quality addressed in maintenance operations, for example: • Street cleansing/sweeping • Stormwater drain maintenance (incl. desilting) • Domestic waste and recycling collection • Litter bin design, positioning and cleaning • Road pavement repairs/resurfacing • Unsealed road maintenance • Maintenance of parks, reserves, golf courses, cemeteries, sports fields, nurseries, depots, road reserves, etc. • Material storage • Plant and equipment maintenance • Maintenance of unloading and loading areas • Building maintenance and construction • Graffiti removal • Swimming pool maintenance (incl. filter backwashing) • Water main maintenance and construction • Sewerage maintenance • Bridge maintenance • Maintenance of street lines/line marking • Footpath maintenance	76	2	78	3 (equal)	73	2	75	2 (equal)
Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	71	6	72	5 (equal)	67	4 (equal)	75	2 (equal)
Stormwater quality management addressed in construction activities regulated by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	66	9	67	7 (equal)	64	6 (equal)	63	9 (equal)

Best Management Practice (BMP) Australian Data	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Case 1 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Source control measures - education programs								
Printed material (e.g. posters, pamphlets, etc.)	50		44		54		47	
Media campaigns (e.g. radio, TV)	60	10	67	7 (equal)	53		67	7 (equal)
Signs (including gully trap stencilling)	41		35		44		40	
Community programs	54		47		57	10 (equal)	53	
Displays (e.g. at major events)	39		30		43		40	
Community water quality monitoring programs	50		48		54		46	
Launches (e.g. of a new stormwater initiative)	32		25		36		35	
Local action committees and groups	49		46		50		51	
Consumer programs (e.g. stormwater awareness at the point of sale)	32		31		28		45	
Business programs (e.g. surveys, targeted workshops)	54		53		54		54	
School education programs	64		62		67	4 (equal)	59	
Source control measures – point source regulation								
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	62		67	7 (equal)	57	10 (equal)	67	7 (equal)
Source control measures – enforcement								
Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	62		64	9 (equal)	60	8	61	
Source control measures - miscellaneous								
Stormwater quality management addressed in staff training for government and private sector staff	72		79	2	65	5	72	4
Management of pet/animal wastes in public open space (parks)	37		29		43		34	
Management of herbicide and pesticide usage	56		58		54		56	
Management of illegal dumping	41		38		43		42	
Emergency response activities	49		48		45		63	9 (equal)
Promoting the use of plants that require little fertilisation	45		39		47		46	
Management of washwaters from cars, boats, mobile industries, etc.	50		46		51		48	
Litter collection programs (e.g. litter collection boats, 'clean-up days')	38		31		42		37	
Initiatives to minimise sewer overflows (assuming the sewerage and stormwater drainage are separated)	55		52		56		54	

Best Management Practice (BMP) **NZ and US Data**	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Formula: Value = [(Current use %*Weighting 1)+(Positive trend in use %*Weighting 2)+(Perceived effectiveness, efficiency and practicality %*Weighting 3)+(Degree of promise for future use %*Weighting 4)]/(sum of all 4 weightings) The highest possible score is 100.	Weighting 1 = 2. Weighting 2 = 3. Weighting 3 = 10. Weighting 4 = 5.		Weighting 1 = 0. Weighting 2 = 0. Weighting 3 = 10. Weighting 4 = 7.		Weighting 1 = 5. Weighting 2 = 5. Weighting 3 = 5. Weighting 4 = 5.		Weighting 1 = 0. Weighting 2 = 0. Weighting 3 = 10. Weighting 4 = 0.	
NON-STRUCTURAL BMPs								
Implementing stormwater quality improvement policy in town/city planning schemes	81	4 (equal)	83	5	79	4 (equal)	80	10
Requiring stormwater quality management to be addressed in development proposals/applications relating to stormwater quality	88	2 (equal)	90	2	85	3 (equal)	93	3
Application of development approval/permit conditions	77	6 (equal)	75	7	77	5	83	7 (equal)
Using covenants on land titles to manage stormwater quality (e.g. for maintenance of on-site controls)	65		63		67		63	
Development of urban stormwater management plans for the city, shire, or catchment for the improvement of urban stormwater quality and protection of urban aquatic ecosystems	90	1	91	1	91	1	85	6
Implementation of State legislation setting out requirements for urban stormwater management	69		70		71	8 (equal)	67	
Water sensitive urban design (WSUD) measures for new development								
WSUD applied to public open space networks	66		65		64		68	
WSUD applied to the layout of residential housing lots	71	9	72	9	69	9	70	
WSUD applied to the road layout for residential areas	68		67		66	10 (equal)	70	
WSUD applied to street scaping layout of residential areas	59		55		60		59	
WSUD applied to commercial/industrial parking areas	61		59		60		65	
WSUD applied to on-site detention for large commercial/industrial areas	65		63		62		72	
Stormwater (and/or shallow groundwater) recycling undertaken (could be considered as a 'structural' measure)	64		65		64		58	
Development density manipulated to minimise inputs of key pollutants	42		37		44		45	
Soil amendment undertaken to minimise the export of nutrients (could be considered as a 'structural' measure)	25		17		27		28	

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Best Management Practice (BMP) NZ and US Data	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Source control measures - construction and maintenance								
Stormwater quality addressed in the planning of government-managed construction and maintenance works	87	3	86	3 (equal)	85	3 (equal)	94	2 (equal)
Stormwater quality addressed in maintenance operations, for example: • Street cleansing/sweeping • Stormwater drain maintenance (incl. desilting) • Domestic waste and recycling collection • Litter bin design, positioning and cleaning • Road pavement repairs/resurfacing • Unsealed road maintenance • Maintenance of parks, reserves, golf courses, cemeteries, sports fields, nurseries, depots, road reserves, etc. • Material storage • Plant and equipment maintenance • Maintenance of unloading and loading areas • Building maintenance and construction • Graffiti removal • Swimming pool maintenance (incl. filter backwashing) • Water main maintenance and construction • Sewerage maintenance • Bridge maintenance • Maintenance of street lines/line marking • Footpath maintenance	88	2 (equal)	86	3 (equal)	86	2	94	2 (equal)
Stormwater quality management addressed in construction activities undertaken by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	77	6 (equal)	71	10	73	7 (equal)	97	1
Stormwater quality management addressed in construction activities regulated by municipalities or State agencies, for example: • Site planning • Drainage, erosion and sediment control • Inspection and maintenance of controls • Management of building, storage and washing activities	74	7	68		73	7 (equal)	89	5

Best Management Practice (BMP) NZ and US Data	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 1 (out of 100)	Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 2 (out of 100)	Case 2 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 3 (out of 100)	Case 3 Ranking (top 10 only, 1 being the highest)	OVERALL VALUE SCORE FOR NON-STRUCTURAL BMPs - case 4 (out of 100)	Case 4 Ranking (top 10 only, 1 being the highest)
Source control measures - education programs								
Printed material (e.g, posters, pamphlets, etc.)	51		43		51		61	
Media campaigns (e.g. radio, TV)	47		48		42		58	
Signs (including gully trap stencilling)	58		49		60		64	
Community programs	64		61		61		72	
Displays (e.g. at major events)	51		47		49		60	
Community water quality monitoring programs	59		51		62		64	
Launches (e.g. of a new stormwater initiative)	42		36		40		53	
Local action committees and groups	55		50		52		70	
Consumer programs (e.g. stormwater awareness at the point of sale)	42		43		34		58	
Business programs (e.g. surveys, targeted workshops)	51		51		43		67	
School education programs	72	8	66		71	8 (equal)	78	
Source control measures – point source regulation								
Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	68		60		66	10 (equal)	83	7 (equal)
Source control measures – enforcement								
Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	81	4 (equal)	85	4	76	6	92	4
Source control measures - miscellaneous								
Stormwater quality management addressed in staff training for government and private sector staff	66		68		62		72	
Management of pet/animal wastes in public open space (parks)	50		50		49		50	
Management of herbicide and pesticide usage	55		57		51		61	
Management of illegal dumping	59		62		57		61	
Emergency response activities	70	10	73	8	64		81	9
Promoting the use of plants that require little fertilisation	51		49		48		57	
Management of washwaters from cars, boats, mobile industries, etc.	48		43		48		56	
Litter collection programs (e.g. litter collection boats, 'clean-up days')	59		57		59		61	
Initiatives to minimise sewer overflows (assuming the sewerage and stormwater drainage are separated)	80	5	79	6	79	4 (equal)	82	8

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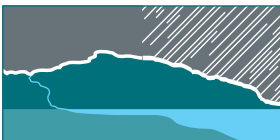
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- Department of Sustainable Natural Resources, NSW
- Goulburn-Murray Water
- Griffith University

- Melbourne Water
- Monash University
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- Natural Resources and Mines, Qld
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- Wimmera Mallee Water

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