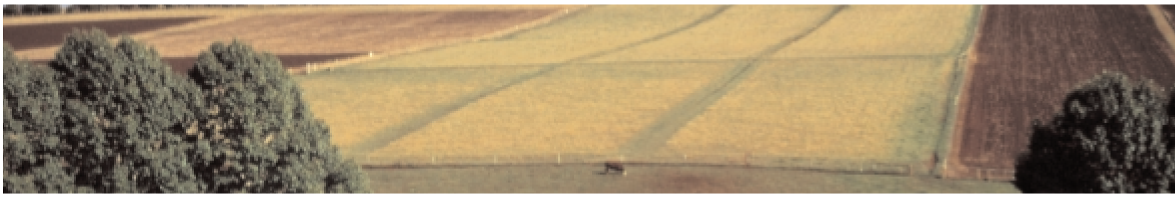
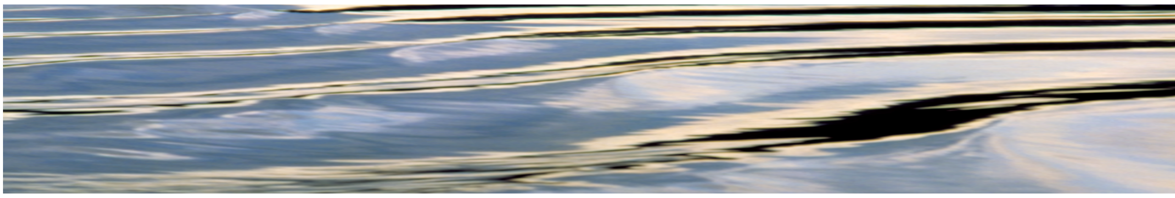
COOPERATIVE RESEARCH CENTRE FOR **CATCHMENT HYDROLOGY**

NON-STRUCTURAL STORMWATER QUALITY BEST MANAGEMENT PRACTICES: GUIDELINES FOR MONITORING AND EVALUATION

TECHNICAL REPORT
Report 03/14
November 2003

André Taylor / Tony Wong





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CATCHMENT HYDROLOGY

EPA VICTORIA

Taylor, André., 1969 -

Non-structural Stormwater Quality Best Management Practices: Guidelines for Monitoring and Evaluation

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ISBN 1 920813 04 7.

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551.4880994

Keywords

Stormwater Management
Best Practice
Urban Areas
Water Pollution Control
Planning Control
Regulatory Authorities
Monitoring
Evaluation
Standards
Data Handling
Environmental Management
Water Quality Control
Surveys
Local Government

Non-structural Stormwater Quality Best Management Practices - Guidelines for Monitoring and Evaluation

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Preface

In 2001 the Cooperative Research Centre (CRC) 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.

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 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 quality 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 a 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.
- CRC for Catchment Hydrology Report 03/14 (No. 4 in the series) is this technical report which provides guidance on **monitoring and evaluating non-structural BMPs** for urban stormwater quality improvement. The report has evolved from an earlier working document (CRC Working Document 02/6) which was trialled during 2002-03. The report presents a new evaluation framework and guidance for measuring the effects 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.

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

Various authors have attempted to categorise non-structural BMPs into homogeneous groups (e.g. Brown, 1999; NSW EPA, 1998; NVPDC, 1996; ASCE & US EPA, 2000; US EPA, 1999; LSRC, 2001; Aponte Clarke *et al.* 1999; Victorian Stormwater Committee, 1999; and ASCE & US EPA, 2002). Although these classification systems vary, five core categories of non-structural BMPs feature strongly and have been used by the CRC for Catchment Hydrology to group non-structural BMPs in our research:

1. **Town planning controls** (e.g. statutory planning instruments requiring stormwater quality to be addressed in new development through Water Sensitive Urban Design [WSUD] principles).
2. **Strategic planning and institutional controls** (e.g. strategic, city-wide urban stormwater quality management plans and secure funding mechanisms to support the implementation of these plans).
3. **Pollution prevention procedures.** Such as:
    - practices undertaken by stormwater management authorities involving maintenance (e.g. maintenance of structural BMPs and the stormwater drainage network); and
    - elements of environmental management systems (e.g. procedures on material storage and staff training on stormwater management).
4. **Education and participation programs** (e.g. targeted media campaigns, training programs and stormwater drain stencilling programs).
5. **Regulatory controls** (e.g. enforcement of local laws to improve erosion and sediment control on building sites and the use of regulatory instruments such as environmental licences to help manage premises likely to contaminate stormwater).

1.2 Why these BMPs Need to be Carefully Evaluated

Non-structural and structural BMPs are increasingly being used at considerable cost in urban areas primarily to improve the health of water bodies that receive stormwater runoff.

Survey results obtained as part of this research project (see Report No. 2 in this series) indicate that:

- Non-structural BMPs are already being widely used in Australia.
- Non-structural BMPs are increasingly being used in Australia (e.g. nine out of the top 11 BMPs associated with the most widespread trend of increasing use are non-structural).
- On average, leading Australian stormwater management agencies responsible for minor and major/trunk drainage spend approximately 57% 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).
- The use of non-structural BMPs may further increase in Australia if stormwater quality management programs mature like those of leading overseas agencies. For example, leading US agencies that were surveyed spend approximately 3.8 times as much (per capita) on stormwater quality management (in total) and the non-structural elements of their programs compared to equivalent Australian agencies.

After reviewing the international literature on attempts to evaluate the performance of non-structural BMPs (see Report No. 3 in this series), it is apparent that:

- our understanding of the magnitude of change that non-structural BMPs can induce (e.g. changes to stormwater quality or waterway health) is generally poor compared to equivalent research for structural BMPs;

- many different approaches and monitoring 'tools' have been used;
- poor evaluation design and reporting is common, especially for those studies that aim to characterise a non-structural BMP's effect on stormwater quality and/or waterway health;
- different styles of evaluation inherently suit different types of non-structural BMPs;
- the limited resources that are available to stormwater management agencies (e.g. expertise, cash and time) often restrict the style of evaluation that can be done for non-structural BMPs;
- little guidance material is available on how to monitor and evaluate non-structural BMPs that can be easily used by local government authorities in Australia;
- where comprehensive stormwater quality-related BMP monitoring and evaluation guidelines are available, they are relatively complex, lengthy, focus on structural BMPs and stormwater quality monitoring, and are aimed at 'advanced users' (e.g. researchers and staff from large stormwater management agencies) with significant monitoring resources; and
- little sharing of data occurs from evaluation projects across Australia.

Given these findings, we suggest there is a duty for urban stormwater managers in Australia to:

- monitor and evaluate those BMPs for which performance is uncertain and usage rates are high;
- ensure that monitoring and evaluation projects are designed and executed in accordance with current best practice;
- maximise the value to the community of such evaluation projects through sound reporting and information sharing; and
- assist local stakeholders who may be monitoring and evaluating non-structural BMPs (e.g. community groups) by providing clear and consistent guidance.

To help exercise such duties, three new products have been developed by the CRC for Catchment Hydrology and are explained in Section four (4) of these guidelines:

1. A comprehensive ***evaluation framework*** for all non-structural BMPs that includes seven (7) different styles of evaluation covering the diversity of these BMPs as well as the different characteristics of stormwater management agencies (e.g. their monitoring objectives and available resources).
2. ***Monitoring and evaluation protocols*** that can be used by stormwater management agencies in Australia (in particular local government agencies) for all types of non-structural BMPs and all common styles of evaluation.
3. ***Data recording sheets*** for each monitoring and evaluation protocol to ensure that the salient details and results of evaluation projects are collated in a manner that facilitates sharing of information, continual improvement, and the maximisation of value from limited stormwater management resources.

Ideally, there would be consistency in the use of the three products listed above by stormwater managers across Australia to best harness the collective benefit of evaluation efforts. For example, if all States used these guidelines to evaluate non-structural BMPs, it would be feasible to simply set up a national, web based database to allow monitoring and evaluation data to be easily shared.

There is also potential for greater data sharing to occur internationally. To help realise this potential, these guidelines adopt terminology and an approach which is broadly consistent with the US BMP Database (www.bmpdatabase.org). If Australian monitoring data is collected and reported in a way that is consistent with the US system (i.e. in accordance with these guidelines), it should be possible to post the data on the US BMP Database to be used globally by stormwater managers.

In the short term, these guidelines can be used to evaluate the gamut of non-structural BMPs currently being applied in Australia to provide valuable feedback to all stakeholders on the merits of specific BMPs. In the longer term, these guidelines should help to produce higher quality data on the value and cost of non-structural BMPs, enabling urban stormwater managers to more confidently:

- allocate public funds to specific non-structural BMPs knowing that positive benefits will result; and
- undertake basic cost-benefit analysis and/or pollutant export modelling involving non-structural BMPs for a given area.

1.3 The Structure of these Guidelines

Sections two (2) and three (3) of these guidelines provide a brief background to the subject of non-structural BMP evaluation to provide some context for the new monitoring and evaluation 'tools'.

Technical guidance material is provided in Section four (4) including:

- A simple conceptual framework for evaluating the value and cost of non-structural BMPs (using seven styles of evaluation).
- Guidance on how to choose the best style(s) of evaluation to suit the objectives of the BMP and available resources.
- A set of step-wise monitoring and evaluation protocols and accompanying data recording sheets that address each style of non-structural BMP evaluation. The monitoring and evaluation protocols provide simple guidance on how to plan, deliver and report on a monitoring and evaluation exercise. These protocols can be used by local government staff as guidelines for their own work, or as project briefs for specialist consultants. They have been deliberately kept short (compared to overseas equivalents), with references being made to more detailed guidelines where necessary. The data recording sheets prompt users to record important details about the nature of the BMPs and monitoring results in a consistent format.

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 (Report No. 1), and will not be repeated in full here. The background section of the overview report contains information on:

- Terminology used in all four reports in this series.
- Types of non-structural BMPs.
- Broad trends in the use 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 key 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 runoff 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.
- 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 argues that 'percent removal' (when used alone) is a poor measure of BMP efficiency compared with alternatives such as the 'effluent probability method' (see ASCE & US EPA, 2002).

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.

'Monitoring' is gathering 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 (Rutherfurd *et al.* 2000). 'Evaluation' is the term used for 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 (Rutherfurd *et al.* 2000).

Additional terms are explained in the Glossary (see Section 6).

2.2 The Status of Attempts to Evaluate Non-structural BMPs

Several authors have highlighted the lack of reliable, quantified data on the life-cycle cost and value of non-structural BMPs as a major impediment to the adoption of these BMPs (NVPDC, 1996; Taylor, 2000; Brown, 1999; US EPA, 1997). This point of view is perhaps best expressed by the Northern Virginia Planning District Commission (NVPDC, 1996): "... many of these non-structural measures are widely recognised by scientists and watershed managers to have clear utility in an integrated nonpoint source management program. However, the lack of credible data, site screening for applicability, and specific design parameters, may result in these measures being neglected, both in research and in jurisdictional nonpoint source program development, under federal, State, and local stormwater management initiatives" (p. 1-4).

In addition, the NVPDC states "reliance on conventional [structural] BMPs stems from the fact that such approaches facilitate the engineering calculations necessary to demonstrate compliance with numerical stormwater quality standards or criteria..." (p. 1-4). This point is particularly relevant to Australian stormwater managers as:

- numerical descriptions of water quality-related objectives are increasingly used in town planning schemes and other legislative instruments to define the quality of stormwater needed from a particular development or catchment; and
- pollutant export modelling tools are being used more widely to quantitatively demonstrate a proposed suite of BMPs will collectively improve stormwater quality so that it complies with water quality-related objectives.

The need for research into the cost and value of non-structural BMPs has been recognised in the literature for more than two decades. For example, in 1980, attempts were made to evaluate the efficiency and cost of street sweeping and the addition of flocculants to stormwater to remove colloids (e.g. Biggers *et al.* 1980). Despite this history, modest progress has been made in quantifying the efficiency of non-structural BMPs, other than street sweeping.

Perhaps the most instructive indicator of the stormwater industry's progress on measuring the life-cycle costs and efficiency of non-structural BMPs for stormwater quality improvement comes from the US National Stormwater Management Practices (BMP) Database (see www.bmpdatabase.org and Clary *et al.* 2000). Established in 1999, the national database centralises data on stormwater BMPs in a standardised format and only includes data that has been screened by experts. When reviewed as part of this project, it contained 113 sets of data on BMPs. Only eight (8) concerned non-structural BMPs, all of which involved street sweeping.

In 1999, the US EPA reviewed the availability of data on the efficiency of BMPs for urban stormwater management and concluded "... there is still a great need for focused research in certain areas, particularly for newer and innovative structural BMP types, as well as non-structural BMPs. However, due to the complexity involved in isolating the reaction of a complex and highly variable system such as a watershed to one isolated input, evaluations of non-structural BMPs are ambitious tasks. Still, where stormwater management is largely driven by the availability of scarce funding, data that indicate the cost effectiveness of various control strategies are badly needed." (US EPA, 1999, p. 5-85).

While sound attempts to evaluate the effects of non-structural BMPs on *stormwater quality* have been rare, many more attempts have been made to evaluate other aspects of these BMPs. For example, stormwater related education campaigns and training events are commonly evaluated by monitoring people's pre- and post-BMP awareness levels.

Unfortunately, the more common styles of evaluation (e.g. assessing changes in people's knowledge) provide little insight into whether real behavioural change has occurred, whether stormwater quality has improved, or whether waterway health has been enhanced.

2.3 The Main Impediments to Sound Evaluation of Non-structural BMPs

We suggest that five primary factors have hindered the progress of sound non-structural BMP evaluation:

1. Monitoring BMPs that seek to change people's behaviour is inherently difficult (Livingston, 2001) because:
    - people's behaviour is extremely complex (Curnow *et al.* 2002 and 2003);
    - direct measurement of people's behaviour (i.e. through an 'observational approach') can be constrained by issues such as privacy, experimental influence on behaviour and the high cost of monitoring infrequent events (e.g. annual use of lawn fertiliser);
    - where studies have measured actual behaviour, the findings often significantly differ from findings based on self-reported behaviour (Curnow and Spehr, 2001 and 2002; Curnow *et al.* 1997; and Williams *et al.* 1997);

- studies have found major differences or incongruities between people's attitudes and their actual behaviour (e.g. littering behaviour as noted by Curnow and Spehr, 2001 and 2002, and Williams *et al.* 1997);
- it is difficult to use suitable control sites for non-structural BMPs designed to operate over large areas and over long time-frames (e.g. on-going stormwater awareness campaigns); and
- the effects of non-structural BMPs can change with time (e.g. the effect of stormwater drain stencilling on public awareness of stormwater issues over time).

2. Over a given geographic area, the effect of some non-structural BMPs may be masked by the effects of other management measures and sources of pollution. These interfering factors are not easily controllable in an experimental sense during monitoring (ASCE & US EPA, 2002). This complexity has lead some authors to comment that when it comes to monitoring the effects on stormwater quality, "... some non-structural BMPs, such as public education programs ... are virtually impossible to monitor or at best can be evaluated using trend analysis." (ASCE & US EPA, 2002, p. 46).
3. There is uncertainty over the transferability of the results obtained from some evaluation programs, as the value of some BMPs depends on the context within which they are applied. For example, suppose an education and enforcement program in a high density urban area was found to have reduced the percentage of the population that used to wash their car on the street (rather than in a sewered wash bay) from 80% to 40%. An identical campaign may be run in another part of the city, but if affordable wash bays were not as readily available, it is unlikely this magnitude of behavioural change would result.
4. Some BMPs can work synergistically (e.g. complementary education and enforcement campaigns). As the US EPA (2001a) stated, "Some individual practices may not be very effective alone but, in combination with others, may provide a key function in highly effective systems." (p. 2). This creates complexity for evaluation exercises as the usual reductionist strategy of monitoring a BMP in isolation may produce misleading results.
5. The determination of BMP efficiency and effectiveness suffers from comparability problems. That is, different evaluation methodologies have been used, making the results difficult to compare. Strecker *et al.* (2001) reported "... the differences in monitoring strategies and data evaluation alone contribute significantly to the range of BMP effectiveness that has been reported." (p. 144). To illustrate this point, Strecker *et al.* (2001) applied three commonly used data evaluation methods to the same structural BMP monitoring data set to derive an estimate of the 'pollutant removal efficiency' percentage for one pollutant. The results ranged from 48% to 66%.

3. Methodology

The primary aim of these guidelines is to present monitoring and evaluation 'tools' that can be used by local government authorities in Australia to evaluate all types of non-structural BMPs for stormwater quality improvement.

To achieve this aim, we gathered information on methods for monitoring and evaluating the value and life-cycle cost of non-structural BMPs via a survey of 36 stormwater managers from Australia, New Zealand and the United States of America, as well as published literature, the internet, case studies and unpublished reports. Useful information typically occurred as:

- Generic guidelines on the evaluation of stormwater quality-related BMPs (e.g. ASCE & US EPA, 2002; US EPA, 1997; US EPA, 2001b).
- Reports on specific monitoring and evaluation projects (e.g. monitoring the impacts of litter reduction campaigns on people's littering behaviour). These typically included details of the methodology used and tailored monitoring tools (e.g. project-specific telephone survey forms, erosion and sediment control audit checklists). In some cases, full details of methodology were not available, due to intellectual property restrictions.

We used this information to:

- develop a conceptual framework for evaluating the value and cost of all non-structural BMPs for stormwater quality improvement (using seven styles of evaluation);
- develop a set of five monitoring and evaluation protocols and accompanying data recording sheets that can be used for all styles of non-structural BMP evaluation; and
- identify some examples of monitoring tools that could be tailored for use in common non-structural BMP monitoring projects by local authorities in Australia (e.g. specific survey sheets and audit checklists).

This information is provided in Section four (4).

The approach outlined in these guidelines has been trialled and refined by the CRC for Catchment Hydrology during 2002-03. Specifically, three trials were undertaken following development of a draft version of these guidelines (i.e. CRC Working Document 02/6):

- An anti-littering education/participation campaign in a small commercial district in Snell Grove, Moreland, Melbourne.
- A town planning control (with associated education) to promote water sensitive urban design in new developments in the City of Moreland, Melbourne.
- A simple stormwater-related training event in Sunbury, Victoria, involving best practice stormwater management on construction sites.

4. Evaluation Framework, Monitoring Protocols and Data Recording Sheets

4.1 A Conceptual Framework for Evaluating Non-structural BMPs

We designed a simple conceptual model to help develop an evaluation framework that would apply to the wide variety of non-structural BMPs. This model is presented in Figure 4.1 with two examples describing how a town planning control and an educational control could improve stormwater quality and waterway health.

After reviewing the available literature on attempts to evaluate the value of non-structural BMPs (see Report No. 3 in this series), it became apparent that evaluation programs seek to monitor discrete aspects of the six outcomes described in Figure 4.1. For example, one of the most common non-structural BMPs for which evaluation is attempted is educational campaigns (e.g. media campaigns to increase awareness and knowledge about urban stormwater quality management and promote behavioural change). Such campaigns are typically evaluated through pre- and post-campaign phone surveys measuring changes in people's level of awareness and knowledge (e.g. knowledge about which waterway receives local stormwater) and self-reported behaviour (e.g. where people wash their car). In this example, assessment of the value of the BMP is typically centred on just two of the six outcomes in the conceptual model of how most non-structural BMPs work (i.e. the 'change in awareness/knowledge' and the 'change in behaviour' outcomes).

We used the six outcomes in the conceptual model to develop six styles of evaluation, with an additional style to distinguish between the measurement of self-reported behaviour and actual behaviour. The resulting seven-step evaluation framework for non-structural BMPs is described in Table 4.1, along with details of typical monitoring tools, the stakeholder groups who typically undertake such evaluations, and the main advantages and disadvantages of each style.

The rationale for the proposed evaluation framework is:

- Stakeholders involved with evaluating the value of non-structural BMPs do not necessarily have the same monitoring objectives, budgets, skills and needs in terms of the desired level of confidence in the evaluation results. An evaluation framework must be developed that can accommodate these differences while raising the standard of all styles of evaluation.
- Similar tiered evaluation systems have been successfully applied in other disciplines. For example, Rutherfurd *et al.* (2000) developed five levels of evaluation for stream restoration and rehabilitation.

To demonstrate the proposed evaluation framework's applicability to all non-structural BMPs, Table 4.2 (in Appendix D) provides examples of how each style of evaluation could be used for a BMP from each of the five categories of non-structural BMP defined in Section 1.1. The italicised text in this table represents recommended evaluation styles, given the nature of the examples.

In addition, Table 4.3 (in Appendix D) recommends evaluation styles for non-structural BMPs determined as the 10 most valuable for stormwater quality improvement, using three assessment and ranking systems (see Report No. 2 in this series for an explanation of this process). These recommendations are made to assist local government authorities choose an appropriate evaluation style (or styles) for specific BMPs.

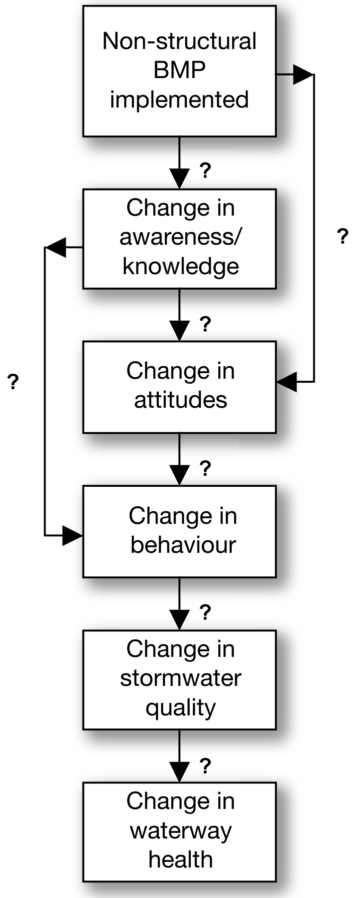
4.2 How to Use the Evaluation Framework and Supporting Protocols

Stormwater managers wishing to evaluate the value and cost of a non-structural BMP for stormwater quality improvement should undertake the following four tasks in sequence:

1. Plan the monitoring and evaluation exercise well *before* the BMP is implemented.

Undertaking monitoring and evaluation after the BMP is underway can be done in some circumstances, but is not recommended. Typically, baseline information

The following conceptual model simply indicates how those non-structural BMPs that seek to improve urban stormwater quality by changing behaviour may operate. Two examples are provided to further explain each step in the model.



Example 1 Town Planning Control	**Example 2 Educational Control**
An amendment is made to a Local Authority's planning scheme that requires new developments to implement 'water sensitive urban design' principles.	A media campaign and training program is implemented to improve erosion and sediment control on construction sites.
The development industry becomes aware of the new requirements (i.e. what they are and how they can be addressed in development applications).	The building industry becomes aware of the nature of the problem, legal requirements and technical solutions (i.e. erosion and sediment controls).
The development industry's attitude towards implementing 'water sensitive design principles' changes. (Note that attitudes regarding the need for the new requirements may not change.)	The building industry's attitude towards implementing erosion and sediment controls changes. (Note that attitudes regarding the need for laws and controls may not change.)
The development industry improves the degree to which water sensitive designs are implemented 'on the ground'.	The building industry improves its erosion and sediment control activities (e.g. makes erosion and sediment control a standard item on all projects and passes the additional cost on to the purchaser of the property).
Compared to a scenario where the BMP was not implemented, a reduced load of stormwater pollution enters the city's stormwater system.	Compared to a scenario where the BMP was not implemented, a reduced load of sediment enters the region's stormwater.
Compared to a scenario where the BMP was not implemented, the health of local and regional aquatic ecosystems is improved as a result of reduced pollutant loadings and hydrological impacts.	Compared to a scenario where the BMP was not implemented, the health of local and regional aquatic ecosystems is improved as a result of reduced loads of suspended sediment in urban stormwater.

Note:

- It cannot be assumed that securing one outcome in this model will automatically lead to another outcome. For example, raising knowledge will not necessarily result in changes to attitudes and/or behaviour. In other words, the 'process' represented above to ultimately improve waterway health through the use of non-structural BMPs may fail at any point indicated by a "?". This uncertainty is one of the reasons monitoring and evaluation is needed for these BMPs.

Figure 4.1 A Simple Conceptual Model of how Non-structural BMPs Operate and the Outcomes they may Produce.

Table 4.1 An Evaluation Framework for Non-structural BMPs that Aim to Improve Stormwater Quality.

Style of Evaluation	Description	Who Typically Does It	Example of 'Monitoring Tools'	Advantages	Disadvantages
1. BMP implementation	Evaluation of whether the BMP has been fully implemented as designed.	Stormwater management agencies (e.g. local or State government authorities) or community groups.	Audits with audit checklists.	• Inexpensive. • Provides the basis for more advanced styles of evaluation (see below). • Simple to design and implement. • Useful for BMPs that have a relatively low risk of failure once implemented. • Can usually also evaluate the quality of implementation (e.g. feedback on the relevance and quality of training materials as well as the quality of its delivery).	• Provides no information on whether the BMP has changed people's behaviour or water quality. • Desktop evaluation may not truly reflect what is happening 'on the ground'.
2. Changes in people's awareness and/or knowledge	Evaluation of whether the BMP has increased levels of awareness and/or knowledge of a specific stormwater issue within a segment of the community.	Stormwater management agencies, often with the help of specialist community survey consultants.	Surveys (with survey forms) that examine people's level of awareness and/or knowledge.	• Relatively inexpensive (depending on the level of confidence needed in the results). • Relatively fast. • Can directly examine levels of awareness and knowledge (i.e. this style of evaluation does not need to rely on *self-reported* changes to awareness and/or knowledge). • Can gather valuable information that helps to improve the *design* of the BMP (e.g. a baseline survey for an educational program may find that a high percentage of people mistakenly believe that stormwater is a minor risk to waterway health in the region). • Can usually monitor changes in people's awareness/knowledge, attitudes and/or self-reported behaviour with the same instrument (e.g. a survey).	• Changes in awareness and/or knowledge do not necessarily lead to a change in people's attitudes, behaviour or water quality.
3. Changes in people's attitude (self-reported)	Evaluation of whether the BMP has changed people's attitudes (either towards the goal of the BMP, or towards implementing the BMP itself), as indicated through self-reporting.	Stormwater management agencies, often with the help of specialist community survey consultants.	Surveys (with survey forms) that examine people's self-reported attitudes.	• Relatively inexpensive (depending on the level of confidence needed in the results). • Relatively fast. • Can gather information that helps to improve the design of the BMP (e.g. people's attitudes may be based on incorrect assumptions that could be easily clarified). • Can usually monitor changes in people's awareness/knowledge, attitudes and/or self-reported behaviour with the same instrument (e.g. a survey).	• Changes in people's attitudes towards stormwater management do not necessarily lead to changes in behaviour. • The evaluation process and social norms may influence *self-reported* attitudes (e.g. some survey respondents may report a 'socially acceptable' attitude rather than their actual attitude). • Potential for confusion exists depending upon the attitude being monitored (e.g. some builders may have the unchanged *attitude* that new erosion and sediment control laws are unnecessary, but their *attitude* towards compliance may have changed simply because of the financial consequences).

Table 4.1 cont. An Evaluation Framework for Non-structural BMPs that Aim to Improve Stormwater Quality.

Style of Evaluation	Description	Who Typically Does It	Example of 'Monitoring Tools'	Advantages	Disadvantages
4. Changes in people's behaviour (self-reported)	Evaluation of whether the BMP has changed people's behaviour, as indicated through self-reporting.	Stormwater management agencies, often with the help of specialist community survey consultants.	Surveys (with survey forms) that examine people's self-reported behaviour.	• Relatively inexpensive (depending on the level of confidence needed in the results). • Relatively fast. • Can examine types of behaviour that are very difficult and expensive to directly observe or monitor (e.g. infrequent application of lawn fertiliser, disposal of used engine oil). • Can usually monitor changes in people's awareness/knowledge, attitudes and/or self-reported behaviour with the same instrument (e.g. a survey).	• Self-reported behaviour can be a very poor indicator of actual behaviour in some contexts (e.g. littering in public places).
5. Changes in people's behaviour (actual)	Evaluation of whether the BMP has changed people's behaviour, as indicated through direct measurement (e.g. the 'observational approach').	Specialists (e.g. research bodies, specialist consultants, trained staff from stormwater management agencies).	Observational studies (e.g. the 'Clean Communities Assessment Tool' and the 'Disposal Behaviour Index' methods used for Australian littering studies) or audits with checklists (e.g. erosion and sediment control audits).	• Changes in actual behaviour is a very good indicator for likely changes to stormwater quality and waterway health. • Data from such evaluations can be used to model predicted changes to stormwater quality and waterway health. • Such evaluations can provide valuable information that can be used for BMP design or improved evaluation strategies (e.g. highlighting errors associated with monitoring self-reported behaviour, and identifying why certain forms of behaviour occurs).	• Can be very difficult and costly to apply in some contexts due to issues such as invasion of people's privacy and the need to monitor a large number of infrequent events. • People's behaviour that influences stormwater quality is inherently complex, and is typically influenced by many variables (e.g. people's age, whether they are in groups, surrounding infrastructure, economic circumstances, etc.). Designing evaluation strategies to accommodate this complexity can be challenging.
6. Changes in stormwater quality	Evaluation of whether the BMP (or set of BMPs) has improved stormwater quality in terms of loads and/or concentrations of pollutants.	Specialists (e.g. research bodies) or stormwater management agencies with a very high level of in-house expertise.	Stormwater quality monitoring programs (e.g. 'BACI' design experiments[1]). Alternatively, pollutant export modelling can be used to translate known changes in behaviour into probable changes in stormwater quality.	• Directly measures changes in stormwater quality (the primary aim of these non-structural BMPs). • The information collected may allow non-structural BMPs to be included in pollutant export modelling exercises when undertaking major stormwater quality management decisions (along with structural BMPs). • Can be used for individual non-structural BMPs or combinations of BMPs (e.g. monitoring the collective effect on stormwater quality over time of implementing a new city-wide urban stormwater management plan).	• Relatively expensive and time-consuming (depending upon the desired level of confidence in the results). • Usually requires a very high level of technical expertise to design the monitoring program and analyse the results. • Can be difficult to measure subtle changes in stormwater quality, given the very high spatial and temporal variability of urban stormwater quality. • Can be difficult to find and maintain suitable control sites or catchments. • Typically, a variety of pollution sources and other types of BMPs heavily influence stormwater quality in areas where non-structural BMPs are applied.
7. Changes in waterway health	Evaluation of whether the BMP (or set of BMPs) has improved the health of receiving waters.	Stormwater management agencies, often with the help of specialist consultants and/or research groups.	Ecological health monitoring programs (e.g. trend analysis). Alternatively, receiving water quality modelling can be used to predict the ecological effect of known changes in stormwater quality (e.g. in estuary systems).	• Directly measures changes in aspects of waterway health (the ultimate goal of stormwater quality managers who are implementing non-structural BMPs). • Can be an efficient form of evaluation where BMPs involve a specific stormwater pollutant with few sources (e.g. an education campaign to phase out the use of specific pesticide in an urban catchment) or where a cause-effect relationship has already been established (e.g. the relationship between sewer overflows and ambient water quality in a river).	• Relatively expensive and time-consuming (depending upon the desired level of confidence in the results). • It is often very difficult to attribute subtle, long-term changes in waterway health to the use of any particular BMP. This style of evaluation is mainly used to evaluate the collective affect of all catchment management activities over time. • Usually requires a very high level of technical expertise to design the monitoring program and analyse the results.

1 'BACI' is an acronym for an experimental design that has Before and After sampling at the Control (no action) site and Intervention/Investigation (action) site.

needs to be gathered before the BMP is implemented (e.g. awareness levels prior to a stormwater awareness campaign). In addition, for some types of BMPs (e.g. educational campaigns), a pre-implementation monitoring exercise can be an extremely valuable input to help the design of the BMP (e.g. to clearly identify who is littering, where, when and why).

Often, the timing of the 'monitoring and evaluation tasks' needs to be carefully synchronised with the 'BMP implementation tasks'. To do this, a working group is often needed (involving the people implementing and monitoring the BMP) as well as a Project Plan that highlights all the tasks that the needed for the project, who is responsible for their implementation, and when they will be done. An example of a project plan for a relatively complex monitoring and evaluation project (i.e. one involving six styles of evaluation) is given in Appendix A.

2. Choose an appropriate style (or styles) of evaluation (from Table 4.1).

This decision is a very important one, and should be made after consideration of the following factors:

- The **objective(s)** of the BMP that will be evaluated. For example, if the objective is simply to raise awareness of stormwater pollution within a target audience through an educational program, style No. 2 is the obvious choice (i.e. monitoring changes to people's awareness or knowledge). However, if the objective is to improve erosion and sediment control compliance 'on the ground', style No. 5 would be the most appropriate (i.e. monitoring changes in people's actual behaviour). For multiple objectives, several styles of evaluation may be needed.
- It is recommended that evaluation style No. 1 (i.e. evaluating the nature of BMP implementation) always be attempted, as this provides a simple basis for more advanced forms of evaluation and often helps to explain the evaluation results. For example, if an enforcement program involving a new local law is found to be unsuccessful in changing people's behaviour, knowledge about the nature of enforcement activities (e.g. how many fines were issued, how many fines were successfully challenged in court, etc.) would be needed to help explain this outcome.
- The **resources** available to the monitoring agency (e.g. cash, time, expertise). As a general rule, style No. 1 is the least-resource intensive, followed by styles No. 2, 3 and 4, then style No. 5, and finally styles No. 6 and 7. Typically, evaluation styles No. 6 and 7 will be beyond the resources of most local government authorities in Australia.
- The **time-frame** over which monitoring needs to occur. For example, a monitoring and evaluation plan may be developed using styles No. 1, 5 and 7 which provides some evaluation results in the short term (e.g. whether the BMP has been fully implemented as planned), in the medium term (e.g. whether the BMP changes people's actual behaviour) and in the long term (e.g. whether waterway health in the region has improved). Short and medium term reporting may be essential to keep stakeholders confident that the project is 'on track', particularly if the ultimate outcomes may not occur for years or even decades.
- The **purpose** of the evaluation. Evaluation is a process not a product (NSW EPA, 2002). Consideration should be given to how the findings of the evaluation will be used, by whom, and their specific needs. Outcomes of evaluation can be used to:
  - assist all stages of the project (e.g. help to influence the BMP design, evaluate the BMP's overall performance);
  - adaptively manage the project (e.g. help to continuously steer the BMP to maximise its performance); and/or
  - communicate the findings of the project (NSW EPA, 2002).
- The **nature of the BMP**. Some styles of evaluation are intrinsically suited to specific BMPs because of the nature of the BMP. For example, an industry education program could easily be evaluated by a pre- and post-campaign audit of industry practices (style No. 5) to see if actual behaviour had changed. This style of evaluation would however be far more difficult if the BMP was an educational campaign promoting a change to fertilisation rates on residential lawns.

To help local government authorities make this decision, evaluation styles have been recommended for specific BMPs, based on our knowledge of the likely costs, degree of difficulty, time-frames, and the resources commonly available to local government authorities. These recommendations are presented in Table 4.3 (see Appendix D).

In addition, it is recommended that expert advice be sought at this critical early planning stage to help select a suitable evaluation style (or styles). Stormwater managers in leading agencies, research bodies and consultancies can assist with this process.

3. **Use a 'monitoring and evaluation protocol' that is relevant to the chosen evaluation style to develop and implement a suitable 'Monitoring and Evaluation Plan'.**

These protocols are described in Section 4.3.

4. **At the completion of the evaluation exercise, record key details of the BMP design, the evaluation design, and the results in the relevant 'data recording sheets'.**

These data recording sheets are described in Section 4.4. To maximise the value from the evaluation exercise, data should be shared with the stormwater management industry (e.g. via the lead agent for stormwater quality management in the region), irrespective of the project's success or failure.

4.3 Monitoring and Evaluation Protocols for Non-structural BMPs

Three detailed US guidelines collectively provide 750 pages of advice on monitoring the implementation and value of stormwater BMPs. They are:

- *Urban Stormwater Best Management Practice (BMP) Performance Monitoring. A Guidance Manual for Meeting the National Stormwater BMP Database Requirements* (ASCE & US EPA, 2002).
- *Techniques for Tracking, Evaluating and Reporting the Implementation of Nonpoint Source Control Measures - Urban* (US EPA, 2001b).
- *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (US EPA, 1997).

While relevant and useful to non-structural BMPs for stormwater quality improvement (particularly ASCE & US EPA, 2002), the vast majority of these guidelines:

- Focus on evaluation involving *stormwater quality* monitoring (i.e. evaluation style No. 6 in the evaluation framework shown in Table 4.1).
- Focus on monitoring and evaluation involving *structural* BMPs (although attempts are made to address non-structural BMPs).
- Are suitable for monitoring projects that are well-funded, have access to high levels of expertise (e.g. to undertake statistical project design and data analysis) and aim to produce results with a high degree of confidence. In Australia, the type of BMP-related monitoring that would most benefit from these guidelines is undertaken by academic institutions.

As the primary audience for this report is local government stormwater managers in Australia, we suggest the US guidelines are too lengthy, complex and detailed to be widely used by local government in the foreseeable future. Few local governments in Australia attempt non-structural BMP evaluations using the sixth style of evaluation (i.e. stormwater quality monitoring), mainly because of the relatively high costs and degree of complexity. To quote the Texas Statewide Storm Water Quality Task Force (2002), "quantitative methods and data provide the surest way of recording change in water quality, however, given budgetary and staffing restraints quantification of changes in run-off quality is not always possible or even feasible and many programs must rely on other means of measurement" (chapter 5.0, p. 2). This is very much the case for local government agencies in Australia.

The approach taken in this Section is to use the generic monitoring and evaluation process recommended in ASCE & US EPA (2002), tailor it for use by local government and summarise the recommended steps to follow for each style of evaluation outlined in Table 4.1. The resulting monitoring and evaluation protocols provide basic guidance on the steps to follow, while the US guidelines can be consulted if more detail is needed (e.g. on statistics, selection of monitoring equipment, etc.).

Some evaluation projects will adopt more than one style of evaluation (e.g. they may monitor BMP implementation, the effect of the BMP on behaviour and changes to stormwater quality). Such projects will need to use more than one protocol to develop a Monitoring and Evaluation Plan. This should not cause difficulties, as all protocols use the same process and structure - only the details of some steps differ.

4.3.1 Monitoring and Evaluation Protocol: BMP Implementation (Evaluation Style No. 1)

PHASES	RECOMMENDED ACTIONS
Phase I - Determine the objectives, scope and nature of the program	**1. Review relevant literature, local case studies, guidelines and/or previous monitoring data (where available).** This step allows one to: • learn from previous experiences (e.g. to identify suitable monitoring methods, the monitoring effort that is likely to be needed and potential impediments to objective evaluation); and • understand the likely magnitude of change that can be induced by the BMP and the timeframe needed for change. **2. Get to know the local context.** As most non-structural BMPs operate by changing people's behaviour, it is important to understand the target audience for behavioural change (e.g. their knowledge levels, attitudes, language skills, etc.) and the environment in which they work. Local contextual information may also be available that can be used in the design of the evaluation process and BMP (e.g. existing reporting systems, obvious impediments to behavioural change). A brief review of the local context should also provide an early indication of the magnitude of change that is desired. **3. Clearly document the objectives being evaluated.** For this style of evaluation, make sure the objectives relate to the extent and/or quality of *BMP implementation* and are S.M.A.R.T (i.e. specific, measurable, achievable, relevant and timeframed). For example, a sound objective is "to determine whether a new local law for stormwater pollution on building sites is being adequately enforced by Council's new enforcement unit, where the performance target for enforcement is for Officers to inspect (on average) a total of ≥30 sites per working day". **4. Broadly determine the level of confidence needed in the evaluation results.** To do this, firstly identify the primary audience for the evaluation results (i.e. the people who are seeking information on the performance of the BMP). Broadly determine these people's needs in terms of the degree of certainty that must accompany the findings of the evaluation. **5. Determine the type of evaluation needed.** When measuring whether non-structural BMPs have been implemented and/or the quality of their implementation, one of two types of evaluation are usually undertaken: 1. a 'desktop' review, which relies on self-reporting by people responsible for BMP implementation (preferably with supporting evidence); or 2. an audit or survey by an independent person (or team) who checks whether the BMP has actually been implemented 'on the ground' (preferred option).

6. **Determine when evaluation results are needed.**

   Consider how the evaluation results will be used. In addition to final reporting, preliminary evaluation results may be needed (e.g. throughout the delivery of the BMP) to fine-tune the implementation process and/or satisfy some stakeholders (e.g. funding bodies who may want quarterly progress reports).

7. **Confirm the project's budget for monitoring and evaluation.**

   This is particularly important when monitoring may extend over several annual budget cycles.

Phase II - Develop a 'Monitoring and Evaluation Plan'

(an example of such a Plan is provided in Appendix B)

1. **Select monitoring parameters.**

   Review the evaluation objectives and become familiar with the key design elements of the BMP that is to be implemented, as monitoring parameters should be chosen to reflect these elements. For example, if the evaluation objective is to simply determine whether a training program has been implemented, in terms of *just BMP implementation* the intention may be to deliver the training, attract a given number of attendees and generate a high level of satisfaction amongst attendees. Thus, suitable monitoring parameters may be the:

   - number of training sessions delivered;
   - number of people trained; and
   - trainees' ratings on the quality of the course's content and its delivery.

2. **Determine the sampling design (e.g. the sample size, monitoring frequency and monitoring timeframe)**.

   Firstly, determine whether it is possible to monitor all instances of BMP implementation or whether a sub-sample of the entire group will need to be monitored (i.e. a probabilistic approach). For example, if one is monitoring the implementation of new maintenance procedures for inspecting and cleaning-out structural BMPs, a stratified random sample may be taken (e.g. randomly select a sub-sample of gross pollutant traps and a sub-sample of constructed wetlands, then inspect and review their maintenance records). US EPA (2001b) provides detailed guidance on such sampling designs.

   Secondly, determine whether the resources are available to take a *statistical approach* to sampling design and the analysis of results. While US EPA (2001b) provides guidance on this aspect, it is recommended that expert statistical advice be obtained, if needed.

   Thirdly, review how the BMP is intended to function, the level of confidence needed in the results of the evaluation, as well as when the evaluation results are needed, and then determine whether monitoring should occur:

   - before implementation (as well as after);
   - several times after implementation (e.g. annually for 3 years) or just once;
   - at several BMP implementation sites; and/or
   - at a control site or sites (i.e. at locations where the BMP is not being implemented).

   Finally, determine a monitoring frequency and timeframe (e.g. once at the end of the 12 month campaign) based on the available monitoring resources and the time needed for the BMP to be implemented to a level where measurement of outcomes is feasible.

3. **Select monitoring locations (where relevant).**

   If a sub-sample of BMP implementation sites is to be monitored, select sites that are representative of the entire population.

4. **Determine and trial the monitoring methodology.**

   Decide *how* the monitoring data will be obtained. For example, measuring attendance at training might be done by simply reviewing signed trainee attendance records, while the trainees' perceptions of the quality of the course content and its delivery can be monitored through a simple Training Evaluation Form. Typically, 'BMP implementation' will be measured in terms of the degree of implementation at a given time and the quality of implementation.

   The use of simple, self-explanatory and tailored auditing checklists (or data recording forms) is strongly encouraged. Such tools are particularly valuable when monitoring is to occur over several years (e.g. measuring the enforcement effort and quality of enforcement associated with a new local law). Table 4.4 provides some examples of monitoring tools that have been developed for various purposes and could be tailored for use.

   If a questionnaire or a series of questionnaires are to be used as monitoring tools, it is strongly recommended that specialist expertise be sought on their design (US EPA, 2001b). Significant mistakes can easily be made in questionnaire design (e.g. introduction of personal bias and assumptions, leading and closed questions, and 'push polling'). If designed well however, such tools can generate a large amount of useful information.

   The monitoring methodology should be briefly trialled to ensure that the approach is practical, efficient and is able to gather the data needed. This is particularly important for methodologies that use questionnaires, seek to survey a large population and/or involve a substantial commitment of resources.

   Typically, monitoring procedures will need to be developed before the BMP is applied to allow data to be collected before, during and/or after the BMP's implementation. For example, before training courses begin, ensure they incorporate attendance records (with trainee contact details for verification) and well-designed Training Evaluation Forms.

5. **Determine who will do the monitoring and evaluation.**

   This decision should be based on available resources (e.g. funds and expertise) and well as the need for impartiality. Ideally, those people undertaking the monitoring and evaluation should be independent of the body that is responsible for the design and implementation of the BMP. If this is not possible, an independent peer review of the Monitoring and Evaluation Plan and Report is recommended.

6. **Prepare a brief quality assurance/quality control (QA/QC) plan.**

   A QA/QC Plan considers potential sources of error and develops strategies to minimise such errors (where possible). At the simplest level, a QA/QC Plan may define the form that data is collected in and how data is transferred from recording sheets to a database for analysis. At the more complex level, a QA/QC Plan for a detailed questionnaire may involve the incorporation of questions that enable the precision of the monitoring instrument to be checked.

Where monitoring methods involve some subjectivity (e.g. rating the degree of BMP implementation on a 1 to 5 rating scale) and measurement by different people, the QA/QC Plan should outline procedures so that consistency can be maintained for the ratings between people and over time. For example, audits of BMP implementation involving an audit team could use guidance notes and photos on the audit checklist, and auditors could collectively evaluate some BMPs before the official audit to calibrate each person's 'rating' system.

The QA/QC plan should also address briefly data management. Before data are collected, determine how they will be handled, briefly reviewed for obvious errors and stored. Typically this part of the plan will ensure that:

- data recording sheets are developed;
- an official file is created to store hard copies of the data;
- a database or spreadsheet is used to electronically store the data; and
- data are not lost in the event of reasonably foreseeable circumstances (e.g. staff movement).

7. **Prepare a workplace health and safety management plan (where relevant).**

   A brief Health and Safety Management Plan may be needed if monitoring BMP implementation involves entry to an area with significant risks to safety (e.g. auditing operational areas). Specialist advice should be sought on the precautions needed.

8. **Estimate the resources required to implement the monitoring and evaluation plan.**

   Ensure that this estimate includes staff time as well as financial resources.

9. **Undertake a reality check of the monitoring and evaluation plan.**

   Before finalising the plan, undertake a reality check to ensure that it is practical and adequately resourced. Input from those people who will be undertaking the monitoring should occur at this stage if they have not been involved in the preparation of the plan. The plan may need revision after this step.

Phase III - Implement the 'Monitoring and Evaluation Plan'

1. **Train the monitoring team (if relevant).**

   Depending on the nature of the proposed monitoring methods, training may be needed to ensure that implementation occurs efficiently. A dry run is essential to check that the training has been successful in communicating the approach.

2. **Implement the monitoring and evaluation plan.**

   Typically, the implementation program for the BMP will change with time. A record should be kept that tracks these changes over time to assist with the interpretation of monitoring data. In addition, it is essential to clearly communicate the timing of: 1) BMP implementation tasks; and 2) the monitoring and evaluation tasks between parties responsible for both of these elements so they can synchronise their work. A regularly updated and circulated 'project plan' that documents both the BMP implementation tasks and the monitoring and evaluation tasks is strongly recommended to address these issues.

   An example of a project plan is given in Appendix A.

Phase IV - Evaluate the success of the project and communicate the results

1. **Review the quality of data collected.**

   During the development of the Monitoring and Evaluation Plan, sources of *possible* errors and uncertainty should have been identified as part of the QA/QC Plan. Once the data are available, they should be briefly reviewed for obvious errors and areas of uncertainty. These should be documented together with any assumptions made during the project.

2. **Evaluate the results.**

   Determine which of two broad categories of data analysis will be undertaken:
   - statistical analysis (drawing on expert advice and/or guidance from US EPA, 2001b); and/or
   - basic visual interpretation, preferably with the use of graphical representation of the data.

   Analyse the results to determine whether sufficient data is available to:
   - meet the objectives of the evaluation; and
   - provide the audience of the evaluation with the level of confidence they need in the findings.

   Determine:
   - whether the objectives being evaluated were achieved; and if enough data is available,
   - the reasons why specific outcomes were or were not achieved (i.e. so future work can seek to replicate 'successes' and avoid 'failures').

3. **Document and communicate the evaluation's findings.**

   Document the findings of the evaluation as either an interim report or final evaluation report. A suggested structure for a final Monitoring and Evaluation Report is:
   - Executive summary.
   - Background and objectives.
   - Monitoring methods.
   - Key results.
   - Data analysis.
   - Conclusions (with caveats regarding errors, the level of certainty, assumptions, etc.).
   - Recommendations.
   - Appendices (including completed data recording sheets, contacts for further information, audit checklists, etc.).

   An example of a final Monitoring and Evaluation Report is given in Appendix C.

   Complete the relevant data recording sheet provided in Section 4.4 and forward a copy to the lead agent for stormwater management in the region (e.g. Vic EPA, NSW EPA, etc.). In terms of sharing knowledge and promoting continuous improvement in this area, reporting the results of projects that failed to meet all of their objectives is just as important as reporting on those that were entirely successful.

   Finally, consult the intended evaluation audience to determine the best way to communicate the results to them. Develop a practical strategy for such communication and implement it.

Table 4.4 Examples of Monitoring Tools That Have Been Used for Different Styles of Non-structural BMP Evaluation.

Evaluation Styles*	Examples of Monitoring Tools for Stormwater-Related BMPs**	References***
1	'Source control checklist' (a checklist to confirm whether key stormwater BMPs are in place within the operational areas of local government authorities).	Victorian Stormwater Committee (1999)
1	'Site management plans: checklist' (a checklist to confirm whether the key stormwater elements of a site management plan for a construction activity are in place).	Victorian Stormwater Committee (1999)
1	'Stormwater quality checklists for businesses' (a checklist to confirm whether typical stormwater BMPs are in place, such as pollution prevention procedures).	Victorian Stormwater Committee (1999)
1	'Council operations checklist' (a guideline/checklist to confirm whether key stormwater BMPs are in place within local government authorities).	NSW EPA (1998)
1	A survey of urban stormwater managers (relates to urban nutrient management programs run by stormwater management agencies).	CWP (1999)
1	Follow-up survey to assess the quality of BMP implementation for an industrial education/participation program.	Sinclair (2001)
1, 2, 3, 4	Several examples of surveys on BMP implementation (e.g. erosion and sediment control programs), and a surveys sheet on residential 'housekeeping' practices that relate to stormwater management.	US EPA (2001b)
2, 3	Two phone surveys involving a commercial/industrial program.	Matthews and Meynink (undated) – see the 'Final Project Evaluation Report'
2, 3	A phone survey of residents as well as staff from retail food outlets.	TRC (2000)
2, 3	A face-to-face survey of residents, shoppers/workers, business owners/shopkeepers and commuters.	UPRCMT (2000)
2, 3, 4	*Several community survey questionnaires (some suitable for face-to-face interviews).*	Nancarrow *et al.* (1998)
2, 3, 4	*A phone survey of residents regarding their nutrient management knowledge and behaviour.*	CWP (1999)
2, 3, 4	*Mail-out surveys for residents.*	University of New South Wales (1999 & 2000)
2, 3, 4	A phone survey questionnaire for a business/industry program.	Laris (2001)
2, 3, 5	*Two erosion and sediment control monitoring tools: a survey of residential builders; and erosion and sediment control audit checklists for residential building sites and larger developments.*	Brisbane City Council (2002) – the audit checklists are available on request.
3, 4	*'Homeowner Research Questionnaire' regarding lawn/garden care activities.*	Haynes (2002)
5	*An erosion and sediment control audit checklist for residential building sites.*	Alviano (2002)
5	*'Clean Communities Assessment Tool'* and 'Disposal Behaviour Index' (copyright protected) – both systems are used for the direct measurement of littering behaviour.	BIEC (1999 and 2001); Curnow (2002); Curnow *et al.* (2002)
5	Audit sheets for measuring the condition of the catchment (i.e. to check whether self-reported behavioural change has resulted in any observable change in the physical condition of the catchment).	Nancarrow *et al.* (1998)

Notes:
* See Table 4.1 for an explanation of these styles.
** Those tools in *italics* are suggested as being the best examples for use by local government authorities.
*** See Reference Section for the full reference details.

4.3.2 Monitoring and Evaluation Protocol: Changes in Awareness/Knowledge, Attitudes and/or Self-reported Behaviour (Evaluation Styles No. 2, 3 and 4)

The following protocol involves the same key steps regardless of whether evaluation involves measuring changes in people's:

- awareness and/or knowledge (evaluation style No. 2);
- self-reported attitudes(evaluation style No. 3); or
- self-reported behaviour(evaluation style No. 4).

PHASES	RECOMMENDED ACTIONS
Phase I - Determine the objectives, scope and nature of the program	**1. Review relevant literature, local case studies, guidelines and/or previous monitoring data (where available).** This step allows one to: • learn from previous experiences (e.g. to identify suitable monitoring methods, the monitoring effort that is likely to be needed and potential impediments to objective evaluation); and • understand the likely magnitude of change that can be induced by the BMP and the timeframe needed for change. The literature reviewed in Report No. 3 in this series (Taylor and Wong, 2002) is particularly relevant, as it covers 'education and participation programs' that seek to change levels of stormwater awareness/knowledge, attitudes and behaviour. In addition, leading stormwater management agencies in Australia should be able to direct people to case studies with similar attributes as the one being evaluated. **2. Get to know the local context.** It is important to understand the target audience for behavioural change (e.g. their knowledge levels, attitudes, language skills, etc.) and the environment in which they work. Local information may also be available that can be used in the design of the evaluation process and BMP (e.g. existing survey mechanisms, existing consultative groups, obvious impediments to behavioural change). A brief review of the local context should also provide an early indication of the magnitude of change that is desired. **3. Clearly document the objectives being evaluated.** For this style of evaluation, make sure the objectives: • relate to the extent knowledge/awareness, attitudes and/or behaviour will change within a target population; and • are S.M.A.R.T (i.e. specific, measurable, achievable, relevant and timeframed). For example, a sound objective is "to determine whether a 6 month stormwater awareness program in a commercial shopping district will affect people's knowledge about stormwater management and their self-reported stormwater management behaviour immediately after the program, as well as 6 months later".

4. **Broadly determine the level of confidence needed in the evaluation results.**

   To do this, firstly identify the primary audience for the evaluation results (i.e. the people who are seeking information on the performance of the BMP). Broadly determine these people's needs in terms of the degree of certainty that must accompany the findings of the evaluation.

5. **Determine when evaluation results are needed.**

   Consider how the evaluation results will be used. In addition to final reporting, preliminary evaluation results may be needed (e.g. throughout the delivery of the BMP) to fine-tune the implementation process and/or satisfy some stakeholders who may want some early feedback on progress (e.g. funding bodies).

6. **Confirm the project's budget for monitoring and evaluation.**

   This is particularly important when monitoring may extend over several annual budget cycles.

Phase II - Develop a 'Monitoring and Evaluation Plan'

(an example of such a Plan is provided in Appendix B)

1. **Select monitoring parameters.**

   Review the evaluation objectives and become familiar with the key design elements of the BMP that is to be implemented, as monitoring parameters should be chosen to reflect these elements. For example, if an educational program aims to promote specific lawn and garden care activities in residential areas to change people's behaviour, the Monitoring and Evaluation Plan may monitor the knowledge/awareness, attitudes and/or behaviours of residents that relate to these activities. In this example, monitoring parameters may be the residents':

   - knowledge/awareness of the correct use of garden fertilisers and pesticides, and/or why they need to be carefully managed;
   - attitudes towards the principles of 'Integrated Pest Management', the use of slow release fertilisers and/or the need to minimise stormwater pollution; and/or
   - self-reported behaviour on the use of fertilisers and pesticides.

2. **Determine the sampling design (e.g. the sample size, monitoring frequency and monitoring timeframe).**

   For this type of evaluation, monitoring usually occurs via pre- and post-BMP surveys using questionnaires.

   Firstly, determine whether it is possible to monitor the entire population of the target audience for the BMP (e.g. all the shopkeepers in a shopping centre) or whether a sub-sample of the population will need to be monitored (i.e. a probabilistic approach). Where a sub-sample needs to be taken, it is strongly recommended that specialist advice be sought on:

   - Whether stratified random sampling is needed (e.g. to select random samples from within separate groups that have different characteristics such as age, language, geographic location, business type, etc.).
   - The size of the sample(s) needed so that they are representative of the total population and produce results with a known degree of confidence.

- Whether the results have to be weighted to reflect known population characteristics (e.g. age, dwelling type).

See US EPA (2001b) for more detailed guidance on sampling design issues.

Secondly, determine whether the desired level of confidence in the results necessitates a *statistical approach* be taken in the sampling design and the analysis of results. For example, statistical analysis may be desired to compare the results of pre- and post-BMP surveys to determine whether the observed change is statistically significant. While US EPA (2001b) provides detailed guidance on this aspect of monitoring, it is recommended that expert statistical advice be obtained if a statistical approach is to be used.

Thirdly, review how it is intended that the BMP will function (e.g. the likely extent of induced change and the likely timeframe for change), the level of confidence needed in the results of the evaluation, as well as when the evaluation results are needed, and then determine whether monitoring should occur:

- before and after implementation of the BMP;
- several times before, during and/or after implementation of the BMP;
- at several BMP implementation sites; and/or
- at a control site or sites (i.e. at locations where the BMP is not being implemented).

Finally, the monitoring timeframe and frequency should then be determined. For this style of evaluation well-designed projects typically survey the target population immediately before, immediately after and 6 - 12 months after the BMP is implemented.

3. **Select monitoring locations (where relevant).**

   If a sub-sample is to be monitored as a representative sample of a larger population, select a site (or sites) that reflects the diversity of the entire population. For example, if interviews are to be conducted with shoppers using a commercial district, identify where these interviews will be conducted so that a typical mix of shoppers are interviewed.

4. **Determine and trial the monitoring methodology.**

   Decide *how* the monitoring data will be obtained. For example, survey methods typically include:

   - telephone surveys;
   - mail-out surveys; or
   - face-to-face interviews.

   Where questionnaires are to be used as monitoring tools, it is strongly recommended that specialist expertise be sought on their design (US EPA, 2001b). Mistakes can easily be made in questionnaire design. If designed well however, such tools can generate a large amount of useful information.

   Table 4.4 provides some examples of monitoring tools that have been developed for this style of evaluation. Some of the recommended features of good surveys include:

   - The use of an introductory letter that precedes a telephone survey.

- Questions that objectively test levels of knowledge (without prompting) rather than asking for a self-assessment about whether knowledge/awareness has been raised.
- Surveys that do not change the nature of their questions throughout the project.
- Studies that collect data from a control site as well as the BMP intervention site.
- The provision of information and questions that minimise the risk of respondents providing a 'socially acceptable' but false answer with respect to their attitudes and/or behaviour.
- Gathering data prior to BMP implementation to help *design* the BMP (e.g. to target specific segments of the community, misunderstandings, attitudes and/or behaviours with educational materials) and remove impediments to behavioural change (e.g. by providing people with infrastructure/services to make it easy for them to change their behaviour).
- Trialling of the questionnaire to test whether it can be clearly understood and how long it takes to complete.

Note that some advanced survey methodologies incorporate a validation step to test the veracity of the self-reported data on behavioural change. For example, a sub-set of businesses who have reported changing their behaviour as a result of an educational BMP, could be visited and evidence sought to substantiate their claims. Essentially this step incorporates a simple form of evaluation style No. 5 (see Table 4.1). Such a step is strongly encouraged, given the unreliability of self-reporting as an indicator of *real* behavioural change in many contexts (see Taylor and Wong, 2002).

5. **Determine who will do the monitoring and evaluation.**

   This decision should be based on available resources (e.g. funds and expertise) and well as the need for impartiality. Ideally, those people undertaking the monitoring and evaluation should be independent of the body that is responsible for the design and implementation of the BMP. At the very least, the methodology, data and conclusions should be reviewed by an impartial and suitably qualified body.

   In some case studies, costs have been minimised by using volunteers in the survey process (e.g. trained members of community groups). Where this is done, care is needed to maintain the quality of collected data, the safety of volunteers, and appropriate insurance cover.

   For statistical analysis of survey data, specialist expertise should be obtained.

6. **Prepare a *brief* quality assurance/quality control (QA/QC) plan.**

   A QA/QC Plan considers potential sources of error and develops strategies to minimise such errors (where possible). At the simplest level, a QA/QC Plan may define the form that data are collected in, and how data are transferred from recording sheets to a database for analysis. At the more complex level, a QA/QC Plan for a detailed questionnaire may involve the incorporation of questions that enable the precision of the monitoring instrument to be checked.

   For stormwater management surveys, three potential sources of errors should be carefully considered when developing the QA/QC Plan:

- the potential for the *respondents* to be an unrepresentative sub-set of the surveyed population (e.g. people who think that a survey on stormwater management is something worth spending their time on may be more easily persuaded or informed by educational BMPs);
- the potential for the *context* of the monitoring to influence the accuracy of self-reported behaviour (e.g. male teenagers interviewed amongst their peers may overstate their littering behaviour); and the potential for *self-reporting* of attitudes and behaviour to be influenced by the respondents' perceptions of what a socially acceptable response should be (e.g. a respondent who learns via an educational campaign that washing your car on the street is 'polluting' and potentially illegal may be less inclined to accurately report their car washing behaviour after the campaign if they still wash their care on the street).

The QA/QC plan should also address *briefly* data management. Before data are collected, determine how they will be handled, briefly reviewed for obvious errors and stored. Typically this part of the plan will ensure that:

- data recording sheets are developed;
- an official file is created to store hard copies of the data;
- a database or spreadsheet is used to electronically store the data; and
- data are not lost in the event of reasonably foreseeable circumstances (e.g. staff movement).

7. **Prepare a workplace health and safety management plan (where relevant).**

   A brief Health and Safety Management Plan may be needed if monitoring involves entry to an area with significant risks to safety (e.g. conducting face-to-face interviews in industrial complexes). Specialist advice should be sought on the precautions needed.

8. **Estimate the resources required to implement the monitoring and evaluation plan.**

   Ensure that this estimate includes staff time as well as financial resources.

   Care should also be taken not to develop a survey that requires too great an investment of time by the respondent ((10 minutes is typical for phone surveys). This is particularly important where follow-up surveys will involve the same people.

9. **Undertake a reality check of the monitoring and evaluation plan.**

   Before finalising the plan, undertake a reality check to ensure that it is practical and adequately resourced. Input from those people who will be undertaking the monitoring should occur at this stage if they have not been involved in the preparation of the plan. The plan may need revision after this step.

   A peer review of the plan is recommended where the monitoring team can get assistance from people who have high levels of relevant expertise and experience (e.g. people from a research group, specialist consultancy, stormwater management authority, or agency that has run a similar evaluation project).

Phase III - Implement the 'Monitoring and Evaluation Plan'	**1. Train the monitoring team (if relevant).** For survey methods where a team of people will survey a large number of people, training of the team will be needed. A dry run is essential to check that the training has been successful in communicating the required approach. **2. Implement the monitoring and evaluation plan.** Typically, the implementation program for the BMP will change with time. A record should be kept that tracks these changes over time to assist with the interpretation of monitoring data. In addition, it is essential to clearly communicate the timing of: 1) BMP implementation tasks; and 2) the monitoring and evaluation tasks between parties responsible for both of these elements so they can synchronise their work. A regularly updated and circulated 'project plan' that documents <u>both</u> the BMP implementation tasks and the monitoring and evaluation tasks is strongly recommended to address these issues. An example of a project plan is given in Appendix A.
Phase IV - Evaluate the success of the project and communicate the results	**1. Review the quality of data collected.** During the development of the Monitoring and Evaluation Plan, sources of *possible* errors and uncertainty should have been identified as part of the QA/QC Plan. Once the data are available, they should be briefly reviewed for obvious errors and areas of uncertainty. These should be documented together with any assumptions made during the project. **2. Evaluate the results.** Determine which of two broad categories of data analysis will be undertaken: • statistical analysis (drawing on expert advice and/or guidance from US EPA, 2001b); and/or • basic visual interpretation, preferably with the use of graphical representation of the data. Analyse the results to determine whether sufficient data is available to: • meet the objectives of the evaluation; and • provide the audience of the evaluation with the level of confidence they need in the findings. Where statistical analysis is undertaken, it should at least report whether there is a statistically significant difference between the pre- and post-BMP data sets for a given degree of confidence (e.g. the 'alpha level' is usually set at 0.05). Determine: • whether the objectives being evaluated were achieved; and if enough data is available, • the reasons why specific outcomes were or were not achieved (i.e. so future work can seek to replicate 'successes' and avoid 'failures').

3. Document and communicate the evaluation's findings.

Document the findings of the evaluation as either an interim report or final evaluation report. A suggested structure for a final Monitoring and Evaluation Report is:

- Executive summary.
- Background and objectives.
- Monitoring methods.
- Key results.
- Data analysis (including statistical analysis).
- Conclusions (with caveats regarding errors, the level of certainty, assumptions, etc.).
- Recommendations.
- Appendices (including completed data recording sheets, contacts for further information, questionnaires, etc.).

An example of a final Monitoring and Evaluation Report is given in Appendix C.

Complete the relevant data recording sheet provided in Section 4.4 and forward a copy to the lead agent for stormwater management in the region (e.g. Vic EPA, NSW EPA, etc.). In terms of sharing knowledge and promoting continuous improvement in this area, reporting the results of projects that failed to meet all of their objectives is just as important as reporting on those that were entirely successful.

Finally, consult the intended evaluation audience to determine the best way to communicate the results to them. Develop a practical strategy for such communication and implement it.

4.3.3 Monitoring and Evaluation Protocol: Changes in Actual Behaviour (Evaluation Style No. 5)

PHASES	RECOMMENDED ACTIONS
Phase I - Determine the objectives, scope and nature of the program	**1. Review relevant literature, local case studies, guidelines and/or previous monitoring data (where available).** This step allows one to: • learn from previous experiences (e.g. to identify suitable monitoring methods, the monitoring effort that is likely to be needed and potential impediments to objective evaluation); and • understand the likely magnitude of change that can be induced by the BMP and the timeframe needed for change. The literature reviewed in Report No. 3 of this series (Taylor and Wong, 2002) should assist this process. It is also recommended that discussions occur with people who have previously undergone similar evaluation programs. Contacts can be obtained from the references in Report No. 3 in this series (Taylor and Wong, 2002), the references in Table 4.4 and relevant staff from leading stormwater management agencies in Australia. **2. Get to know the local context.** It is important to understand the target audience for behavioural change (e.g. their knowledge levels, attitudes, language skills, etc.) and the environment in which they work. Local information may also be available that can be used in the design of the evaluation process and BMP (e.g. existing auditing and/or record-keeping systems, obvious impediments to behavioural change). A brief review of the local context should also provide an early indication of the magnitude of change that is desired. **3. Clearly document the objectives being evaluated.** For this style of evaluation, make sure the objectives: • relate to the behavioural change within a target population (e.g. littering behaviour) and/or outcomes produced by such behavioural change (e.g. the extent to which new development includes water sensitive urban design features); and • are S.M.A.R.T (i.e. specific, measurable, achievable, relevant and timeframed). For example, a sound objective is "to determine whether a 12 month erosion and sediment control education and enforcement program has improved the percentage of building sites in the city that comply with new erosion and sediment control standards". **4. Broadly determine the level of confidence needed in the evaluation results.** To do this, firstly identify the primary audience for the evaluation results (i.e. the people who are seeking information on the performance of the BMP). Broadly determine these people's needs in terms of the degree of certainty that must accompany the findings of the evaluation.

5. **Determine when evaluation results are needed.**

   Consider how the evaluation results will be used. In addition to final reporting, preliminary evaluation results may be needed (e.g. throughout the delivery of the BMP) to fine-tune the implementation process and/or satisfy some stakeholders who may want some feedback on progress (e.g. funding bodies).

6. **Confirm the project's budget for monitoring and evaluation.**

   This is particularly important when monitoring may extend over several annual budget cycles.

Phase II - Develop a 'Monitoring and Evaluation Plan'

(an example of such a Plan is provided in Appendix B)

1. **Select monitoring parameters.**

   Review the evaluation objectives and become familiar with the key design elements of the BMP that is to be implemented, as monitoring parameters should be chosen to reflect these elements. For example, an industry-based stormwater education campaign may aim to change behaviour by promoting specific management practices such as the use of covered storage areas, the use of spill clean-up kits, sweeping-up (rather than hosting) wastes, etc. In this example, the promoted practices could be included as monitoring parameters in an audit program.

2. **Determine the sampling design (e.g. the sample size, monitoring frequency and monitoring timeframe).**

   For this type of evaluation, monitoring usually occurs via two methods:

   - direct observations of behaviour (e.g. littering studies, observations of people washing their car); or
   - audits of premises/sites (e.g. building sites, industrial sites, new development).

   Firstly, determine whether it is possible to monitor the entire population of the target audience for the BMP (e.g. all the businesses licensed by a local authority that have the potential to pollute stormwater) or whether a sub-sample of the population will need to be monitored (i.e. a probabilistic approach). Where a sub-sample needs to be taken, it is recommended that specialist advice be sought on:

   - Whether stratified random sampling is needed (e.g. to select random samples from within separate groups that have internally homogeneous characteristics such as the nature of the industry/business, the type of building/construction site, the size of business, etc.).
   - The size of the sample(s) needed so that they are representative of the total population and produce results with a known degree of confidence.
   - Whether the results have to be weighted to reflect known population characteristics (e.g. the type of industry/business or building/construction site).

   See US EPA (2001b) for more detailed guidance on sampling design issues.

Secondly, determine whether the desired level of confidence in the results necessitates a *statistical approach* be taken in the sampling design and the analysis of results. For example, statistical analysis may be desired to compare the results of pre- and post-BMP observational studies to determine whether the observed behavioural change is statistically significant (for a given degree of confidence). While US EPA (2001b) provides detailed guidance on this aspect of monitoring, it is recommended that expert statistical advice be obtained if a statistical approach is to be used.

Thirdly, review how it is intended that the BMP will function (e.g. the likely extent of induced behavioural change and the likely timeframe for change), the level of confidence needed in the results of the evaluation, as well as when evaluation results are needed, and then determine whether monitoring should occur:

- before and after implementation of the BMP;
- several times before, during and/or after implementation of the BMP;
- at several BMP implementation sites; and/or
- at a control site or sites (i.e. at locations where the BMP is not being implemented).

Finally, the monitoring timeframe and frequency should then be determined. For this style of evaluation well-designed projects typically survey the target population immediately before, immediately after, and 6 - 12 months after the BMP is implemented. As mentioned previously, annual audits are also common for on-going BMPs (e.g. regulatory programs).

3. **Select monitoring locations (where relevant).**

If a sub-sample is to be monitored as a representative sample of a larger population, select a site (or sites) that reflects the diversity of the entire population. For example, if a group of residential building sites are to be audited across a city, the chosen sites should be representative of the entire population of such sites in terms of the: soil type; slope of the ground surface; size of the blocks; affluence of the suburb; building companies; building methods; and regulatory regime.

4. **Determine and trial the monitoring methodology.**

Decide *how* the monitoring data will be obtained. For example, through direct observation of people's behaviour in public places or audits of premises/sites to check the outcomes of people's behaviour.

Table 4.4 provides some examples of monitoring tools that have been developed for this style of evaluation. They include observational methods used for measuring littering behaviour (e.g. the Clean Communities Assessment Tool and the Disposal Behaviour Index) and audit checklists for measuring erosion and sediment control on building sites. Note that where guidelines or licence/permit conditions are available that specify the desired behaviour and/or outcomes of such behaviour, the content of these documents can easily be converted to audit checklists.

When developing a methodology for measuring behavioural change, consideration should be given to also monitoring the knowledge/awareness and attitudes of those people whose behaviour is being monitored, as well as exactly when the BMP was implemented (i.e. evaluation style No. 1). This information can help to:

- explain the evaluation results;
- develop improved BMPs for future use; and, in relation to baseline data
- design the BMP.

For example, an auditing program of new developments may include an attitudinal survey of developers, and find that poor compliance with recently strengthened development permit/approval conditions relating to stormwater quality is likely to be a result of a strongly held belief of developers that it costs more to comply than not to comply. This finding would enable non-structural strategies to be developed to provide a stronger financial incentive to comply with development conditions.

Some other recommended features of good observational surveys and audits include:

- Surveys that do not change the nature of their methodology throughout the project (this is a significant risk for monitoring programs that measure change over many years, such as erosion and sediment control audits).
- Studies that collect data from a control site (or sites) as well as the BMP intervention site.
- Studies that measure the effect of the BMP on several occasions after implementation to determine how the BMP's effect on behaviour may change with time.
- The use of monitoring data gathered prior to BMP implementation to help *design* the BMP (e.g. baseline littering surveys may find that particular items are littered more frequently, identify hot spots for littering, or identifying reasons for littering).

Trialling the proposed methodology is particularly important when the monitoring tools (e.g. audit checklists) includes subjective elements and when results gathered by different auditors need to be compared. For example, auditors assessing erosion and sediment control (ESC) compliance on building sites may need to determine on a scale from 1 - 5 the over-all performance of the sites' ESC controls. To help promote consistency in the audit results so that results from different auditors can be compared, the audit checklist could provide guidance notes and photographs, and the checklist could be *jointly* trialled by all of the auditors at the start of the project.

5. **Determine who will do the monitoring and evaluation.**

   This decision should be based on available resources (e.g. funds and expertise) and well as the need for impartiality. Ideally, those people undertaking the monitoring and evaluation should be independent of the body that is responsible for the design and implementation of the BMP. At the very least the methodology, data and conclusions should be reviewed by an impartial and suitably qualified body.

   For statistical analysis of survey data, specialist expertise should be obtained.

6. **Prepare a brief quality assurance/quality control (QA/QC) plan.**

   A QA/QC Plan considers potential sources of error and develops strategies to minimise such errors (where possible). At the simplest level, a QA/QC Plan may define the form that data is collected in and how data is transferred from recording sheets to a database. At the more complex level, a QA/QC Plan for a detailed auditing checklist may include notes and photographs to the auditor to help maintain consistency in the assessment criteria where there is an element of subjectivity.

The QA/QC plan should also address *briefly* data management. Before data are collected, determine how they will be handled, briefly reviewed for obvious errors and stored. Typically this part of the plan will ensure that:

- data recording sheets are developed;
- an official file is created to store hard copies of the data;
- a database or spreadsheet is used to electronically store the data; and
- data are not lost in the event of reasonably foreseeable circumstances (e.g. staff movement).

7. Prepare a workplace health and safety management plan (where relevant).

A brief Health and Safety Management Plan may be needed if monitoring involves entry to an area with significant risks to safety (e.g. conducting audits of industrial premises or construction sites). Specialist advice should be sought on the precautions needed.

8. Estimate the resources required to implement the monitoring and evaluation plan.

Ensure that this estimate includes staff time as well as financial resources.

9. Undertake a reality check of the monitoring and evaluation plan.

Before finalising the plan, undertake a reality check to ensure that it is practical and adequately resourced. Input from those people who will be undertaking the monitoring should occur at this stage if they have not been involved in the preparation of the plan. The plan may need revision after this step.

A peer review of the plan is recommended where the monitoring team can get assistance from people who have high levels of relevant expertise and experience (e.g. people from a research group, specialist consultancy, stormwater management authority, or agency that has run a similar evaluation project).

Phase III - Implement the 'Monitoring and Evaluation Plan'

1. Train the monitoring team (if relevant).

Monitoring methods for this style of evaluation often involve a team of observers or auditors. Accordingly, training of the team will be needed. A dry run is essential to check that the training has been successful in communicating the required approach.

2. Implement the monitoring and evaluation plan.

Typically, the implementation program for the BMP will change with time. A record should be kept that tracks these changes over time to assist with the interpretation of monitoring data. In addition, it is essential to clearly communicate the timing of: 1) BMP implementation tasks; and 2) the monitoring and evaluation tasks between parties responsible for both of these elements so they can synchronise their work. A regularly updated and circulated 'project plan' that documents <u>both</u> the BMP implementation tasks and the monitoring and evaluation tasks is strongly recommended to address these issues.

An example of a project plan is given in Appendix A.

Phase IV - Evaluate the success of the project and communicate the results

1. **Review the quality of data collected.**

   During the development of the Monitoring and Evaluation Plan, sources of *possible* errors and uncertainty should have been identified as part of the QA/QC Plan. Once the data are available, they should be briefly reviewed for obvious errors and areas of uncertainty. These should be documented together with any assumptions made during the project.

   Examine the potential for inconsistency in the assessment results where data is collected by different observers/auditors using subjective assessment systems (e.g. 1 - 5 scoring systems).

2. **Evaluate the results.**

   Determine which of two broad categories of data analysis will be undertaken:

   - statistical analysis (drawing on expert advice and/or guidance from US EPA, 2001b); and/or
   - basic visual interpretation, preferably with the use of graphical representation of the data.

   Analyse the results to determine whether sufficient data is available to:

   - meet the objectives of the evaluation; and
   - provide the audience of the evaluation with the level of confidence they need in the findings.

   Where statistical analysis is undertaken, it should at least report whether there is a statistically significant difference between the pre- and post-BMP data sets for a given degree of confidence (e.g. the ‘alpha level’ is usually set at 0.05).

   Determine:

   - whether the objectives being evaluated were achieved; and if enough data is available,
   - the reasons why specific outcomes were or were not achieved (i.e. so future work can seek to replicate ‘successes’ and avoid ‘failures’).

3. **Document and communicate the evaluation’s findings.**

   Document the findings of the evaluation as either an interim report or final evaluation report. A suggested structure for a final Monitoring and Evaluation Report is:

   - Executive summary.
   - Background and objectives.
   - Monitoring methods.
   - Key results.
   - Data analysis (including statistical analysis).
   - Conclusions (with caveats regarding errors, the level of certainty, assumptions, etc.).
   - Recommendations.
   - Appendices (including completed data recording sheets, contacts for further information, audit checklists, etc.).

An example of a final Monitoring and Evaluation Report is given in Appendix C.

Complete the relevant data recording sheet provided in Section 4.4 and forward a copy to the lead agent for stormwater management in the region (e.g. Vic EPA, NSW EPA, etc.). In terms of sharing knowledge and promoting continuous improvement in this area, reporting the results of projects that failed to meet all of their objectives is just as important as reporting on those that were entirely successful.

Finally, consult the intended evaluation audience to determine the best way to communicate the results to them. Develop a practical strategy for such communication and implement it.

4.3.4 Monitoring and Evaluation Protocol: Changes in Stormwater Quality (Evaluation Style No. 6)

4.3.4.1 Preliminary Comments

Careful consideration is needed before attempting this style of evaluation. To determine with confidence that a non-structural BMP has improved stormwater quality requires a significant investment of resources and specialist skills. The main reasons being that:

- urban stormwater flows and quality are extremely variable over space and time;
- monitoring stormwater quality (or litter loads) to detect the effect of non-structural BMPs for urban stormwater quality improvement typically involves trying to detect a small positive signal within a large amount of 'noise';
- typical monitoring methods are relatively expensive (e.g. gauged monitoring stations with automatic water samplers)[2]; and
- a large number of samples are often needed to produce results with a high degree of statistical power and confidence.

For example, the City of Fresno's stormwater quality monitoring program in California only involves monitoring 15 storm events per year, yet costs approximately US$1.55 million over 10 years (21% of the City's total stormwater management budget), and has only a 20% probability of detecting a 20% change in stormwater quality at a confidence level of 95% (ASCE & US EPA, 2002). A 20% change in stormwater quality represents a large degree of change for a non-structural BMP (e.g. Cave and Rosener [1994] estimated that typical non-structural BMPs are likely to have pollutant removal efficiencies of approximately 5% - 10%).

Given the relatively high degree of complexity and cost of generating meaningful results from this style of evaluation, the American Society of Civil Engineers and the US EPA (2002) suggested that "devoting large amount of time and money to achieve a higher level of accuracy may not be the best use of stormwater program resources. It might be more cost effective to spend less on trend monitoring and more on source identification, sediment monitoring, and/or control measures" (p. 51). Other alternatives are to:

- adopt another style (or styles) of evaluation as described in Table 4.1 that is simpler and/or less expensive; and/or
- use pollutant export modelling to predict likely changes in stormwater quality from:
  - known changes in behaviour (i.e. measured via evaluation style No. 5) and known relationships between such behaviour and stormwater pollutant export rates; or
  - a limited stormwater quality and flow monitoring program that is sufficient to calibrate the model.

The following monitoring and evaluation protocol is effectively a summary of the detailed 'Urban Stormwater BMP Performance Monitoring' guideline produced by ASCE & US EPA (2002) to support the US BMP Database Project (see www.bmpdatabase.org). The protocol attempts to highlight the key steps that are required as well as emphasise those actions that relate to the evaluation of non-structural BMPs. Given the substantial investment of resources typically associated with the style of evaluation, it is recommended that those using the protocol also be familiar with the contents of the ASCE & US EPA (2002) guideline before commencing monitoring activities.

For stormwater quality monitoring associated with non-structural BMPs, the use of a paired catchment study design where monitoring is undertaken before and after the implementation of the BMP is recommended where feasible. Such designs involve the monitoring of two catchments that are very similar in nature (e.g. land use, percent impervious area, climatic factors), where one is the intervention site for the BMP(s) while the other is the control site. Given the importance of fully understanding the nature of the catchments' characteristics and activities that occur within each catchment, the data recording sheet for this protocol (see Section 4.4.4) includes a variety of catchment details (e.g. percent impervious area).

2 It is noted that litter load monitoring is usually less expensive than monitoring chemical parameters in stormwater (e.g. nutrients), particularly when existing gross pollutant traps can be used to sample pollutants. Litter load monitoring can also be done without the need for monitoring stormwater flows (other than a simple 'flow bypass indicator' at each litter trap). A control site is however usually needed.

Finally, the protocol has been written with the understanding that this form of evaluation typically aims to produce quantitative pollutant removal efficiency data for the non-structural BMPs being evaluated. That is, the monitoring attempts to identify the approximate percentage of stormwater pollutants that are removed/reduced by the BMP.

4.3.4.2 Monitoring and Evaluation Protocol

PHASES	RECOMMENDED ACTIONS
Phase I - Determine the objectives, scope and nature of the program	**1. Review relevant literature, local case studies, guidelines and/or previous monitoring data.** This step allows one to: • learn from previous experiences (e.g. to identify suitable monitoring methods, the monitoring effort that is likely to be needed and potential costs); and • understand the likely magnitude of change that can be induced by the BMP and the timeframe needed for such change. The literature reviewed in Report No. 3 (Taylor and Wong, 2002) in this series should assist this process. It is strongly recommended that the detailed monitoring guidelines produced by ASCE & US EPA (2002), US EPA (1997) and Wong *et al.* (2003) be read at this stage. They are highly relevant to this style of evaluation, particularly if stormwater quality is to monitored via automatic samplers. Note that the CRC for Catchment Hydrology's 'Urban Stormwater Quality Monitoring Protocols' (Wong *et al.* 2003) provide general advice on monitoring stormwater quality and flows. The CRC is also in the process of producing new guidelines on monitoring the effectiveness *structural* BMPs for stormwater quality improvement (e.g. gross pollutant traps). These guidelines may be of use if gross pollutant traps are being used to measure changes in litter loads as a result of a non-structural BMP (e.g. an anti-litter educational campaign). **2. Get to know the local context.** As most non-structural BMPs operate by changing people's behaviour, it is important to understand the target audience for behavioural change (e.g. their knowledge levels, attitudes, language skills, etc.) and the environment in which they work. Local information may also be available that can be used in the design of the evaluation process or BMP (e.g. existing gross pollutant traps or side entry pit traps, obvious impediments to behavioural change). A brief review of the local context may also provide an early indication of the magnitude of change that is desired. **3. Clearly document the objectives being evaluated.** For this style of evaluation, make sure the objectives: • relate to the extent to which a BMP (or combination of BMPs) will change stormwater quality for a given area and pollutant(s) of concern; and • are S.M.A.R.T (i.e. specific, measurable, achievable, relevant and timeframed). For example, a sound objective is "to determine the extent to which an education campaign at the ... commercial shopping centre reduces the load of gross pollutants in the centre's stormwater in the 6 months after the campaign, compared to baseline conditions and a control site".

4. **Broadly determine the level of confidence needed in the evaluation results.**

   To do this, firstly identify the primary audience for the evaluation results (i.e. the people who are seeking information on the performance of the BMP). Broadly determine these people's needs in terms of the degree of certainty that must accompany the findings of the evaluation. For example, the needs of a PhD student working on the project are likely to be very different from those of the general public.

5. **Determine when evaluation results are needed.**

   Consider how the evaluation results will be used. In addition to final reporting, preliminary evaluation results may be needed (e.g. throughout the delivery of the BMP) to fine-tune the implementation process and/or satisfy some stakeholders who may want some early feedback on progress (e.g. funding bodies).

6. **Confirm the project's budget for monitoring and evaluation.**

   This is particularly important when monitoring may extend over several annual budget cycles.

7. **Carefully consider whether this style of evaluation is affordable and the best use of public resources.**

   As mentioned previously in the preliminary comments section, this style of evaluation has the potential to be relatively complex and expensive. It is critical to ensure that the project's objectives and the level of accuracy and confidence needed in the results match the project's resources.

   A high level of technical expertise is also needed, as well as involvement by field personnel who may have to work in difficult conditions (e.g. installing monitoring stations) and outside of normal working hours.

Phase II - Develop a 'Monitoring and Evaluation Plan'

(an example is provided in Appendix B)

1. **Select monitoring parameters.**

   Review the evaluation objectives and become familiar with the key design elements of the BMP that is to be implemented, as monitoring parameters should be chosen to reflect these elements. For example, an intensive education campaign and training program in a residential area may focus on reducing the load of nutrients in stormwater that originate from lawns and gardens. Consequently, obvious monitoring parameters would include N and P (as well as stormwater flows and rainfall).

   When selecting monitoring parameters, also consider:

   - the land use of the catchment being monitored (e.g. potential for other sources of pollutants);
   - what can be learnt from existing stormwater quality data sets and similar evaluation projects;
   - the nature of receiving waters (e.g. their environmental values and those pollutants that pose a risk to these values);
   - what parameters can be monitored via automatic water samplers/probes; and
   - whether 'proxy parameters' can be used to minimise analytical costs (e.g. monitoring turbidity as a proxy for total suspended solids, where the relationship between the two has been established).

Wong *et al.* (2003) also provides guidance on selecting stormwater quality monitoring parameters.

In addition to stormwater quality, monitoring for this style of evaluation will typically include local rainfall data (i.e. quantity and intensity), relevant catchment characteristics (e.g. area, land use, percent impervious area) and relevant catchment activities (e.g. street sweeping events, litter bin clean-outs, construction activities, incidents in the area, etc.).

2. Determine the sampling design (e.g. the sample size and monitoring timeframe).

For this style of evaluation, statistical analysis is sometimes undertaken to determine the number of water quality samples needed to achieve the desired level of confidence in the results. Typically the confidence level is set to 95% (i.e. there is only a 5% probability of drawing an incorrect conclusion) and the statistical power is set at 80% (i.e. there is a 20% probability that a significant change will be overlooked). ASCE & US EPA (2002) provides detailed guidance on this process.

It is recommended that "statistical confidence in the results of the monitoring program (collecting samples from a significant number of events) should be assigned a higher importance than collecting information from a larger number of locations or testing a multitude of water quality parameters" (ASCE & US EPA, 2002, p. 67).

If statistics are not used to determine a suitable number of monitoring events, it is recommended that at least 10 storm events be monitored before and after the BMP is implemented (i.e. 20 in total).

Monitoring is recommended before and after the implementation of the BMP. To allow pre- and post-implementation data sets to be compared, it is essential that data be gathered on variables such as rainfall and activities in the catchment. If these variables differ significantly before and after the implementation of the BMP it may prevent sound evaluation of the effect of the BMP, even with the use of modelling.

The use of a paired catchment study design is also recommended for this style of evaluation where:

- two <u>very</u> similar local catchments can be found;
- a degree of influence is secured to ensure activities in both catchments that may affect the monitoring program do not significantly change (e.g. road works, street sweeping, litter management activities); and
- resources are available for the additional monitoring costs.

Under this approach similar catchments are jointly monitored, while the BMP is implemented in only one of the catchments. This approach is recommended for two reasons. Firstly, most non-structural BMPs do not have a clear inlet and outlet like structural BMPs. Secondly, variations in climatic conditions can be statistically controlled via this approach.

Key elements of the paired catchment study design include:

- the paired catchments' characteristics should be as similar as possible (e.g. area, land use, percent impervious area, climatic conditions and catchment activities) if a slight improvement in stormwater quality is to be recognised from the surrounding 'noise' in the stormwater data set; and

- accurate measurement and documentation is needed of the differences between catchment characteristics, as well as the activities that occur within them (e.g. street sweeping, educational programs, structural BMPs).

The chosen timeframe for monitoring will depend on the number of samples that need to be taken to deliver the desired level of confidence in the results (e.g. X storm events per station), the project's monitoring budget, the nature of rainfall/runoff, when evaluation results are needed, the timeframe of the BMP and the how the BMP is likely to change stormwater quality with time.

3. Select monitoring locations.

For this style of evaluation, automatic monitoring equipment would be used for most water quality parameters. In addition, stormwater flow measurements would normally be taken from gauged stations and rainfall data collected from stations at or near the stormwater monitoring locations.

For monitoring gross pollutants/litter however, existing or temporary gross pollutant traps may be used to collect materials after each storm event (e.g. side entry pit litter baskets). In addition, monitoring of rainfall and stormwater events that bypass the traps would be needed.

When choosing a monitoring location for stormwater quality, factors to consider include:

- whether the extent and nature of the catchment is well-known;
- the need to monitor well mixed stormwater under uniform flow conditions;
- the need for a suitable hydraulic control in open channels so that rating curves can be developed for flow measurements;
- the risk of obstructing stormwater flows and causing localised flooding;
- the need to avoid areas with backwater effects or tidal conditions;
- whether the site is representative of the 'target catchment' (i.e. no extraneous inputs);
- gaining safe access to monitoring equipment under a variety of weather conditions; and
- the risk of vandalism or the theft of monitoring equipment.

It is recommended that *potential monitoring* sites be inspected during a flow event where possible, to identify any potential sampling problems.

The owner of stormwater drainage assets (e.g. the local Council) should also be consulted on the feasibility of proposed sampling locations.

4. Determine and trial the monitoring methodology.

ASCE & US EPA (2002) provides detailed guidance on the choice of monitoring equipment and methods for monitoring physico-chemical parameters in stormwater (e.g. TN, TP, TSS).

For monitoring gross pollutants/litter a typical methodology involves:

- the installation of side entry pit litter baskets to collect gross pollutants (or other gross pollutant traps);

- measuring the mass of captured gross pollutants and litter after each significant rainfall event, along with rainfall characteristics, catchment activities and whether any bypass of the traps has occurred; and
- monitoring loads before and after the installation of the BMP (with a control catchment if possible).

In some cases, *pollutant export modelling* may be used as a substitute for extensive monitoring. For example, various models may be able to estimate:

- the likely loads and concentrations of stormwater pollutants;
- stormwater flow; and
- rainfall.

In particular, limited stormwater quality monitoring data may be used to inform the calibration of a pollutant export model (e.g. the CRC's 'MUSIC' model - see www.catchment.crc.org.au for details). This model can then be used as a tool for evaluation, involving the simulation of runoff events over much longer timeframes than the initial monitoring period.

5. **Select a suitable set of storm criteria.**

Decide whether to monitor a large range of storm conditions or only monitor storms that represent the worst-case scenario (e.g. those with long antecedent dry periods).

Where practical, the worst-case scenario is recommended as "the level of effort required to sample all representative types and combinations of storm conditions in order to generate reliable population statistics is beyond the resources of most agencies" (ASCE & US EPA, 2002, p. 126). ASCE & US EPA (2002) recommend a set of storm criteria that can be used to trigger a stormwater sampling event for monitoring the worst-case scenario in the absence of any basis for selecting a specific storm volume.

Often however, the limited time for pre- and post-BMP monitoring activities results in all runoff 'events' being monitored. Here an 'event' is defined as having an antecedent period of >6 hours.

For gross pollutant/litter monitoring, it is recommended that the minimum rainfall volume for a rainfall - runoff event be 4mm. In addition, a decision will need to be made whether to exclude data derived from large storm events where the gross pollutant traps are bypassed by some stormwater.

6. **Determine who will do the monitoring and evaluation.**

This decision should be based on available resources (e.g. funds and expertise) and well as the need for impartiality. Ideally, those people undertaking the monitoring and evaluation should be independent of the body that is responsible for the design and implementation of the BMP. At the very least, the methodology, data and conclusions should be reviewed by an impartial body of suitable expertise.

7. **Prepare a brief quality assurance/quality control (QA/QC) plan.**

A QA/QC Plan considers potential sources of error and develops strategies to minimise such errors (where possible). Errors include paper errors (e.g. errors made transferring data from recording sheets to a database), reporting errors (e.g. poor estimates of the catchment characteristics) and chance variations (random variations in measured parameters that cannot be completely eliminated).

The QA/QC plan should be prepared with the knowledge of the analytical methods, field sampling procedures and data validation procedures. Accordingly, it should be developed in consultation with field staff and laboratory personnel (where relevant).

The QA/QC plan should also summarise the organisational aspects of the project (e.g. roles and responsibilities of personnel), data quality objectives, field methods (e.g. collection of field duplicate samples) and laboratory procedures (e.g. laboratory performance standards).

ASCE & US EPA (2002) provides guidance on recommended field QA/QC procedures (e.g. the use of field blanks, field duplicate samples, field sample volumes and chain of custody procedures) as well as laboratory QA/QC procedures (e.g. the use of method blanks, laboratory duplicates, matrix spike and spike duplicates and external reference standards) that are relevant to stormwater quality monitoring.

It is recommended for stormwater quality monitoring that laboratories undertaking sample analysis have some form of external quality accreditation (e.g. NATA).

The QA/QC plan should also address *briefly* data management. Before data are collected, determine how they will be handled, briefly reviewed for obvious errors and stored. Typically this part of the plan will ensure that:

- data recording sheets are developed;
- an official file is created to store hard copies of the data;
- a database or spreadsheet is used to electronically store the data;
- chemical analysis data is briefly reviewed when it is received from the laboratory (e.g. checks are made to ensure all the analyses are been done, the QA/QC laboratory procedures have been followed and there are no obvious errors); and
- data are not lost in the event of reasonably foreseeable circumstances (e.g. staff movement).

Where large volumes of data are produced by a laboratory, the plan should seek to ensure that this data can be easily transferred in electronic form into an appropriate database or spreadsheet.

Note that seven data recording sheets for stormwater quality-based BMP efficiency monitoring have been developed by the US BMP Database Project (see www.bmpdatabase.org). The minimum/mandatory reporting requirements from these sheets have been incorporated in the data recording sheet provided in Section 4.4. For the full data recording forms, see the above website.

8. Prepare a workplace health and safety management plan (where relevant).

A brief Health and Safety Management Plan is likely to be needed if monitoring involves entry to an area with significant risks to safety (e.g. an enclosed space). Specialist advice should be sought on the precautions needed.

9. Estimate the resources required to implement the monitoring and evaluation plan.

Ensure that this estimate includes staff time as well as financial resources.

10. **Undertake a reality check of the monitoring and evaluation plan.**

    Before finalising the plan, undertake a reality check to ensure that it is practical and adequately resourced. Input from those people who will be undertaking the monitoring should occur at this stage if they have not been involved in the preparation of the plan. The plan may need revision after this step.

    A peer review of the plan is recommended where the monitoring team can get assistance from people who have high levels of relevant expertise and experience (e.g. people from a research group, specialist consultancy, stormwater management authority, or agency that has run a similar evaluation project).

Phase III - Implement the 'Monitoring and Evaluation Plan'

1. **Train the monitoring team.**

   Monitoring methods for this style of evaluation often involve more than one person (e.g. a person and his/her back-up). Training of involved personnel will be needed. A dry run is also essential to check that the training has been successful in communicating the required approach.

2. **Install the equipment (where necessary).**

   For the installation of automatic stormwater monitoring equipment, guidance is available from ASCE & US EPA (2002) and the manufacturer's instructions.

3. **Test and calibrate the equipment.**

   Automated samplers, water quality probes and flow meters need to be periodically calibrated. Guidance is available from ASCE & US EPA (2002) and the manufacturer's instructions.

4. **Implement the monitoring and evaluation plan.**

   This includes taking samples and getting them analysed. For water quality analyses, coordination may be needed with the laboratory to ensure that the samples are analysed within their allowed sample holding times.

   Typically, the implementation program for the BMP will change with time. A record should be kept that tracks these changes over time to assist with the interpretation of monitoring data. In addition, it is essential to clearly communicate the timing of: 1) BMP implementation tasks; and 2) the monitoring and evaluation tasks between parties responsible for both of these elements so they can synchronise their work. A regularly updated and circulated 'project plan' that documents *both* the BMP implementation tasks and the monitoring and evaluation tasks is strongly recommended to address these issues.

   An example of a project plan is given in Appendix A.

Phase IV - Evaluate the success of the project and communicate the results

1. **Review the quality of data collected.**

   During the development of the Monitoring and Evaluation Plan, sources of *possible* errors and uncertainty should have been identified as part of the QA/QC Plan. Once the data are available, they should be briefly reviewed for obvious errors and areas of uncertainty. These should be documented together with any assumptions made during the project.

   For water quality analyses, ASCE & US EPA (2002) recommend the following steps for data validation once results return from the laboratory:

   - check that all the analyses have been undertaken, including the QA/QC samples;
   - check that all samples were analysed within their allowed sample holding times;

- check that the laboratory met their performance objectives for accuracy and precision;
- check that the field QA/QC was acceptable; and
- assign qualifiers on the data (as needed) to alert future users to any areas of uncertainty.

2. Evaluate the results.

Analyse the results to determine whether sufficient data is available to:

- meet the objectives of the evaluation; and
- provide the audience of the evaluation with the level of confidence they need in the findings.

Determine:

- whether the objectives being evaluated were achieved; and if enough data is available,
- the reasons why specific outcomes were or were not achieved (i.e. so future work can seek to replicate 'successes' and avoid 'failures').

ASCE & US EPA (2002) recommend two stages of data evaluation for stormwater quality monitoring data:

- Preliminary evaluation, where hydrographs are examined along with the water quality data and initial statistical analysis is undertaken of chemical analysis data (assuming at least four events have been monitored) to generate summary statistics. These statistics include sample mean, variance, standard deviation, coefficient of variation, coefficient of skewness, median and kurtosis.
- Definitive evaluation, where additional statistical analyses are undertaken (or perhaps pollutant export modelling) to answer key questions about the BMP.

In terms of the overall approach for determining the BMP's pollutant removal efficiency once data is available, the effluent probability method is recommended (see ASCE & US EPA [2002] for details). Using this method:

- It is firstly determined whether the event mean concentrations from the stormwater quality data sets being compared (e.g. the sets collected before and after the implementation of the BMP) are statistically different (usually to a 95% confidence level); and then
- A cumulative distribution function of the two data sets or a standard parallel probability plot are examined.

This analysis produces quantitative information on how efficient the BMP is in removing specific pollutants under all conditions (e.g. when the stormwater is relatively clean and when it is highly polluted).

For gross pollutants/litter, estimate the total loads generated before and after the BMP was implemented and calculate an approximate percent reduction. As the effect of many non-structural BMPs changes with time (e.g. a once-off educational campaign), calculated reductions may need to relate to specific time periods (e.g. "over the first 2 months following the BMP's implementation there was a ~20% reduction in litter loads, which reduced to ~10% over the next 2 months, and returned to normal over the following 2 months").

3. **Document and communicate the evaluation's findings.**

Document the findings of the evaluation as either an interim report or final Monitoring and Evaluation Report. A suggested structure for a final evaluation report is:

- Executive summary.
- Background and objectives.
- Monitoring and analytical methods.
- Key results.
- Data analysis (including statistical analysis and data validation information).
- Summary and conclusions (with caveats regarding errors, the level of certainty, assumptions, etc.).
- Recommendations.
- Appendices (including completed data recording sheets, contacts for further information, maps of sampling locations, etc.).

An example of a simple Monitoring and Evaluation Report is given in Appendix C.

Complete the relevant data recording sheet(s) provided in Section 4.4 and forward a copy to the lead agent for stormwater management in the region (e.g. Vic EPA, NSW EPA, etc.). For this style of evaluation, consideration should also be given to sending the data sheet(s) to the administrators of the US BMP Database (www.bmpdatabase.org) for their information/use. In terms of sharing knowledge and promoting continuous improvement in this area, reporting the results of projects that failed to meet all of their objectives is just as important as reporting on those that were entirely successful.

Finally, consult the intended evaluation audience to determine the best way to communicate the results to them. Develop a practical strategy for such communication and implement it.

4.3.5 Monitoring and Evaluation Protocol: Changes in Waterway Health (Evaluation Style No. 7)

4.3.5.1 Preliminary Comments

Monitoring waterway health as an indicator of the ultimate performance of urban stormwater management initiatives is generally only suitable where:

- a stormwater management program is being implemented that is likely to create a *significant* change in pollutant loads entering the receiving waters (e.g. a new city-wide stormwater management program) and/or the receiving water's hydrologic regime;
- a management initiative is being undertaken that targets a specific stormwater pollutant that is not significantly influenced by other activities in the catchment (e.g. a city-wide education program to reduce the use of particular pesticide); and/or
- significant resources are available over several years to design a monitoring program that is capable of distinguishing between changes in waterway health caused by management initiatives and those associated with natural variation.

Waterway health monitoring programs in this context typically have the following characteristics:

- They seek to broadly evaluate the *cumulative* effect of catchment management initiatives (e.g. improved wastewater treatment, urban stormwater management and non-urban land use management).
- They monitor trends in waterway health over long time periods (e.g. a decade).[3]
- They have a strong statistical element to their design and data analysis.
- They involve high levels of expertise in their design and the interpretation of their results.
- They involve significant resources in terms of cash and/or in-kind support for monitoring and evaluation activities.

Because of these characteristics, careful consideration is needed before embarking on this style of evaluation. Like evaluation style No. 6 (see Section 4.3.4), it is an *advanced* style of evaluation where there is a significant risk of substantial resources being utilised for little benefit.

Traditionally, waterway health monitoring programs have focused on physico-chemical indicators of waterway health, such as the quality of water in receiving environments. Modern programs are however increasingly focused on monitoring *ecological* health. Dennison and Abal (1999) define ecological health as a state where:

- key processes operate to maintain stable and sustainable ecosystems (e.g. denitrification processes in a waterway);
- zones of anthropogenic impacts do not deteriorate further (e.g. areas of poor water quality around major stormwater drains); and
- critical habitats remain intact (e.g. areas of seagrass, wetlands, in-shore reefs).

Ecological health monitoring measures a change in the boundaries of functional zones identified by ecological health indicators, where:

- 'Change' is the difference between the measured state and either historical scenarios, appropriate contemporary reference sites or standards.
- A 'functional zone' is a geographic entity which:
    - has common structural and functional characteristics; in particular it is homogeneous in key processes, relevant anthropogenic impacts and critical habitats;
    - can be defined in a conceptual model; and
    - can be quantified by measurement.
- 'Ecological health indicators' are measurable ecosystem features that provide information on processes, anthropogenic impacts and habitats (Dennison and Abal, 1999).

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3 Trend monitoring is defined as low-frequency, long duration and low-moderate intensity monitoring (US EPA, 1997).

4.3.5.2 Monitoring and Evaluation Protocol

PHASES	RECOMMENDED ACTIONS
Phase I - Determine the objectives, scope and nature of the program	**1. Review relevant literature, local case studies, guidelines and/or previous monitoring data.** This step allows one to: • learn from previous experiences (e.g. to identify suitable monitoring methods and parameters, the monitoring effort that is likely to be needed and potential costs); and • understand the likely magnitude of change that can be induced by the BMP(s) and the timeframe needed for such change. It is recommended that the following guidelines be read at this stage: • 'Monitoring Guidelines for Determining the Effectiveness of Nonpoint Source Controls' (US EPA, 1997); and • 'Australian Guidelines for Water Quality Monitoring and Reporting' (ANZECC & ARMCANZ, 2000). For monitoring programs covering large areas (e.g. an estuary) identify opportunities to integrate related monitoring programs in the region. Successful waterway health monitoring programs are often formed by consolidating numerous small monitoring programs. **2. Get to know the local context.** Local information may be available that can be used in the design of the evaluation process (e.g. existing monitoring programs, existing conceptual models of the system being monitored). A brief review of the local context may also provide an early indication of the magnitude of change that is desired. **3. Clearly understand the system being monitored.** Ensure that the nature of the catchment and receiving waters are well understood, including: • the physical characteristics of the waterway (e.g. hydrodynamics); • key ecological processes in and around the waterway (e.g. denitrification); • zones of anthropogenic impacts (e.g. zones of poor water quality); • critical habitats; • the sources of pollution/impacts (e.g. stormwater, wastewater); and • the likely cause-effect relationships between stormwater pollution and waterway health. It is strongly recommended that the above information be included in a simple three dimensional conceptual model of the waterway (e.g. see Dennison and Abal, 1999). This model can be used as a tool for communication and during the design of the Monitoring and Evaluation Plan.

4. **Clearly document the objectives being evaluated.**

   Make sure the objectives are S.M.A.R.T (i.e. specific, measurable, achievable, relevant and timeframed).

   Determine whether the monitoring program will attempt to link measured changes in waterway health to just urban stormwater management initiatives or the cumulative effect of all catchment management initiatives.

   An example of a sound monitoring objective is "to determine over 2003-08 whether the ... estuary's denitrification processes, seagrass meadows and water quality are being maintained as a result of catchment management initiatives, which include implementation of a new city-wide urban stormwater management plan".

5. **Define the type of monitoring program.**

   The use of trend monitoring over several years is recommended for this style of evaluation. Paired catchment monitoring is usually unsuitable, due to:

   - comparisons between receiving waters being difficult due to the complexity of their physical, chemical and biological processes;
   - the difficulty of finding a control site with a similar catchment and where BMPs will not be implemented over many years; and
   - substantially increased cost.

6. **Determine the scope of the monitoring program.**

   Determine the monitoring program's spatial boundaries and duration.

   Chose a monitoring timeframe that allows enough time for change in the health of a waterway to occur as a result of stormwater management initiatives. For example, it may take decades for strict, city-wide *planning controls* on new development to reduce stormwater pollutant loads to such an extent that changes are measured in indicators that reflect the health of receiving waters.

7. **Broadly determine the level of confidence needed in the evaluation results.**

   To do this, firstly identify the primary audience for the evaluation results (i.e. the people who are seeking information on the performance of the BMP). Broadly determine these people's needs in terms of the degree of certainty that must accompany the findings of the evaluation.

8. **Determine when evaluation results are needed.**

   Consider how the evaluation results will be used. In addition to final reporting, preliminary evaluation results may be needed (e.g. throughout the delivery of the BMP) to fine-tune the implementation process and/or satisfy some stakeholders (e.g. funding bodies). For long-term trend monitoring projects, 6 monthly or annual reporting is common.

9. **Confirm the project's budget/resources for monitoring and evaluation.**

   This is particularly important as this style of evaluation is likely to extend over several annual budget cycles.

   For major waterway health monitoring programs, consider including a contingency in the budget to allow monitoring of unusual events if they occur during the programs (e.g. algal blooms, major floods, a chemical spill).

10. **Carefully consider whether this style of evaluation is affordable and the best use of public resources.**

    This style evaluation has the potential to be relatively complex and expensive. It is critical to ensure that the project's objectives and the level of accuracy and confidence needed in the results match the project's budget.

11. **Manage the expectations of stakeholders.**

    At the start of large waterway health monitoring programs, it may be necessarily to liaise with key stakeholder groups to manage expectations about what the program will be able to deliver and by when. In addition, regular communication mechanisms (e.g. a web site, newsletter, annual report card) should be established early in the process to keep stakeholders informed at all times.

Phase II - Develop a 'Monitoring and Evaluation Plan'

(an example is provided in Appendix B)

1. **Select monitoring parameters.**

   Review the evaluation objectives and become familiar with the key design elements of the BMP that is to be implemented and the nature of the receiving environment, as monitoring parameters should be chosen to reflect these elements. For example, a city-wide urban stormwater program may include BMPs to reduce copper loads to an estuary as concerns have been raised over the toxicity of copper to local biota. Consequently, a long term trend monitoring program could measure the concentration of copper in the estuary's water column, sediment and biota. As mentioned previously, a conceptual model of the receiving environment can assist in selecting critical parameters to monitor.

   For ecological health monitoring, consider monitoring:

   - key processes that maintain stable and sustainable ecosystems (e.g. denitrification processes);
   - the nature and extent of zones of anthropogenic impacts (e.g. water and sediment quality); and
   - the nature and spatial extent of critical habitats (e.g. seagrass distribution).

   Monitoring parameters may include:

   - physico-chemical parameters (e.g. traditional water quality, sediment quality);
   - phytoplankton growth responses/bioassays;
   - biological monitoring (e.g. macroinvertebrate assemblages, shellfish, algal blooms);
   - habitats (e.g. seagrass distribution, deep river pools);
   - sediment accumulation rates; and
   - catchment characteristics (e.g. land use changes).

2. **Determine the sampling design (e.g. the sample size and monitoring frequencies).**

   For this form of evaluation, statistical analysis is often undertaken to determine the minimum number of samples needed to achieve the desired level of confidence in the results. While US EPA (1997) provides guidance on the use of statistics in this context, it is recommended that statistical expertise be obtained.

Ecological health monitoring programs may involve several levels of monitoring where each level has differing sampling frequencies and/or locations. For example, a program may monitor some parameters:

- monthly over the entire receiving water (e.g. traditional water quality);
- annually over the entire receiving water (e.g. seagrass distribution surveys); and
- fortnightly in specific areas (e.g. intensive sampling of water quality in a sensitive portion of the receiving waters).

3. **Select monitoring locations.**

   For this style of evaluation, it is recommended that a conceptual model of the catchment and receiving waters be used to help identify initial monitoring locations. As information is gathered about the system being monitored, these locations may be adjusted.

4. **Determine and trial the monitoring methodology.**

   There are a wide variety of methods for monitoring aspects of waterway health, from traditional water quality sampling and analysis, to the use of isotopes and remote sensing. While ANZECC & ARMCANZ (2000) provides guidance on these methods, it is recommended that expert guidance should be sought on selecting a cost-effective monitoring methodology.

5. **Determine who will do the monitoring and evaluation.**

   This decision should be based on available resources (e.g. funds and expertise) and well as the need for impartiality.

   It is recommended that for large monitoring programs, an independent peer review body of suitable expertise be engaged to regularly oversee the quality and impartiality of the program.

6. **Prepare a *brief* quality assurance/quality control (QA/QC) plan.**

   A QA/QC Plan considers potential sources of error and develops strategies to minimise such errors (where possible). Errors include paper errors (e.g. errors made transferring data from recording sheets to a database), reporting errors (e.g. poor estimates of the historic distribution of critical habitats) and chance variations (random variations in measured parameters that cannot be completely eliminated).

   The QA/QC plan should be prepared with the knowledge of the field sampling procedures, chemical analytical methods and data validation procedures. Accordingly, it should be developed in consultation with field staff and laboratory personnel.

   The QA/QC plan should also summarise the organisational aspects of the project (e.g. roles and responsibilities of personnel), data quality objectives, the field methods (e.g. requirements for sample containers, preservation and storage) and laboratory procedures (e.g. laboratory performance standards).

   ASCE & US EPA (2002) and ANZECC & ARMCANZ (2000) provide guidance on recommended field QA/QC procedures (e.g. the use of field blanks, field duplicate samples, field sample volumes and chain of custody procedures) as well as laboratory QA/QC procedures (e.g. the use of method blanks, laboratory duplicates, matrix spike and spike duplicates and external reference standards).

It is recommended for water quality monitoring that laboratories used for sample analysis have some form of external quality accreditation (e.g. NATA).

The QA/QC plan should also address briefly data management. Before data are collected, determine how they will be handled, briefly reviewed for obvious errors and stored. Typically this part of the plan will ensure that:

- data recording sheets are developed;
- an official file is created to store hard copies of the data;
- a database or spreadsheet is used to electronically store the data;
- chemical analysis data is briefly reviewed when it is received from the laboratory (e.g. checks are made to ensure all the analyses are been done, the QA/QC laboratory procedures have been followed and there are no obvious errors); and
- data are not lost in the event of reasonably foreseeable circumstances (e.g. staff movement).

Where large volumes of analysis data is produced by a laboratory, the plan should seek to ensure that this data can be easily transferred in electronic form into an appropriate database or spreadsheet.

7. **Prepare a workplace health and safety management plan (where relevant).**

A brief Health and Safety Management Plan is likely to be needed if monitoring involves significant risks to safety (e.g. water sampling from a boat). Specialist advice should be sought on the necessary precautions.

8. **Estimate the resources required to implement the monitoring and evaluation plan.**

Determine the resource requirements in terms of the likely financial cost, staff time commitment and the need to access specific expertise.

If the design of the monitoring program moves beyond just monitoring water and/or sediment quality, and starts to involve a broad range of ecological health indicators, there will be an increased need to involve suitably qualified experts in:

- the design of the program;
- the execution of some monitoring methods (e.g. biological monitoring);
- interpretation of the data; and/or
- peer review processes.

9. **Undertake a reality check of the monitoring and evaluation plan.**

Before finalising the plan, undertake a reality check to ensure that it is practical, adequately resourced and sustainable over the proposed timeframe. Input from those people who will be undertaking the monitoring should occur at this stage if they have not been involved in the preparation of the plan. The plan may need revision after this step.

A peer review of the plan is recommended where the monitoring team can get assistance from people who have suitable expertise and experience (e.g. people from a research group, specialist consultancy, environmental protection authority, or agency that has run a similar program).

	10. Be prepared to regularly review and amend the monitoring and evaluation plan. For long-term trend monitoring programs, changes will usually need to be made to respond to new knowledge about the system being monitored, monitoring technology, funding arrangements and political priorities.
Phase III - Implement the 'Monitoring and Evaluation Plan'	**1. Train the monitoring team (where necessary).** For programs that run for several years there is often a turn-over of field personnel, which necessitates the need to have the monitoring methodology well documented (e.g. in written form and/or on video) and to undertake training. Following training, a dry run is essential to check that it has been successful in communicating the required approach. **2. Install, test and calibrate the monitoring equipment (where necessary).** For the installation of automatic monitoring equipment (e.g. water quality probes), guidance is available from ASCE & US EPA (2002) and the manufacturer's instructions. **3. Implement the monitoring and evaluation plan.** This includes taking samples and getting them analysed. Coordination may be needed with the laboratory to ensure that the samples are analysed within their allowed sample holding times. Typically, the implementation program for the BMP will change with time. A record should be kept that tracks these changes over time to assist with the interpretation of monitoring data. In addition, it is essential to clearly communicate the timing of: 1) BMP implementation tasks; and 2) the monitoring and evaluation tasks between parties responsible for both of these elements so they can synchronise their work. A regularly updated and circulated 'project plan' that documents <u>both</u> the BMP implementation tasks and the monitoring and evaluation tasks is strongly recommended to address these issues. An example of a project plan is given in Appendix A.
Phase IV - Evaluate the success of the project and communicate the results	**1. Review the quality of data collected.** During the development of the Monitoring and Evaluation Plan, sources of possible errors and uncertainty should have been identified as part of the QA/QC Plan. Once the monitoring data is available, it should be briefly reviewed for obvious errors and areas of uncertainty. These should be documented together with any assumptions made during the project. ASCE & US EPA (2002) recommend the following steps for data validation once results return from the laboratory: • check that all the analyses have been undertaken, including the QA/QC samples; • check that all samples were analysed within their allowed sample holding times; • check that the laboratory met their performance objectives for accuracy and precision; • check that the field QA/QC was acceptable; and • assign qualifiers on the data (as needed) to alert future users to any areas of uncertainty. **2. Evaluate the results.** Analyse the results to determine whether sufficient data is available to:

- meet the objectives of the evaluation; and
- provide the audience of the evaluation with the level of confidence they need in the findings.

Determine:

- whether the objectives being evaluated were achieved; and if enough data is available,
- the reasons why specific outcomes were or were not achieved (i.e. so future work can seek to replicate 'successes' and avoid 'failures').

Where trend monitoring is used for this style of evaluation, the results should indicate if aspects of waterway health (e.g. median water quality concentrations, denitrification processes, the spatial extent of critical habitats) have improved, remained stable or deteriorated over the monitoring timeframe. Care is needed to also consider the influence of factors on waterway health other than the stormwater quality BMP(s). These may include climatic conditions (e.g. wet and dry years) and other catchment management initiatives (e.g. land development, sewage treatment plant upgrades).

3. **Document and communicate the evaluation's findings.**

Document the findings of the evaluation as either an interim report or final Monitoring and Evaluation Report. A suggested structure for a final evaluation report is:

- Executive summary.
- Background and objectives.
- Monitoring and analytical methods.
- Key results.
- Data analysis (including statistical analysis).
- Summary and conclusions (with caveats regarding errors, the level of certainty, assumptions, etc.).
- Recommendations.
- Appendices (including completed data recording sheets, contacts for further information, maps of sampling locations, etc.).

An example of a simple Monitoring and Evaluation Report is given in Appendix C.

Complete the relevant data recording sheet provided in Section 4.4 and forward a copy to the lead agent for stormwater and waterway management in the region (e.g. Vic EPA, NSW EPA, etc.). If a causative relationship is identified between changes in waterways health and urban stormwater management activities (as opposed to the cumulative effect of all catchment management activities), the data recording sheet could also be sent to the administrators of the US BMP Database (www.bmpdatabase.org).

Consult the intended evaluation audience to determine the best way to communicate the results to them. Develop a practical strategy for such communication and implement it.

For ecosystem health monitoring which seeks to regularly communicate an overall picture of the health of a system and how it has changed with time, consideration should be given to using simple communication strategies such as an annual Report Card (using 'A+' to 'F-' ratings) with supporting maps and the graphical presentation of results.

4.4 Data Recording Sheets for Monitoring Non-structural BMPs

This section outlines the minimum recommended data recording requirements for monitoring and evaluating non-structural BMPs.

The intention of these sheets is to prompt people undertaking monitoring and evaluation of non-structural BMPs to record key details of their work in a format that promotes:

- consistency in reporting;
- comprehensive reporting of all salient details; and
- sharing of information on BMP value and cost around Australia and overseas.

Our approach builds on the work of the US BMP Database Project (see www.bmpdatabase.org), which defines data recording requirements for monitoring all types of BMPs for stormwater quality improvement, although the US recording sheets focus heavily on structural BMPs and stormwater quality monitoring (i.e. evaluation style No. 6).

The US BMP Database Project defines minimum and recommended data recording requirements under the headings of:

- General test site information.
- Watershed/catchment information.
- Monitoring station information.
- Non-structural BMP information.
- Precipitation information.
- Flow information.
- Water quality information.

Unfortunately, some of the minimum data requirements specified in the US data recording sheets under these headings are not applicable to some styles of non-structural BMP monitoring as defined in Table 4.1 (e.g. recording stormwater flow information has no relevance to evaluation styles No. 1 to 5). Accordingly, the US BMP Database Project's minimum data recording requirements have been reviewed and amended so they apply to each of the seven styles of non-structural BMP evaluation defined in these guidelines.

In addition, the data recording sheets prompt users to record valuable information that was often missing in reports reviewed by Taylor and Wong (2002) when they reviewed approximately 200 references relating to non-structural BMP value and cost.

4.4.1 Evaluation of BMP Implementation (Evaluation Style No. 1) - Minimum Data Recording Requirements

HEADING	RECORDED DATA
BMP INFORMATION	
Name of the BMP being monitored: (e.g. Stirling City Council's local law for stormwater pollution)	
Type and nature of the BMP: (e.g. a local law for the control of erosion and sediment control on building sites)	
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	
Life span of the BMP: (i.e. the time over which the BMP will operate)	
TEST SITE INFORMATION	
Location of BMP implementation:	
Agency implementing the BMP **Name:** **Type of agency:** **Address:**	
CATCHMENT INFORMATION	
Catchment name:	
Receiving waters:	
Area over which the BMP operates: (i.e. the potential area of influence of the BMP in ha, km^2 or m^2)	
Population over which the BMP operates (if applicable): (e.g. the approximate number of people who live in the area potentially influenced by the BMP)	
MONITORING INFORMATION	
Objectives being evaluated:	
Type of evaluation: (e.g. 'desk top' review or independent audit/survey of 'on the ground' outcomes)	
Monitoring parameters: (i.e. what is being monitored/measured)	
Sampling design: (e.g. whether the implementation of all BMPs are being monitored or just a sub-set - see Phase II, Step 2 of the monitoring and evaluation protocol)	
Monitoring frequency and timeframe: (e.g. immediately after BMP implementation, then 6 months later)	
Monitoring location(s):	
Monitoring method: (describe the monitoring tools that were used, such as audit checklists, questionnaires, review of written records)	
Who did the monitoring and evaluation: (include a comment regarding their degree of independence)	

Continued ...

HEADING	RECORDED DATA
EVALUATION RESULTS	
Key findings: (include quantitative information on the effects the BMP produced, where available)	
Caveats, assumptions and areas of uncertainty:	
Overall assessment of BMP 'value' (a score of 1 - 5): (where: • '0' = detrimental impacts; • '1' = no positive or detrimental impacts; • '2' = fair [achieved <1/2 of the objectives/expectations]; • '3' = average [achieved 1/2 of the objectives/expectations]; • '4' = good [achieved >1/2 of the objectives/expectations]; and • '5' = excellent [achieved all of the objectives/expectations])	
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Total cost to develop the BMP or combination of BMPs (AUD$):	
Total cost to implement the BMP (AUD$): (over the implementation period, or annually if implementation is on-going)	
Estimated total life-cycle cost of the BMP (AUD$): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	
Estimated total cost to monitor and evaluate the BMP (AUD$):	
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation: **Name:** **Organisation:** **Contact details (ph and e-mail):**	
Date of data entry:	
COMMENTS (e.g. reasons for the evaluation findings, and recommendations for future projects of a similar nature)	

4.4.2 Evaluation of Changes in Awareness/knowledge, Attitudes and/or Self-reported Behaviour (Evaluation Styles No. 2, 3 and 4) - Minimum Data Recording Requirements

HEADING	RECORDED DATA
BMP INFORMATION	
Name of the BMP being monitored: (e.g. the Stirling City Council's 'Stormwater Awareness Campaign 2003')	
Type and nature of the BMP: (i.e. include the key elements of the BMP, such as the strategies used in the educational program, the target audience[s] and target pollutants)	
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	
Life span of the BMP: (i.e. the time over which the BMP is expected to operate)	
TEST SITE INFORMATION	
Location of BMP implementation:	
Agency implementing the BMP **Name:** **Type of agency:** **Address:**	
CATCHMENT INFORMATION	
Catchment name:	
Receiving waters:	
Area over which the BMP operates: (i.e. the potential area of influence of the BMP in ha, km^2 or m^2)	
Population over which the BMP operates (if applicable): (e.g. the approximate number of people who live in the area potentially influenced by the BMP)	
Specific details of the number of participants and area of managed land (if applicable): (e.g. an annual city-wide lawn/garden care program may train 300 people and result in 30 ha of managed lawn/garden over the entire city)	
MONITORING INFORMATION	
Objectives being evaluated:	
Monitoring parameters: (i.e. what is being monitored/measured)	
Sampling design: (e.g. how the sample was selected for the survey - see Phase II, Step 2 of the monitoring and evaluation protocol)	
Monitoring frequency and timeframe: (e.g. immediately before, immediately after, and 6 months after the implementation of the BMP)	
Monitoring location(s):	
Monitoring method: (e.g. phone survey, face-to-face interviews, mail-out survey, focus groups)	
Who did the monitoring and evaluation: (include a comment regarding their degree of independence)	

Continued ...

HEADING	RECORDED DATA
EVALUATION RESULTS	
Key findings: (include quantitative information where available, such as the change in the % of respondents who gained relevant knowledge, adopted 'desirable' attitudes or adopted 'desirable' self-reported behaviours)	
Caveats, assumptions and areas of uncertainty: (e.g. where relevant, include a brief comment on the reliability of the project's self-reported data, or other influences on the target audience's behaviour)	
Overall assessment of BMP 'value' (a score of 1 - 5): (where: • '0' = detrimental impacts; • '1' = no positive or detrimental impacts; • '2' = fair [achieved <1/2 of the objectives/expectations]; • '3' = average [achieved 1/2 of the objectives/expectations]; • '4' = good [achieved >1/2 of the objectives/expectations]; and • '5' = excellent [achieved all of the objectives/expectations])	
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Total cost to develop the BMP or combination of BMPs (AUD$):	
Total cost to implement the BMP (AUD$): (over the implementation period, or annually if implementation is on-going)	
Estimated total life-cycle cost of the BMP (AUD$): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	
Estimated total cost to monitor and evaluate the BMP (AUD$):	
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation: **Name:** **Organisation:** **Contact details (ph and e-mail):**	
Date of data entry:	
COMMENTS (e.g. reasons for the evaluation findings, and recommendations for future projects of a similar nature)	

4.4.3 Evaluation of Changes in Actual Behaviour (Evaluation Style No. 5) - Minimum Data Recording Requirements

HEADING	RECORDED DATA
BMP INFORMATION	
Name of the BMP being monitored: (e.g. the Stirling City Council's 'Stormwater Quality Policy' for new development in the city)	
Type and nature of the BMP: (i.e. include the key elements of the BMP, such as the strategies used to change behaviour, the target audience[s] and target pollutants)	
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	
Life span of the BMP: (i.e. the time over which the BMP is expected to operate)	
TEST SITE INFORMATION	
Location of BMP implementation:	
Agency implementing the BMP **Name:** **Type of agency:** **Address:**	
CATCHMENT INFORMATION	
Catchment name:	
Receiving waters:	
Area over which the BMP operates: (i.e. the potential area of influence of the BMP in ha, km^2 or m^2)	
Population over which the BMP operates: (e.g. the approximate number of people who live in the area potentially influenced by the BMP)	
Specific details of the number of participants and area of managed land (if applicable): (e.g. an ESC program may target 5,000 building sites in a city per year, managing 500 ha of land)	
MONITORING INFORMATION	
Objectives being evaluated:	
Monitoring parameters: (i.e. what is being monitored/measured)	
Sampling design: (e.g. how the sample was selected for the survey - see Phase II, Step 2 of the monitoring and evaluation protocol)	
Monitoring frequency and timeframe: (e.g. immediately before, immediately after, and 12 months after the implementation of the BMP)	
Monitoring location(s):	
Monitoring method: (e.g. audits or direct observation using referenced methodology)	
Who did the monitoring and evaluation: (include a comment regarding their degree of independence)	

Continued ...

HEADING	RECORDED DATA
EVALUATION RESULTS	
Key findings: (include quantitative information where available, such as the measured change in behaviour and/or the outcomes produced by such behaviour)	
Caveats, assumptions and areas of uncertainty: (e.g. where relevant, include a brief comment on the consistency and comparability of data collected by different observers/auditors, or other influences on the target audience's behaviour)	
Overall assessment of BMP 'value' (a score of 1 - 5): (where: • '0' = detrimental impacts; • '1' = no positive or detrimental impacts; • '2' = fair [achieved <1/2 of the objectives/expectations]; • '3' = average [achieved 1/2 of the objectives/expectations]; • '4' = good [achieved >1/2 of the objectives/expectations]; and • '5' = excellent [achieved all of the objectives/expectations])	
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Total cost to develop the BMP or combination of BMPs (AUD$):	
Total cost to implement the BMP (AUD$): (over the implementation period, or annually if implementation is on-going)	
Estimated total life-cycle cost of the BMP (AUD$): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	
Estimated total cost to monitor and evaluate the BMP (AUD$):	
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation: **Name:** **Organisation:** **Contact details (ph and e-mail):**	
Date of data entry:	
COMMENTS (e.g. reasons for the evaluation findings, and recommendations for future projects of a similar nature)	

4.4.4 Evaluation of Changes in Stormwater Quality (Evaluation Style No. 6) - Minimum Data Recording Requirements

HEADING	RECORDED DATA
BMP INFORMATION	
Name of the BMP being monitored: (e.g. the Stirling City Council's 'Stormwater Education & Enforcement Program' for the White's Hill Industrial Estate)	
Type and nature of the BMP: (i.e. include the key elements of the BMP, such as the strategies used to improve stormwater quality, the target audience[s] and target pollutants)	
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	
Life span of the BMP: (i.e. the time over which the BMP is expected to operate)	
TEST SITE INFORMATION	
Location of BMP implementation:	
Agency implementing the BMP **Name:** **Type of agency:** **Address:**	
CATCHMENT INFORMATION	
Catchment name:	
Catchment area (in ha, km^2 or m^2):	
Altitude of study area (m): (relevant only if evaluation information will be shared internationally)	
Land uses in the catchment being monitored and their % of the total catchment area:	
Total % impervious area of the catchment being monitored:	
Receiving waters:	
Area over which the BMP operates: (i.e. the potential area of influence of the BMP in ha, km^2 or m^2)	
Population over which the BMP operates: (e.g. the approximate number of people who live/work in the area potentially influenced by the BMP)	
Specific details of the number of participants and area of managed land (if applicable): (e.g. a local industrial regulation program may involve 100 businesses and cover 200 ha of land)	
MONITORING INFORMATION	
Objectives being evaluated:	
Monitoring parameters: (i.e. what is being monitored)	
Monitoring locations and station information: (e.g. name, type, location, relationship to area affected by BMP)	
Rainfall information/data: (see Appendix E for a 1 page form to record precipitation/rainfall data, which is the same as that used for the US BMP Database)	
Stormwater flow information/data: (see Appendix E for a 1 page form to record this information, which is the same as that used for the US BMP Database)	

Continued ...

HEADING	RECORDED DATA
Stormwater quality information/data: (see Appendix E for a 1 page form to record this information, which is the same as that used for the US BMP Database)	
Sampling design: (e.g. explain how the number of samples were determined and if a paired catchment study design was used)	
Monitoring frequency and timeframe: (e.g. 10 storm events were sampled over the 6 months period before the BMP was implemented, then another 10 were sampled in the 6 months period after the BMP was implemented)	
Monitoring method: (e.g. briefly describe how stormwater quality, flow and/or rainfall data was obtained)	
Storm criteria used to trigger monitoring events: (e.g. rainfall events ≥4mm)	
Who did the monitoring and evaluation: (include a comment regarding their degree of independence and expertise)	
EVALUATION RESULTS	
Key findings: (include information on the BMP's efficiency, using the effluent probability method where possible - see ASCE & US EPA, 2002)	
Caveats, assumptions and areas of uncertainty: (e.g. where relevant, include a brief comment on the similarity of the intervention and the control catchments)	
Overall assessment of BMP 'value' (a score of 1 - 5): (where: • '0' = detrimental impacts; • '1' = no positive or detrimental impacts; • '2' = fair [achieved <1/2 of the objectives/expectations]; • '3' = average [achieved 1/2 of the objectives/expectations]; • '4' = good [achieved >1/2 of the objectives/expectations]; and • '5' = excellent [achieved all of the objectives/expectations])	
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Total cost to develop the BMP or combination of BMPs (AUD$):	
Total cost to implement the BMP (AUD$): (over the implementation period, or annually if implementation is on-going)	
Estimated total life-cycle cost of the BMP (AUD$): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	
Estimated cost to monitor and evaluate the BMP (AUD$):	
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation: **Name:** **Organisation:** **Contact details (ph and e-mail):**	
Date of data entry:	
COMMENTS (e.g. reasons for the evaluation findings, and recommendations for future projects of a similar nature)	

4.4.5 Evaluation of Changes in Waterway Health (Evaluation Style No. 7) - Minimum Data Recording Requirements

HEADING	RECORDED DATA
BMP INFORMATION	
Name of the BMP (or combination of BMPs) being monitored: (e.g. the Stirling City Council's 'City-wide Stormwater Management Program')	
Type and nature of the BMP: (i.e. include the key elements of the BMP, such as the strategies used to improve stormwater quality, the target audience[s] and target pollutants)	
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	
Life span of the BMP: (i.e. the time over which the BMP is expected to operate)	
TEST SITE INFORMATION	
Location of BMP implementation:	
Agency implementing the BMP **Name:** **Type of agency:** **Address:**	
CATCHMENT INFORMATION	
Catchment name:	
Catchment area (in ha, km^2 or m^2):	
Land uses in the catchment being monitored and their % of the total catchment area:	
Total % impervious area of the catchment being monitored:	
Name and type of receiving waters: (include a copy of a conceptual model of the system being monitored, if available - see Phase I, Step 3 of the Monitoring and Evaluation Protocol)	
Area over which the BMP operates: (i.e. the potential area of influence of the BMP in ha, km^2 or m^2)	
Population over which the BMP operates: (e.g. the approximate number of people who live/work in the area potentially influenced by the BMP)	
Specific details of the number of participants and area of managed land (if applicable): (e.g. a local industrial regulation program may involve 100 premises and cover 200 ha of land)	
MONITORING INFORMATION	
Objectives being evaluated:	
Type of monitoring program: (e.g. a 5 year trend monitoring program focusing on the ecological health of a river system, and specifically its water quality, in-stream habitat and denitrification processes)	
Scope of the monitoring program: (e.g. the spatial boundaries and duration of the program)	
Monitoring parameters: (e.g. concentrations of nutrient species in the water column, seagrass distribution, frequency of algal blooms, etc.)	

Continued ...

HEADING	RECORDED DATA
Sampling design (including sample size and frequency): (e.g. explain the levels of monitoring, where relevant - see Phase II, Step 2 of the Monitoring and Evaluation Protocol)	
Monitoring locations: (attach a map, where relevant)	
Monitoring method: (e.g. briefly describe how data on waterway health was obtained)	
Peer review: (include a comment on whether a peer review was done, and if so, the degree of independence and expertise of the review body)	
EVALUATION RESULTS	
Key findings: (include a statement on whether measured changes to waterway health can be attributed to stormwater management initiatives, as opposed to the cumulative impact of all catchment management initiatives)	
Caveats, assumptions and areas of uncertainty: (e.g. whether measured changes in waterway health are the result of stormwater management initiatives or some other cause, such as natural variation, or other form of catchment management)	
Overall assessment of BMP 'value' (a score of 1 - 5): (where: • '0' = detrimental impacts; • '1' = no positive or detrimental impacts; • '2' = fair [achieved <1/2 of the objectives/expectations]; • '3' = average [achieved 1/2 of the objectives/expectations]; • '4' = good [achieved >1/2 of the objectives/expectations]; and • '5' = excellent [achieved all of the objectives/expectations])	
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Total cost to develop the BMP or combination of BMPs (AUD$):	
Total cost to implement the BMP (AUD$): (over the implementation period, or annually if implementation is on-going)	
Estimated total life-cycle cost of the BMP (AUD$): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	
Estimated cost to monitor and evaluate the BMP (AUD$):	
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation: **Name:** **Organisation:** **Contact details (ph and e-mail):**	
Date of data entry:	
COMMENTS (e.g. reasons for the evaluation findings, and recommendations for future projects of a similar nature)	

5. Summary and Conclusions

These guidelines present monitoring and evaluation 'tools' that can be used by local government authorities in Australia to evaluate all types of non-structural BMPs for urban stormwater quality improvement.

The guidelines also briefly summarises the status of attempts to evaluate non-structural BMPs. Researchers in this area have noted a lack of reliable, quantified data on the value and life-cycle cost of non-structural BMPs for over two decades despite calls for additional research and a trend of increasing use. The lack of such data is a major impediment to more rapid and widespread adoption of non-structural BMPs, and well considered decisions involving their use.

Impediments to sound evaluation have also been summarised and include:

- The intrinsic difficulty of measuring the effect of those BMPs that operate through changing people's behaviour, due to issues such as the complexity of human behaviour, privacy issues, experimental influence, and the unreliability of self-reported behaviour.
- The beneficial effects of non-structural BMPs on stormwater quality within a catchment may be subtle and masked by the influence of other BMPs and/or activities within the catchment.
- There is often uncertainty associated with transferring the findings from one monitoring and evaluation study to another context.
- Some non-structural BMPs work synergistically (e.g. a complementary education and enforcement campaign), so that monitoring a BMP in isolation may produce misleading results.
- Different methodologies are used to describe aspects of a BMP's value (e.g. their 'pollutant removal efficiency') which can significantly affect the results.

To develop monitoring and evaluation tools that can be used by local government authorities, we gathered information on methods for monitoring and evaluating the value and life-cycle cost of non-structural BMPs via a survey of 36 stormwater managers from Australia, New Zealand and the United States of America, as well as published literature, the internet, case studies and unpublished reports.

We used this information to develop:

- A new ***evaluation framework*** for all non-structural BMPs that includes seven different styles of evaluation. This framework accommodates the wide diversity of non-structural BMPs as well as the different characteristics of stormwater management agencies who may undertake the evaluation (e.g. their monitoring objectives and available resources).
- A set of five step-wise ***monitoring and evaluation protocols*** that can be used for all non-structural BMPs. The monitoring and evaluation protocols provide simple guidance on how to plan, deliver and report on a monitoring and evaluation project. These protocols have been written primarily for use by local government authorities as guidelines for their own work or as project briefs for specialist consultants. They have been deliberately kept short (compared to overseas equivalents), with references being made to more detailed guidelines where necessary.
- ***Data recording sheets*** for each monitoring and evaluation protocol to ensure that the salient details and results of monitoring and evaluation projects are collated in a manner that facilitates sound reporting, sharing of knowledge and continual improvement.

In addition, these guidelines also provide simple guidance on how to use the monitoring and evaluation tools outlined above, and in particular, how to choose the best style(s) of evaluation to suit the objectives of the BMP and available evaluation resources.

In the short term, these monitoring and evaluation tools can be used on all types of non-structural BMPs to provide valuable feedback to stakeholders on the merits and cost of specific BMPs. In the longer term, these tools should help to produce higher quality data on the value and cost of non-structural BMPs, enabling urban stormwater managers to more confidently use such BMPs in their urban stormwater management programs to improve the health of the nation's waterways.

6. Glossary of Key Terms and Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council.
ARMCANZ	Agriculture and Resource Management Council of Australia.
ASCE	American Society of Civil Engineers.
BACI	An acronym for an experimental design that has **B**efore and **A**fter sampling at a **C**ontrol site (where no BMP is implemented) and the **I**ntervention /Investigation site (i.e. the site where the BMP has been implemented).
Baseline	Conditions prior to the implementation of a non-structural BMP.
BIEC	Beverage Industry Environment Council (Australia).
BMP	Best management practice - A device, practice or method for removing, reducing, retarding or preventing targeted stormwater runoff 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.
CCAT	Clean Communities Assessment Tool - A holistic measurement method for evaluating initiatives to change littering behaviour. The CCAT has been designed for use by trained and accredited local government authorities, community groups and non-government agencies. It is a simplified method compared to the DBI (see definition below), involving assessment of the context, facilities, attitudes and behaviour associated with littering and includes both observational measurements and litter counts. (Formally called the 'Situational Litter Score'.)
Control site	A sampling site which is as similar as possible to the intervention site (i.e. where the BMP is to be implemented) in every way, except that the BMP is not applied there.
CRC for Catchment Hydrology	Cooperative Research Centre for Catchment Hydrology (Australia). See www.catchment.crc.org.au for details.
CWP	Centre for Watershed Protection, Maryland.
Data recording sheets	Forms used to gather data in a consistent format on the nature of the BMP being evaluated, the monitoring location(s), the monitoring program, the results, and the agency doing the evaluation. These are presented in Section 4.4.
Data quality objectives	A description of the type, quality and quantity of data needed to support a specific decision, based on the results of the project.
DBI	Disposal Behaviour Index - An observational approach for measuring the effect of anti-littering BMPs. An objective, mathematical measure of all the environmentally desirable disposal behaviours found for a specified site and observation session.

Ecological health monitoring — Ecological health monitoring measures a change in the boundaries of functional zones identified by ecological health indicators, where:

- 'Change' is the difference between the measured state and either historical scenarios, appropriate contemporary reference sites or standards.
- A 'functional zone' is a geographic entity which:
  - has common structural and functional characteristics; in particular it is homogeneous in key processes, relevant anthropogenic impacts and critical habitats;
  - can be defined in a conceptual model; and
  - can be quantified by measurement.
- 'Ecological health indicators' are measurable ecosystem features that provide information on processes, anthropogenic impacts and habitats.

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.

ESC — Erosion and sediment control.

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.

Evaluation style — The type of evaluation chosen to match the objectives of the BMP and available evaluation resources (e.g. examining whether behaviour changed as a result of the non-structural BMP, as opposed to whether stormwater quality or waterway health changed). Seven styles of evaluation are presented in Table 4.1 for evaluating non-structural BMPs for stormwater quality improvement.

Event mean concentration (EMC) — A method for characterising pollutant concentrations in stormwater during a runoff event. The value may be determined by compositing (in proportion to the stormwater flow rate) a set of samples, taken at various points in time during a runoff event, into a single sample for analysis.

Integrated pest management — A practice of using biological and physical measures to control pests while minimising or eliminating the use of synthetic chemical pesticides.

Intervention site — The site whether the BMP was applied.

Kurtosis — Kurtosis is a statistical term used to describe the 'peakedness' of a distribution curve, relative to the length and size of its tails (see US EPA, 1997).

LBI	Littering Behaviour Index - A simple observational approach for measuring the effect of anti-littering BMPs. A measure of the amount of littering in a specified site for an observation session. The LBI is focused on negative behaviour and used as a proxy measure for the DBI (see the definition for DBI).
Life-cycle cost	The total cost of the design, implementation, operation and maintenance of the BMP over its life span.
LSRC	Land of Sky Regional Council (US).
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.
Monitoring and evaluation protocols	Step-wise guidelines on how to scope, prepare, implement and assess the results from a 'Monitoring and Evaluation Plan' for non-structural BMPs that aim to improve stormwater quality.
Monitoring tools	Specific measuring instruments that are used to gather data on the performance or cost of non-structural BMPs for stormwater quality improvement (e.g. tailored audit checklists or survey questionnaires).
NATA	National Association of Testing Authorities.
Non-structural BMP	A range of institutional and pollution prevention practices that are designed to prevent or minimise pollutants from entering stormwater runoff 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 and/or economic instruments.
NSW EPA	New South Wales Environmental Protection Authority. (Incorporated into the new NSW Department of Environment and Conservation in late 2003.)
NVPDC	Northern Virginia Planning District Commission.
Paired catchment study design	A monitoring design where two catchments are monitored concurrently. One is the catchment where the BMP is being implemented (the intervention site), while the other is a control site. Paired catchments should be similar in terms of land use, percent impervious area, climatic conditions and catchment activities (e.g. maintenance activities).
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.
QA/QC	Quality assurance/quality control.
Stratified random sampling	Sampling in which the sampling population is first divided into separate subgroups, each of which is more internally similar than the over-all population, prior to random sample selection from within each subgroup.

Structural BMP	Engineered devices implemented to control, treat, or prevent stormwater runoff pollution.
TN	Total nitrogen.
TP	Total phosphorus.
TRC	Taverner Research Company (Australia).
Trend monitoring	Low-frequency, long duration and low-moderate intensity monitoring of changes (or lack thereof) in parameters compared to baseline conditions.
TSS	Total suspended solids.
UPRCMT	Upper Parramatta River Catchment Management Trust (Australia).
US BMP Database Project	A cooperative arrangement between the US Urban Water Resources Research Council of the American Society of Civil Engineers and the US EPA to promote technical design improvements for BMPs and to better match their selection and design to local stormwater problems. The project involves collecting and evaluating existing BMP performance data, designing and creating an on-line national BMP database (www.bmpdatabase.org) and developing BMP performance evaluation protocols. When the database was reviewed as part of this project, it focused on *structural* BMPs for stormwater quality improvement.
US EPA	United States Environment Protection Agency.
Value	The term 'value' is used in these guidelines 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 in this section); and • ability to improve waterway health.
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 life cycle costs.

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Appendix A

Example of a 'Project Plan' for a relatively complex non-structural BMP evaluation project involving several styles of evaluation

(A plan used for an anti-litter education/participation campaign in Snell Grove, Oak Park, Moreland, Melbourne, 2002-04)

Moreland City Council

Moonee Ponds Creek keep it clean

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

Project Plan

Monitoring and Evaluating An Education/Participation Campaign to Reduce Stormwater Litter Loads in a Small Commercial Shopping District in Melbourne

Example Version

2003

Prepared by: André Taylor (Cooperative Research Centre for Catchment Hydrology) in consultation with Staff from Melbourne Water and Moreland City Council.

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APPENDIX

1 Not included in this example report (see Table 4.1 of the main guideline for equivalent information).

1. Aim

The purpose of this Plan is to briefly outline the proposed approach to monitoring and evaluating the performance of a targeted education/participation campaign that will be implemented in Moreland in 2003. Specifically, the Plan relates to monitoring the performance of an education/participation campaign that aims to reduce the loads of litter in stormwater within a small commercial district around Snell Grove in Oak Park, Melbourne.

Note that this Project Plan has been updated several times during 2002-03 as the project as evolved.

2. Background

In 2002 the 'Moonee Ponds Creek Litter Initiative' ran a non-structural program to reduce littering and the load of litter entering stormwater within the Moonee Ponds Creek Catchment. One of the projects proposed by this initiative was a targeted education/participation campaign in the small commercial district along Snell Grove, Oak Park.

It was proposed that the design of this education/participation campaign should draw upon:

- the experience of similar projects in Victoria and NSW[2];
- findings of an international literature review recently conducted by the Cooperative Research Centre for Catchment Hydrology (the CRC) into the effectives of non-structural measures for stormwater quality improvement (including education and participation programs); and
- relevant information on people's knowledge, attitudes and behaviour that has been collected from the Snell Grove district during two baseline surveys in 2002-03.

It is proposed that the education/participation campaign will focus on two target groups:

- shopkeepers in the 20-30 shops along Snell Street (the *primary* focus); and
- the public using the area along the Snell Grove shopping strip (i.e. those groups that frequently use the area and are likely to be successfully targeted by educational messages).

In late 2002 the Moonee Ponds Creek Litter Initiative (representing its partners) formed a partnership with the CRC to assist with the monitoring and evaluation of the litter-related education/participation campaign. The Moonee Ponds Creek Litter Initiative agreed to focus on the preliminary design of the education/participation campaign. The CRC agreed to run the associated monitoring and evaluation, with the bulk of the CRC's funding originating from a 2002-03 Victorian Stormwater Action Program grant.[3]

Due to the uncertainty regarding ongoing funding for the Moonee Ponds Creek Litter Initiative, the responsibility for finalising the design of the education/participation campaign and its delivery moved to Moreland City Council (i.e. Moreland's Education Officer).

[2] A fact finding trip to NSW was undertaken by Jacquie White, the Coordinator of the Moonee Ponds Creek Litter Initiative, in 2002 to gather this experience.

[3] Note that some of the CRC's funding (approximately $10,000) will be allocated to the delivery of the education/participation campaign to minimise the risk that the campaign will not induce a large enough change in behaviour and/or litter loads in stormwater to be identified by the monitoring program.

The CRC has recently developed a proposed evaluation framework, monitoring protocols and data collection sheets for evaluating the performance and life cycle cost of all types of non-structural best management practices (BMPs) for stormwater quality improvement. It is proposed that these monitoring 'tools' be trialled at Snell Grove.

This project is running in parallel with another CRC monitoring project involving non-structural stormwater management practices in Moreland. The other project involves evaluating the effectiveness of new town planning controls for stormwater management and associated training. A Steering Group has been formed to oversee both trials. This Group meets quarterly and includes representatives from Moreland City Council, Melbourne Water, the CRC, and the Victorian EPA.

Clearly, interaction and coordination between partner organisation is needed throughout the project at Snell Grove. This Project Plan briefly outlines the proposed approach including key tasks and milestones, so partner organisations and individuals can synchronise their activities throughout 2002-04.

More detail on the proposed monitoring and evaluation methodology has been provided in two 'Monitoring and Evaluation Plans', which were developed in 2002-03 (in accordance with recently developed CRC monitoring protocols). One Plan relates to monitoring activities undertaken by the CRC (i.e. monitoring BMP implementation and litter loads), while the other relates to activities undertaken by a specialist consultancy[4] (i.e. monitoring changes to people's awareness, attitudes, self-reported behaviour and actual behaviour).

3. The Stormwater Management Practice Being Evaluated

The *primary* management practice that is proposed to be monitored and evaluated is a three-stage education/participation campaign that targets shopkeepers and the public, in the commercial district of Snell Grove, Oak Park, Melbourne.

The objectives of the campaign are:

1. To implement a best practice education/participation campaign to raise awareness, promote positive behavioural change with respect to waste management and reduce litter loads in the commercial district of Snell Grove, Oak Park, Melbourne from April to September 2003.

2. To raise the awareness and promote positive behavioural change in respect to littering and waste management in the Snell Grove *business community* (i.e. shop-keepers) immediately following and up to six months after the campaign.

3. To raise the awareness and promote positive behavioural change in respect to littering in target audiences within the *broader community* immediately following and up to six months after the campaign.

4. To reduce litter loads in stormwater drainage from the commercial district immediately following and up to six months after the campaign.

[4] Community Change Pty Ltd.

4. The Proposed Styles of Evaluation

The CRC has recently developed a generic evaluation framework for non-structural stormwater management practices that has seven styles of evaluation. These styles are summarised in Appendix 1.

The seven styles reflect approaches to evaluation that are suitable for different best management practices, monitoring objectives and available resources. Generally speaking, the complexity, cost and value of the results increases as one moves from evaluation style No. 1 to No. 7.

The proposed evaluation styles for the Snell Grove education/participation campaign are outlined in Table 1.

Table 1 - Evaluation Styles for the Snell Grove Education/Participation Campaign

PROPOSED EVALUATION STYLE(S)*	COMMENTS	WHO WILL DO IT?
1 – BMP Implementation (i.e. was the campaign fully implemented as planned?)	Easily monitored and evaluated after implementation of the campaign.	CRC
2, 3 & 4 – Changes in awareness/knowledge, attitude and self-reported behaviour with respect to littering and litter prevention	Monitored using two face-to-face survey instruments (one targeting shop-keepers and one targeting segment of the public) before and after the campaign.	Specialist consultant – Community Change Pty Ltd
5 – Changes in people's behaviour with respect to littering and litter prevention	Monitored using littering observations (targeting the public in public places) and audits of large litter items, before and after the campaign.	Specialist consultant – Community Change Pty Ltd
6 – Stormwater quality (i.e. litter loads entering stormwater)	Monitored using side entry pit litter baskets on Snell Grove which capture gross pollutants before and after the campaign.**	CRC

Notes:
* See Appendix 1 for a brief explanation of styles.
** A control site has also been established at Gaffney Street (Pascoe Value) for litter load monitoring.

5. Project Plan Actions

The purpose of this section is to outline the major tasks that are needed so that monitoring and evaluation can occur as briefly outlined in Table 1. In addition, relevant timeframes and responsibilities are defined for each task. This list of actions (Table 2) is intended to promote understanding between partners involved with the project on the nature and timing of actions that need to be undertaken in 2002-03.

Actions have been drawn from:

- the expertise of the CRC in the design of monitoring and evaluation campaigns;
- the accepted evaluation proposal by Community Change Pty Ltd (prepared by Rob Curnow) for those elements that involve measuring people's knowledge, attitudes and behaviour; and

- advice from Iona Theodoridis (Moreland's Education Officer), who is leading the final design and delivery of the education/participation campaign.

More detail on the specific nature of the monitoring approach is available the two 'Monitoring and Evaluation Plans' (see Section 2 for details).

Table 2 – Project Plan Actions

Major Tasks (Campaign implementation and monitoring tasks)	Lead Person	When (& current progress)
PROJECT MANAGEMENT TASKS		
Undertake project management of all monitoring and evaluation tasks.	André Taylor (until 30 June 2003 when the role will be fulfilled by MCC)	Ongoing
Undertake the final design and delivery of the education/participation campaign.	Iona Theodoridis Nicolette Rose	Design: Mar to April 2003 (Done) Delivery: May to Oct 2003
Organise, chair, and minute the Steering Group meetings on a quarterly basis.	André Taylor (until 30 June 2003 when the role will be fulfilled by MCC)	From Sep 2002 to April 2004
Undertake the management of the budget for monitoring and evaluation.	Tony Wong	Ongoing
PRE-CAMPAIGN ACTIONS		
1. Install side entry gully pit litter baskets at Snell Grove and Gaffney Street (the control site) and develop a mechanism to signal when the litter traps have been bypassed due to a large storm event.	Justin Lewis	Sep 2002 (Done)
2. Ensure an appropriate rainfall station is in operation nearby.	Justin Lewis in consultation with Tony Wong and/or Robin Allison	Sep 2002 (Done)
3. Remove gross pollutants from the litter traps after each storm event and quantify the weight of litter and gross pollutants (total).	Justin Lewis in consultation with Tony Wong	Sep 2002 to April 2004 (In progress)
4. Council to ensure activities in the Snell Grove catchment that are managed by Council do not substantially change over 2002-04 (e.g. litter bin clean-outs, street sweeping) unless they are part of the education/participation campaign. Major activities that may affect stormwater pollutant loads will also need to be avoided (e.g. construction work on the street).	Les Horvath	Sep 2002 to April 2004 (In progress)
5. Gather information on catchment characteristics (e.g. a map, total catchment area, % impervious area, sources of litter) and activities from Council (e.g. street sweeping, litter collections, litter bin management).	Justin Lewis	Sep 2002 to June 2003 (In progress)
6. Develop a <u>preliminary</u> best practice, intensive Education/Participation Campaign drawing upon advice from NSW EPA and the literature. This will include a fact-finding trip to NSW during 22-23 August 2002. The focus will be on the shop keepers and to a lesser extent any public group using the area that frequently uses the area and is likely to be significantly exposed to educational messages.	Jacquie White	July to Oct 2002 (Done)
7. Engage a specialist consultant to do monitoring and evaluation for evaluation styles No. 2, 3, 4, and 5 (see Table 1).	Andre Taylor	Oct 2002 (Done)

Major Tasks (Campaign implementation and monitoring tasks)	Lead Person	When (& current progress)
8. Develop detailed Monitoring and Evaluation Plans using draft CRC protocols for the CRC's monitoring activities and those undertaken by the specialist consultant (see above)	Andre Taylor, Community Change	Oct - April 2002 (50% complete)
9. Identify key catchment characteristics and litter-related activities.	Community Change	October 2002 (Done)
10. Conduct pilot tests and consult with project partners about refinements to methods.	Community Change	Nov 2002 (Done)
11. Gather initial baseline information and brief project partners to enable adjustment to education/participation program.	Community Change	Nov - Dec 2002 (Done)
12. Gather second round of baseline information immediately before the campaign (i.e. litter observations, shop-keepers & public surveys).	Community Change	February 2003 (Done)
13. Provide feedback on baseline outcomes to refine education/participation program.	Community Change	March - April 2003 (Done)
14. Provide suggestions on improving the draft CRC monitoring and evaluation guidelines.	Community Change	March - April 2003
THE EDUCATION/PARTICIPATION CAMPAIGN		
Business Program Stage I:		
1. Review I (e.g. examination of litter).	Iona Theodoridis (with help from Justin Lewis) Nicolette Rose	April 2003
2. Meeting (with key stakeholders).	Iona Theodoridis Nicolette Rose	April 2003
3. Information flyer (for businesses).	Iona Theodoridis Nicolette Rose	April – May 2003
4. Introductory visit.	Iona Theodoridis Nicolette Rose	May 2003
5. Review II (of information gathered to date, and confirm campaign actions).	Iona Theodoridis Nicolette Rose	June 2003
6. Clean up event (dependent on trader interest).	Iona Theodoridis Nicolette Rose	June 2003
7. Media (promote outcomes of clean-up event).	Iona Theodoridis Nicolette Rose	June 2003
Business Program Stage II:		
1. Site visit (work with each business).	Iona Theodoridis Nicolette Rose	July 2003
2. Newsletter/fact sheets.	Iona Theodoridis	July – Aug 2003
3. Council (communicate recommendations from businesses to Council).	Iona Theodoridis Nicolette Rose	July – Aug 2003
4. Address issues (e.g. develop tools to help businesses with identified needs).	Iona Theodoridis Nicolette Rose	Aug 2003
5. Recognition (positive reward incentive system, e.g. window sticker).	Iona Theodoridis Nicolette Rose	Aug 2003
6. Media.	Iona Theodoridis Nicolette Rose	Aug - Sep 2003
Community Program:		
1. Bin facility review.	Iona Theodoridis	May 2003

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Major Tasks (Campaign implementation and monitoring tasks)	Lead Person	When (& current progress)
2. Street signage (include educational messages).	Iona Theodoridis Nicolette Rose (with help from Victorian Litter Action Alliance)	June – July 2003
3. Railway signage.	Iona Theodoridis Nicolette Rose (with help from M-Train and the Victorian Litter Action Alliance)	June – July 2003
4. Clean up event (as joint community/ schools/ trader event- dependent on interest).	Iona Theodoridis Nicolette Rose	June 2003
5. Posters (developed by school children and placed in shop windows).	Iona Theodoridis Nicolette Rose	June 2003
6. Drain stencilling.	Iona Theodoridis Nicolette Rose	June 2003
7. Complete education program.	Iona Theodoridis Nicolette Rose	Sep 2003
MONITORING ACTIONS DURING THE EDUCATION/PARTICIPATION CAMPAIGN		
1. Review immediate impacts during campaign.	Community Change	June 2003
2. Provide feedback to facilitate adjustments to the education/participation campaign.	Community Change	June 2003
3. Finalise draft CRC monitoring and evaluation protocols and make them available to stakeholders.	Andre Taylor	Finalise by June 2003 (publication may take longer)
POST-CAMPAIGN ACTIONS		
1. Review immediate impacts at end of campaign.	Community Change	Oct 2003
2. Conduct follow up observations and surveys 6 months after the campaign; with shop-keepers and the public.	Community Change	Mar 2004
3. Liaise with project partners to review all monitoring data and key findings.	Community Change and the CRC (Andre Taylor, Justin Lewis)*	April 2004
4. Prepare draft Community Change report and incorporate feedback.	Community Change	May 2004
5. Present final Community Change report.	Community Change	May June 2004
6. Evaluate and report on the effectiveness of the campaign in terms of: ▪ raising awareness/knowledge and changing attitudes; ▪ changing behaviour; ▪ reducing litter loads in stormwater; and ▪ the need to revise the draft CRC monitoring protocols.	CRC to coordinate a final report for the whole project.*	June 2004

Note:
* If required by Moreland City Council, as Council will manage the project after 30 June 2003.

6. Project Management and Reporting Arrangements

The project will be steered by a Project Steering Group consisting of representatives from Moreland City Council, the CRC, the Victorian EPA and Melbourne Water. It is envisaged that this group will meet every 3 – 6 months throughout the project.

Day-to-day project management of the tasks associated with implementing the education/participation campaign in 2003 will lie with Iona Theodoridis (Education Officer, Moreland City Council).

Day-to-day project management of the tasks associated with monitoring and evaluating will lie with André Taylor (Research Fellow, Monash University) until 30 June 2003 when responsibility for managing the project will be transferred from the CRC to Moreland City Council. Over-all responsibility for the CRC's involvement for this project lies with Tony Wong (Assoc. Prof., Monash University).

Iona Theodoridis and Les Horvath (Moreland City Council) will liaise with Council staff and groups as required (e.g. maintenance staff, the 'Sustainable Moreland Interdepartmental Committee' and the 'Moreland Stormwater Action Team').

André Taylor will also prepare brief, quarterly progress reports to meet the requirements of the Victorian Stormwater Action Program and for the information of other organisations with a stake in the project.

7. Budget

As of 3 April 2003, sufficient funds had been obtained via the Victorian Stormwater Action Program and from in-kind resources from the CRC and Moreland City Council and Melbourne Water to deliver the project as outlined in Table 2 with two exceptions:

- Due to the initially unplanned addition of a control site at Gaffney Street, and the additional litter load monitoring and additional funding is required (estimated at $28,125).
- Due to the initially unplanned extension of the project into the 2003-04 financial year, additional funds are needed to manage the monitoring and evaluation elements over this time frame (including the final data evaluation and reporting stage). These costs have been estimated at $15,375.

To cover these unfunded tasks, a grant application was made to the Victorian Stormwater Action Program in November 2003. As of the date of this Project Plan, the grant application is still pending.

8. Final Reporting

A final evaluation report will be prepared for the project. It is envisaged that CRC will be requested by Moreland City Council to undertake this task. This report will document the findings of the monitoring and evaluation activities. Stakeholders represented on the Project Steering Group will be consulted on the content of this report while it is in draft form.

The report will eventually be forwarded to the Victorian Environmental Protection Authority as required by the Victorian Stormwater Action Program funding agreement between the CRC and the

Victorian Government. The CRC may also publish some or all of the results in an 'Industry Report' or as part of its monthly 'Catchword' newsletter. Stakeholders represented on the Project Steering Group will be consulted on the content of these reports.

APPENDIX 1

A Seven Step Evaluation Framework for Non-structural Best Management Practices for Stormwater Quality Improvement (Taylor and Wong, 2002)[5]

[5] Not included in this example plan (see Table 4.1 in the main guideline for equivalent information).

Appendix B

Example of a simple 'Monitoring and Evaluation Plan'

(A plan used for a stormwater-related training event titled "Doing it Right On-site' in Sunbury, Victoria, 2003)

Monitoring and Evaluation Plan

Monitoring and Evaluating a Stormwater Quality-related Training Program

"Doing it Right On-site – Managing Building and Construction Sites for Stormwater Protection"

Example Version

2003

Prepared by: André Taylor, Cooperative Research Centre for Catchment Hydrology

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APPENDICES

[1] Not included in this example plan (see Table 4.1 in the main guideline for equivalent information).

1. Aim

The purpose of this Plan is to document the proposed approach to monitoring and evaluating the performance a stormwater quality-related training program[2] in Melbourne.

2. Background

The Victorian Stormwater Action Program (VSAP) has funded a comprehensive stormwater related Capacity Building Program in Victoria. This program is being managed by the Municipal Association of Victoria (MAV) and the Stormwater Industry Association of Victoria (SIAV).

One of the elements of the program is a training/seminar program titled "Doing it Right On Site – Managing Building and Construction Sites for Stormwater Protection", which will be delivered from 10am to 3:00pm on 5 March 2003 in Sunbury, Victoria. This training event was jointly planned and delivered by the Victorian Litter Action Alliance (VLAA).

The primary purpose of this training is to educate key stakeholders on how they can better manage building/construction sites to protect stormwater quality. Information and key messages will be communicated, as well as the launch of a new resource kit.

The Cooperative Research Centre for Catchment Hydrology (the CRC) has recently developed an evaluation framework, monitoring protocols and data collection sheets for evaluating the performance and life-cycle cost of non-structural best management practices (BMPs) for stormwater quality improvement. It is proposed that these monitoring 'tools' be trialled during the "Doing it Right On Site" forum, as training is a common type of 'non-structural BMP'. The CRC has also been partially funded by the VSAP to undertake this task.

In the CRC's draft working document titled "Non-structural Stormwater Quality Best Management Practices – Guidelines for Monitoring and Evaluation" (Taylor and Wong, 2002), seven (7) styles of evaluation are presented (see Appendix 1). It is proposed that the trial of these guidelines involving the "Doing it Right On Site" training event will only involve styles #1 and #2 (i.e. evaluation of 'BMP implementation' and 'changes in people's knowledge/awareness').

While this form of evaluation is relatively simple and straight-forward, the approach will be clearly documented in this Plan and in a final evaluation report, as it is part of a trial which will be used to:

- refine draft CRC 'monitoring tools' for all non-structural BMPs for stormwater quality improvement; and
- guide others on how such monitoring can be planned, implemented and reported.

Section 3 and 4 of the Plan below are structured using the steps in the draft CRC Monitoring and Evaluation Guidelines for evaluation styles #1 and #2.

[2] Advertised as a "Forum".

3. Phase I (determine the objectives, scope and nature of the program)

Review relevant literature, local case studies, guidelines and/or previous monitoring data (where available)

The proposed BMP is a traditional training/awareness session involving several speakers, each presenting a brief seminar. There is credible evidence to suggest that such training programs can increase levels of awareness/knowledge in a short period, particularly where such training programs are interactive and intensive. How well increased levels of knowledge and awareness are maintained is less well-known. It is *suspected* that increased levels of awareness and knowledge will peak immediately after the training then begin to decrease over the next 3-6 months to a level above the baseline.

Get to know the local context

The target audience is expected to be primarily government staff (e.g. from local and State government agencies). Some representatives from the housing industry and the erosion and sediment control industry are also expected to be present. The level of knowledge on the subjects being covered by the speakers is expected to be highly variable.

Time will be made available on the training agenda to explain and undertake the evaluation exercise. Suitable forms and pens (if necessary) will be provided to trainees as part of the exercise. It is anticipated that the target audience will understand why there will be an increased focus on evaluation at the training event, and will participate.

Clearly document the objectives being evaluated

The objectives of this evaluation are to:

- Determine whether the training program was fully implemented as planned.
- Determine the quality of the training program (in terms of its content and delivery) from the perspective of participants.
- Determine whether the stormwater quality-related awareness/knowledge of participants immediately increased as a result of the training.[3]

Where the term "participants" primarily includes government representatives (e.g. Council staff) and members of the local development industry (e.g. building site supervisors, etc.).

Broadly determine the level of confidence needed in the evaluation results

The primary audience for the results of this evaluation are managers in MAV/SIAV and VLAA who have a responsibility to ensure that the training was effective and improvements are identified for future events. To a lesser extent, the Victorian Environment Protection Authority (VEPA) would also be interested in the results, as they are partially funding the training initiative as part of their VSAP grant program.

It is suggested that this audience needs a 'moderate' degree of confidence in the results, which can be achieved through the sound design of the monitoring approach, and the use of an independent evaluating body (i.e. the CRC). Detailed statistical analysis of errors associated with the results are not considered necessary for this monitoring exercise.

[3] Ideally, a follow-up survey of participants would occur 3-6 months after the training to determine whether key messages had been retained. This has not been done here however, as the primary purpose of the trial is to refine draft CRC monitoring tools which have to be finalised in 3 months.

Determine the type of evaluation needed

To determine whether the training program has been implemented as planned, an independent body (i.e. the CRC) will verify that the training events occurred, and survey participants just to assess their degree of satisfaction in the content and delivery of the training materials. In addition, a survey instrument will be used to measure the level of relevant knowledge/awareness of participants prior to and immediately after the training event.

As the primary researcher (André Taylor) is one of the seven presenters/trainers, the final evaluation report will be subject to peer review with the CRC to ensure there are no perception of potential bias in the findings[4].

Confirm the project's budget for monitoring and evaluation

For the proposed monitoring and evaluation, required resources include staff time (i.e. staff of the CRC and to a lesser extent, the MAV/SIAV and VLAA) and minor project related expenses (copying evaluation sheets). A small budget for consultancy fees associated with statistical advice may also be needed (<$300). The CRC's current resources that are available for the project are considered to be adequate.

4. Phase II (develop a 'monitoring and evaluation plan')

Select monitoring parameters

The monitoring parameters will be:

- whether or not the training event took place as planned;
- the numbers of participants at the training event and the number who expressed interest in attending the event but could not be accommodated;
- a set of 1 - 5 ratings in terms of the quality of the content *and* delivery of the training program (with the ratings to be scored by participants); and
- awareness/knowledge of key stormwater quality messages communicated via the training.

Determine the sampling design (e.g. the sample size, monitoring frequency and monitoring timeframe)

Two monitoring events will occur:

1. Immediately before the training event: The stormwater quality-related knowledge/awareness levels of training participants will be assessed prior to the training. A survey instrument will be used (see Appendix 2). All attendees will be asked to participate in the survey. A brief explanation of the purpose of the pre-training survey will be given.

2. Immediately after the training event: The stormwater quality-related knowledge/awareness levels of training participants will be assessed immediately after the training using the same survey instrument in Appendix 2. All attendees will be asked to participate in the survey. In addition, attendees will be asked to rate the quality of the training in terms of its content and delivery, using a feedback sheet (see Appendix 3).

4 Note that the potential for such bias is considered to be very low given the level of proposed data analysis will not reveal the *individual* performance of each speaker in communicating their key objectives.

It is not proposed to incorporate a control group into the monitoring program as:

- it would substantially increase the workload on the monitoring task (as the control group would be harder to identify and survey);
- the monitoring and evaluation plan only aims to produce a 'moderate' degree of confidence in the results given the intended audience (i.e. the additional degree of confidence in the results that the control group would provide is not warranted in this case); and
- given significant change in knowledge/awareness levels is anticipated as a result of the training and the absence of other influences on the day, the difference between the "before" and "after" surveys of participants is likely to be a true reflection of the influence of the training program.

The proposed timing for the training is 5 March 2003 (10am – 3pm), with monitoring occurring immediately before and immediately after such training.

Determine and trial the monitoring methodology

The following steps will be used:

1. The knowledge survey sheet in Appendix 2 will be given to attendees at the start of the training exercise. They will be asked to complete the sheet and it will be collected before the training begins. This survey will test their current levels of stormwater related knowledge/awareness. The survey focuses on those key messages that training is designed to communicate. A multiple choice method of assessing people's knowledge will be used for simplicity. The key messages will be sourced from the presenters. For all questions, the answer "Not sure/don't know" will be an option. Participants will be asked to put their name (or unique identifier if they wish to remain anonymous) on the sheets before and after the training, so that a 'paired assessment' can be done (i.e. each participant's before and after response can be checked).

2. During the training, information on attendees will be gathered through a standard attendance sheet (like the one in Appendix 4). Information gathered will include: name, contact phone number, contact e-mail address, and type of organisation. The MAV/SIAV and VLAA will undertake this task.

3. At the conclusion of training, the survey sheet in Appendix 2 will again be given to attendees to complete. In addition, they will be given the feedback form in Appendix 3 to complete which prompts participants to rate the quality of the training course in terms of its content and delivery. Both of these forms will be gathered from participants before they leave the training venue.

Note that the survey sheets in Appendix 2 and 3 will be trialled before being used. Where necessary, amendments will be made.

At least nine (9) summary statistics will be generated from the survey data and used to evaluate the overall success of the training event:

1. The number of people who expressed interest in attending the event (as a general measure of community engagement).
2. The number of people who attended (as a measure of interest and the successful organisation of the event itself).
3. The percentage of attendees who correctly answered more questions after the training than before.

4. The percentage of attendees who correctly answered fewer questions after the training than before.
5. The average increase in the number of correctly answered questions after the training compared to before.
6. The participants' rating of the course content (using a 1 – 5 rating system).
7. The participants' rating of the relevance of the course content (using a 1 – 5 rating system).
8. The participants' rating of the trainers' collective ability to communicate key messages (using a 1 – 5 rating system).
9. The participants' overall rating of the value of the course to them (using a 1 – 5 rating system).

Basic statistical analyses will be undertaken to determine if these differences are statistically valid. Statistical expertise will be utilised at this point.

Determine who will do the monitoring and evaluation

Monitoring immediately before and after the training will be undertaken by the CRC for Catchment Hydrology (André Taylor) in cooperation with the facilitators of the training session.

For statistical analysis of survey data, specialist expertise will be obtained from a suitable consultant or Monash University staff member (a minor task for this project).

Prepare a brief quality assurance/quality control (QA/QC) plan

Sources of possible error and management strategies are given in Table 1 below.

Table 1 – QA/QC Plan

Sources of Possible Errors	**Proposed Management Strategies**
Confusion over the questions and/or the scoring system on the survey sheets.	▪ Trial the sheets before finalising. ▪ Keep the survey sheets simple. ▪ Invite questions on the day.
Translation errors entering the data into a software package for analysis.	▪ Design the survey sheets to make entering the data into MS Excel easy to do (and less likely to involve errors). ▪ Enter data into MS Excel in such a way that individual responses can be randomly checked after data entry to check the accuracy of translation.
Poor statistical analysis.	▪ Obtain expert advice.
Poor survey sheet response rate.	▪ Keep the survey short and simple. ▪ Incorporate the survey sheet into the training program. ▪ Explain why an emphasis is being placed on the evaluation.

In terms of data management, data from paper-based survey sheets will be entered into an MS Excel spreadsheet. Individual responses will be able to be tracked. At the completion of this process, several responses will be selected at random, and their entries in the spreadsheet checked for accuracy.

Note that *only* data from knowledge survey sheets that enable paired assessment will be analysed (i.e. information from participants that have completed a pre- and post-training survey sheet, and have used the same name/unique identifier on each sheet).

The data will be briefly reviewed for obvious errors and for entries that may be a result of misunderstanding the scoring system (e.g. someone may have mistakenly reversed the scoring system). Where there is doubt over the quality of the data, the participant will be contacted and their entries checked or the data will be removed from the data set. Where this occurs, notes will be made on the spreadsheet.

A file has been created to store all data (paper-based and electronic) and reports from this project. At the completion of the project, copies of the final report will be held by the CRC, the MAV/SIAV and VLAA.

Estimate the resources required to implement the monitoring and evaluation plan

The major resource required for this project is staff time by the CRC. Some assistance will be needed from MAV/SIAV and VLAA staff (i.e. the people facilitating the training program) and potentially, a statistical expert.

The survey sheets will be designed to keep the time commitment for training participants below five minutes per survey.

Undertake a reality check of the plan

Overall, the Plan is considered to be relatively simple and practical, albeit a step above what most trainers and trainees are used to. The only element of risk to the successful execution of the Plan concerns the surveying of participants two times in the same day. Keeping the survey sheets short and simple should minimise this risk.

APPENDIX 1

A Seven Step Evaluation Framework for Non-structural Best Management Practices for Stormwater Quality Improvement (Taylor and Wong, 2002)[5]

[5] Not included in this example plan (see Table 4.1 in the main guideline for equivalent information).

APPENDIX 2

Survey of Knowledge/Awareness Levels

PRE- AND POST-FORUM AWARENESS SURVEY

"Doing it Right On Site"

5 March 2003

Participant's name (or unique identifier): . . . .

For each question, please circle the answer you believe to be correct:

1. What causes the biggest impact on streams from urbanisation?
   a) Changed weather patterns.
   b) Changes in the amount of impervious area.
   c) Changed vegetation.
   d) Don't know/not sure.

2. Which two features are hallmarks of successful Erosion and Sediment Control (ESC) Programs in Australia and overseas?
   a) Multi-faceted programs with a stable funding base.
   b) Multi-faceted programs with a strong, sustained enforcement element.
   c) Multi-faceted programs with a strong educational campaign.
   d) Multi-faceted programs with frequent 'blitzes' in enforcement.
   e) Don't know/not sure.

3. In terms of the percentage of sites that are complying with erosion and sediment control requirements, what percentage is a reasonable target for a best practice ESC Program that runs over 10 years:
   a) 50%.
   b) 75%.
   c) 90%.
   d) 100%.
   e) Don't know/not sure.

4. Controlling runoff and producing a clean site is best achieved on-site through:
   a) Physical measures (e.g. sediment fences).
   b) Education of employees and contractors.
   c) A combination of a) and b).
   d) Don't know/not sure.

5. When Polystyrene Foam Pods are used in Concrete Slabs, who is responsible to ensure they do not contaminate stormwater and waterways?
   a) Pod Supplier.
   b) Concrete contractor.
   c) Builder.
   d) Local Council.
   e) a), b) and c).
   f) Don't know/not sure.

Please turn the page over. . .

1 of 2

6. Changing building site practices to protect stormwater quality is best accomplished using:
   a) Information only.
   b) Enforcement only.
   c) Information and enforcement.
   d) Don't know/not sure.

7. Currently in Victoria the best method to enforce improved building site practices involves using:
   a) A local law.
   b) State legislation.
   c) A combination of a) and b).
   d) Don't know/not sure.

8. Where is the best place to gain ready access to a new CD ROM containing a wide variety of information on managing building sites to protect stormwater?
   a) The Municipal Association of Victoria or Victorian Litter Action Alliance.
   b) Victorian EPA.
   c) Melbourne Water.
   d) The Housing Industry Association.
   e) Don't know/not sure.

THAND YOU FOR YOUR PARTICIPATION

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APPENDIX 3

Feedback Form on the Quality of Training

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

VICTORIAN LITTER ACTION ALLIANCE · MUNICIPAL ASSOCIATION OF VICTORIA · Stormwater Industry Association of Victoria

POST-FORUM FEEDBACK SHEET

"Doing it Right On Site"

5 March 2003

Participant's name (optional): . . . .

The Forum's Content and Materials

- A. How would you rate the quality of the information provided today?

  ❒ Poor ❒ Below Average ❒ Average ❒ Good ❒ Excellent

- B. How would you rate the relevance of the information provided?

  ❒ No relevance ❒ Little relevance ❒ Some relevance ❒ Moderately relevant ❒ Highly relevant

Delivery of Information

- C. How would you rate the presenters collective success at communicating key messages?

  ❒ Poor ❒ Below Average ❒ Average ❒ Good ❒ Excellent

Strengths of the Forum (optional)

<u>Please nominate what you think were the best thing(s) about the forum:</u>

. . . .
. . . .
. . . .
. . . .

Areas for Improvement (optional)

<u>Please suggest ways in which similar events can be improved in future:</u>

. . . .
. . . .
. . . .
. . . .

Over-all Assessment

- D. How you would rate the over-all value of the forum to you?

  ❒ Poor ❒ Below Average ❒ Average ❒ Good ❒ Excellent

1 of 2

Please turn the page over. . .

Building Skills to Better Manage Stormwater Pollution in Victoria (optional)

Which areas of 'stormwater management' do you see as a priority for building capacity?:

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

In what ways could the 'Stormwater Capacity Building Project' help in this area (e.g. specific training needs, new educational products, demonstration projects)?:

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

For more information on the 'Stormwater Capacity Building Project', please contact Jacquie White on ph. 9667 5523

THANK YOU FOR YOUR FEEDBACK

2 of 2

APPENDIX 4

Example of a Training Attendance Sheet

ATTENDANCE RECORD

"Doing it Right On Site"

5 March 2003

Name	Organisation	Phone No.	e-mail

Appendix C

Example of a simple 'Monitoring and Evaluation Report'

(A report used for a stormwater-related training event titled "Doing it Right On-site' in Sunbury, Victoria, 2003)

Monitoring and Evaluation Report

Monitoring and Evaluating a Stormwater Quality-related Training Program

"Doing it Right On-site – Managing Building and Construction Sites for Stormwater Protection"

Example Version

2003

Prepared by: André Taylor, Cooperative Research Centre for Catchment Hydrology

Contents

APPENDICES

1. Monitoring and Evaluation Plan[1]
2. Data Recording Sheet for the Evaluation Exercise

[1] Not included in this example report (see Appendix B of the main guideline for equivalent information).

1. Executive Summary

This report presents the results of a simple monitoring exercise that was used to evaluate the performance of a stormwater quality-related training program in Victoria.

The training event was a series of short seminars held on 5 March 2003 titled "Doing it Right On Site – Managing Building and Construction Sites for Stormwater Protection". The event primarily aimed to increase the knowledge of stormwater managers on matters concerning the improved management of stormwater quality on building/construction sites.

The monitoring and evaluation process was used to trial draft guidelines that were developed by the Cooperative Research Centre for Catchment Hydrology (the CRC) for monitoring and evaluating non-structural stormwater quality best management practices. These practices include educational programs.

The evaluation by the CRC found that the training met its primary objectives and was highly successful in terms of delivering an event that:

- attracted a relatively large number of attendees;
- met the expectations of attendees in terms of the quality of training material, the relevance of material, the effectiveness of communication and over-all value; and
- increased the knowledge of participants in terms of key principles of best practice stormwater management on building/construction sites.

2. Background and Objectives

This report presents the results of a simple monitoring exercise that was implemented to:

- evaluate the performance a stormwater quality-related training program in Victoria[2] in terms of delivery of a high quality event and successful communication of key messages; and
- trial draft guidelines that were developed by the CRC for monitoring and evaluating non-structural stormwater quality best management practices (e.g. training, enforcement campaigns, town planning controls).

The draft CRC guidelines (Taylor and Wong, 2002) were used to plan, execute and report on the monitoring and evaluation exercise. Experience gained through this trial, along with two others currently underway in Melbourne, will be used to refine the guidelines before they are published.

The Victorian Stormwater Action Program (VSAP) has funded a comprehensive stormwater related Capacity Building Program in Victoria. This program is being managed by the Municipal Association of Victoria (MAV) and the Stormwater Industry Association of Victoria (SIAV). One of the elements of the Capacity Building Program was a training event titled "Doing it Right On Site – Managing Building and Construction Sites for Stormwater Protection", which was delivered from 10am to 3:00pm on 5 March 2003 in Sunbury, Victoria. This training event was jointly planned and delivered by the Victorian Litter Action Alliance (VLAA).

[2] Advertised as a "Forum".

The primary objective of this training was to educate key stakeholders on how they can better manage building/construction sites to protect urban stormwater quality. Information and key messages were communicated by several speakers, and a new resource kit was launched.

To determine the effectiveness of the training event, three (3) specific objectives have been evaluated. These were to determine:

1. Whether the training program was fully implemented as planned.
2. The quality of the training program (in terms of its content *and* delivery) from the perspective of participants.
3. Whether the stormwater quality-related awareness/knowledge of participants immediately increased as a result of the training.

In the CRC's draft working document titled "Non-structural Stormwater Quality Best Management Practices [BMPs] – Guidelines for Monitoring and Evaluation (Taylor and Wong, 2002)", seven (7) styles of evaluation are presented. These styles reflect different ways of monitoring and evaluating BMPs to suit the nature of the BMP, the monitoring objectives and the resources available to stormwater managers[3]. The trial involving the "Doing it Right On Site" training event only involved styles #1 and #2 (i.e. evaluation of 'BMP implementation' and 'changes in people's knowledge/awareness').

While this approach to evaluation is relatively straight-forward compared to other styles, it has been clearly documented in a Monitoring and Evaluation Plan (see Appendix 1) and in this evaluation report to assist with the trial process and to provide a simple example to others.

3. Monitoring Methods

The approach to monitoring is fully outlined in the Monitoring and Evaluation Plan (Appendix 1), which includes the monitoring instruments (e.g. the 'Feedback Sheet' and the 'Awareness Survey'). In summary, the monitoring involved:

- Using only two (2) styles of evaluation from the seven (7) styles outlined in the draft CRC guidelines, these being to determine whether the BMP had been implemented as planned and whether the training had increased the participants' level of knowledge/awareness.

- Using four (4) key monitoring parameters to evaluate the success of the training:
  - whether or not the training event took place as planned;
  - the numbers of participants at the training event and the number who expressed interest in attending the event but could not be accommodated;
  - a set of 1 - 5 ratings to reflect the quality of the content *and* delivery of the training program (with rating scores being provided by the participants); and
  - awareness/knowledge of key stormwater quality messages communicated via the training.

[3] For a brief explanation of these styles, refer to Appendix A in the Monitoring and Evaluation Plan (Appendix 1), or the draft guidelines (Taylor and Wong, 2002).

Using the following monitoring tools:

- Attendance records and 'head counts' on the day to check the approximate numbers of attendees.
- Records held by MAV/SIAV and VLAA on the number of people who expressed interest in the training.
- A 'Feedback Sheet' (using sets of 1 - 5 ratings) to determine the participants' views on the quality of the information provided, the relevance of the material provided, the effectiveness of presenters in communicating key messages, and the overall value of the forum.
- A pre- and post-training 'Awareness Survey' that included eight (8) multiple choice questions that were formulated to determine whether the key messages communicated by the presenters had been understood. The questions were formulated in consultation with the main presenters and were deliberately challenging.

- Using a basic quality assurance/quality control (QA/QC) plan to identify sources of possible error and develop strategies to minimise the risks of such errors.

- Using a basic data management plan to handle and store the monitoring data, as well as to quickly check for obvious errors in the data.

- Using statistical expertise within the CRC to help analyse the data.

- Balancing the ideal monitoring approach with practical considerations. For example, ideally, the CRC would have liked to do a follow-up knowledge survey of participants within three (3) to six (6) months after the training to see how the awareness levels changed with time. However, given the time available to the CRC to complete the trial process and finalise the Monitoring and Evaluation Guidelines, this was not feasible.

Note that the development and execution of the Monitoring and Evaluation Plan, as well as data analysis and reporting was undertaken by the CRC. One of the invited speakers at the training forum was also responsible for the evaluation process. As none of the data used in this evaluation reflects *directly* on the performance of this speaker, it is suggested there is negligible potential for bias in the evaluation of data.

Note also that an internal Peer Review was undertaken on the Monitoring and Evaluation Plan and this report to ensure that the adopted methodology was sound and the interpretation of results was reasonable. This review was undertaken by Dr Tim Fletcher, Program Leader, Urban Stormwater Quality Program.

4. Key Results

4.1. BMP Implementation

The forum was delivered as planned from 10am to 3pm on 5 March 2003.

One hundred and sixty one (161) people indicated they would attend. Actual attendance was estimated at approximately 150-160. Official records indicate attendance included four (4) staff, seven

(7) speakers, 10 trade display personnel and 122 registered participants. However, many attendees failed to officially register on arrival.

In addition, as expressions of interest to attend the event exceeded the places available, 22 people registered for a future repeat of the training event. Accordingly an estimate of the total number of people who expressed interest in attending the training is approximately 170-180.

One hundred and two (102) people completed a 'Feedback Sheet' at the completion of the event (see the Monitoring and Evaluation Plan in Appendix 1 for a copy of the sheet). Four key questions were asked to gauge the attendees' degree of satisfaction with the event. These questions and results are given in Figures 1 to 4.

In addition, qualitative information was gathered from participants to improve future training events via the following two questions on the 'Feedback Sheet':

- "Which areas of 'stormwater management' do you see as a priority for building capacity?"
- "In what ways could the 'Stormwater Capacity Building Project' help in this area (e.g. specific training needs, new educational products, demonstration projects)?"

This data is not presented here, but was forwarded to the Project Manager of the MAV/SIAV Stormwater Capacity Building Program for assessment.

Figure 1. Attendees' Perception of the Quality of the Forum's Content and Materials

Qu: "How would you rate the quality of the information provided today?"

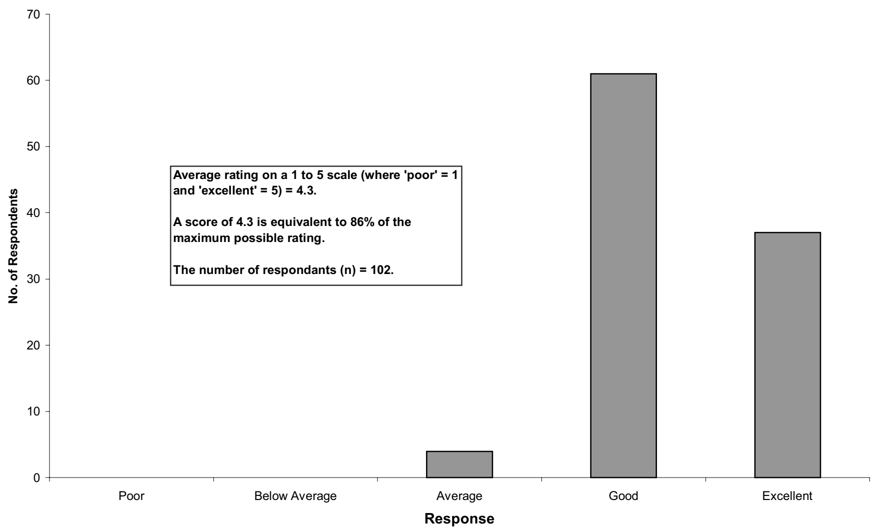


Figure 2. Attendees' Perception of the Quality of the Forum's Content and Materials

Qu: "How would you rate the relevance of the information provided?"

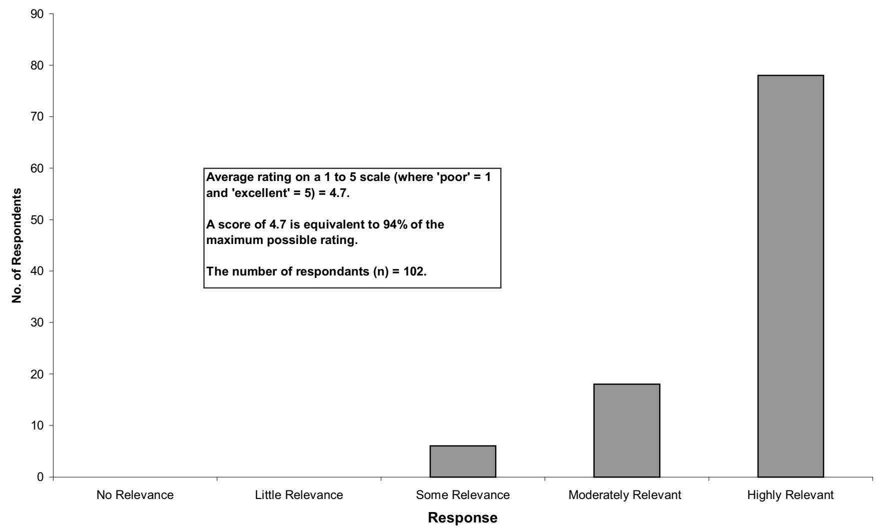


Figure 3. Attendees' Perception of the Quality of Communication

Qu: "How would you rate the presenters collective success at communicating key messages?"

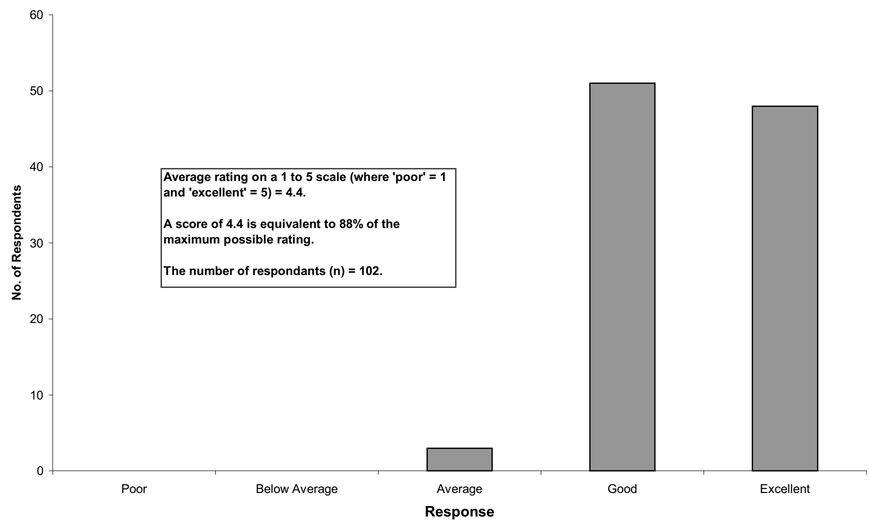
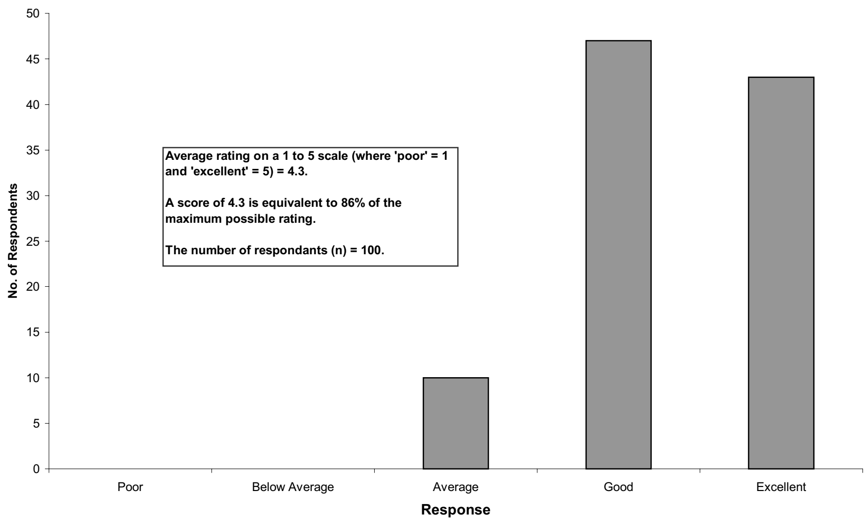


Figure 4. Attendees' Perception of the Overall Quality of the Forum

Qu: "How you would rate the over-all value of the forum to you?"



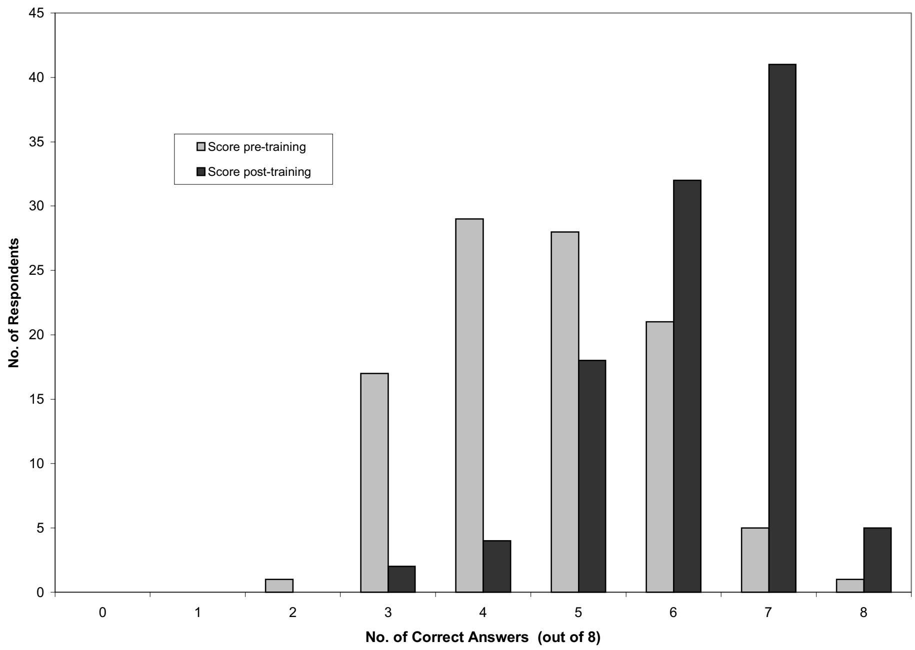
4.2. Changes in People's Knowledge/Awareness

One hundred and two (102) attendees completed a multiple choice questionnaire ('Knowledge Survey') immediately before and after the forum. The results are given in Table 1 and Figure 5.

Table 1. Results of the Pre- and Post-training Knowledge Survey

Summary Statistic	Result
Average score (out of 8) for the pre-training questionnaire	4.7 (n = 102)
Average score (out of 8) for the post-training questionnaire	6.2 (n =102)
Average level of improvement expressed as the number of questions correctly answered	1.5
Average level of improvement expressed as a percentage	18.8%
Percentage of people whose score improved following training	73.5%
Percentage of people whose score did not change following training	17.7%
Percentage of people whose score decreased following training	8.8%

Figure 5. Results of a Multiple Choice Knowledge Survey Before and After the Training



5. Data Analysis

In terms of attendance results, the data quality is poor, given the official attendance sheet did not record all those that were present. The estimate of numbers (150 - 160) is based upon the number of chairs that were occupied during the event. The approximate error range would be ± 10.

Basic data analysis for the 'Feedback Sheet' results is provided in the text boxes within Figures 1 to 4. These boxes include average scores (out of 5 and expressed as a percentage) for each of the four questions that tested the participants' perception of the quality of the information provided, the relevance of material, the success at communicating key messages and the course's over-all value to them.

In terms of the 'Knowledge Survey', summary statistics are given in Table 1. A statistical test was also undertaken to determine whether one can say with a high degree of confidence that the trainees who completed the assessment had improved their knowledge of key messages following the training.

The pre- and post-training scores from the 'Knowledge Survey' were found to be non-normally distributed, so a non-parametric approach was taken to the statistics. A 'Wilcoxon Matched Pairs Test' was undertaken. The conclusion of this test was the before and after results were found to be highly significantly different, with a p-value of <0.001 (Fletcher, personal communication, 2003). The analysis was undertaken using the Statistica software (Statsoft, 1999).

One source of potential bias is that approximately 70% of attendees completed the 'Knowledge Survey' rather than all trainees. People who struggled to understand key messages may have been reluctant to complete the sheets resulting in a bias towards more positive results. The potential for this bias is considered to be minor however, as participants were encouraged to use an alias if they wished to remain anonymous during the knowledge survey.

6. Conclusions

Conclusions are provided below for each of the evaluation's three primary objectives as outlined in Chapter 2 and the Monitoring and Evaluation Plan (Appendix 1):

1. Determine whether the training program was fully implemented as planned

The training event was highly successful. The delivery of the event went smoothly, approximately 170-180 expressed an interest in attending and approximately 150-160 attended. This level of interest exceeded the organiser's initial expectations.

2. Determine the quality of the training program (in terms of its content and delivery) from the perspective of participants

Feedback from participants indicated that the quality of training material and its delivery was good to excellent. On average, participants indicated that:

- the quality of information provided was "good" to "excellent";
- the content was "moderately relevant" to "highly relevant";
- the presenters' collective success at communicating key messages was "good" to "excellent"; and
- the over-all value of the forum was "good" to "excellent".

The data presented in Figure 1 to 4 indicates that although the feedback was very positive, there was still some room for improvement in the quality of information and communication.

3. Determine whether the stormwater quality-related awareness/knowledge of participants immediately increased as a result of the training

For the vast majority of participants who completed the 'Knowledge Survey' (73.5%) their knowledge concerning key messages communicated by the forum's speakers increased after training. On average, participants after the training increased their scores on the 'Knowledge Survey' by 18.8%.

The difference between the measured knowledge levels before and after training was found to be "highly significant" with a confidence level of 99.9% (p value < 0.001) using a Wilcoxon Matched Pairs test (Fletcher, personal communication).

In summary, the training met its primary objectives and was highly successful in terms of the delivery of an event that:

- attracted a relative large degree of interest and number of attendees;
- met the expectations of attendees in terms of the quality of training materials, its relevance, the effectiveness of communication and overall value; and
- increased the knowledge of participants in terms of key principles of best practice stormwater management on building/construction sites.

5. Recommendations

1. The MAV/SIAV Stormwater Capacity Building Program and Victorian Litter Action Alliance continue to plan and deliver events using the strategies that have worked for this event, while analysing qualitative feedback from participants on ways that future events could be improved.

2. The MAV/SIAV Stormwater Capacity Building Program and Victorian Litter Action Alliance ensure that exact numbers of participants be recorded in future training events to assist with assessment processes and follow-up exercises (if they are needed).

3. The MAV/SIAV Stormwater Capacity Building Program and Victorian Litter Action Alliance seek to continuously improve the quality of training information and communication at their training events (e.g. by selecting good communicators as presenters and editing training materials).

4. The MAV/SIAV Stormwater Capacity Building Program and Victorian Litter Action Alliance communicate the success of the "Doing it Right On Site – Managing Building and Construction Sites for Stormwater Protection" training event to stakeholders (including funding bodies) via mechanisms such as the MAV/SIAV's 'Water Ways' newsletter.

5. The lessons learnt from planning and running this simple monitoring and evaluation exercise be incorporated into the CRC's draft monitoring and evaluation guidelines for non-structural stormwater quality best management practices.

6. The Monitoring and Evaluation Plan (in Appendix 1) and this Monitoring and Evaluation Report be included as simple examples in the CRC's final monitoring and evaluation guidelines for non-structural stormwater quality best management practices.

7. This report (including the Data Recording Sheet provided in Appendix 2) be forwarded to the Victorian Environmental Protection Authority as the lead agent for urban stormwater quality management in Victoria, to potentially share the knowledge gained from this evaluation exercise.

APPENDIX 1

Monitoring and Evaluation Plan[4]

[4] Not included in this example report (see Appendix B of the main guideline for equivalent information).

APPENDIX 2

Data Recording Sheet for the Evaluation Exercise

(A form of summary reporting recommended in the draft CRC Monitoring and Evaluation Guidelines for Non-structural Stormwater Quality Best Management Practices)

Data Recording Sheet for Evaluation of 'BMP Implementation' (Evaluation Style No. 1) and 'Changes in Awareness/Knowledge' (Evaluation Style No. 2)

HEADING ***(from the draft CRC Monitoring and Evaluation Guidelines – Taylor and Wong, 2002)***	**RECORDED DATA** ***(for the "Doing It Right On Site – Managing Building and Construction Sites for Stormwater Protection" training event)***
BMP INFORMATION	
Name of the BMP being monitored: (e.g. the Stirling City Council's 'Stormwater Awareness Campaign 2002')	"Doing it Right On Site – Managing Building and Construction Sites for Stormwater Protection" (a stormwater-related training event).
Type and nature of the BMP: (i.e. include the key elements of the BMP, such as the strategies used in the educational program, the target audience and target pollutants)	▪ A training event that ran for most of one day, and involved several speakers. The event was a series of short, informative seminars with opportunities for questions. ▪ The target audience was government agencies responsible for managing stormwater quality from building sites and the building industry (note however that 89% of the participants were government representatives). ▪ The target pollutants are sediment, litter, paint, alkaline wastes, and acidic wastes from building sites. Ideally the enhanced knowledge from the training will lead to improved on-site practices and reduced stormwater pollution.
Date(s) of BMP implementation: (i.e. start and finish dates, where relevant)	5 March 2003.
Life span of the BMP: (i.e. the time over which the BMP is expected to operate)	Unknown. It is hoped that some of the knowledge gained through the training will be permanently retained and used by participants. It is likely however that refresher courses (with some new information) will be needed every 1-2 years.
TEST SITE INFORMATION	
Location of BMP implementation:	The training was held in Sunbury, 30 minutes drive north west of the Melbourne CBD. The bulk of the attendees where from the greater Melbourne area.
Agency implementing the BMP **Name:**	The forum was jointly organised by: ▪ the Municipal Association of Victoria (MAV) and the Stormwater Industry of Victoria (SIAV), via the Stormwater Capacity Building Project; and ▪ the Victorian Litter Action Alliance (VLAA).
Type of agency:	Government.
Address:	GPO Box 4326PP, Melbourne, Victoria, 3000 (MAV's postal address)
CATCHMENT INFORMATION	
Catchment name:	Various. The trainees primarily came from the greater Melbourne area.
Receiving waters:	Various. Port Phillip Bay is the most significant waterway that would potentially benefit from the training in the long term.
Area over which the BMP operates: (i.e. the *potential* area of influence of the BMP in ha, km^2 or m^2)	Primarily the greater Melbourne area (approximately 8,300 km^2).
Population over which the BMP operates (if applicable): (e.g. the approximate number of people who live in the area potentially influenced by the BMP)	Primarily the greater Melbourne area (approximately 3.5 million).
Specific details of the number of participants and area of managed land (if applicable): (e.g. an annual city-wide lawn/garden care program may train 300 people and result in 30 ha of managed lawn/garden over the entire city)	Approximately 150-160 people ($\pm$10) were trained. No information is available on the average annual area of building/construction sites in the greater Melbourne area at this time.
MONITORING INFORMATION	
Objectives being evaluated:	1. To determine whether the training program was fully implemented as planned. 2. To determine the quality of the training program (in terms of its content and delivery) from the perspective of participants. 3. To determine whether the stormwater quality-related awareness/knowledge of participants immediately increased as a result of the training.

Continued . . .

HEADING *(from the draft CRC Monitoring and Evaluation Guidelines – Taylor and Wong, 2002)*	RECORDED DATA *(for the "Doing It Right On Site – Managing Building and Construction Sites for Stormwater Protection" training event)*
Type of evaluation (only relevant to evaluation style No. 1): (e.g. 'desk top' review or independent audit/survey)	Independent survey. The CRC for Catchment Hydrology evaluated the success of the training and was present at the event on 5 March 2003.
Monitoring parameters: (i.e. what is being monitored/measured)	▪ Whether or not the training event took place as planned. ▪ The numbers of participants at the training event and the number who expressed interest in attending the event but could not be accommodated. ▪ A set of 1 - 5 ratings in terms of the quality of the content *and* delivery of the training program (with the ratings to be scored by participants). ▪ Awareness/knowledge of key stormwater quality messages communicated via the training.
Sampling design: (e.g. how a sample was selected for the survey – see Phase II, Step 2 of the monitoring and evaluation protocol)	▪ All trainees were asked to participate in two assessment processes (a Feedback Sheet and a pre- and post-training Knowledge Survey). One hundred and two (102) attendees participated in these assessment processes.
Monitoring frequency and timeframe: (e.g. immediately before, immediately after, and 6 months after the implementation of the BMP)	▪ Data on expressions of interest and attendance was collected before and during the training. ▪ The data from the Feedback Sheet was collected after the training. ▪ The data from the Knowledge Survey was collected immediately before and after the training.
Monitoring location(s):	The Goona Warra Vineyard training venue, Sunbury Road, Sunbury, Victoria.
Monitoring method: (e.g. phone survey, face-to-face interviews, mail-out survey)	Primarily four (4) survey tools: a Feedback Sheet, pre- and post-training Knowledge Survey sheets, and attendance records.
Who did the monitoring and evaluation: (include a comment regarding their degree of independence)	The Cooperative Research Centre for Catchment Hydrology. One of the speakers was from the CRC and also managed the monitoring and evaluation. However, none of the evaluation results reflected on the individual performance of this speaker, so that there is little risk of bias in the analysis of data and the drawing of conclusions.
EVALUATION RESULTS	
Key findings: (include quantitative information where available, such as the change in the % of respondents who had certain knowledge, attitudes or self-reported behaviours)	**BMP Implementation (evaluation style #1):** There was a high level of interest (~170-180 people) and attendance (~150-160). The event was delivered as planned. On average, participants indicated via the Feedback Sheet that: ▪ the quality of information provided was "good" to "excellent" (ave = 4.3 of 5); ▪ the content was "moderately relevant" to "highly relevant" (ave = 4.7 of 5), ▪ the presenters' collective success at communicating key messages was "good" to "excellent" (ave = 4.4 of 5); and ▪ the overall value of the forum was "good" to "excellent" (ave = 4.3 of 5). **Changes in Knowledge/Awareness (evaluation style #2):** ▪ Average score (out of 8) for the pre-training questionnaire = 4.7 (n = 102). ▪ Average score (out of 8) for the post-training questionnaire = 6.2 (n =102). ▪ Average level of improvement (expressed as the number of questions correctly answered) = 1.5 or 18.8%. ▪ Percentage of people whose score improved following training = 73.5%. ▪ Percentage of people whose score did not change following training = 17.7%. ▪ Percentage of people whose score decreased following training = 8.8%.
Caveats, assumptions and areas of uncertainty: (e.g. where relevant, include a brief comment on the reliability of self-reported data concerning behaviour)	▪ Only the attendance data is of low quality as it is only an estimate (the error range is estimated as $\pm$ 10). Unfortunately not all attendees registered on the day. ▪ The change in measured knowledge levels pre- and post-training was found to be "highly significant" with a confidence level of 99.9% (p value < 0.001) using a Wilcoxon Matched Pairs test (Fletcher, personal communication, 2003).
Overall assessment of BMP 'value' (1 – 5): (where: ▪ '0' = detrimental impact; ▪ '1' = no positive or detrimental impact; ▪ '2' = fair [achieved <1/2 of the objectives/expectations]; ▪ '3' = average [achieved 1/2 of the objectives/expectations]; ▪ '4' = good [achieved >1/2 of the objectives/expectations]; and ▪ '5' = excellent [achieved all of the objectives/expectations])	The trainees who completed the Feedback Sheet rated the "over-all value of the forum" to them as 4.3 (out of 5). Other performance data generally supports this assessment (i.e. "good" to "excellent").

Continued . . .

HEADING *(from the draft CRC Monitoring and Evaluation Guidelines – Taylor and Wong, 2002)*	**RECORDED DATA** *(for the "Doing It Right On Site – Managing Building and Construction Sites for Stormwater Protection" training event)*
COST INFORMATION (include the cost of staff time and overheads, where appropriate)	
Cost to *develop* the BMP or combination of BMPs ($):	Approximately $22,025 (raw cost estimates from White, personal communication, 2003).
Cost to *implement* the BMP ($): (over the implementation period, or annually if implementation is on-going)	Approximately $15,650 (raw cost estimates from White, personal communication, 2003).
Estimated *total life-cycle cost* of the BMP ($): (e.g. use the simplistic approximation that life cycle cost ≈ development cost + [annual cost x life span in years])	Approximately $37,675. It is suggested that the life-cycle of the training would be approximately 1 year after which another training course would be needed to refresh and update people's knowledge of the key messages.
Estimated total cost to *monitor and evaluate* the BMP ($):	Approximately $5,100. This cost would be unusually high given it is a trial project and all stages have been carefully documented to use as a worked example. Say 2 weeks time by a CRC Researcher at $29 per hour plus 100% on-costs ≈ $4,600 (approx). In addition, the MAV/SIAV and VLAA assisted in the collation of some data - say 1 day at $29 per hour plus 100% on-costs ≈ $500 (approx).
ADMINISTRATIVE INFORMATION	
Contact person for the evaluation:	
Name:	André Taylor
Organisation:	Cooperative Research Centre for Catchment Hydrology
Contact details (ph and e-mail):	ph. 0438182709 e-mail: andretaylor@iprimus.com.au
Date of data entry:	8 April 2003.
COMMENTS: (e.g. reasons for the project's success or failure)	▪ Overall the project was very successful at achieving its objectives. Keys to success included professional project management, good advertising, choice of a good venue, low (no) cost, selection of speakers and topics, provision of good information (e.g. a new CD rom resource kit) and responding to a definite training need. ▪ The evaluation only focused on the quality of BMP implementation and whether knowledge/awareness levels had changed as a result of the BMP. No assessment was done on whether the training led to positive behavioural change, improvement in stormwater quality and/or improvement in waterway health.

Appendix D

Tables 4.2 and 4.3

Table 4.2 Five Examples of How the Evaluation Framework for Non-structural BMPs Can Be Applied.

The monitoring and evaluation options below give an indication of how different 'styles' of evaluation may be applied to different types of BMPs. The options in *italics* represent the more feasible evaluation options for the given examples.

Style of Evaluation	**Types of Non-structural BMP and Some Examples**				
	Town Planning Controls	**Strategic Planning & Institutional Controls**	**Pollution Prevention Procedures**	**Education And Participation Programs**	**Regulatory Controls**
	Example A - A New Water Sensitive Urban Design Policy in a City-Wide Local Planning Scheme	**Example B - A New City-Wide Urban Stormwater Management Plan**	**Example C - An Improved Maintenance Procedure for Structural BMPs**	**Example D - A Multi-Dimensional Media Campaign**	**Example E - A Local Law for Improved Erosion and Sediment Control On Building Sites**
1. BMP implementation	*Audit the percentage of development applications that satisfactorily apply the new policy. A baseline and annual audits could be undertaken.*	*Undertake a 'desk top audit' of all actions in the Urban Stormwater Management Plan. A baseline audit could be undertaken (as some actions would already be in place), as well as annual audits thereafter. Data could be collected on the status of all actions and whether budgets have been spent.*	*Undertake a 'desk top audit' to check whether the improved procedure is in place and associated funds are being spent.*	*Undertake a 'desk top audit' to check whether the elements of the media campaign were delivered as planned (e.g. check whether advertisements were placed at the right location and at the right time).*	*Undertake a 'desk top audit' to check whether the new local law has been implemented. Annual audits could collect data on the number of:* ▪ *sites inspected;* ▪ *warnings issued;* ▪ *fines issued; and* ▪ *fines successfully challenged.*
2. Changes in people's awareness and/or knowledge	Randomly survey local developers and their consultants before and after the application of the policy. The survey would determine levels of awareness and knowledge with respect to: ▪ water sensitive urban design; and ▪ the Local Authority's requirements for water sensitive urban design in new developments.	Conduct a baseline and annual surveys of those people responsible for the implementation of the plan's actions. Measure their level of awareness and knowledge with respect to: ▪ stormwater quality management in general; ▪ the existence, and aims of the plan; and ▪ their responsibilities in the plan.	Conduct a baseline and annual surveys of those people responsible for the implementation of new procedure. Measure their level of awareness and knowledge with respect to: ▪ stormwater quality management in general; ▪ the existence, and aims of the procedure; and ▪ their responsibilities in the procedure.	*Conduct a pre- and one or two post-campaign phone surveys of the target audience to:* ▪ *measure changes in their awareness and knowledge; and* ▪ *help design the campaign (i.e. the baseline survey can help to identify gaps in knowledge, specific attitudes to address, segments of the community to target, media that is most likely to be effective, etc.).*	*Survey a random sample of builders (and sub-contractors) as part of annual erosion and sediment control audits of building sites (which include a baseline audit). Gather information on the builders' level of awareness and knowledge with respect to:* ▪ *why erosion and sediment control is needed;* ▪ *the law; and* ▪ *how they can comply with the law.* *(Information could also be gathered to help improve the design of associated educational BMPs.)*
3. Changes in people's attitude (self-reported)	Using the same survey instrument as above, measure the attitude of developers and their consultants towards: ▪ the need for water sensitive urban design; ▪ applying water sensitive urban design principles; and ▪ complying with the Local Authority's requirements for water sensitive urban design in new developments.	Using the same survey instrument as above, measure the attitude of those people responsible for the implementation of the plan's actions towards: ▪ the management of stormwater quality in general; ▪ the need for, and aims of, the plan; and ▪ exercising their responsibilities in the plan.	Using the same survey instrument as above, measure the attitude of those people responsible for the implementation of the procedure towards: ▪ the management of stormwater quality in general; ▪ the need for, and aims of the procedure; and ▪ exercising their responsibilities in the procedure.	Using the same survey instruments as above, measure the attitude of the target audience towards the behaviour being encouraged (e.g. the degree of importance the target audience places on adopting the behaviour).	Using the same survey instrument as above, measure the attitude of the builders (and sub-contractors) towards: ▪ the need for erosion and sediment controls; ▪ the need for the law; ▪ the need to comply with the law; and ▪ erosion and sediment control measures that have been promoted.

Style of Evaluation	Types of Non-structural BMP and Some Examples				
	Town Planning Controls	**Strategic Planning & Institutional Controls**	**Pollution Prevention Procedures**	**Education And Participation Programs**	**Regulatory Controls**
	Example A - A New Water Sensitive Urban Design Policy in a City-Wide Local Planning Scheme	**Example B - A New City-Wide Urban Stormwater Management Plan**	**Example C - An Improved Maintenance Procedure for Structural BMPs**	**Example D - A Multi-Dimensional Media Campaign**	**Example E - A Local Law for Improved Erosion and Sediment Control On Building Sites**
4. Changes in people's behaviour (self-reported)	Using the same survey instrument as above, measure the self-reported behaviour of developers and their consultants in terms of: ▪ the percentage of their developments that have complied with the new WSUD policy; and ▪ details of these developments (e.g. site area, % impervious area, adopted BMPs, area 'treated' by BMPs, the pollutant removal efficiency of BMPs, etc.).	For those actions in the plan that involve a change of behaviour (e.g. implementation of new procedures), survey those people responsible for the implementation of these actions via a baseline and annual surveys. The surveys would gather data on: ▪ whether behaviour has significantly changed as a result of the plan; and ▪ the nature of behavioural change (if relevant).	Using the same survey instrument as above, survey those people responsible for the implementation of the procedure via a baseline and annual surveys. The surveys would gather data on: ▪ whether people report that their behaviour has significantly changed as a result of the new procedure; and ▪ the nature of behavioural change.	Using the same survey instruments as above, gather data on: ▪ whether people report that their behaviour has significantly changed as a result of the media campaign; ▪ the nature of behavioural change; and ▪ how any change in behaviour is affected by time (if relevant).	Using the same survey instrument as above, survey builders (and sub-contractors) on: ▪ whether they have improved their erosion and sediment control activities as a result of the law; and ▪ the nature of this improvement (if any).
5. Changes in people's behaviour (actual)	*Before and after the implementation of the policy, randomly select newly completed developments, review their development applications and approvals and audit the sites. Collect site details as per style No. 4 above.*	*Undertake a baseline and annual audits of 'on-ground activities' where behavioural change should be occurring as a result of actions in the plan. Gather data on the nature of behavioural change via direct observation or measurement (e.g. the extent to which erosion and sediment controls are installed on major construction and maintenance projects).*	*Undertake a baseline and annual audits of on-ground activities where behavioural change should be occurring as a result of the new procedure. Gather data on the nature of behavioural change (e.g. the frequency of inspections and 'clean-outs' of structural BMPs).*	*Use observational approaches to directly measure behaviour before and after the campaign. For example:* ▪ *littering in public places can be directly measured through the 'Disposal Behaviour Index' or 'Clean Communities Assessment Tool' (see Curnow and Spehr, 2001 and Curnow et al., 2003); and* ▪ *relatively frequent and public forms of behaviour, like where people wash their car, can be directly measured by observational audits.* *OR* *Validate the self-reported results derived from using style No. 4 above, through site inspections involving a sub-set of the survey respondents (where feasible). These inspections aim to test whether self-reported behavioural change is an acceptable surrogate indicator of actual behavioural change.*	*As part of the annual erosion and sediment control audits of randomly selected sites, collect data on:* ▪ *the over-all performance of erosion and sediment controls (i.e. whether the sites meet the standards required by the new law);* ▪ *specific areas of good and poor performance (e.g. whether sediment fences are adequately maintained); and* ▪ *related data that could be needed to model the effects of improved erosion and sediment control on stormwater quality (e.g. the disturbed area, soil type, period of disturbance, slope, etc.).*

Style of Evaluation	Types of Non-structural BMP and Some Examples				
	Town Planning Controls	**Strategic Planning & Institutional Controls**	**Pollution Prevention Procedures**	**Education And Participation Programs**	**Regulatory Controls**
	Example A - A New Water Sensitive Urban Design Policy in a City-Wide Local Planning Scheme	**Example B - A New City-Wide Urban Stormwater Management Plan**	**Example C - An Improved Maintenance Procedure for Structural BMPs**	**Example D - A Multi-Dimensional Media Campaign**	**Example E - A Local Law for Improved Erosion and Sediment Control On Building Sites**
6. Changes in stormwater quality	*Using data collected from style No. 5 above and development assessment records, undertake a pollutant export modelling exercise to predict likely reductions in the average annual load of pollutants in the city's stormwater (e.g. for TSS, TN, TP and gross pollutants) that could be attributed to the introduction of the new policy. Three scenarios could be modelled:* ▪ *a base case (no new policy);* ▪ *the actual case (based on measured behavioural change); and* ▪ *the ideal case (based on full implementation of the policy).* OR Undertake a paired catchment study, where: ▪ stormwater quality is monitored by automatic samplers at gauged monitoring stations over several years; and ▪ monitoring occurs according to a 'BACI' experimental design.[a] OR Stormwater quality is monitored for several years before and after the implementation of the policy, and data is analysed to detect long-term trends.[a]	*Stormwater quality is monitored before and after the implementation of the plan, and data is analysed to detect long-term trends.[a]* OR Undertake a paired catchment study, where: ▪ stormwater quality is monitored by automatic samplers at gauged monitoring stations over several years; and ▪ monitoring occurs according to a 'BACI' experimental design.[a]	*Using data collected from style No. 5 above and data from structural BMP 'pollutant removal efficiency' monitoring, undertake a pollutant export modelling exercise to predict likely reductions in the average annual load of pollutants in the city's stormwater (e.g. TSS, TN, TP and gross pollutants) that can be attributed to the introduction of the new maintenance procedure. Three scenarios could be modelled:* ▪ *a base case (no new procedure);* ▪ *the actual case (based on measured behavioural change); and* ▪ *the ideal case (based on full implementation of the procedure).*	*Undertake experimental trials to convert data collected from style No. 5 (i.e. on actual behavioural change) into likely changes to stormwater quality. For example, known changes in the use of residential lawn fertiliser can be replicated in experimental trials, where rainfall is simulated and stormwater runoff quantity and quality can be monitored. The results could then be used in a pollutant export model (or in calculations) to estimate the cumulative improvement of stormwater quality over the geographic area that was affected by the media campaign.* OR Stormwater quality is monitored before and after the implementation of the media campaign, and data is analysed to detect long-term trends.[a, b] OR *Undertake a paired catchment study, where:* ▪ *stormwater quality is monitored by automatic samplers at gauged monitoring stations (or litter loads are captured by gross pollutant traps); and* ▪ *monitoring occurs according to a 'BACI' experimental design.[a, b]*	*Using data collected from style No. 5 above and data on the efficiency of erosion and sediment controls[c], undertake a pollutant export modelling exercises to predict likely reductions in the average annual load of sediment (TSS) in the city's stormwater that can be attributed to the introduction of the new law. Three scenarios could be modelled:* ▪ *a base case (no new law);* ▪ *the actual case (based on measured changes in erosion and sediment control performance); and* ▪ *the ideal case (based on full compliance with the law).*

Style of Evaluation	Types of Non-structural BMP and Some Examples				
	Town Planning Controls	**Strategic Planning & Institutional Controls**	**Pollution Prevention Procedures**	**Education And Participation Programs**	**Regulatory Controls**
	Example A - A New Water Sensitive Urban Design Policy in a City-Wide Local Planning Scheme	**Example B - A New City-Wide Urban Stormwater Management Plan**	**Example C - An Improved Maintenance Procedure for Structural BMPs**	**Example D - A Multi-Dimensional Media Campaign**	**Example E - A Local Law for Improved Erosion and Sediment Control On Building Sites**
7. **Changes in waterway health**	Undertake long-term waterway health monitoring (e.g. physico-chemical and ecological monitoring) for several years before and after the implementation of the policy to detect long-term trends.[a] OR Using stormwater quality data collected from style No. 6 above, undertake a receiving water modelling exercises to predict likely changes to water quality (and by inference, waterway health) due to the introduction of the new policy. OR Undertake a paired catchment study, where waterway health is monitored according to a 'BACI' experimental design.[a]	*Undertake long-term waterway health monitoring (e.g. physico-chemical and ecological monitoring) for several years before and after the implementation of the plan to detect long-term trends.*[a]	As per Example A.	As per Example A.	As per Example A.

Notes:

- See Table 4.1 for a summary of the typical advantages and disadvantages of each evaluation style.
- [a] Data would also need to be collected on the nature of all catchment activities that could significantly affect stormwater quality during the monitoring time-frame.
- [b] Major stormwater quality-related educational campaigns typically change focus and tactics on a frequent basis (e.g. annually), making a correlation between trends in long term stormwater (or receiving water) quality and the use of educational campaigns very difficult. This style of evaluation would be more applicable for educational campaigns that are very specific (e.g. those that target the residential use of a small group of pesticides and run relatively unchanged for several years, or focussed anti-litter education campaigns in small commercial districts).
- [c] Approximate pollutant removal efficiency data on specific types of erosion and sediment controls (e.g. sediment fences, sediment basins) is available in the literature (see Report No. 3 in this series).

Table 4.3 Non-structural BMP Evaluation Styles Recommended for Use by Local Government Authorities.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 BMP implementation	**2** Changes in people's awareness and/or knowledge	**3** Changes in people's attitude (self-reported)	**4** Changes in people's behaviour (self-reported)	**5** Changes in people's behaviour (actual)	**6** Changes in stormwater quality	**7** Changes in waterway health	
1. Planning and regulatory measures Requiring stormwater quality management to be addressed in development proposals/applications	Highly recommended (a)	Recommended for training elements of this BMP (e.g. training people on new development assessment requirements)	Of little value	Of little value	Highly recommended (b)	Recommended (c)	Not recommended	a) Simple (e.g. is the appropriate planning policy in place?). Should form the basis for more advanced styles of evaluation. b) Monitor the degree to which the BMP is improving the quality of development applications and what is actually built 'on the ground'. c) Changes in stormwater quality (i.e. reductions in pollutant loads) may be predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option.
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	Highly recommended	Recommended (a)	Recommended (a)	Of little value	Recommended for specific BMPs that are easy to audit 'on the ground'	Recommended (b)	Highly recommended (c)	a) Monitoring city-wide changes in awareness and attitudes can be valuable as a broad indicator of the collective success of educational BMPs. b) Recommended where there is an established stormwater quality monitoring network and substantial funds and expertise are available for evaluation. c) The collective impact of city-wide BMPs (structural and non-structural) could be monitored via this style (e.g. ecological health trend monitoring over a decade or longer).
3. Planning and regulatory measures Implementing stormwater quality improvement policy in town planning schemes	Highly recommended	Recommended for training elements of this BMP	Of little value	Of little value	Highly recommended	Recommended	Not recommended	See comments above for BMP No. 1.
4. Source control measures - construction and maintenance Stormwater quality addressed in a wide variety of maintenance operations (e.g. structural BMP, drain and road maintenance)	Highly recommended (a)	Of little value	Of little value	Recommended (b)	Highly recommended (c)	Recommended (d)	Not recommended	a) Monitor the existence of environmental management systems, procedures, training programs, etc. b) Recommended only for BMPs and implementation environments where self-reporting is likely to be a good surrogate indicator for actual behaviour. c) Monitor through audits of actual behaviour and outcomes of such behaviour. d) Changes in stormwater quality for specific BMPs (e.g. new maintenance procedures) may be measured through stormwater monitoring investigations and/or predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 BMP implementation	**2** Changes in people's awareness and/or knowledge	**3** Changes in people's attitude (self-reported)	**4** Changes in people's behaviour (self-reported)	**5** Changes in people's behaviour (actual)	**6** Changes in stormwater quality	**7** Changes in waterway health	
5. Source control measures - construction and maintenance Stormwater quality management addressed in construction activities *undertaken* by municipalities or State agencies	Highly recommended (e.g. to assess whether elements of an environmental management system are in place)	Recommended (a)	Recommended (a)	Of little value	Highly recommended (b)	Not recommended (c)	Not recommended	a) Awareness of staff regarding new procedures and their attitudes towards using such procedures can provide useful information on the likelihood of the BMP's success. b) Audits of on-site erosion and sediment control performance over time are highly recommended. c) Even though site-based stormwater quality monitoring is often done for large construction works (e.g. for discharges from sediment basins) to demonstrate compliance with 'best practice' water quality standards, it is difficult to compare these results to a meaningful baseline or control site (and thereby evaluate the value of the BMP).
6. Planning and regulatory measures Application of development approval/permit conditions	Highly recommended (a)	Recommended (i.e. to assess whether development assessment officers are aware of new conditions)	Not recommended	Of little value	Highly recommended (b)	Recommended (c)	Not recommended	a) Simple (i.e. are appropriate conditions available and being applied?). Should form the basis for more advanced styles of evaluation. b) Monitor the degree to which the BMP is improving 'on the ground' outcomes over time (e.g. the degree to which WSUD is being implemented via audits). c) Changes in stormwater quality (i.e. reductions in pollutant loads) on a site to city-wide scale could be predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option.
7. Source control measures - construction and maintenance Stormwater quality management addressed in construction activities *regulated* by municipalities or State agencies	Highly recommended (a)	Recommended (b)	Recommended (b)	Not recommended	Highly recommended (c)	Not recommended (d)	Not recommended	a) Simple (i.e. are appropriate education, regulation and enforcement strategies being applied?). Should form the basis for more advanced styles of evaluation. b) Erosion and sediment control (ESC) audits that measure 'on the ground' compliance can <u>also</u> gather valuable information from site personnel about whether educational messages are being understood, and whether attitudes towards compliance are changing. This information can help to refine the over-all ESC strategy. c) Regular ESC audits are highly recommended. d) See comments for BMP No. 5.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 **BMP implementation**	**2** **Changes in people's awareness and/or knowledge**	**3** **Changes in people's attitude (self-reported)**	**4** **Changes in people's behaviour (self-reported)**	**5** **Changes in people's behaviour (actual)**	**6** **Changes in stormwater quality**	**7** **Changes in waterway health**	
8. Source control measures – enforcement Enforcement of State and/or local laws for point and diffuse sources of stormwater pollution	Highly recommended (a)	Recommended (b)	Recommended (b)	Not recommended	Highly recommended (c)	Recommended (d)	Not recommended	a) Simple (i.e. is the enforcement effort occurring and is the quality of enforcement acceptable?). Should form the basis for more advanced styles of evaluation. b) Can provide valuable information on why people are complying or not complying (e.g. economic drivers, lack of awareness). c) Audits of 'on the ground' compliance are highly recommended. d) Changes in stormwater quality (i.e. reductions in pollutant loads) may be predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option and requires research information to convert a measured change in behaviour into a predicted change in stormwater pollutant load.
9. Source control measures – miscellaneous Initiatives to minimise sewer overflows and illicit discharges to stormwater	Highly recommended (a)	Of little value	Of little value	Not recommended	Highly recommended (b)	Recommended (c)	Highly recommended (d)	a) Monitor implementation of BMPs such as number of premises inspected/tested and number of illicit discharges found. b) Measure the number of illicit discharges (or overflows) that are removed and estimate pollutant loads from each discharge. c) Estimate reductions in total pollutant loads using information from evaluation style No. 5. d) Recommended where such pollution is thought to be a major determinant to the health of the region's waterways.
10. Source control measures - education programs Media campaigns (e.g. radio, television)	Recommended (e.g. checking that the elements of the campaign were delivered as planned)	Highly recommended (a)	Highly recommended (a)	Often of little value unless validated by measurements of actual behaviour (b)	Highly recommended (c)	Recommended (d)	Not recommended	a) Changes to awareness and attitudes can be easily evaluated (e.g. through pre- and post-BMP surveys). b) Extreme care is needed with this style of evaluation as its value is often dependent on the context. In *some* contexts (e.g. littering behaviour), self-reported behaviour has been shown to be a very poor indicator of real behaviour. c) In most contexts this form of evaluation for media campaigns is difficult (e.g. monitoring infrequent behaviour and/or behaviour where privacy must be respected), but where possible (e.g. through observational studies or audits) it generates highly valuable data. d) Changes in stormwater quality (i.e. reductions in pollutant loads) may be predicted using: the results of evaluation style No. 5 and pollutant export modelling (assuming a quantitative relationship between the behaviour and stormwater quality is known); or local stormwater quality monitoring (e.g. monitoring litter loads in stormwater using a paired catchment, BACI experimental design). This is an advanced evaluation option.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 **BMP implementation**	2 **Changes in people's awareness and/or knowledge**	3 **Changes in people's attitude (self-reported)**	4 **Changes in people's behaviour (self-reported)**	5 **Changes in people's behaviour (actual)**	6 **Changes in stormwater quality**	7 **Changes in waterway health**	
11. Source control measures - construction and maintenance Stormwater quality addressed in the *planning* of government-managed construction and maintenance works	Highly recommended (a)	Recommended (b)	Recommended (b)	Of little value	Highly recommended (c)	Not recommended	Not recommended	a) Simple (e.g. checking whether 'best practice' ESC management plans now prepared as part of the organisation's procedures). b) Awareness of staff regarding the need for the BMP and their attitudes towards implementation can provide useful information on the likelihood of the BMP's success. c) Audits of compliance are highly recommended (e.g. are adequate ESC management plans are in existence and fully implemented).
12. Source control measures – enforcement Point source regulation of stormwater discharges (e.g. licensing and inspecting/auditing industry)	Highly recommended (a)	Of little value	Of little value	Of little value unless results can be validated through observational studies and/or audits	Highly recommended (b)	Not recommended (c)	Not recommended	a) Monitor implementation of BMPs such as number of premises licensed and inspected/audited. b) Measure parameters such as the number of premises complying with stormwater-related conditions over time, the degree of compliance with various conditions, etc.
13. Source control measures - miscellaneous Stormwater quality management addressed in staff training for government and private sector staff	Highly recommended (a)	Highly recommended (b)	Recommended (b)	Often of little value (context dependent)	Highly recommended (c)	Not recommended	Not recommended	a) Monitor implementation of BMPs such as number of people trained and the quality of training (e.g. from feedback forms). b) Monitor changes to awareness and attitudes over time to see if training is making a difference. c) Monitor aspects of staff behaviour over time (e.g. use of development conditions, use of enforcement instruments, improved erosion and sediment control on work sites) to see if changes in awareness are leading to improved stormwater management.
14. Water sensitive urban design (WSUD) measures for new development WSUD applied to public open space networks (e.g. use of such space for stormwater treatment and infiltration, use of the 'cluster development' principle)	Recommended (a)	Of little value	Of little value	Of little value	Highly recommended (b)	Recommended (c)	Not recommended	a) Undertake desk-top audits to monitor whether town planning requirements are promoting/requiring this design philosophy in new developments. b) Monitor the degree to which the design philosophy is being implemented in newly built developments via regular audits of newly approved and constructed developments. c) Changes in stormwater quality (i.e. reductions in pollutant loads) can be predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 BMP implementation	**2** Changes in people's awareness and/or knowledge	**3** Changes in people's attitude (self-reported)	**4** Changes in people's behaviour (self-reported)	**5** Changes in people's behaviour (actual)	**6** Changes in stormwater quality	**7** Changes in waterway health	
15. Source control measures - education programs Community programs (e.g. the successful US 'Master Gardeners' program that promotes resource-sensitive garden management practices)	Highly recommended (a)	Recommended (b)	Recommended (b)	Usually of little value unless validated by measurement of actual behaviour (c)	Highly recommended (d)	Recommended (e)	Not recommended	a) Monitor aspects such as the number of people trained, the number of demonstration projects and the quality of the program (via feedback forms). A good basis for more advanced styles of evaluation. b) Changes to awareness and attitudes can be easily evaluated (e.g. through pre- and post-BMP surveys). c) Extreme care is needed with this style of evaluation as its value is context dependent. In *some* contexts (e.g. littering behaviour), self-reported behaviour has been shown to be a very poor indicator of real behaviour. d) In some contexts this form of evaluation can be difficult (e.g. where observation may invade a person's privacy), but where possible it generates highly valuable data. e) Changes in stormwater quality (i.e. reductions in pollutant loads) may be predicted using the results of evaluation style No. 5 and pollutant export modelling. This is an advanced evaluation option and relies upon research findings being available to convert behavioural changes into predicted changes in stormwater pollutant loads.
16. Source control measures - education programs School education programs	Highly recommended (a)	Recommended (b)	Recommended (b)	Usually of little value	Highly recommended (c)	Not recommended	Not recommended	a) Monitor aspects such as the number of students involved in the program and the quality of the program (via feedback forms). A good basis for more advanced styles of evaluation. b) Changes to awareness and attitudes can be easily evaluated (e.g. through pre- and post-BMP surveys). A control study group is recommended due the wide range of messages/programs being directed towards school children. c) In some contexts this form of evaluation can be difficult (e.g. where observation may invade a person's privacy), but where possible it generates highly valuable data (e.g. measurements of littering, binning and recycling behaviour).
17. Water sensitive urban design (WSUD) measures for new development WSUD applied to the layout of residential housing lots (e.g. the philosophy of disconnecting impervious services)	Recommended	Of little value	Of little value	Of little value	Highly recommended	Recommended	Not recommended	See comments for BMP No. 14.

Non-structural BMPs Deemed To Be of Most Value*	BMP Evaluation Style**							Comments
	1 BMP implementation	**2** Changes in people's awareness and/or knowledge	**3** Changes in people's attitude (self-reported)	**4** Changes in people's behaviour (self-reported)	**5** Changes in people's behaviour (actual)	**6** Changes in stormwater quality	**7** Changes in waterway health	
18. Source control measures - education programs Business programs (e.g. education and auditing programs aimed at unlicensed premises)	Highly recommended (a)	Recommended (b)	Recommended (b)	Usually of little value unless validated by measurement of actual behaviour	Highly recommended (c)	Not recommended	Not recommended	a) Monitor aspects such as the number of premises involved in the program and the number of people trained. A good basis for more advanced styles of evaluation. b) Changes to awareness and attitudes can be easily evaluated (e.g. through pre- and post-BMP surveys). c) Monitor stormwater management behaviour of businesses (e.g. through pre- and post-BMP audits that measure changes in management practices).
19. Source control measures - miscellaneous Emergency response activities (e.g. to minimise the risk of stormwater and waterway pollution during incidents)	Highly recommended (a)	Recommended (b)	Of little value	Recommended when used in combination with evaluation style No. 5 (c)	Highly recommended (c)	Not recommended	Not recommended	a) Monitor aspects such as the existence of procedures, training programs, and related management systems. b) Monitor staff awareness of the correct procedures. c) Monitor whether the correct procedures have been followed during training exercises and real incidents (e.g. interview staff and review records to validate verbal reports).

Notes:

- * The listed non-structural BMPs in this table are those that ranked in the top 10 when three separate sets of data were used to derive an index of a BMP's relative value (i.e. data provided by Australian and overseas stormwater managers as well as the Author's opinion after conducting a review of the literature). See Report No. 2 in this series for more information.
- ** See Table 4.1 for a description of each evaluation style.
- The order of listed BMPs approximates the collective view of relative value based on the three separate sets of data mentioned above (with the most valuable BMPs being listed first).
- Style No. 1 (i.e. BMP Implementation) should be the basis for more informative styles of evaluation wherever resources allow.
- An evaluation style (or styles) should be chosen that is most highly recommended and is able to be adopted given the project's objectives, resources and timeframe.

Appendix E

Supplementary data recording sheets for BMP evaluation style No. 6

Rainfall Information/Data for Evaluation Style No. 6

BMP Name: . . . .

Catchment Name: . . . . **Monitoring Station Name:** . . . .

Start date	Start time	End date	End time	Storm precipitation depth	Units	Peak 1 hr Precipitation rate	Units

Source: ASCE & US EPA (2002).

Stormwater Flow Information/Data for Evaluation Style No. 6

BMP Name: . . . .

Catchment Name: . . . . **Monitoring Station Name:** . . . .

Flow start date*	Flow start time	Type of flow: runoff or base-flow*	Related precipitation event*	Flow end date	Flow end time	Total flow volume*	Peak flow rate	Total bypass volume* *(if relevant)*	Peak bypass flow rate *(if relevant)*	Dry weather base-flow rate*

Note:
- * Fields marked as mandatory by the US BMP Database Project (www.bmpdatabase.org).

Source: ASCE & US EPA (2002).

Water Quality Information/Data for Evaluation Style No. 6

BMP Name: .... **Catchment Name:** ....

Monitoring Station Name*: .... **Station Type*:** ....

QA/QC Description: .... **No. of samples (if composite):** ....

Comments: ....

Sample ID	Sample date*	Sample time*	Related flow event*	Water quality parameter*	Value/result*	Qualifier*	Analysis method

Note:
- * Fields marked as mandatory by the US BMP Database Project (www.bmpdatabase.org).

Source: ASCE & US EPA (2002).

Appendix F - Acknowledgements

The following people are acknowledged for kindly assisting the CRC for Catchment Hydrology with aspects of this project:

- David Perry and Maeve O'Leary, Communications and Adoption Program, Cooperative Research Centre for Catchment Hydrology, Melbourne, Victoria.
- Geoff Young, Manager Community Education Unit, New South Wales Environment Protection Authority, Sydney, New South Wales.
- Jane Clary, Regulation Specialist, Wright Waters Engineers Inc., Denver, Colorado.
- Joanne Sinclair, Regional Education Officer, Least Waste, Mitcham, Victoria.
- Jody Haynes, Program Extension Agent, Florida Yards and Neighbourhoods Program, University of Florida, Homestead, Florida.
- Justin Lewis, Research Assistant, Urban Stormwater Quality Program, Cooperative Research Centre for Catchment Hydrology, Melbourne, Victoria.
- Lyndall Pickering, Environmental Officer Communications, Mosman Municipal Council, Sydney, New South Wales.
- Mark Taylor, Program Officer - Pollution Prevention, Brisbane City Council, Brisbane, Queensland.
- Neville Pavan, New South Wales Department of Land and Water Conservation, Sydney, New South Wales.
- Paul Smith, former Masters Student, Centre for Systemic Development, University of Western Sydney, Sydney, New South Wales.
- Peter Morison, former Environmental Programs Officer, Upper Parramatta River Catchment Trust, Sydney, New South Wales.
- Peter Salier, Senior Stormwater Education Officer, New South Wales Environment Protection Authority, Sydney, New South Wales.
- Phil Smith, former Senior Education Officer - Stormwater, New South Wales Environment Protection Authority, Sydney, New South Wales.
- Philip Alviano, former Stormwater Project Officer, Construction and Building Sites, City of Kingston, Melbourne, Victoria.
- Richard McManus, former Stormwater Officer, Stormwater Team, New South Wales Environmental Protection Authority, Sydney, New South Wales.
- Rob Curnow, Director, Community Change Pty Ltd, Melbourne, Victoria.
- Roberta Ryan, Associate Director, Elton Consulting, Sydney, New South Wales.
- Staff from Moreland City Council (i.e. Les Horvath, Nic Drent, Nancy Krause, Iona Theodoridis and Jane Homewood), the Moonie Ponds Creek Litter Initiative (i.e. Nicolette Rose) and the 'Clearwater' capacity building program (i.e. Jacquie White) who assisted with the trial projects in Melbourne, Victoria.
- Tanja Mueller, Victorian Stormwater Action Program Coordinator, Victorian Environmental Protection Authority, Traralgon, Victoria.
- Tim Fletcher, Program Leader, Urban Stormwater Quality Program, Cooperative Research Centre for Catchment Hydrology, Melbourne, Victoria.
- Tony Weber, former Senior Waterways Program Officer - Water Quality, Brisbane City Council, Brisbane, Queensland.

In addition, the Victorian Government is acknowledged for providing the bulk of the funding for this project through the Environmental Protection Authority as part of the Victorian Stormwater Action Program.

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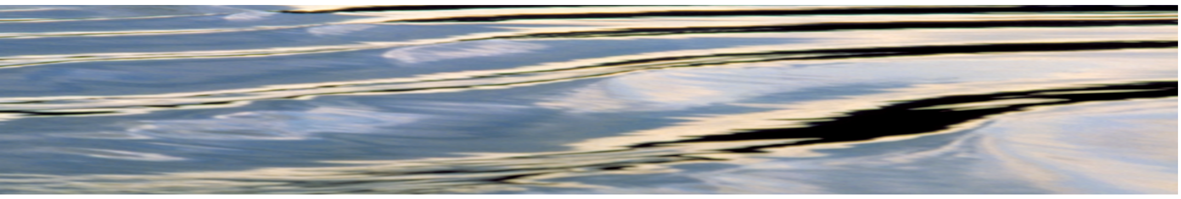

The Cooperative Research Centre for Catchment Hydrology is a cooperative venture formed under the Commonwealth CRC Program between:

- Brisbane City Council
- Bureau of Meteorology
- CSIRO Land and Water
- Department of Infrastructure, Planning and Natural Resources, NSW
- Department of Sustainability and Environment, Vic
- Goulburn-Murray Water
- Griffith University
- Melbourne Water
- Monash University
- Murray-Darling Basin Commission
- Natural Resources and Mines, Qld
- Southern Rural Water
- The University of Melbourne
- Wimmera Mallee Water

Associate:

- Water Corporation of Western Australia

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Established and supported under the Australian Government's Cooperative Research Centre Program