Municipal Engineers Foundation, Victoria

2003 Study tour to USA, Canada & UK

"Review of the status and trends in best management practices for stormwater quality."

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Introduction

This paper provides the results of a study tour to the USA, Canada and the UK in 2003, which was made possible by the Municipal Engineers Foundation of Victoria. The annual scholarship provides an excellent opportunity for municipal engineers to research and explore topical issues and developments overseas and importantly to then share this information with the industry.

The topic that I chose relates to the best management practice for stormwater quality and is an issue that is growing in importance in the publics view and is also becoming very prevalent in new developments within Victoria. I have aimed to provide an overview of the trends overseas, but importantly listed areas where we need to improve and learn from. I would like to acknowledge the great opportunity these study tours provide and thank the trustees of the Municipal Engineers Foundation of Victoria.

Executive Summary

Traditionally urban drainage systems have been managed to focus on hydraulic capacity and transport of stormwater to minimise the threat of flooding rather than environmental quality. With increased urban development there has been a significant increase in the amount of pollutants carried in stormwater, with a resultant adverse impact on the environment. So there is now a strong trend to introduce "best management practices" (BMP's) into the urban infrastructure to reduce the amount of pollutants carried to the receiving waters and improve the ecology of the waterways.

There is limited experience in designing, constructing and more importantly maintaining these BMP's and this study tour provided some valuable insight into the trends in America and United Kingdom. The key outcomes of the study tour relate to five main areas:

1. An increased knowledge base of BMPs
2. Clear maintenance responsibilities for BMPs
3. Better implementation of stormwater plans
4. Financing stormwater management plans, and
5. Evaluation and effectiveness of BMPs

Out of the places visited on our study tour, it was found that America was well advanced and has a significant amount of research (since the mid 1990s) and information relating to BMPs. In comparison England is behind Australia, although it is interesting to explore how they are looking to address the issue through their legislative framework.

California was the most progressed location in relation to this study topic. In particular our visit to the County of San Diego and the inspection of the Caltrans BMP retrofit pilot sites was the most informative (refer section 5.2.1 for details) and provides excellent information to be able to expand on and research the 5 key outcomes.

1. Background

Australia is recently (late 1990's) starting to look at improved environmental performance in relation to stormwater management to ensure that the environmental values and beneficial uses of receiving waters are sustained or enhanced. Best practice guidelines have been developed to assist urban catchment managers to protect stormwater quality.

Traditionally urban drainage systems have been managed to focus on hydraulic capacity and transport of stormwater to minimise the threat of flooding rather than environmental quality. With the increased flows and velocities in urban waterways, this has led to a significant increase in the amount of material (pollutants) carried by the flows. Run off carries these pollutants into waterways and the total loads can affect the environmental quality of downstream aquatic habitats and coastal waters. Common pollutants include:

- Sediment and suspended solids
- Gross pollutants and litter
- Nutrients (primarily phosphorous and nitrogen)
- BOD and COD (biochemical and chemical oxygen demand)
- Micro-organisms
- Metals,
- Toxic organics, oils and surfactants.

In Australia we now use three principles in management of stormwater quality:

1. **Preservation**: preserve existing valuable elements of the stormwater system such as natural channels, wetlands and stream side vegetation. This can be achieved through planning controls and design practices
2. **Source control:** limit changes to the quantity and quality of stormwater at or near the source
3. **Structural control**: use of structural measures such as treatment techniques or detention basins to improve water quality and control streamflow discharges

The study tour focused on the third principle, that of structural controls and included a review of:

1. The types of structural measures used
2. The performance of structural measures used, and
3. The ongoing maintenance requirements to ensure they continue to be effective measures and
4. Funding for these controls, capital and recurrent

2. <u>The “treatment train” approach.</u>

Constructing a “treatment train” using structural treatment measures involves the selection and sequential ordering of treatments to achieve optimal pollutant removal. The ordered process involves:

1. Screening	Remove gross pollutants/litter & gravel
2. Sedimentation	Remove coarse to medium sediments
3. Enhanced sedimentation	Remove fine sediments
4. Adhesion and filtration	Remove attached pollutants
5. Biological uptake	Remove dissolved pollutants

(From Fig 2.3 Best Practice Environmental Management Guidelines for Urban Stormwater, CSIRO)

These structural treatments can be grouped into three categories:

1. <u>Primary treatment</u> – physical screening or rapid sedimentation techniques (gross pollutants and coarse sediments)
2. <u>Secondary treatment</u> – finer particle sedimentation and filtration techniques (fine particles and attached pollutants)
3. <u>Tertiary treatment</u> – enhanced sedimentation and filtration, biological uptake, adsorption onto sediments (nutrients and heavy metals)

The various techniques used in any of the above three levels, to improve water quality, are known as best management practices (BMPs) in the United States or Sustainable Urban Drainage (SUDS) in United Kingdom.

A poorly maintained treatment measure may not only perform badly, it may become a flood hazard or a source of pollution itself. Treatment measure operation and maintenance requirements are critical to the whole process and consideration is required of the following issues:

- Ease and safety of maintenance and operation
- Extent of maintenance (need to be within operators capability)
- Access to the treatment site
- Frequency of maintenance (resources available to carry out required activities at the required frequency)
- Debris and pollutant clearing (treatment should not require direct human contact)
- Disposal (consider the disposal of waste which may be contaminated)

3. Study Tour details

The study tour included selected visits to areas within the three countries of USA, Canada & the United Kingdom and provided an opportunity to review current trends, research and confirm the priority allocated to best management practice of stormwater.

The places visited included:

- Foster City in San Francisco, California
- Orange County in Los Angeles, California
- County of San Diego, California
- City of Indianapolis, Indiana
- Ottawa, Canada
- Liverpool, United Kingdom
- Telford, United Kingdom
- London, United Kingdom

Whilst all places visited provided valuable information, It was found that America is the most advanced in this area due to a combination of the national approach used (enforced by the USA EPA) and the length of time BMP's have been used (since mid 1990's). The County of San Diego and their work with Caltrans was the most informative of the tour.

England and Wales could be considered behind Australia but their current review of Sustainable Urban Drainage (SUDS) reinforces the key areas that Australia needs to focus on.

In Canada we had a very limited overview but it would appear that water is an abundant resource and at this point in time there is not a strong focus on water quality. In addition the colder climates in Canada provide a different situation to most Australian sites.

The APWA conference also provided a huge number of contacts, conference papers and websites applicable to the study topic, an example being the information provided in section 5.2.2 of this report and the appendices. The conference also highlighted the importance and topical nature of stormwater quality issues with 10% of the 146 papers presented being on stormwater quality issues.

4. Legislative frameworks/ incentives to employ best practice

4.1 Australian framework.

Best Practice Environmental Management Guidelines for Urban Stormwater were commissioned by the Stormwater Committee (a partnership between Environment Protection Authority, Melbourne Water Corporation and local government) aimed at improved stormwater quality. These were published by the CSIRO in 1999.

The EPA use these guidelines to provide advice on environmental management of stormwater and to assess the environmental performance of stormwater managers but are not regulations.

The EPA also establish environmental standards for urban waterways and bays through the State Environmental Protection Policies (SEPP). The SEPPs provide a clear statutory framework of publicly agreed environmental objectives.

Melbourne Water is the regional drainage authority in the Melbourne Metropolitan area and plays a critical role beyond the local drainage system. The Best Practice Guidelines set out a range of performance objectives that should be able to be met through current best practice and Melbourne Water are aiming to achieve these standards through requirements placed on new developers but they are not currently enforced uniformly.

The preparation of stormwater management plans has taken place in most Victorian councils and these provide a framework for best practice. Some Councils have then adopted their own guidelines such as the Knox City Council Water Sensitive Urban Design Guidelines – April 2002 which are aimed at encouraging these principles in new and existing developments. Such guidelines provide the tools to achieve the standards set in the planning provisions. There is no consistent approach to this, although the MAV through their "Clearwater Program" are working towards a more uniform approach within Victorian Local Government

4.2 The American framework

In America the quality of urban stormwater was largely ignored in the design of urban drainage systems until approximately 1980. In 1982 Florida became the first state to pass a law requiring that the urban runoff be treated to remove pollutants. In 1988, the US Environmental Protection Agency (US EPA) promulgated its first draft regulations for the nationwide control of urban runoff quality and in 1990 published final regulations governing municipalities with populations more than 100,000 people. These regulations established application requirements for stormwater NPDES permits (National Pollution Discharge Elimination System).

The aim of the permit is to reduce stormwater pollution to the maximum extent possible (MEP) and this is set by the local entities through a comprehensive planning process considering:

- The magnitude of the problem
- Constraints on its resolution
- The effectiveness and track record of available BMPs and
- Costs

The common practice is to define MEP using a combination of source control BMPs and treatment control BMPs. The MEP is not a fixed target but should be re-examined to incorporate current knowledge. Several states have adopted regional approaches to managing stormwater runoff.

America is a leading country in the area of stormwater quality and this is mainly due to this "nationwide" approach and enforcement of these regulations.

4.3 The England & Wales framework

I was fortunate to visit Graham Fairhurst from the Borough of Telford & Wrekin who was a member of the national SUDS working group who had just issued a framework document entitled "Framework for sustainable drainage systems (SUDS) in England & Wales, May 2003." (SUDS is defined as a sequence of management practices and control structures designed to drain surface water in a sustainable way.)

The purpose of the framework is to provide a set of core standards and agreements between those public organisations with statutory or regulatory responsibilities relating to SUDS, leading to a code of practice for the industry. The framework is designed to provide support for developers in promoting and implementing SUDS, to ensure their long-term viability and to promote consistent use. The document was out for a three month public consultation period, which had just closed when I visited and the comments received were being compiled into a summary report leading to a final SUDS code of practice, expected late 2003.

The following extract from the forward provides a valuable setting of where England and Wales are at with best practice management of stormwater:
"Publishing this framework is part of a wider range of actions being pursued to ensure that the potential of sustainable drainage systems to offer cost effective solutions is fully exploited. They can also be used in conjunction with conventional piped systems and can slow the flow to these thereby improving their performance. Certainly for new developments, and any redevelopment, we must seriously consider using sustainable drainage systems. Flooding and reducing the risk of flooding, is a big issue, and while sustainable drainage systems are not a panacea for all our flood problems they can, in certain circumstances, reduce the level of flood risk and clean up water contaminated by human activity.

The Water Framework Directive will require us to manage water resources sustainably. Sustainable drainage systems have a part to play in an integrated approach to water management. Rather than wait for the directive to come fully into force we should act now to improve the management of water in the urban setting. It is time to look at water in the built environment in a different light; rather than see it as a threat we should take the opportunity to protect it more carefully. After all, there are many benefits, for us as individuals, for society as a whole, for industry and for wildlife."

It can be seen that the United Kingdom appear to agree with Australia in that they recognise the importance of best management practices for stormwater, but are still determining the best way to implement these practices into the industry. They do not seem to be as well advanced as Australia in specifying the targets or measures of best practice and it is concluded that Australia, in general, is ahead of the UK.

5. The American experience.

In America they have generally adopted a six-step decision making process for developing a stormwater management program as follows:

1. Define objectives
2. Assess existing conditions
3. Establish program framework
4. Select appropriate BMPs
5. Implement program and
6. Evaluate effectiveness

This framework is very effective in America and there are a lot of aspects we can learn from and utilise and some of the key findings are discussed below. In particular we can learn from the vast amount of information and research undertaken on BMPs and further we need to have some measures to evaluate effectiveness (an area we are sadly lacking in). The California area is an area that has a great emphasis on water quality (perhaps driven by the need to have nice clean beaches) and they also have a lot of information and research as detailed in section 5.2 below.

5.1 Existing conditions.

The Americans provide a lot of consideration to the watershed characteristics focusing on factors that will influence the nature of stormwater management and collecting all information necessary to select BMPs. Characteristics include:

- Land use (ex land use when built out, proximity to sensitive receiving waters)
- Physiology (ex Slopes, soil erosivity, groundwater)
- Climate (rainfall intensity)
- Habitat
- Drainage system
- Community profile

In Australia these factors are given some consideration in preparing Stormwater Management Plans but further consideration needs to be given in selecting the most appropriate BMPs. This is where we can learn from America as they have a huge amount of information and research about BMPs.

5.2 Selecting, implementing and evaluating BMPs

There are several general points to be considered when selecting and designing any treatment controls:

- Source control (the first step to avoid before more expensive TC)
- Local climate (many treatments rely on the “wet” state)
- Design storm size (quality concern is more the small frequent events)
- Soil erosion (sediment loads affect performance)
- Stormwater pollutant characteristics (can be particulate or dissolved)

- Multiple uses (combine with other uses, ex groundwater recharge, wildlife habitat, active or passive recreation)
- Maintenance (consider life cycle costs)
- Physical and environmental factors (ex slope, area required, soil,etc)
- On site versus regional controls (this is a topic that could be expanded, but all I will mention is that the accumulated effect in numerous on site controls is less predictable than with regional controls)
- Robustness of design technology (with so many new technologies the tested designs have the best probability of performing as intended)

California has a tremendous amount of information and very valuable research on BMPs and an example is the following two websites that provide some very extensive information on BMPs:

5.2.1 Caltrans website. *www.dot.ca.gov/hq/env/stormwater/index.htm*

This website has many reports but one that relates directly to the sites we visited was "Storm water treatment technology research status report". We were fortunate to visit several of the sites for this BMP retrofit pilot study, which is being managed by Caltrans (The Californian Transport Authority). The program commenced in 1997 and retrofitted 39 BMPs in Los Angeles and San Diego representing a broad base of state of the art BMP technology. It is a 5 year, $30 million dollar research effort and looks at:

1. Site selection
2. Design & construction
3. Operation, maintenance and monitoring
4. Vector and biological assessments
5. Documentation and reporting

What we were able to do is visit and inspect some of these sites that had been in operation for several years and to see the actual progress that had been made. One particular site was the wet basin at La Costa Park and Ride interchange in District 11 (San Diego). Our host confirmed the importance of the need for good maintenance practices, including the major activities of vegetation control and de-silting which had been required during the pilot period. Unfortunately the results of the 5 year study are being compiled and should be available by early 2004 and will give valuable information on their performance in improving water quality and the cost of maintaining such features. The types of BMPs piloted included extended detention basins, drain inlet inserts, infiltration basins and trenches, oil/water separators, media filters, multi chambered treatment trains, bio-filtration swales and strips, continuous deflection separators (CDS units) and wet basins. Appendix 1 provides an overview of this pilot study

5.2.2 CSQA website. *www.cabmphandbooks.com*

The second website is the "California Stormwater Quality Association" which has two valuable handbooks. The first, being the Municipal handbook, and the second being the New Development & Redevelopment handbook. In California, the

Federal NPDES stormwater permitting program, is administered by the State Water Resources Control Board. Municipalities (over 100,000) are required to implement a stormwater management program and this handbook provides guidance for selecting and implementing BMPs.

An area that we sadly lag in Australia is in the successful implementation of BMPs and section 5 (Appendix 2) of the Municipal handbook provides an excellent guide to municipal employees and the activities they need to undertake, including:

- Staff training
- Site inspections
- Treatment control maintenance (TC-20 wet pond attached)
- Analytical monitoring
- Enforcement
- Reporting

Section 6 (Appendix 3) of the New Development & Redevelopment handbook provides further valuable information relating to the need for detailed maintenance plans and to identify the responsible party and funding requirements. In America a lot of BMPs are maintained privately and maintenance agreements are drawn up as detailed in this section. It goes on to indicate that local agencies may be willing to assume responsibility for stormwater BMPs **but** it is essential to identify the long term funding sources, which could be:

- General tax revenues
- Utility charges
- Permit fees
- Dedicated contributions.

In Australia, councils (and in some cases regional water authorities) take on these long-term maintenance responsibilities without question and fund it solely from general tax revenues. To me this is just another burden for local government and we need to look seriously at the other funding options as they do in America. The maintenance responsibilities are indicated in MP-20 (and also TC-20) and suggest regular harvesting of vegetation and even every few years to remove the entire plant mass including roots. This is a very significant process and cost. Add to this the reaction you will get from residents and environmentalists of the impact of such a process and long term maintenance becomes a significant issue just for wetlands alone.

A further fact sheet (Appendix 4) is a similar fact sheet from North Carolina and reinforces the above findings. A very interesting statistic quoted in this sheet is that the estimated annual operation and maintenance costs for wet basins are 3% to 5% of construction costs. Mowing and sediment removal are the most costly activities.

It is made very clear in all documents that regular inspection and maintenance of BMPs are a necessity if these controls are to consistently perform up to expectations. If they do not work effectively, or as designed, then they will not meet the regulations set by the US EPA.

5.3 Financing stormwater management programs.

What is identified as an important issue in most of the US information is that the stormwater management programs need a reliable source of revenue for general administration, operation, capital improvement and most importantly maintenance to ensure the long term effectiveness.

In the APWA publication "Financing stormwater utilities" it is noted that historically storm water management has only addressed the quantity component of runoff and was financed with general revenues from property taxes. This has now proven inadequate to meet the needs for services and to provide the expected levels of service. The best alternative appears to be storm water utility charges, which are user fees paid by property owners in proportion to some estimate of the amount of runoff from their properties.

Prior to the introduction of the Clean Water Act (early 1990's), there were only 19 communities using the utility approach, mainly to address quantity issues. In 2003 it is estimated that in excess of 500 communities and regional governments now use the utility approach in the USA. This is a trend that may become more prevalent in Australia to finance the growing gap. Further details are available in the APWA publication.

6. The England and Wales experience.

The key issues that are identified in the "Framework for SUDS in England & Wales – May 2003" are listed below and provide a valuable comparison to the issues being experienced in Australia.

1. Purpose of the framework.
   "*The need for sustainable drainage is not disputed, but SUDS, if not properly designed and maintained, can lead to a number of problems*" *(Page 6)*. It is important to note that this is one of the key reasons why the framework was introduced and maintenance is identified as one of the essential elements for SUDS to be successful.
2. Planning.
   "*The role of local planning authorities is pivotal in relation to ensuring that SUDS are incorporated into developments. There is a clear need for guidance on design standards, a satisfactory mechanism for approval, and implementation, leading to long-term ownership, management and maintenance. It is therefore essential for there to be legally binding obligations in respect of the provision of SUDS. The most appropriate method of achieving this is an agreement under section 106 TCPA 1990. An initial draft of a section 106 agreement and a maintenance framework agreement are included at Appendix A." (Page 10)*. This proposed agreement does provide a critical element that I believe is missing in Victoria at the local level. That is a clear agreement about design, implementation and importantly maintenance of SUDS. The proposed agreement is a good basis for local authorities to develop their own agreements.
3. Benefits and constraints on SUDS are listed in the planning policies guidelines (PPG25) and identifies a number of ways in which SUDS can contribute towards more sustainable development, by:
   - *Managing environmental impacts at source rather than downstream*
   - *Managing surface water runoff rates, reducing the impact of urbanisation on flooding*
   - *Protecting or enhancing water quality*
   - *Being sympathetic to the environmental setting and the needs of the local community*
   - *Providing opportunities to create habitats for wildlife in urban watercourses*
   - *Encouraging natural groundwater recharge.*

   The constraints include:
     - *The surface structures that may be needed can take more space than conventional drainage systems*
     - *The opportunities for infiltration devices may be limited where the soil is not very permeable, the water table is shallow, the groundwater under the site may be put at risk, or infiltration of water into the ground may adversely affect ground stability*

     (Page 11, see also page 23)

Whilst the above are certainly agreed with, there is a concern in the Australian context that managing the impacts at or as close to the source puts the responsibility back to the local authority, and this burden will usually go to the local council and funding is an issue.

The point raised about groundwater recharge is an interesting one and the concern about possible contamination of the groundwater adds further to this point. It is one that I am unaware has entered into the Victorian discussion.

Finally the last dot point is very valid and is an area that we need to place more consideration on, that is the suitability of each site needs a lot more investigation as many sites may not be suitable.

4. <u>Implementation of SUDS.</u>
   The PPG 25 emphasises the need for consideration of SUDS at both the conception and detailed stages of development schemes. In particular, it highlights the following issues for consideration:
   - *Integration of SUDS into the overall site concept and layout*
   - *The need for investigation and subsequent remediation of contaminated land*
   - *Agreements on adoption, maintenance and operation of the systems*
   - *The need for monitoring long-term performance*

   (Page 12)

   In Victoria we need better integration into the site concept and layout. It is occurring on some developments but is still a very ad hoc approach. The points about ensuring we have clear responsibilities regarding the maintenance and ongoing operation as well as monitoring the performance are very valid points and are reinforced in the American cases.

5. <u>Conservation and habitat enhancement.</u>
   The SUDS sites should not be identified as "protected conservation/wildlife zones". Most SUDS facilities will require some major maintenance work at some stage to ensure satisfactory operation. Legal protection should not obstruct these operations. However, the possibility of natural colonisation by protected species may need to be considered. (Page 20)

   This brings up a very interesting consideration that there may well be a future conflict between the maintenance requirements such as major de-silting and the habitat (of wetland plants and animals) that is created over several years. It is essential to remember that the created wetland is a treatment system and needs to be maintained to remain effective in an urban environment

6. <u>Disposal of sediment.</u>
   Sedimentation is likely to occur in SUDS and there will be a need to periodically remove deposited sediment to ensure that the system continues to operate efficiently and effectively (as designed) and also to

control the risk of environmental pollution. However, depending on the characteristics of the catchment these sediments could be contaminated to varying degrees, which presents a potential risk to the land upon which the sediments are deposited and any receiving surface or groundwater. The sediment waste must be treated as controlled waste and therefore subject to controlled disposal. (Page 35)

This is a real concern for the wetlands we are establishing and this point only adds weight to the importance of having a clear maintenance program.

7. <u>Local authorities' powers to adopt and maintain SUDS, and need for funding regime.</u>
   The developer will need to provide a maintenance plan that properly addresses the initial maintenance and extended maintenance of the SUDS facilities. Such a plan should include additional dredging and cleaning works during the development phase and in the years following, cyclical maintenance requirements and recommendations for dealing with any toxic material that may accumulate in the facilities.
   The local authority should secure a financial mechanism (through commuted sums, or properly bonded arrangements), identified in the adoption agreement, to facilitate to undertake the life cycle maintenance and management requirements. This would allow adoption of the areas within an acceptable timeframe without placing unbalanced burdens on the council's resources.
   To ensure compliance with health and safety legislation, formal risk assessments should be carried out especially where wet ponds or large areas of water are expected to exist for any significant length of time. (Page 36)

   The above is one of the critical findings of the study tour that we need to explore and establish a financing arrangements for the large number of best management practices we are now seeing introduced into developments. If we don't it will place an "unbalanced burden on councils"

8. <u>Ownership, maintenance and funding.</u>
   While local authorities can adopt SUDS infrastructure, they do not have the power to levy a maintenance charge on individual customers, and ongoing maintenance can only be funded through agreements. The main mechanism for this has historically been through commuted sums taken from the developer. The larger SUDS infrastructure on new developments is likely to be co-incident with the open space provision and is likely to be transferred to the local authority on completion. Commuted sums, however, are not a wholly satisfactory funding mechanism as these sums are site specific and are taken to cover a 25 year period only (this may well be the time scale when a major SUDS feature requires significant maintenance inputs). Considering the further maintenance horizon the local authority will need to maintain an income stream to cover the maintenance costs.

For the time being the current method of obtaining commuted sums from developers through Section 106 planning agreements will have to suffice. It is, however, absolutely critical that the problems with the current arrangements for funding the work of local authorities are addressed. (Page 41)

The above is also very critical to local government in Australia and reinforces point 7 above. At the moment local government is taking on the extra responsibility of a huge additional workload and future liability and we have no income stream established except our general rate, and this is becoming more difficult (if not impossible) to increase.

Summary of the England and Wales experience.

Progress in introducing surface water systems in England & Wales has been painfully slow. The government issued PPG25 some 18 months ago and they have been stumbling across the same issues and so a serious look at the legislation is required, hence the framework for SUDS. A code of practice is needed as in the meantime opportunities to transform drainage in England & Wales, to manage flood risk, to promote wildlife habitat and improve water and landscape quality will continue to be lost (Brian Baker, Surveyor, The technical services weekly, August 2003). Australia although experiencing some of the same frustrations mentioned above, is well ahead of England & Wales in managing stormwater quality.

7. Conclusions.

BMPs for improving stormwater quality is an area of increasing public awareness and concern around the world. The trend towards the use of BMPs fits in with the general trend toward more sustainable infrastructure. The key outcomes/actions that have been identified from the study tour can be summarised in the following points:

1. An increased knowledge base of BMPs is required. The USA has a large knowledge base and research information relating to BMPs and this should be utilised to increase our knowledge of best management practices. We found that California, and in particular San Diego, have some excellent pilot sites with research over several years (refer to three key websites provided in the bibliography). In particular, in Australia we need:
    - An accurate assessment of the cost of design, construction and importantly maintenance of the various BMPs being used
    - To build a database of suitable BMPs based on the factors listed above

    Australia is however, well ahead of the UK who are just becoming aware of the importance of BMPs and are starting to look at the legislative framework required to implement BMP.

2. Clear maintenance responsibilities for BMPs are required. It is critical that we identify clear long term maintenance responsibilities (such as in the form of agreements) for BMPs to ensure they continue to function as designed. We need to develop "fact sheets" for the BMPs we adopt, similar to those in the appendices 2 - 4, and ensure those who are maintaining the devices are familiar with and implement these requirements.

3. We require a better system to ensure implementation of stormwater plans. We need to implement a better regulatory framework that will ensure stormwater quality improvements are introduced in new and existing developments and that they are evaluated and monitored properly. The US EPA framework seems to be working, but our framework requires stronger enforcement and better defined planning controls. A recent VSAP funded project released a paper "Clean Stormwater – a planning framework" that makes a positive first step in this area.

4. Sustainable financing of stormwater management plans needs to be arranged. There is a need to ensure we have an adequate financing stream in place to fund the stormwater management plans. At present this is through general rate revenue, which will most likely become unsustainable if we look at the whole of life costs and numbers of treatments to be implemented. One possibility is the introduction of stormwater utilities or other financing options. Refer item 1 of the bibliography.

5. A system of evaluating the effectiveness of BMPs is required. Evaluation and importantly monitoring, of the measures employed, needs to be undertaken on a regular basis to ensure the BMPs function as designed. We do little or no monitoring at the moment and so cannot confirm if we are improving the water quality or at least minimising the impact of urbanization.

Where to from here?

Best management practice of stormwater quality is rapidly growing in importance to the public and is being introduced through new developments (such as the Lyndbrook Estate in Cranbourne) and redevelopments (works in the City of Kingston) as a challenge for the public works engineer. There are many lessons to be learnt to manage these practices effectively and to also manage the potential conflicts with the publics' impressions of these BMPs (essential maintenance practices such as de-silting can be seen as destroying the native habitat created).

Local government can act on the five key actions listed above using the information available through the appendices, through programs such as the Clearwater Program and by then adding this information to their stormwater management plans.

Most importantly this topic is continually and rapidly developing. Much of the research information is still being released or developed and consequently the key will be to monitor and keep in touch with current developments such as the Caltrans research website and future study tours would be of benefit in this area. The East Coast of America, around Chesapeak Bay area, would well be an excellent future tour as its climate and conditions are very similar to Victoria.

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5. California Stormwater Quality Association, Municipal Handbook and New Development and Redevelopment Handbook, retrieved from: *www.cabmphandbooks.com*

6. Clearwater Information Exchange *www.clearwater.asn.au*

7. Framework for sustainable drainage systems (SUDS) in England and Wales – National SUDS working group, May 2003.

8. Maintaining Wet Detention Ponds Fact Sheet
North Carolina Department of Environment and Natural Resources, Division of Water Quality, retrieved from:
http://h2o.enr.state.nc.us/su/PDF Files/Land of Sky factsheets/FactSheet 7.pdf

9. Water Sensitive Urban Design – Knox City Council, April 2002

10. Urban runoff quality management – WEF manual of practice No. 23, ASCE 1996

Appendices:

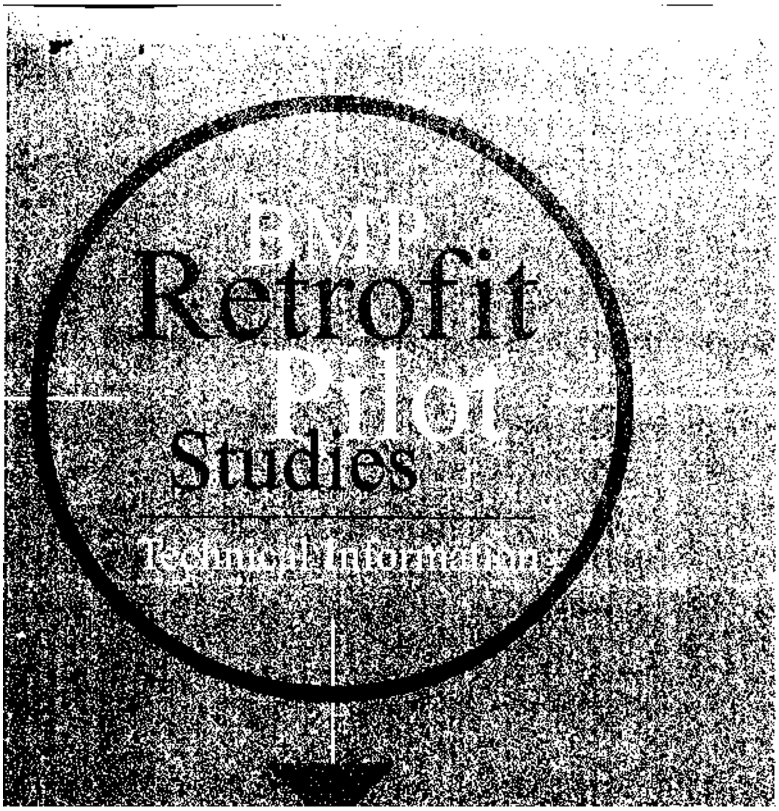
1. Caltrans storm water program – BMP retrofit pilot studies. An overview

2. California Stormwater Quality Association – California Stormwater BMP handbook – Municipal. Extract , Section 5 BMP implementation and evaluation and includes an example fact sheet TC-20 Wet Pond

3. California Stormwater Quality Association – California Stormwater BMP handbook – New Development and Redevelopment. Extract , Section 6 Long term maintenance of BMPs and includes an example maintenance practice MP-20 Wetland

4. North Carolina Department of Environment and Natural Resources, Division of Water Quality. Maintaining Wet Detention Ponds Factsheet No. 7.

APPENDIX 1



A fire-year $30 million dollar research effort to retrofit selected Caltrans facilities in the Los Angeles and San Diego areas

Caltrans began an extensive program in 1997 to retrofit selected facilities with structural Best Management Practices (BMPs) in District 7 (Los Angeles) and District 11 (San Diego). Cost effectiveness and water quality benefits will be determined for retrofitting structural BMPs to freeways, interchanges, park and rides, and maintenance stations. Thirty-nine BMPs are being constructed; 26 BMPs in District 7 (at 21 sites) and 13 BMPs in District 11 (at 12 sites). Thirty-seven of the sites are currently in operation.

Extract from Caltrans BMP retrofit pilot studies

1. Site selection

Prior to construction, Caltrans conducted scoping and siting studies to determine the design criteria and appropriate sites for the BMPs. Numerous site locations in both the Los Angeles and San Diego Districts were assessed to determine their compatibility with the selected BMPs. Research objectives and methods were developed in the project's scoping study, which provided guidance for site selection, BMP design maintenance, water quality monitoring, schedules, and costs. The siting study evaluated potential sites by using a weighted decision matrix to compare physical site characteristics and potential constituents in runoff with the monitoring requirements and performance characteristics of the selected BMPs. Specific sites were carefully selected to ensure that the data collected in the studies would be accurate and transferable.

2. Design and Construction

Design of the BMPs was based on the latest published design criteria. Construction began in September 1998 and was substantially complete in March 1999. Total construction costs are estimated to be about $5 million for District 7, and about $4 million for District 11.

3. Operations, Maintenance and Monitoring

These pilot studies are intended to produce data for each BMPs retrofit requirements, construction costs, efficiency of constituent removal, and operation and maintenance requirements. To accomplish these objectives, Operation, Maintenance, and Monitoring (OMM) Plans have been developed to ensure that project data will be collected uniformly using established protocols. The OMM Plans provide detailed guidelines for monitoring and recording each BMP site including:

- storm water sample characteristics,
- flow into and out of the BMP,
- analyses of the BMP influent and effluent as collected by flow-weighted samples with automated monitoring equipment,
- analyses of grab samples for the BMP influent and effluent,
- empirical observations on the performance of the BMP during storm and post-storm periods, and
- man-hour and equipment-hour requirements for maintaining the BMP, and the resulting costs.

A Maintenance Indicator Document provides a long-term protocol for maintaining the pilot BMPs. This will encourage consistency and control efficiency of maintenance and operation of the BMPs.

4. Vector and Biological Assessments

Coordination with vector control agencies has been incorporated into the studies. The Department of Health Services will review the design and operations data to help determine the tendency of BMPs to produce vectors (e.g., mosquitos and rodents).

A Biological Assessment is being prepared to determine the extent that protected and sensitive species are attracted to the BMPs and how these species affect operations. Both the Vector and Biological assessments will be used to refine guidelines for BMP maintenance protocols.

5. Documentation and Reporting

A standardized documentation and reporting format is being used for these studies. Detailed records will be maintained for each of the **39 BMP** sites to document the complete process: siting, design, construction, and operation and maintenance (O&M) for each BMP

A final report will be prepared with detailed documentation for each BMP site. In addition, deviations from standard designs that were necessary to accommodate site constraints will be documented. The performance of these BMPs will be compared to other BMPs in siimilar projects.

Constituents to be monitored in the BMPs

Total suspended solids
Zinc (total and dissolved)
Copper (total and dissolved)
Lead (total and dissolved)
Nitrate
Total Kjeldahl nitrogen
Total phosphorus
Fecal coliform
Total recoverable petroleum
Hydrocarbons
Gasoline
Oil
Diesel
PH
Hardness
Specific conductance

Types of BMPs

Extended Detention Basin
These basins capture storm water runoff and allow for an extended drain time to remove particulates and other associated pollutants through sedimentation

Drain Inlet Inserts
Devices are inserted into storm drain inlets to filter absorb sediment, oil and grease, and other pollutant

Infiltration Basins and Trenches
Trenches are lined with filter fabric and filled with rock. Storm water runoff captured in the trenches then infiltrates into the soil. Basins are excavated depressions that infiltrate captured storm water.

Oil / Water Separator
These plate separators treat runoff from Caltrans facilities that generate oil and grease. Vertical plate separate oil from water, while a vault traps and collects sediments.

Media Filters
Fine sediments and pollutants are filtered through chambers containing sand or perlite/zeolite media.

Multi-Chambered Treatment Trains (MCTT)

Three vaults capture sediment and debris, remove oil and grease with absorbent pillows, and filter pollutants through fabric and a mixture of peat and sand

Biofiltration Swales and Strips
Grassy pathways, also known as biofilters, filter and deposit pollutants from storm water when water flows through the vegetation.

Continuous Deflection Separators (CDS™)
CDS™ units treat runoff by screening' sediment and debris and depositing the debris in a sump. **CDS™** units create a vortex of water that allows water to escape through the screen, while pollutants are deflected into the storage sump.

Wet basins
A wet basin removes sediment, nutrients and particulate metals from stormwater runoff. An in line permanent pool or basin enhances settling

Caltrans Web site

Upon completion., information from these BMP pilot studies will be made available to the public through Caltrans statewide water quality database at the following website: **www.dot.ca.gov/hq/env/stormwater/index.htm**

APPENDIX 2

Section 5
BMP Implementation and Evaluation

5.1 Introduction

As noted in Section 1 each municipality regulated under stormwater NPDES permits, whether categorized as a Phase I or Phase II municipality, is required to implement a stormwater management program and to assess the effectiveness of the program. Although specific program requirements and the level of implementation required differ between Phase I and Phase II municipalities, both prohibit non-stormwater discharges into storm drains, and require controls to reduce the discharge of pollutants to the maximum extent practicable (MEP). As part of the program the municipalities are required to address public agency (municipal) operations to reduce the discharge of pollutants and to assess these efforts. Section 2 provides information on some of the necessary elements and steps involved in identifying BMP's for municipal activities occurring at fixed facilities and in field programs, whereas this Section discusses the components necessary to successfully implement a BMP and evaluate its effectiveness.

5.2 BMP Implementation

Municipal employees perform numerous municipal activities that have the ability to discharge pollutants. Staff should consistently implement the procedures or BMPs applicable to these activities. Some municipal activities are contracted to other parties. For example, many municipalities contract out street sweeping or waste collection. Similarly, many municipalities lease city-owned facilities to other parties, at which activities take place that have the potential to discharge pollutants. To ensure measures are taken to reduce pollutants while contractors or lessees perform such activities, contract and lease language should explicitly specify requirements to comply with all BMP specifications. Example contract/lease language is presented in Appendix D.

Successful implementation of a BMP is dependent on the following components:

Effective training of municipal and contract employees working in both fixed facilities and field programs.

- Regular inspections of fixed facilities, field programs, and treatment controls.
- Maintenance of treatment controls as needed to ensure proper functioning.
- Periodic evaluation/monitoring of BMP performance consistent with NPDES permit requirements.
- Follow-up action to correct deficiencies in BMP implementation noted during inspections.
- Accurate record keeping to track training, inspections, monitoring, and BMP maintenance.
- Submittal of an annual report to the applicable RWQCB regarding the effectiveness of the municipal efforts to reduce pollutants from fixed facilities and field programs.

- For Phase II Programs, documentation showing how the municipality has met its measurable goals, or revisions to those goals with supporting documentation.

5.3 Staff Training

Education and training is the key to the success of BMP implementation. Typically, municipalities provide annual training sessions. In addition to municipally sponsored training, staff may. also attend local, regional, statewide, or national training seminars or workshops related to stormwater management and water quality conducted by other organizations.

In general, a municipality should consider a training program for employees working infixed facilities and/or field programs. The training program should address the following subjects:

- Maintenance Procedure Implementation and Inspection - In this training effort, proper procedures for performing municipal activities that may adversely affect stormwater quality are addressed. Maintenance procedures cover a wide range of municipal activities and the training may address either all maintenance procedures applicable to the municipality or a specific procedure (e.g.. fertilizer and pesticide use). This training can be conducted in either a formal or tailgate-style format.

- Pollution Prevention/Spill Awareness - This training addresses the general techniques municipal staff may implement to prevent pollution, as well as to respond to spills once they have occurred. Training can be tailored to management and other municipal staff that oversee pollution prevention measures, to field staff conducting activities that may result in spills, or to field staff that may encounter spills or illicit discharges.

5.4 Site Inspections

Inspections of municipal fixed facilities and field programs should be performed to verify that BMPs are being implemented, that they are appropriate for that facility or program, and that they continue to reduce the discharge of pollutants. Inspections generally consist of the following:

- Fixed Facilities - Inspections are typically performed by a combination of stormwater program staff and on-site fixed facility managers. The inspection of a fixed facility may include spot checks of the facility and activities being performed at the facility, and interviews with key line staff.

- Field Programs- Inspections are typically performed by a combination of stormwater program staff and field program supervisors. The inspection of a field program may include spot checks of activities being performed, and interviews with key staff.

- Contracted Activities - Inspections are typically performed by municipal staff to supplement and check on self-inspections and reporting by the management staff of the contract firm performing the activity. Performance should be checked against contract/lease language (see Appendix D).

- Leased Facilities - Inspections are typically performed by municipal staff to supplement and check on self-inspections and reporting by the management staff of the lessor (see Appendix D).

5.4.1 Inspection Frequencies

Fixed facility or field program inspection frequency depends on the nature of the facility or program. Annual inspection is typical, with a more frequent schedule for facilities/activities that pose a greater threat to discharge pollutants (e.g.. corporation yards). In the event of an observed problem, such as ineffective maintenance procedures or detected non-stormwater discharges, the inspection frequency should be increased as appropriate to facilitate correction of the problem (see section 5.7 for discussion regarding follow-up enforcement).

5.4.2 Inspection Documentation Procedures

Inspection forms may be developed and used to properly document all inspections and gather the necessary information for record keeping and annual reporting. Examples include:

- General Inspection Forms - These primary forms provide for a general characterization of the fixed facility or field program being inspected, including the type of facility or program, the reason for inspection, activities that may take place, and BMPs applicable for the facility. A general form for all inspections and a single fixed facility specific form should be completed.

- Activity Specific Inspection Forms - These secondary forms include a series of questions or checklist items about specific activities taking place at a fixed facility or as part of a field program, as well as a list of suggested corrective action plans that can be implemented should a problem be found. All forms applicable to the activities being performed at a fixed facility or field program should be completed.

5.5 Treatment Control BMP Maintenance

Maintenance of treatment controls and drainage conveyance systems (e.g.. detention and retention basins, infiltration devices, catch basins) including regular inspections as presented in Section 4, is needed to maintain efficient pollutant reduction. If treatment control BMPs are not properly maintained, BMP effectiveness is reduced and water quality deteriorates. Training should be provided where needed. Maintenance schedules should be periodically reviewed and updated as needed to maintain BMP effectiveness. Where regular scheduled maintenance is not appropriate, regular inspections should be scheduled to determine when repairs, cleaning, or replacement are necessary. See Section 4 for a comprehensive discussion regarding maintenance of treatment control BMPs.

Where municipal contractors are responsible for maintenance of treatment controls, special attention should be directed toward ensuring proper maintenance procedures are implemented. Contract and lease language should include recommended maintenance procedures and schedules. Regularly scheduled inspections of facilities or programs operated by the contractor should include compliance with BMP maintenance requirements.

5.6 Analytical Monitoring

Although expensive, stormwater monitoring is a valuable way to assess long term BMP effectiveness and cost-effectiveness of selected BMPs at reducing pollutants to the "maximum extent practicable". For Phase I municipalities, specific monitoring requirements depend on the individual NPDES permits issued. Phase II municipalities are covered by the general permit Phase II and are not explicitly required to conduct chemical monitoring. Monitoring activities can include source identification, and chemical characterization of effluent/runoff, and nonstormwater discharges.

It is beyond the scope of this handbook to describe specific sampling and analytical techniques. For guidance on conventional stormwater sampling techniques and protocol, the reader should refer to NPDES Stormwater Sampling Guidance Document, 1992, published by the USEPA, or Caltrans' Guidance Manual: Stormwater Monitoring Protocols, 2000.

5.7 Enforcement

To ensure proper BMP performance, enforcement procedures and mechanisms should be established for the municipal fixed facilities and field programs. Enforcement actions may occur as a result of a problem found during an inspection or in response to a complaint that is received. Several different types of enforcement mechanisms and penalties can be utilized to ensure compliance. The internal enforcement procedures, directed toward municipal staff, include initial verbal warnings, written warnings, and more serious disciplinary actions if verbal and written warnings do not result in appropriate action. External enforcement procedures, which pertain to municipal contractors, may be undertaken primarily by the municipality's inspectors, managers and supervisors who possess enforcement authority through established policies and procedures or ordinances. Depending on the severity of the violation, enforcement could range from the issuance of a notice of noncompliance to the loss of a contract or lease, or a fine.

5.8 Recordkeeping

As applicable the municipality should maintain records demonstrating successful implementation of BMPs. Recordkeeping may include training, site inspection and maintenance, and if applicable, monitoring.

Training and Workshops

Records of all training sessions provided to staff should be maintained to allow for:

- determining which staff requires which training;
- determining when training sessions must be conducted; and
- documenting training activities for enforcement and compliance purposes.

Municipal staff may attend training sessions or workshops sponsored by non-Permittees such as local or national organizations. For these sessions, the following information should be recorded:

  - Name of Workshop/Training
  - Sponsoring Organization
  - General Description of the Subject Matter
  - Location
  - Date

- Attendee information (name, title, department, phone and/or e-mail)

Site Inspection and BMP Maintenance

Inspection reports should be kept to track frequency and results of inspections, BMPs implemented, condition of BMPs inspected, and follow-up actions taken. It is also important to keep a record of maintenance activities or any other BMPs that are of an "action" nature. It is easy to demonstrate that a BMP that involves a physical change, such as berming or covering, has been accomplished. But actions that relate to good housekeeping can only be demonstrated by recordkeeping. Besides demonstrating compliance, records can assist in BMP management. Keeping a record of catch basin cleaning, for example, also provides insight into how long it takes for the catch basin sump to refill.

Monitoring

Records of all stormwater monitoring information, inspections and visual observations, certifications, corrective actions and follow-up activities, and copies of all reports must be retained for a period of at least five years. These records shall include at a minimum, when applicable:

- Date, place, and time of sampling, visual observations, and/or measurements.
- Individual(s) who performed the sampling, visual observations, and or measurements.
  - Visual observation records for storm events.
  - Visual observations and inspections of non-stormwater discharges.
- Calibration and maintenance records of on-site instruments used.
- Visual observations and sample collection exception records,
- Date and approximate time of analyses.
- Individual who performed the analyses.
- Analytical results, method detection limits, and the analytical techniques or methods used.
- Quality assurance/quality control records and results.

- Sampling and analysis exemption and reduction certifications and supporting documentation.
- Records of any corrective actions and follow-up activities that resulted from the visual observations.

5.9 Reporting

Phase I municipalities are required to submit annual reports documenting BMP implementation, with due dates varying depending on individual NPDES permit requirements. Specific reporting requirements differ between individual permits. Typically they include, but are not limited to, the following:

- Program implementation status.
- Summary of stormwater activities performed.
- Stormwater monitoring results summary and analysis.
- Assessment of the effectiveness of selected control measures or BMPs.
- Changes or suggested changes to the BMP that will improve overall effectiveness of the program.

Phase II municipalities will be required under the Phase II general NDPES permit, beginning in 2004, to submit annual reports to the appropriate RWQCB by August 15th of each year, or as otherwise required by the RWQCB executive officer. Specific reporting requirements will include:

- Program implementation status.
- Summary of stormwater activities performed
- Results of information collected, such as monitoring data
- Summary of proposed stormwater activities for the next reporting cycle.
- Changes made in BMP selection.
- Changes in stormwater management

personnel. Changes made in program or

measurable goals.

Wet Pond
TC- 20

Maintenance Concerns, Objectives, and Goals

- Vegetation/Landscape Maintenance
- Endangered Species Habitat Creation
- Pollutant Removal Efficiency
- Clogging of the Outlet
- Invasive/exotic Plant Species
- Vector Control

General Description

Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from constructed wetlands primarily in having a greater average depth. Ponds treat incoming stormwater runoff by settling and biological uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, but pollutant uptake, particularly of nutrients, also occurs to some degree through biological activity in the pond. Wet ponds are among the most widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff and promote settling. The schematic diagram is of an on-line pond that includes detention for larger events, but this is not required in all areas of the state.

Inspection/Maintenance Considerations

In order to maintain the pond's design capacity, sediment must be removed occasionally and adequate resources must be committed to properly maintain peripheral aquatic vegetation, control vector production, and to maintain effective pool volume. Wet ponds can become a nuisance due to mosquito and midge breeding unless carefully designed and maintained. A proactive and routine preventative maintenance plan (which can vary according to location) is crucial to minimizing vector habitat. A vegetated buffer should be preserved around the pond to protect the banks from erosion and provide some pollutant removal before runoff enters the pond by overland flow.

Targeted Constituents

- Sediment
- Nutrients
- Trash
- Metals
- Bacteria
- Oil and Grease
- Organics
- Oxygen Demanding **Legend** ***(Removal Effectiveness)***
- Low High Medium

Checklist	Suggested frequency
• Inspect after several storm events to confirm that the drainage system functions, and bank stability and vegetation growth are sufficient.	Post construction
• Inspect for invasive vegetation, trash and debris, clogging of inlet/outlet structures, excessive erosion, sediment buildup in basin or outlet, cracking or settling of the dam, bank stability, tree growth on dam or embankment, vigor and density of the grass turf on the basin side slopes and floor, differential settlement, leakage, subsidence, damage to the emergency spillway, mechanical component condition, and graffiti.	Semi-annual, after significant storms, or more frequent as needed
• Inspect condition of inlet and outlet structures, pipes, sediment forebays, basin, and upstream and downstream channel conditions. Monitor drain times, and check for algae growth, signs of pollution such as oil sheens, discolored water, or unpleasant odors, and signs of flooding.	Annual inspection
• During inspections, note changes to the wet pond or the contributing watershed as these may affect basin performance.	
• Introduce mosquito fish, Gambusia spp., (where permitted by the Department of Fish and Game or other agency regulations) to enhance natural mosquito and midge control and regularly maintain emergent and shoreline vegetation to provide access for vector inspectors and facilitate vector control if needed.	Post construction
• Perform vector control, if necessary. • Remove sediment from outlet structure. Dispose of properly. • Remove accumulated trash and debris in the basin, inlet/outlet structures, side slopes, and collection system as required. • Repair undercut areas and erosion to banks and basin.	Semi annual, after significant storm events
• Maintain protected vegetated buffer around pond. Mow side slopes and maintain vegetation in and around basin to prevent any erosion or aesthetic problems. Minimize use of fertilizers and pesticides. Reseed if necessary. • Manage and harvest wetland plants. • Structural repair or replacement, as needed.	Annual maintenance (if needed)
• Remove sediment from the forebay and regrade when the accumulated sediment volume exceeds 10-20% of the forebay volume. Clean in early spring so vegetation damaged during cleaning has time to re-establish.	5- to 7-year maintenance
• Remove sediment when the permanent pool volume has become reduced significantly (sediment accumulation exceeds 25% of design depth), resuspension is observed, or the pond becomes eutrophic.	>5 year maintenance

Additional Information

In most cases, sediment from wet ponds do not contain toxins at levels posing a hazardous concern. Studies to date indicate that pond sediments are generally below toxicity limits and can be safely landfilled or disposed onsite. Onsite sediment disposal is always preferable (if local authorities permit) as long as the sediments are deposited away from the shoreline to prevent their reentry into the pond and away from recreation areas, where they could possibly be ingested by young children.

Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. Sediments containing high levels of pollutants should be disposed of properly.

For the best water quality benefit, the pond should hold water for at least 24 hours. It should drain down to the permanent water level within 72 hours of a storm event to avoid conditions which might increase water temperatures, deplete oxygen, promote vector growth, and/or cause odors.

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APPENDIX 3

Section 6
Long-term Maintenance of BMPs

6.1 Introduction

The long-term performance of BMPs hinges on ongoing and proper maintenance. In order for this to occur detailed maintenance plans are needed that include specific maintenance activities and frequencies for each type of BMP. In addition, these should include indicators for assessing when "as needed" maintenance activities are required. The fact sheets included in this volume contain the basic information needed to develop these maintenance plans, but municipalities and other regulatory agencies also need to identify the responsible party and potentially to address funding requirements. The following discussion is based primarily on data developed by Horner et al. $_{(1994)}$ and information available at http://www.stormwatercenter.net/

6.2 Critical Regulatory Components

Critical regulatory components identified by Horner et al. $_{(1994)}$ include:

- Regulations should officially designate a responsible party, frequently the development site owner, to have ultimate responsibility for the continued maintenance of stormwater facilities. This official designation provides the opportunity for appropriate preparation and budgeting prior to actually assuming responsibilities. It also facilitates enforcement or other legal remedies necessary to address compliance or performance problems once the facility has been constructed.

- Regulations should clearly state the inspection and maintenance requirements. Inspection and maintenance requirements should also comply with all applicable statutes and be based on the needs and priorities of the individual measure or facility. A clear presentation will help owners and builders comply and inspectors enforce requirements.

- Regulations should contain comprehensive requirements for documenting and detailing maintenance. A facility operation and maintenance manual should be prepared containing accurate and comprehensive drawings or plans of the completed facility and detailed descriptions and schedules of inspection and maintenance.

- The regulations should delineate the procedure for maintenance noncompliance. This process should provide informal, discretionary measures to deal with periodic, inadvertent noncompliance and formal and severe measures to address chronic noncompliance or performance problems. In either case, the primary goal of enforcement is to maintain an effective BMP - the enforcement action should not become an end in itself.

- Regulations should also address the possibility of total default by the owner or builder by providing a way to complete construction and continue maintenance. For example, the public might assume maintenance responsibility. If so, the designated public agency must be alerted and possess the necessary staffing, equipment, expertise, and funding to assume this responsibility. Default can be addressed through bonds and other performance guarantees obtained before the project is approved and construction begins. These bonds can then be used to fund the necessary maintenance activities.

The regulations must recognize that adequate and secure funding is needed for facility inspection and maintenance and provide for such funding.

6.3 Enforcement Options

A public agency will sometimes need to compel those responsible for facility construction or maintenance to fulfill their obligations. Therefore, the maintenance program must have enforcement options for quick corrective action. Rather than a single enforcement measure, the program should have a variety of techniques, each with its own degree of formality and legal weight. The inspection program should provide for nonconforming performance and even default, and contain suitable means to address all stages.

Prior to receiving construction approval, the developer or builder can be forced to provide performance guarantees. The public agency overseeing the construction can use these guarantees, usually a performance bond or other surety in an amount equal to some fraction of the facility's construction cost, to fund maintenance activities.

Enforcement of maintenance requirements can be accomplished through a stormwater maintenance agreement, which is a formal contract between a local government and a property owner designed to guarantee that specific maintenance functions are performed in exchange for permission to develop that property (http://www.stormwatercenter.net/). Local governments benefit from these agreements in that responsibility for regular maintenance of the BMPs can be placed upon the property owner or other legally recognized party, allowing agency staff more time for plan review and inspection.

6.4 Maintenance Agreements

Maintenance agreements can be an effective tool for ensuring long-term maintenance of on-site BMPs. The most important aspect of creating these maintenance agreements is to clearly define the responsibilities of each party entering into the agreement. Basic language that should be incorporated into an agreement includes the following:

1. Performance of Routine Maintenance
Local governments often find it easier to have a property owner perform all maintenance according to the requirements of a Design Manual. Other communities require that property owners do aesthetic maintenance (i.e., mowing, vegetation removal) and implement pollution prevention plans, but elect to perform structural maintenance and sediment removal themselves.

2. Maintenance Schedules
Maintenance requirements may vary, but usually governments require that all BMP owners perform at least an annual inspection and document the maintenance and repairs performed. An annual report must then be submitted to the government, who may then choose to perform an inspection of the facility.

Section 6
Long-term Maintenance of BMPs

3. Inspection Requirements

Local governments may obligate themselves to perform an annual inspection of a BMP, or may choose to inspect when deemed necessary instead. Local governments may also wish to include language allowing maintenance requirements to be increased if deemed necessary to ensure proper functioning of the BMP.

4. Access to BMPs

The agreement should grant permission to a local government or its authorized agent to enter onto property to inspect BMPs. If deficiencies are noted, the government should then provide a copy of the inspection report to the property owner and provide a timeline for repair of these deficiencies.

5. Failure to Maintain

In the maintenance agreement, the government should repeat the steps available for addressing a failure to maintain situation. Language allowing access to BMPs cited as not properly maintained is essential, along with the right to charge any costs for repairs back to the property owner. The government may wish to include deadlines for repayment of maintenance costs, and provide for liens against property up to the cost of the maintenance plus interest.

6. Recording Of The Maintenance Agreement

An important aspect to the recording of the maintenance agreement is that the agreement be recorded into local deed records. This helps ensure that the maintenance agreement is bound to the property in perpetuity.

Finally, some communities elect to include easement requirements into their maintenance agreements. While easement agreements are often secured through a separate legal agreement, recording public access easements for maintenance in a maintenance agreement reinforces a local government's right to enter and inspect a BMP.

Examples of maintenance agreements include several available on the web at: http://www.stormwatercenter.net/

6.5 Public Funding Sources

If local agencies are willing to assume responsibility for stormwater BMPs, it is essential to identify the long-term funding sources. Several of these are described below:

General Tax Revenues

Tax revenues are an obvious source of funding, particularly for the long-term inspection and maintenance of existing runoff and drainage facilities. The benefits and protection to the public from continued safe and effective operation of the facility justifies using revenues from general funds.

To use tax revenues, particularly from a general fund, the inspection and maintenance program must annually compete with all other programs included in the government's annual operating budget. This inconsistent and unreliable funding makes securing a long-term financial commitment to inspection and maintenance difficult and subject to political pressures. Nevertheless, tax revenues remain a popular funding source because the collection and disbursement system is already in place and familiar.

Utility Charges

Using utility charges to fund inspection and maintenance is a somewhat recent application of an already established financing technique. In addition, several municipalities and counties throughout the country have runoff management, drainage, and flood control authorities or districts to provide residents with runoff related services.

Using utility charge financing has several advantages. By addressing only runoff needs and benefits, utility funding avoids competing with other programs and needs. Utility funding also demonstrates a direct link between the funding and the services it provides. This approach can require an entirely new operating system and organization that needs legal authorization to , exist, operate, and assess charges. The effort required to create such an entity can deter many, although the continued success of established authorities and growth of new ones have done much to allay concerns over the effort required.

In a runoff utility, the user charges are often based on the need for services rather than the benefits derived from them. While charges are based on actual costs to inspect and maintain runoff facilities and measures within the service area, the assessed rate structure should relate to site characteristics. These include property area size, extent of impervious coverage, and other factors with a direct and demonstrable effect on runoff. To be fair, the rate structure should also remain simple and understandable to the ratepayer.

To finance the stormwater utility in Prince William County, Virginia, residential and nonresidential owners of developed property pay based on the amount of impervious area (rooftops, paved areas, etc.) on their property. Residents pay $10.38 billed twice a year ($20.76 total annual fee) for detached singe-family homes. Town home and condominium owners will pay $7.785 billed twice a year ($15.57 total annual fee). Nonresidential property owners pay $0.84 per 1,000 ft2 of impervious area per month. Fee adjustments or credits may be available if a stormwater management system is already in place. The fee will be on the real estate bills.

Fees for the stormwater utility in Austin, Texas are higher with residential users billed $5.79/mo, while commercial users pay $94.62/mo/acre of impervious cover. These fees cover not only maintenance of existing BMPs, but also capital improvement projects related to the drainage infrastructure.

Permit Fees

Collecting permit fees to finance runoff inspection and maintenance is a long standing funding procedure. Most governmental entities local, county, and state can establish and collect fees and other charges to obtain operating funds for programs and services. Many inspection services, most notably the construction inspection of both ESC measures and permanent drainage and runoff management facilities, are financed at least in part through fees collected by permitting agencies. Unlike taxes or some utility charges, inspection costs are borne by those who need them.

The permit fee collection program should have a demonstrable link to the runoff management or drainage systems. The public agency should demonstrate a direct link between the permit fees collected and the permitted project one method is using dedicated accounts for individual projects and facilities. Finally, the rate structure should reflect site characteristics such as area size or imperviousness that directly relate to the measure or facility by affecting runoff or erosion.

Dedicated Contributions

Public agencies at times have used developer contributions to fund long-term facility maintenance. This approach is particularly appropriate in single-family residential subdivisions, where numerous individual property owners served by a single runoff facility can result in confusion over who has maintenance responsibility.

The exact funding technique depends on many factors, including community attitude and knowledge, economic and political viability, and program needs and costs. Some techniques, including permit fees and dedicated contributions, may be more appropriate for short-term activities, such as construction inspection. Others utility charges and specialized tax revenues may apply to all phases of an inspection and maintenance program but require considerable effort and special legal authorization to operate.

Wetland MP-20

Description

A manufactured wetland is similar to public domain stormwater wetlands. In a manufactured wetland, gravel substrate and subsurface flow of the stormwater through the root systems force the vegetation to remove nutrients and dissolved pollutants from the stormwater.

Only one company currently manufactures a pre-engineered wetland: It consists of a standard module, about 9.5 feet in diameter and 4 feet in height. The module is constructed of recycled polyethylene. The number of units is varied to meet the design volume of the site.

California Experience

There are currently only a few installations in California.

Advantages

- Constructed wetlands remove dissolved pollutants unlike many of the other treatment technologies, whether manufactured or in the public domain.
- Gravel substrate and subsurface flow of the stormwater through the root systems forces the vegetation to remove nutrients and dissolved pollutants from the stormwater.
- Unlike standard constructed wetlands (TC-21), there is no standing water in the manufactured wetland between storms (after emptying with each storm). This minimizes but does not entirely eliminate the opportunity for mosquito breeding.
- Can be incorporated into the landscaping of the development.
- The gravel substrate likely provides a good environment for bacteria, facilitating the removal of nitrogen and the degradation of oil and greases, and other organic compounds.
- The gravel substrate can be augmented with media that is specifically effective at removing dissolved pollutants, increasing further the performance of the system.
- Vegetation is more easily harvested in comparison to a wet pond or standard constructed wetland (TC-21).
- Provides modest habitat for insects and other small invertebrates which in turn provide food for birds and other small animals.

Design Considerations

- Drainage Area Size
- Potential Pretreatment Requirements

Targeted Constituents

- Sediment
- Nutrients
- Trash
- Metals
- Bacteria
- Oil and Grease
- Organics

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Limitations

- Not likely suitable for drainage areas greater than an acre due to the number of units that is required for larger sites.
- May attract invasive wetland species
- May require irrigation during the dry season
- With an emptying time as much as 5 days, a breeding ground for mosquitoes may occur during and immediately following each storm
- If site development requirements of local government also includes detention for flow control, the drawdown characteristics of the system must be compatible with the detention system.

Where many units are required, the pattern of circular plastic covers of the center wells may not be appealing.

Design and Sizing Guidelines

The unit consists of two concentric chambers, analogous to a doughnut. The inner chamber is open whereas the outer chamber is filled with gravel in which the wetland plants reside. The water enters a center well, moving in a circular motion around nearly the entire circumference of the well. Via floating surface skimmers the water then enters the outer chamber. The flow rate is controlled at the outlet with a valve. The substrate for the vegetation is small gravel. Gravel substrate encourages the wetland vegetation to use nutrients and metals in the stormwater. The concept of subsurface flow through gravel has its parentage with subsurface flow constructed wetlands used to treat wastewater.

The unit includes a burlap bag over the inlet to remove debris, and screens within the center well for the same purpose. However, the upstream drainage system is considered the primary remover of coarse solids and debris. If the drainage system lacks drain inlets with sumps where coarse sediments and floatables are removed, it is desirable to include a pretreatment unit for this purpose such as a manhole or wet vault of suitable size.

Table 1 Supplemental Media

Targeted Pollutant	Alternative Media	References
Complex organics (e.g., pesticides)	Activated carbon	Metcalf and Eddy (2002), Minton (2002)
Petroleum hydrocarbons	Activated carbon, organoclay, granular polymer	Minton (2002)
Dissolved metals	Zeolite, activated carbon	Minton (2002), Groffman, et al. (1997), Netzer and Hughes (1984), Stormwater Management Inc. technical memos
Dissolved phosphorus	Blast furnace slag, iron-ore, iron wool, limestone, aluminum oxide, dolomite, iron-infused resin	James, et al. (1992), Minton (2002), Shapiro (1999), Ayoub, et al. (2001), Storm-water Management Inc memos

The design water quality volume is determined by local governments or sized so that 85% of the annual runoff volume is treated.

Construction/Inspection Considerations
Refer to manufacturer guidelines.

Performance
There is little operating data for the manufactured wetland, although these data indicate very high removal efficiencies, similar to created stormwater wetlands. An advantage of wet ponds and standard constructed wetlands over most other treatment technologies is the removal of dissolved pollutants. However, this occurs only to the extent that the stormwater pollutants are able to diffuse into the soil where they are removed by the soil or the plants. Except for nonrooted plants, pollutant uptake by vegetation does not occur in the overlying wet pool (Minton, 2002). Placement of wetland plants in gravel with the stormwater flowing directly through the root system forces uptake by the vegetation. To maintain performance therefore requires annual or harvesting of the vegetation (See Maintenance). However, the removal of dissolved phosphorus, metals, and complex organics like pesticides in earthen-lined ponds and wetlands is primarily by chemical sorption or precipitation with the soil, not uptake by plants (Minton, 2002). Gravel substrate does not provide ideal conditions for these chemical processes. There are currently no operating data for the manufactured wetland with respect to the removal of dissolved pollutants and therefore whether uptake solely by plants is sufficient is unknown. It may be desirable to augment the gravel with media capable of removing dissolved pollutants. The supplemental media can be specific for the pollutant that is to be removed. Table 1 lists media that have been evaluated in either stormwater or wastewater constructed wetlands or filtration systems.

The gravel substrate likely provides a good environment for bacteria, facilitating the removal of nitrogen (its primary mechanism of removal) and the degradation of petroleum and other organic compounds. While this has been confirmed to occur in the manufactured product discussed here, experience with constructed wetlands used for wastewater treatment (Minton, 2002) suggests that it likely occurs

Siting Criteria
While not stated by the manufacturer, the system is likely most appropriate for small drainage areas of an approximately an acre or less, given the number of units required per acre.

Additional Design Guidelines
As noted previously, the number of units installed is the function of the volume of water to be treated: multiple units are installed in parallel with incoming stormwater split via a manifold. The storage volume of one unit is approximately 185 ft. The recommended emptying rate is 0.25 gallons per minute (average). To illustrate sizing, assume a development site of one acre and the design event is o.75 inches. The total volume of the design event is 2,722 cubic feet. Thus, a minimum of 15 units is required, ignoring throughput during the storm. At this rate, a unit drains in approximately 3.8 days.

However, the emptying time must be considered with respect to the inter-event time between storms. If the emptying time is too great there is a statistical probability of some water being present in the units when the next storm occurs. If so, the full volume of the design event is not treated over the long term. The manufacturer currently does not provide a design method that considers this factor. The recommended approach is to use the method presented in TC-22 for Extended Detention systems inasmuch as the Storm Treat is a "fill-and-draw" system that functions like Extended Detention and should be expected to capture and treat the same stormwater volume over time.

Fewer units are possible if the upstream drainage system is able to store water, although this extends the emptying time. If a detection facility is required for flow control, it can provide the necessary storage and the number of wetland units is reduced, but not substantially given the need to drain the system in a timely fashion. Furthermore, if a detention facility is included it must control the release rate, not the manufactured wetland. This may require a more rapid release rate than recommended by the manufacturer. However, there are no data relating emptying rate with performance. Since the system also functions in effect as a horizontal filter, throughput rates higher than what is recommended by the manufacturer may be possible without a significant reduction in performance.

Maintenance

To maximize the benefits of wetland vegetation in its removal of pollutants, the vegetation must be harvested each growth season. Harvesting is particularly important with respect to the removal of phosphorus and metals, less so nitrogen. Harvesting should occur by mid-summer before the plants begin to transfer phosphorus from the aboveground foliage to subsurface roots, or begin to lose metals that desorb during plant die-off. While not stated by the manufacturer, it is also desirable that every few years the entire plant mass including roots is harvested. This is because the belowground biomass constitutes a significant reservoir (possibly half) of the nutrients and metals that are removed from the stormwater by plants (Minton, 2002). Annual maintenance is typical.

If debris and floatable material is not effectively removed in the pretreatment unit, premature clogging of the debris bag may occur.

- Crop vegetation near end of each growth season to capture the nutrients and pollutants removed by the wetland vegetation.
- Inspect periodically to ensure that invasive species of wetland plants is not occurring
- Conduct inspection during the dry season to determine if irrigation of plants is necessary
- Clean center well periodically.

Cost

Manufacturers provide costs for the units including delivery. Installation costs are generally on the order of 50 to 100 % of the manufacturer's cost.

Cost Considerations

- If the drainage system lacks drain inlets with sumps where coarse sediments and floatables are removed, it is desirable to include a pretreatment unit forthis purpose such as a manhole or wet vault of suitable size. This should be factored in the cost-analysis when comparing to other treatment BMPs. If already a requirement of the local government, a detention facility for flow control can serve this purpose.

- In comparison to public domain wet ponds (TC-20) and constructed wetlands (TC-21), vegetation harvesting is simpler, and therefore less costly.

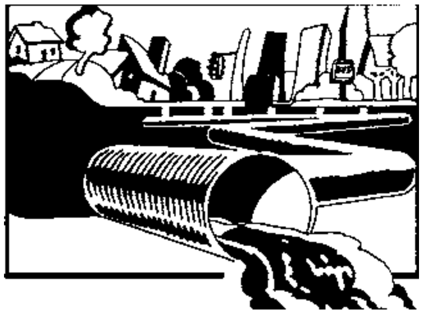
References and Sources of Additional Information

Ayoub, G.M., B. Koopman, and N. Pandya, 2001, Iron and aluminum hydroxy (oxide) coated filter media for low-concentration phosphorus removal, Water Environ. Res., 73, 7, 478

Groffman, A., S. Peterson, D. Brookins, 1997, The removal of lead and other heavy metals from wastewater streams using zeolites, zeocarb, and other natural materials as a sorption media, presented to the 70th Annual Conference, Water Environment Federation, Alexandria, Virginia

James, B.R., M.C. Rabvenhorst, and G.A. Frigon, 1992, Phosphorus sorption by peat and sand amended with iron oxides or steel wool, Water Environ. Res., 64, 699. Manufacturer's literature Metcalf and Eddy, Inc., 2002, Wastewater Engineering: Treatment, Disposal, Reuse, McGraw-Hill, New York, New York. Minton, G.R., 2002, Stormwater Treatment: Biological, Chemical, and Engineering Principles, RPA Press, Seattle, Washington, 416 pages. Netzer, A., and D.E. Hughes, 1984, Adsorption of copper, lead, and cobalt by activated carbon, Water Res., 18, 927. Shapiro and Associates and the Bellevue Utilities Department, 1999, Lakemont stormwater treatment facility monitoring report, Bellevue, Washington

APPENDIX 4



Maintaining Wet Detention Ponds

Stormwater
Fact Sheet
No. 7

This fact sheet is part of a series for local government officials and citizens on stormwater runoff problems and control strategies. The series covers:
1. Stormwater Problems And Impacts
2. Control Principles And Practices
3. Rules And Regulations
4. Local Program Elements And Funding Alternatives
5. Municipal Pollution Prevention Planning
6. Managing Stormwater In Small Communities: How To Get Started
7. Maintaining Wet Detention Ponds
8. Plan Early For Stormwater In Your New Development
9. How Citizens Can Help Control Stormwater Pollution

Introduction

Stormwater runoff is a significant source of water pollution in urbanizing areas. To address this problem, the State of North Carolina and some local governments have adopted programs that require or encourage the use of wet detention ponds to treat stormwater runoff. Studies have shown that wet detention ponds can be very effective in removing certain pollutants including sediment, some nutrients and heavy metals.

If properly designed, constructed and maintained, wet ponds will not only protect water quality, but can reduce peak stormwater flows and can be an attractive feature of a development.

Why Some Ponds Fail

Studies have shown that poor operation and maintenance is the leading cause of pond failure. Poor maintenance can also create nuisance odors, insects, algae blooms and unsightly areas. Detention ponds can fail for several reasons including:

- Improper design and siting
- Poor vegetation management
- Inlets and outlets clogged by sediment or trash and debris
- Storage capacity of pond reduced due to sediment accumulation
- Failed sideslopes or dam
- Inadequate access for maintenance

Ponds Can Be Attractive Features Within A Development.

Land-Of-Sky Regional Council
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(704) 251-6622

Maintenance Considerations

Routine maintenance is vital to the proper operation of a wet basin. Every pond is different and its maintenance needs will depend on the size, type and condition of the watershed that contributes runoff to the pond. For example, a pond serving a large commercial district with several land disturbing activities may require more maintenance than one serving a small established neighborhood. Maintenance should always include minimizing erosion problems and pollutant introduction in the contributing watershed.

The location of the pond in the development may have a bearing on how well it's maintained. People have more favorable impressions of wet ponds, are less likely to throw trash in them and are more likely to clean and maintain basins when they are provided a prominent position in the development.

The *O&M* Program

An effective Operation and Maintenance Program requires:

1. A good O&M Plan that specifies what O&M actions are needed and when they will be performed;
2. The identification of responsible parties; and 3. Adequate funding for maintenance activities.

In general, maintenance programs should contain the following components:

Components of a Maintenance Program

Routine

- Inspection
- Vegetation Management
- Debris/Litter **Control**
- **Mechanical Components Maintenance**

Non-Routine

- **Bank Stabilization**
- **Sediment Removal**
- **Outlet structure maintenance/replacement**

Routine Maintenance

Inspections

Frequent inspections by the responsible party are required to ensure proper operation. An inspection should be made after major rainfall events to check for any obstructions or damage and to remove accumulated trash and debris. Other inspections should be made according to the responsible party's operation and maintenance plan required by the state or local government.

At a minimum, an inspection should include review of the following:

<u>Minimum Inspection Checklist</u>

- Obstructions of the inlet or outlet devices by trash and debris
- Excessive erosion or sedimentation around the basin
- Cracking or settling of the dam
- Deterioration of inlet or outlet pipes
- Condition of the emergency spillway
- Stability of sideslopes
- Up and downstream channel conditions
- Woody vegetation in or on the dam

Vegetation Management

Vegetation in and around the pond must be mowed or maintained on a regular basis to prevent any erosion or aesthetic problems. Cattails, and other indigenous wetland plants are encouraged along the pond perimeter for pollutant uptake and breakdown, but must be removed when they cover the entire pond surface. Use of fertilizers and pesticides in or around ponds should be minimized to avoid their entry into the pond and downstream waters.

Debris and Litter Removal

Debris and litter control checks for inlet, outlet and orifice obstructions should be made after every runoff producing rainfall. Side slopes and the. collection system (i.e. catch basins, piping and grassed swales) also need litter and debris removal on a regular basis.

Mechanical Components Maintenance

The inspector should check the operation of any valves, pumps, fence gates, locks or mechanical components on a regular basis and make immediate repairs or replacements.

Non Routine Maintenance

Bank Stabilization

It is important to keep an effective ground cover on all vegetated areas. This helps to prevent erosion, stabilize banks and prevent any unnecessary sediment from entering the basin. These areas should be reseeded or stabilized immediately.

Sediment Removal

Every six months, any accumulated sediment should be removed from the bottom of the outlet structure and the pond depth should be checked at various points. If depth is reduced to 75% of original design depth, sediment should be removed to the design depth to ensure adequate storage capacity. In general, sediment removal will be required every 5 to 15 years. A forebay placed upstream or incorporated into the upper portion of the pond enhances the sedimentation process and sediment and debris removal, and lowers maintenance costs. Onsite disposal of the sediment is the cheapest alternative. Some communities allow its use as landfill cover.

Outlet Maintenance / Replacement

Eventually the outlet structure or other structural components will need repair or replacement.

Who's Responsible?

Designation of a responsible party(ies) is important to assure proper inspection and maintenance. Maintenance is usually the responsibility of the property owner or a homeowners association. In some cases, a local government may accept maintenance responsibility and charge a fee for this service. Under the NC Water Supply Watershed Protection Act, local governments must inspect wet ponds at least annually to ensure proper maintenance by the responsible party.

Costs & Funding

Estimated annual operation and maintenance costs for wet basins are 3% to 5% of construction costs. Mowing and sediment removal are the most costly activities.

Responsible parties should establish a maintenance fund and assess annual fees on appropriate property/home owners. Local governments can establish stormwater utilities or charge inspection fees to carry out their maintenance responsibilities.

For More Information

Reference Documents

- An Overview of Wet Detention Pond Design, 1994, NC DEM - (919) 733-5083.
- Stormwater Management Guidance Manual, 1994, NC Cooperative Extension Service and NC DEHNR - (919) 5153723.

Contacts

- NC DEM Stormwater Management Group - (919) 733-5083, and DEM Regional Offices.
- Contact the appropriate local government.

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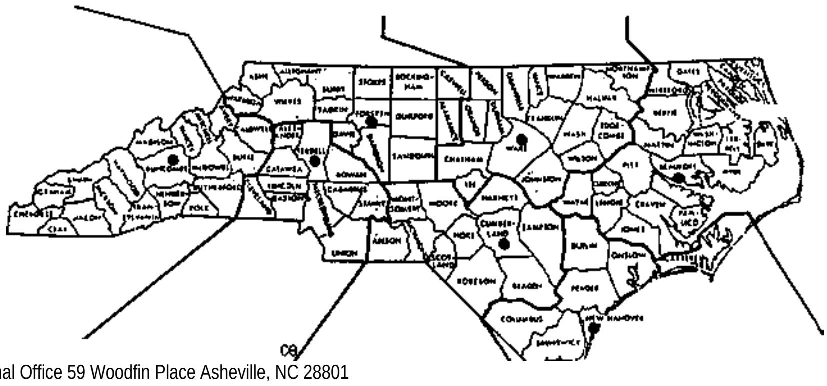

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