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GLOBAL WATCH MISSION REPORT

# Sustainable drainage systems: a mission to the USA

MARCH 2006

## Global Watch Missions

DTI Global Watch Missions enable small groups of UK experts to visit leading overseas technology organisations to learn vital lessons about innovation and its implementation, of benefit to entire industries and individual organisations.

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## Disclaimer

# Sustainable drainage systems:

## – a mission to the USA

REPORT OF A DTI GLOBAL WATCH MISSION

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BRITISH WATER

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## FOREWORD AND ACKNOWLEDGMENTS

During most of the twentieth century the municipal water industry met water supply and wastewater treatment requirements by increasing its treatment plants and networks and channelling excess surface and waste water into rivers. The end of the century saw significant changes with the privatisation of the industry and a consequent increase in regulations. The implementation of the Water Framework Directive (WFD) will add a further overarching layer of regulation designed to coordinate water use from resource to treatment and discharge in a sustainable way.

Demographic changes are also increasingly challenging the industry, raising the importance of resource management as well as surface and wastewater discharge, and putting pressure on environmental protection. Climate change is adding to these challenges and, along with the demands for continual urban expansion, is heightening the need to control surface water drainage to minimise flooding and its impact on communities and the wastewater network. Initially, sustainable urban drainage systems (SUDS) were given much attention but the need to manage the drainage of all surface water, whether rural or urban, has changed the emphasis to sustainable drainage systems (so maintaining the acronym SUDS) and to integrated water management.

In planning the mission the team was faced with balancing the opportunities of visiting regions of different climatic, demographic and environmental challenges with the time constraints of travel. The severe hurricane season of 2005 accentuated the extreme challenges for SUDS in the southern states of the US and so we decided to target regions where the challenges were more comparable to those the UK faced now or would face in the near future. Consequently, the itinerary featured locations away from the south and up to the east and west coasts of the US to evaluate different solutions for surface water and drainage problems relevant to the UK.

The mission was planned with assistance from a combination of personal contacts and US offices, or sister companies, of British Water members. We met and had full and informative discussions with many significant experts, regulators and practitioners. Many of our hosts also accompanied us on the site visits so maximising the benefits of seeing the application of a diverse range of solutions to stormwater and drainage issues.

We are extremely grateful to everyone, from the UK and the US, who contributed to the development of our extensive, diverse and comprehensive programme.

Arranging such an interesting and extensive series of visits inevitably affected the timelines and completion of the plans. We are very grateful for the support of the Global Watch team at DTI, especially to Harsha Patel, whose flexibility and patience, particularly with travel details, was very much appreciated by us all.

Ultimately, the success of the mission was down to the constructive and friendly cooperation of the team. I am extremely grateful for their support and fortitude as we covered more than 9,000 air miles and 700 road miles in the US, visited 13 centres and held obligatory end-of-day meetings to review the visits. This report is a tribute to everyone's commitment and reflects Professor Ashley's leadership and determination to maximise the

benefits from the mission. Even on visit 12, day 12 everyone could still raise a smile (see picture) – testimony to their stamina.

My sincere thanks are due to everyone who contributed to making the SUDS Global Watch Mission so enjoyable, rewarding and above all so informative.

Ian H Pallett
Technical Director, British Water

*Exhibit S.1 The team watching filter maintenance on a drain emptying into Los Angeles bay*

## EXECUTIVE SUMMARY

Surface 'stormwater' is water that can be seen in gutters and drains and on surfaces when it rains. The stormwater arises when rain falls on to surfaces and complex processes result in the water running off overland and into water bodies or into the ground. Stormwater causes problems of flooding, and, by conveying contaminants (natural and man made) picked up from the surfaces over which it flows, also pollutes. The management of stormwater is a challenging problem which is exacerbated by uncertainty about future drivers such as climate change. Historically in the UK and most of the developed world, stormwater problems have been addressed using systems (drains, sewers and watercourses) to dispose of excess stormwater runoff as quickly as possible away from urban areas in particular, to points where it is no longer believed to be a problem.

The realisation over the last century that stormwater disposed of in this way can lead to problems downstream due to high flows, flooding, watercourse erosion, pollution and consequential ecological impacts, has led to the development of alternatives to piped and channelled drainage systems that try to more realistically replicate the natural physical, chemical and biological processes of evapotranspiration, filtration, detention and dispersion. These systems do not have a universally accepted collective name, and are known variously as: best management practices (BMP) and/or low impact developments (LID) in the US and as sustainable drainage systems (SUDS) in the UK. Elsewhere other terms are used, such as water sensitive urban design (WSUD) in Australia and much of the Far East. In Scandinavia the term source control is also used when dealing with stormwater near to the point at which it first originates.

A major facet of these new 'natural' stormwater management approaches is the need for greater engagement of those involved in development planning, maintenance, operation, use and in generally sustaining the performance of these systems.

There are major impediments to the use of these systems in the UK, many of which arise owing to urban density, regulatory inadequacies and institutional constraints. Elsewhere in the world, such as in the US, many of these barriers do not exist, as institutional arrangements are different to the UK, although there are other challenges to overcome. In some parts of the US 'natural' stormwater systems, originally defined as BMPs, have been in use for at least 50 years as an alternative to traditional piped drains and sewers. Therefore, there is a long history of experience in regulating, implementing and use.

The UK, as elsewhere in Europe, is faced with implementing the requirements of the WFD by 2015. The directive is predicated on the need to ensure good ecological status of water bodies within defined river basin districts, of which there are 11 in England and Wales. The majority of stormwater in the UK is currently collected and conveyed in sewers that combine both stormwater and foul sewage in 'combined' systems. 70% of the sewers in the UK are currently combined; however, there are also networks of separate stormwater drains and sewers that convey runoff to a convenient watercourse or other receiving water body. These may be owned privately or be part of the 'public' network that is operated by sewerage undertakers. Other than oil interception, only in Scotland are there currently constraints on the discharge of separate stormwater into watercourses that require such discharges to be treated. It is likely, however, that in order to comply with the WFD, virtually all discharges of stormwater will in the future require some form of treatment.

There are clear parallels between the WFD and the equivalent legislation in the US, the Clean Water Act (CWA). The latter was implemented in the early 1970s and, despite some difficulties in implementation and enforcement, has resulted in significant efforts to improve the quality of America's 'impaired' water bodies, much of which has included improvements to stormwater management. US experience has shown clearly that the use of BMPs and LIDs can be a much more cost-effective way of ensuring protection to receiving waters than the UK approach of stormwater control using drains, sewers and (when enforced) some treatment at the 'end-of-pipe' prior to discharge. In addition to separate storm drainage, BMPs can also help to better manage the stormwater that is discharged into combined sewers by slowing down the rate of runoff, or even by removing these inputs altogether.

This mission investigated US practice in relation to UK practice and concluded that there are a number of important lessons and opportunities of relevance. There are apparent similarities in the reasons why there is a need to develop innovative stormwater systems, making the US experience very valuable in a UK context. These similarities include above all, the perceived and real need to improve environmental quality and the regulations driving this.

It is clear that the drivers for change need to be properly understood, influenced where possible, and planned for in good time using approaches that are flexible and likely to be adaptable as knowledge advances. Drivers such as the uncertainties of climate change can provide an opportunity to engage a large stakeholder community. They help to raise the resources needed to deliver the innovative solutions required if the responses are to be affordable. The delivery of these solutions also requires 'champions'- leading individuals or organisations with the vision and competence to bring others with them.

A wide range of proprietary technologies is now available that offers solutions to particular stormwater management problems; new systems are being developed all the time. Although there are units now available that appear to deal simultaneously with a range of pollutants for situations where there are physical, chemical and biological pollutants, it is essential to utilise a 'treatment train approach' with a number of separate BMP units used together. It is also vital to ensure that the performance of proprietary systems has been demonstrated at least by pilot scale accredited testing before any large scale utilisation.

An incremental approach to the improvement of stormwater quality for new developments and existing drainage systems seems to offer the best hope for cost-effective management of stormwater problems now and into the future. A large number of smaller units dispersed throughout catchments can utilise various innovative techniques and can be tested to assess how effective their individual performance is. Although this does spread the maintenance burden to a larger number of operators, investment in large 'end-of-pipe' systems is traditional in the UK and risks 'technology lock-in'. There will be a need to continue to use these systems even where they are shown in the future not to be sustainable. Local solutions also provide aesthetic and amenity benefits where the BMPs used have open surface water. Fears about health and safety problems associated with these seem to be largely unfounded, although there are some concerns in the US about mosquito breeding and the spread of West Nile virus.

Engagement of all stakeholders in sustainable drainage systems is essential and specific requirements under the CWA relate to public participation. Innovative service provision measures via, for example, a separate stormwater utility, coupled with distinct charging systems for stormwater, facilitate better engagement and responsibility. There is also the opportunity to use financial benefits (via rebates and special offers) to encourage those willing to take a more active role in stormwater management. In parts of the US this has led to the disconnection of individual property stormwater inputs (downspout disconnection) from the main drainage network, allowing cheaper alternatives to be used to deal with downstream problems in combined sewer networks.

Although shown to be effective, the 130+ types of BMP specified by the USEPA still require more investigation to determine when, where and how they should be used. Monitoring for compliance with the regulations, together with a number of national programmes in the US, such as the national urban runoff program (NURP) and the BMP database, have revealed the wide performance range of structural BMPs in terms of water quality improvements. Despite a number of recent research projects experience in the UK is even more limited. There is therefore a need to collect more and better information about the performance of these systems. Clear and statistically valid programmes of study are needed which will require considerable resources if they are to be of use.

In the UK the impediments to the use of BMP and LID approaches rest mainly on issues to do with ownership, responsibility and long-term maintenance. Notwithstanding the recent UK Water Industry Research (UKWIR)/Water and Environments Foundation (WERF) project on the whole life costs of these systems, there are significant and unquantifiable risks to any party adopting non-sewered stormwater systems in the UK. The adoption of BMPs and their maintenance in the US is varied. In some places it is the regulatory agency, usually the local municipality, elsewhere it can be the land owner or the property owner adjacent to the BMP who is expected to take responsibility, usually supported by the municipality. Separate stormwater utilities can provide these services, and as they do not need to own any assets (unlike the sewerage undertakers in England and Wales), can also be effective at promoting the use of non-structural BMPs through local education and capacity building.

# 1 INTRODUCTION

## 1.1 Context and aims of SUDS/Global Watch Mission

The management of stormwater has become much more complex as urban areas have developed, populations increased and expectations about environmental quality become higher. Within the past few decades, the developed world has experienced considerable changes in the management of stormwater. Considered as a means to simply convey stormwater away from cities and towns 'as efficiently as possible' in the 19th and most of the 20th century, stormwater systems now have to balance flood control, environmental protection and, where feasible, amenity provision. In Europe the WFD is now posing new challenges as it introduces a catchment-wide perspective to all water management, together with new ideas about the protection of the waters that receive stormwater runoff.

A number of countries worldwide have utilised systems for stormwater management that differ from the established 'piped' systems traditionally utilised in the UK.

The mission aimed to look at how the US manages storm and surface water from a number of different perspectives. The objectives were to:

- understand US institutional arrangements, federal and state regulations in relation to stormwater management, and how these are being applied in practice
- look at methodologies to control and treat stormwater such as BMPs, LID and proprietary systems, and the associated aspects of these systems in respect of design, application and maintenance (long term)
- investigate how contaminants are removed from surface water by various techniques and technologies, and how these could be applied in the UK
- understand the costs and charging arrangements that finance the stormwater infrastructure in the US and compare these to sewerage charges in the US and UK
- review the contribution of stormwater management solutions, and their relative cost-benefits, to the sustainability of water resources
- look at the methods of engagement of all the interested parties to see if these are effective
- understand where stormwater related research funds are being targeted in the US and what is driving these activities
- look at the effects on local developments, properties and receiving waters – where they could be observed – and to see if the stormwater solutions in use could provide additional local amenities
- gather information about water management in the US for dissemination in the UK.

## 1.2 The importance of stormwater management

Stormwater is a fundamental part of the natural water cycle; in addition to providing the main input to surface waters, it can also replenish groundwater aquifers. However, when surface and stormwater comes into contact with human activities pollution, in the form of particles, chemicals and biological contaminants, is picked up from both urban and rural runoff. Pollution from natural sources can also be captured in stormwater when rain falls on to natural surfaces and water flows through soil, across hillsides, in streams and rivers. Pollution arises via a large number of 'diffuse sources'. The overall effect from the runoff from a large number of relatively small diffuse sources should not be underestimated. When accumulated (downstream), they make a significant impact on environmental systems, which may be immediate (acute) or occur over longer periods of time (chronic). Because of the nature of diffuse pollution in urban environments, it is unlikely that there will ever be a simple and inexpensive solution for the control and removal of contaminants from stormwater. New ideas and methods are essential for a future solution to the problems that contaminants cause. This is reflected in the requirements in the WFD.

When stormwater is polluted it impacts on the food chain that supports fish and ecosystems in general. The rapid transfer of stormwater runoff also causes the scouring and erosion of watercourses and silting up of downstream areas. This damage by volume, speed and contamination is apparent in widespread areas: from poorer quality beaches to the destruction of the habitats of shellfish and other species.

## 1.3 The problems of stormwater and runoff

There are a large number of factors that contribute to making stormwater management a complex challenge:

- The topography and composition of each catchment area, soil type, degree and type of urbanisation etc
- Rainfall events are variable in space and time, and are likely to become more unpredictable due to climate change
- Runoff pollution can be characterised as biological, physical, chemical, with pathogenic impacts being important. The processes are driven by hydrology. These effects, and particulate transport, are coupled and complex phenomena
- The measurement of any aspects of storm events and runoff is complex, expensive and time consuming.

The complex issues and problems above mean that each individual site needs a unique solution in order to develop appropriate 'sustainable' drainage systems, which may currently be expensive, particularly where this is a highly engineered solution. An easy to understand applications guide on systems selection does not currently exist anywhere, although there is a large number of guidance documents in the US (See Section 2.5).

## 1.4 How stormwater is managed in the UK

Much of the existing sewerage and drainage systems in the UK originate from the Victorian era. A significant proportion of the sewers combine the foul and stormwater flows into a single 'combined' sewer. Sewer systems built since the Second World War usually keep the foul and stormwater separate. However, these invariably recombine in downstream main sewers. There is also a problem with the housing stock as the in-property drainage may already be configured for downstream combined sewerage.

When rain events occur the combined sewers have to convey the surface water runoff from the catchment areas. As it is too costly to allow for the largest events in the sewer network (even more so in the future with the uncertainty of climate change) the sewers need 'safety valves', which are outfalls known as combined sewer overflows (CSOs). These CSOs are only expected to operate during exceptional conditions, and there are agreements with the Environment Agency on how frequently they can operate in any 12-month period. Generally, 6 mm (in any two directions) screens are fitted to CSOs to protect the receiving watercourse from litter and any 'human debris'.

The main thrust today for controlling or attenuating stormwater flows is by recommending that all new developments embrace ‘sustainable drainage’ techniques. This is in an attempt to ensure that the runoff from any development does not exceed the ‘pre-development’ rate and also mimics nature as far as practicable. The use of SUDS systems is encouraged by the Local Authority planning system as it is a condition of granting the various building permissions. The Environment Agency is a statutory consultee in this process. However, it is widely acknowledged that the UK institutional, regulatory and financial systems have not achieved the desired outcome of ensuring that the newly developed site has the same runoff characteristics as a pre-developed site by the use of suitable SUDS.

At best, the planning system may seek to mitigate flood risks; however, virtually no stormwater quality issues are currently being addressed in England and Wales, although they are in Scotland. The European WFD will, by constraining the discharge of priority hazardous substances and discharges to groundwater, have a large impact on surface water quality issues in the future. The Freshwater Fish, Habitats and Bathing Water Directives can also impose a need to better control the quality of stormwater runoff.

### 1.5 BMPs, LIDs and proprietary systems in the US

There are two types of approach utilised in the US: BMPs and LIDs. Unfortunately, definitions vary. One definition of a BMP is a technique, measure or structural control that is used to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner. Whereas LID is a site design strategy used to achieve the goal of maintaining the pre-development hydrologic regime, or through the use of selected techniques to create functionally equivalent or minimally changed hydrologic landscapes.[1] This was reinforced by the USEPA, which indicated that: ‘*BMPs cover the widest category of wet weather flow controls from upland at points of pollution/flow origin to within the stream. LIDs are merely smaller controls placed upland at the residential/commercial site. BMPs can also be soft (education, elimination of pollution causing man-induced materials) or hard (ponds etc)*.’ Elsewhere the mission was told that: *‘the components of LID are BMPs. However, not all BMPs are LIDs (at least in some opinions). For example, a bio filtration system is a BMP and can be a component of LID. Most would argue that an underground ‘magic swirley device’, however, would be a BMP, but would not be considered LID.’*

According to Field et al[1]: BMPs are stormwater pollution control measures that include source controls (which keep pollutants from entering the stormwater runoff), structural controls (which remove pollutants from stormwater runoff before it reaches the water course) and non-structural controls (which seek to change and manage what people do in drainage areas, such as the use of garden pesticides). BMPs are also used for controlling the quantity and rate of water entering a stream in order to reduce erosion and flood risks. BMPs are not standardised and vary depending on the policies of counties, townships and states, many of whom have their own design manuals and guidance documents (Section 2.5). BMPs may be a series of unit processes each with particular stormwater management characteristics comprising what is known as a BMP ‘treatment train’ (See section 2.2).

LIDs are site level (decentralised) stormwater and other water and town planning management practices that maintain the hydrologic cycle or meet targeted watershed

1 Field et al (2006). The use of best management practices (BMPs) in urban watersheds. DEStech pub. Inc, Lancaster Pennsylvania. ISBN 1-932078-46-0

objectives. They also include water recycling and reuse systems. This is accomplished by a combination of planning and design strategies that use conservation approaches and techniques to reduce the site development impacts along with integrated water management practices.

Proprietary products are engineered artefacts generally fabricated offsite in a factory or pre-designed systems constructed on-site. They have specific hydraulic and water quality design criteria and performance characteristics and are applied in 'known' circumstances. Proprietary systems can be part of a stormwater treatment train.

There are many terms used to describe 'non-piped' stormwater management systems. The term SUDS is only used in the UK and is not understood elsewhere in the world. In the US both BMP and LID are used, sometimes interchangeably, despite having distinct meanings as outlined above. Elsewhere in the world, other terms are also used, such as water sensitive urban design (WSUD) in Australia. In some countries the term for these systems is simply source control systems. The major problem with the UK term SUDS is that such systems are not a priori necessarily sustainable, as it depends entirely on the context in which they are used.

### 1.6 Setting up the visit

The group met on several occasions before deciding on the subjects within the stormwater area that it wanted to study. A list of potential contacts was drawn up from known US experts and centres of excellence and matched with the logistics of travel before deciding on the final venues and locations visited. Travel was a major factor in the process owing to the requirements of gathering as much information as possible and meeting the mission objectives. It was not possible to do everything that the group wanted to do within the time constraints.

Each visit usually took the format of the group presenting an outline of the visit objectives, then the host presenting information or defining what could be provided in the time allocated; this was followed by question and answer sessions. Site visits were essential to see what the stormwater problems and solutions were like in practice. The group met at the end of each day to consider the conclusions – it was usual to have more than 30 –, along with information from the hosts. One person from the delegation was then assigned to write up that particular day. These visit reports, summarised, are in Appendix C.

The final report was written by all members of the group after the mission. Each was assigned sections that best utilised their personal interests and specialties in storm and surface water management. Several post-mission meetings were needed to conclude the report.

# 2 US PRACTICE

## 2.1 Regulations and responsibilities

### 2.1.1 Clean Water Act (CWA)

#### *2.1.1.1 Background*

The EPA leads the nation's environmental science, research, education and assessment efforts and works to develop and enforce regulations that implement environmental laws enacted by congress.

The agency advances educational efforts to develop an environmentally conscious and responsible public and to inspire personal responsibility in caring for the environment. In recent years, approximately half of the EPA's budget has provided financial support to fund the state environmental applications and research programmes. The EPA is responsible for setting national standards for a variety of environmental programmes and has the power to delegate these responsibilities to the various states and municipalities for the issuing of permits and for monitoring and enforcing compliance. Where national standards are not met the EPA can issue sanctions and take other steps to assist the various states and municipalities in reaching the desired levels of environmental quality.

Growing public awareness and concern for controlling water pollution in the US, as evidenced by a series of litigations brought by environmental activists, led to the enactment of the Federal Water Pollution Control Act Amendments of 1972. Amended in 1977, this law became commonly known as the Clean Water Act (CWA).

The CWA established the basic structure for regulating discharges of pollutants into the waters of the US. It gave the Federal Agency and the EPA (see 2.1.3.1) the authority to implement pollution control programmes such as setting wastewater standards for industry. The CWA also continued requirements to set water quality standards for all contaminants in surface waters. The act made it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants programme and recognised the need for planning to address the critical problems posed by non-point source pollution.

The background is given in Maestre et al[2] and reproduced here. The National Pollutant Discharge Elimination System NPDES MS4: Municipal Separate Storm Sewer Systems was developed by the EPA in response to the United States Congress to protect US receiving waters from contaminated stormwater discharges. In 1972 the CWA expanded the federal role of water pollution control. Some of the effects of the CWA were to increase the federal funding for construction of publicly owned wastewater treatment works (POTW), and to develop community participation and a permit for each point discharge, among other activities. The NPDES established effluent guidelines for point discharges that contaminate the nation's water. The first stormwater regulation was issued in 1973[3], but the EPA believed that the traditional end-of-pipe controls used for

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2 Maestre, A., Pitt, R. E., Williamson D. 'Nonparametric statistical tests comparing first flush with composite samples from the NPDES Phase 1 municipal stormwater monitoring data.' Stormwater and Urban Water Systems Modeling. In: Models and Applications to Urban Water Systems, Vol. 12 (edited by W. James). CHI. Guelph, Ontario, pp. 317 - 338. 2004.

3 38 FR 13530, May 22

process discharges and treatment works could not be used to control stormwater pollution. In addition, it would require a tremendous effort to issue NPDES permits for each of the stormwater sources in the US.

The initial stormwater regulations (phase I) were developed for large municipalities (>100,000 population) and for certain industrial categories. Current regulations associated with phase II of the stormwater permit programme now require stormwater management for all urban areas in the US. The CWA of 1972 provided an important tool for communities. Section 208 provided the capability to implement stormwater management plans at the regional level. The task was welcomed by planning offices, which in some cases received advice from the US Army Corps of Engineers. In 1976, the EPA enlarged the planning initiative through the 'Section 208: Area-wide Assessment Procedures Manual'. However, in the late 1970s some problems arose with the 208 planning projects underway owing to inadequate data and lack of technological development.

Between 1978 and 1983, the EPA conducted the NURP that sought to determine water quality from separate storm sewers for different land uses. This programme studied 81 outfalls at 28 sites, monitoring approximately 2,300 storm events.

In 1987, the amendments to the CWA established a two-phase programme to regulate 13 classes of stormwater discharges. Two of these classifications were discharges from large and medium Municipal Separate Storm Sewer Systems (MS4s). A large MS4 serves an urban population of 250,000 or more, while a medium MS4 serves communities between 100,000 and 250,000. The EPA set up a permit strategy for communities complying with NPDES requirements.

Subsequent enactments modified some of the earlier CWA provisions. Revisions in 1981 streamlined the municipal construction grants process, improving the capabilities of treatment plants built under the programme. Changes in 1987 phased out the construction grants programme, replacing it with the State Water Pollution Control Revolving Fund, more commonly known as the Clean Water State Revolving Fund. This new funding strategy addressed water quality needs by building on EPA-state partnerships.

For many years following the passage of the CWA in 1972 the EPA, states and first nation indigenous tribes focused mainly on the chemical aspects of the 'integrity' goal. During the last decade, however, more attention has been given to physical and biological integrity. Also, in the early decades of the Act's implementation, efforts focused on regulating discharges from traditional 'point source' facilities, such as municipal sewage plants and industrial facilities, with little attention paid to runoff from streets, construction sites, farms, and other 'wet-weather' sources.

Starting in the late 1980s, efforts to address polluted runoff have increased significantly. For 'non-point' runoff, voluntary programmes, including cost-sharing with landowners, are the key tool. For 'wet weather point sources' like urban storm sewer systems and construction sites, a regulatory approach is being employed.

Evolution of CWA programmes over the last decade has also included something of a shift from a programme-by-programme, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach equal emphasis is placed on protecting healthy waters and restoring those that are 'impaired'. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining state water quality and other environmental goals is another hallmark of this approach.

#### *2.1.1.2 Delivering the CWA*

The CWA is the cornerstone of surface water quality protection in the US but it does not deal directly with issues relating to ground water or quantity. The statute employs both regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways and to assist in the financing of municipal wastewater treatment facilities and to manage polluted runoff. These initiatives are required to support in particular the protection and propagation of wildlife, including fish and shellfish, and recreation both in and on the water.

Programmes over the last decade have resulted in a shift from a source-by-source and pollutant-by-pollutant approach to more holistic water-based strategies. Under the watershed (ie whole catchment area) approach, equal emphasis is placed on protecting healthy waters and restoring those that are impaired. This new approach also included the involvement of stakeholder groups in the development and implementation of strategies for improving and maintaining state water quality and other environmental goals.

Congress amended the CWA in 1987 to establish the non-point source management programme. This section deals with a range of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific non-point source implementation projects.

In April 2000, the EPA and the states joined together to form a new state and EPA Non-Point Source Partnership to identify, prioritise and provide resolutions to non-point source problems.The states and the EPA have established eight work groups to focus on non-point source topic areas:

- watershed planning and implementation
- rural non-point sources
- urban non-point sources
- non-point source grants management
- non-point source capacity building and funding
- information transfer and outreach
- non-point source results
- non-point source monitoring.

It is anticipated that the information and products emerging from these eight groups should assist the individual states to more effectively implement their non-point source management programmes.

#### *2.1.1.3 Total maximum daily load (TMDL)*

The precise way in which the requirements of the CWA are implemented at site level is via the definition of TMDLs for any impaired water bodies. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet pre-defined water quality standards, and an allocation of that amount to the source of pollutants causing the impairment.

The typical steps for developing a TMDL include[4]:

- identify linkages between water quality problems and pollutant sources
- estimate total acceptable loading rate that achieves water quality standards
- allocate acceptable loading rates between sources
- package the TMDL for EPA approval.

4 USEPA Office of Water Nonpoint source control Branch, Washington (2005). Handbook for developing watershed plans to restore and protect our waters. EPA 841-B-05-005. Draft October.

The most common reported impairments are: metals (19%), pathogens (13%), nutrients (9%) and sediment (8%).

The CWA section 303 establishes the water quality standards and TMDL programmes. The justification for which was that over 40% of assessed waters in the US still do not meet the water quality standards states, territories and authorised tribes have set for them. This amounts to over 20,000 individual river segments, lakes and estuaries. These impaired waters include approximately 300,000 miles of rivers and shorelines and approximately 5 million acres of lakes polluted mostly by sediments, excess nutrients and harmful micro-organisms. An overwhelming majority of the population – 218 million – live within 10 miles of these impaired waters.

Under section 303(d) of the 1972 CWA, states, territories and authorised tribes are required to develop lists of impaired waters. These impaired waters are those that do not meet the water quality standards that states, territories and authorised tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters.

A TMDL specifies the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and allocates pollutant loadings among point and non-point pollutant sources. By law, the EPA must approve lists and TMDLs established by states, territories and authorised tribes. If a state, territory or authorised tribe submission is inadequate, the EPA must establish the list or the TMDL. The EPA issued regulations in 1985 and 1992 that implement section 303(d) of the CWA – the TMDL provisions.

Local water quality standards are therefore set by states, territories and authorised tribes. These identify the uses for each water body, for example, drinking water supply, contact recreation (swimming) and aquatic life support (fishing), and also the relevant

| Water body | TMDL pollutant | Water quality target | Natural allocation | TMDL goal | Targeted beneficial uses |
|---|---|---|---|---|---|
| A. Hiddenwood watershed, Walworth County South Dakota (February 1999) | Accumulated sediment | Increase/maintain lake storage capacity by 53 acres | 94% of loading attributable to natural background | 5% decrease in sediment loads from watershed | Immersion recreation; limited contact recreation; warm water semi-permanent fish life propagation |
| | Total phosphorus | Increased visitor days/camp site use; decreased incidence of winter fish kills | 95% of loading attributable to natural background | 2% decrease in total phosphorus loads from watershed | |
| B. Hunt River watershed Rhode Island (February 2001) | Fecal coliforms | Shall not exceed a geometric mean value of 20 FC/ 100 ml and not more than 10% of the samples shall exceed a value of 200 FC/100 ml. | Natural background loads from wildlife, especially geese, and other sources are thought to make up a significant portion of the total fecal coliform load in the Hunt River watershed. Precise levels are unknown. | Between zero and 99% load reduction in FC depending on the source and current input loading. | A source of public drinking water supply, primary and secondary contact recreational activities, and fish and wildlife habitat. |

*Table 2.1 Examples of TMDLs from EPA website (http://www.epa.gov/owow/tmdl/examples/)*

scientific criteria to support that use. The calculation must include a margin of safety to ensure that the water body can be used for the purposes the state has designated. The calculation must also account for seasonal variation in water quality. Examples are illustrated in Table 2.1.

Example A in Table 2.1 illustrates the use of 'blanket' reductions in solids loads and phosphorous across a catchment, for which the TMDL is related to a specific percentage reduction in concentrations of discharged pollutants. Whereas example B shows a much more detailed application with assigned reductions in inputs to each of the contributory sources. In the latter example, there are five major sources of fecal coliform bacteria in the Hunt River watershed. These include stormwater runoff from highways and residential/commercial areas, a dairy farm, pigeons roosting under a highway, a horse farm and resident waterfowl, domestic pets, and wildlife. The largest dry weather sources of bacteria are the dairy farm, pigeons roosting under the highway overpass, domestic pets, resident waterfowl and other wildlife. The largest wet weather source of bacteria to the watershed is stormwater runoff. Although other sources are significant during wet weather, stormwater runoff has a greater cumulative impact in the watershed. There are clear difficulties in reaching either of the targets presented in each example. In example B, the EPA provides suggestions for BMPs, as illustrated in Table 2.2.

| Recommended BMP | Responsible entity |
|---|---|
| Discourage the presence of resident waterfowl | Residents and property owners, towns of North Kingstown and East Greenwich |
| Structural stormwater management BMP(s) | Town of North Kingstown |
| Agricultural BMPs, including a waste storage structure, roof runoff management. | Farm owner |

*Table 2.2 Examples of BMPs suggested to achieve the TMDLs for example B in Table 2.1*

Specific guidance is also provided in the regulatory guidance on the public outreach programme. For Example B, this should be aimed at informing and educating residents in the watershed about the sources of bacteria in streams and ways to eliminate or reduce these sources. The local towns would be responsible for carrying out this programme. The public outreach programme in the Hunt River watershed should focus on educating the public about the negative water quality impacts that resident waterfowl can have, and the potential health risks associated with encouraging the presence of these waterfowl in local ponds, impoundments and on lawn areas. Additionally, educational information should be distributed concerning the importance of proper maintenance and pet waste clean-up.

While TMDLs have been required by the CWA since 1972, states, territories, authorised tribes and the EPA had not developed many until recently. This led to citizen organisations bringing legal actions against the EPA seeking the listing of waters and development of TMDLs. To date, there have been some 40 such legal actions in 38 states. The EPA is under court order or consent decrees in many states to ensure that TMDLs are established, either by the state or by the EPA.

In an effort to speed US progress toward achieving water quality standards and improving the TMDL programme, the EPA began a comprehensive evaluation of EPA and the states' implementation of its CWA section 303(d) responsibilities in 1996. The EPA convened a committee under the Federal Advisory Committee Act, which issued its recommendations in 1998. These were used to guide the development of proposed changes to the TMDL regulations, which the EPA consulted on and published the final rule on in July 2000. However, Congress added a 'rider' to one of their appropriations bills that prohibited the EPA from spending money in 2000 and 2001 to implement the new rule.

The current rule remains in effect until 30 days after Congress permits the EPA to implement the new rule. TMDLs continue to be developed and completed under the current rule as required by the 1972 law and many court orders. The regulations that currently apply are those that were issued in 1985 and amended in 1992.[5] These regulations mandate that states, territories and authorised tribes list impaired and threatened waters and develop TMDLs.

For more information, see the EPA TMDL web site: (http://www.epa.gov/owow/tmdl/)

### 2.1.2 Institutional arrangements, regulations and standards, planning systems and master planning

#### *2.1.2.1. Adoption (permitting)*

As authorised by the CWA, the National Pollutant Discharge Elimination System (NPDES) permit programme controls water pollution by regulating point sources that discharge pollutants into waters of the US. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, that use a septic system or do not have a surface discharge, do not need an NPDES permit. However, industrial, municipal and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit programme is administered by authorised state governments.[6] Since its introduction in 1972, the NPDES permit programme has been responsible for significant improvements to water quality.

#### *2.1.2.2 State and tribal programme authorisation status*

States, tribes and territories are authorised through a process that is defined by the CWA. States that want to be authorised to administer the NPDES programme submit a letter to the EPA from the Governor requesting review and approval. The EPA then determines whether the package is complete within 30 days of receipt. Within 90 days of receipt the EPA renders a decision to approve or disapprove the programme. The time for review may be extended by agreement.

The NPDES programme[7] consists of various components, including:

- NPDES base programme for municipal and industrial trial facilities
- federal facilities
- general permitting
- pre-treatment programme
- biosolids.

A state may receive authorisation for one or more of the NPDES programme components. For example, if the state had not received authorisation for federal facilities, the EPA would continue to issue permits to federal facilities (eg military bases, national parks, federal lands etc).

The process of authorisation includes a public review and comment period and a public hearing. If the EPA disapproves the programme, it remains the permitting authority for that state, tribe or territory. If the programme is approved, the state assumes permitting authority in lieu of the EPA. All new permit applications would then be submitted to the state agency for NPDES permit issuance. Even after a state receives NPDES authorisation, the EPA continues to issue NPDES permits on tribal lands (if the tribe is not administering its own approved NPDES programme). The current status of each state is given in Table 2.1.

5 40 CFR Part 130, section 130.7

6 http://cfpub.epa.gov/npdes/statestats.cfm).

7 http://cfpub.epa.gov/npdes/index.cfm

| State | Approved state NPDES permit programme | Approved to regulate federal facilities | Approved state pre-treatment programme | Approved general permits programme | Approved biosolids (sludge) programme |
|---|---|---|---|---|---|
| Alabama | ✔ | ✔ | ✔ | ✔ | |
| Alaska | | | | | |
| American Samoa | | | | | |
| Arizona | ✔ | ✔ | ✔ | ✔ | ✔ |
| Arkansas | ✔ | ✔ | ✔ | ✔ | |
| California | ✔ | ✔ | ✔ | ✔ | |
| Colorado | ✔ | | | ✔ | |
| Connecticut | ✔ | ✔ | ✔ | ✔ | |
| Delaware | ✔ | | | ✔ | |
| District of Columbia | | | | | |
| Florida | ✔ | ✔ | ✔ | ✔ | |
| Georgia | ✔ | ✔ | ✔ | ✔ | |
| Guam | | | | | |
| Hawaii | ✔ | ✔ | ✔ | ✔ | |
| Idaho | | | | | |
| Illinois | ✔ | ✔ | | ✔ | |
| Indiana | ✔ | ✔ | | ✔ | |
| Iowa | ✔ | ✔ | ✔ | ✔ | |
| Johnston Atoll | | | | | |
| Kansas | ✔ | ✔ | | ✔ | |
| Kentucky | ✔ | ✔ | ✔ | ✔ | |
| Louisiana | ✔ | ✔ | ✔ | ✔ | |
| Maine | ✔ | ✔ | ✔ | ✔ | |
| Maryland | ✔ | ✔ | ✔ | ✔ | |
| Massachusetts | | | | | |
| Michigan | ✔ | ✔ | ✔ | ✔ | |
| Midway Island | | | | | |
| Minnesota | ✔ | ✔ | ✔ | ✔ | |
| Mississippi | ✔ | ✔ | ✔ | ✔ | |
| Missouri | ✔ | ✔ | ✔ | ✔ | |
| Montana | ✔ | ✔ | | ✔ | |
| Nebraska | ✔ | ✔ | ✔ | ✔ | |
| Nevada | ✔ | ✔ | | ✔ | |
| New Hampshire | | | | | |
| New Jersey | ✔ | ✔ | ✔ | ✔ | |
| New Mexico | | | | | |
| New York | ✔ | ✔ | | ✔ | |
| North Carolina | ✔ | ✔ | ✔ | ✔ | |
| North Dakota | ✔ | ✔ | ✔ | ✔ | |
| Northern Mariana Islands | | | | | |
| Ohio | ✔ | ✔ | ✔ | ✔ | ✔ |
| Oklahoma | ✔ | ✔ | ✔ | ✔ | ✔ |
| Oregon | ✔ | ✔ | ✔ | ✔ | |
| Pennsylvania | ✔ | ✔ | | ✔ | |
| Puerto Rico | | | | | |
| Rhode Island | ✔ | ✔ | ✔ | ✔ | |
| South Carolina | ✔ | ✔ | ✔ | ✔ | |
| South Dakota | ✔ | ✔ | ✔ | ✔ | ✔ |
| Tennessee | ✔ | ✔ | ✔ | ✔ | |
| Texas | ✔ | ✔ | ✔ | ✔ | ✔ |
| Trust Territories | | | | | |
| Utah | ✔ | ✔ | ✔ | ✔ | ✔ |
| Vermont | ✔ | | ✔ | ✔ | |
| Virgin Islands | ✔ | | | | |
| Virginia | ✔ | ✔ | ✔ | ✔ | |
| Wake Island | | | | | |
| Washington | ✔ | | ✔ | ✔ | |
| West Virginia | ✔ | ✔ | ✔ | ✔ | |
| Wisconsin | ✔ | ✔ | ✔ | ✔ | ✔ |
| Wyoming | ✔ | ✔ | | ✔ | |

***Exhibit 2.1** National Pollutant Discharge Elimination System (NPDES) – status of US states*

There are certain omissions in Table 2.1. For example, Massachusetts Water Resources Authority (MWRA) controls all discharges and maintains systems in the Greater Boston area, but does not have approved regulatory authority.

*2.1.2.3 Issuing of permits*

The control of stormwater in the US depends ultimately on the appropriateness of the local municipality within the regulatory system. Whilst the granting of permits is delegated from the EPA to state level, this is often further delegated downwards. In general, this usually reflects the population of the area. For example, major cities such as New York or Boston would have their own role in the form of the authorities that are responsible to control stormwater. Where populations are less dense, this authority would be administered at county level, and in sparsely populated areas would probably be retained at state level.

Whilst the CWA is an overarching federal piece of legislation, there is a major variation in the discharge of its operation. The EPA provides advice on the drafting of 'state ordinances' and these are discussed further in the section on maintenance (2.3.4). Ultimately, it is the 'state ordinance' delegated to the appropriate authority that underpins the granting of the stormwater permits.

There is also a major variation in the way that stormwater regulations are enforced. The coastal states have a much wider appreciation of environmental issues and this has generally been focused in the local environment owing to direct and obvious impacts. Examples of these are pollution of beaches, degradation of streams and rivers, and the effect on wildlife (eg Chesapeake Bay, Boston).

Whilst it would appear that the regulations are disjointed – some states have still not achieved phase I of the CWA, let alone started working towards phase II, which has a delivery date of 2008 – this is in some ways understandable. Each state can have widely different approaches to the control of stormwater discharges and very often this is caused by extreme variations in climate, culture, city layout and demographics.

For instance, Los Angeles city is a huge conurbation (approximately 20 million people) and has little in the way of public parks and green areas. The stormwater runoff is predominantly from roof and road areas. Hence, polluted sediments washed off the surface are carried by the storm sewers directly to the sea where it pollutes the bathing waters and beaches. Hence the Los Angeles approach is to trap sediments. Examples of this are shown in the maintenance section (2.3). Much of this work has been undertaken as a result of court cases where the failure to achieve the limits on TMDLs has resulted in litigation.

However, there has been a sea change in attitude of the Los Angeles (and California) area. One of the biggest sustainable developments is taking place at Playa Vista where more than 1,000 acres of land is being developed with major features for the control of stormwater. These features range from water recycling to the avoidance of pollution using BMPs and LIDs.

In contrast to Los Angeles, the standards and regulations enforced in Washington state are considerably different. The biggest city is Seattle and the regulatory requirements of stormwater control and the administration of these is strictly enforced. New developments such as High Point utilise many techniques in the treatment of stormwater, including porous surfacing, bio-remediation swales and major ponds. In addition, they are engaged in major retrofitting exercises where bio-remediation swales are being introduced into existing neighbourhoods (SEA streets).

In summary, it is apparent that the regulatory practices from state to state are variable, but in general they are appropriate to the locale which they serve. Certain states, such as Washington and Oregon, perform to a very high standard and are the benchmarks for sustainable systems, whereas other states do not perform so highly, such as Texas.

Provided the construction of the stormwater systems receives the appropriate permits, then these will be adopted by the municipality, county or state.

#### *2.1.2.4 Municipal permitting process*

Any project that involves a new or change-of-use of property, construction or renovation, or other building and design elements, usually requires a permit from the Department of Planning and Development (DPD) of the municipality specific to the development location. The DPD administers construction and land use or zoning regulations for the development of all construction works within the limits of the municipality. Permits must be obtained prior to any works being carried out. There are two major types of permit issued by the respective DPD and these cover land use and construction and they may be applied for separately or together.

These permits are to assure that all structures meet the zoning requirements and comply with all environmental regulations including state acts and local plans and programmes. The construction related permits provide reviews of the required structural and safety elements and will determine whether any additional permits or a drainage review are required. Construction related permits include building, demolition and the re-grading of land. Other required permits are related to internal construction such as electrical wiring and plumbing, as well as those for working on public highways.

Zoning plans, stormwater and other related design manuals, permit application forms and checklists are available from municipalities in both printed and digital formats via their respective websites (eg http://www.epa.gov/npdes/authorisation).

#### *2.1.2.5 Drainage review*

A drainage review is required when any proposed project is subject to a development permit or approval, and the project:

- would result in 220 metres squared (2,000 feet squared) or more of impervious surface
- would involve 780 metres squared (7,000 feet squared) or more of land disturbing activity
- would construct or modify a drainage pipe or ditch that is 300 mm or more in size, or which receives surface and stormwater runoff from a drainage pipe or ditch
- is within or adjacent to a flood hazard area as defined in the municipality codes
- is located within a critical drainage area
- is a re-development project with a budget of $100,000 (approx. £53,000), or
- is a re-development project on a site where the total of the new plus the replaced impervious surface area is 550 metres squared (5,000 feet squared) or more

There are four drainage review types intended to evaluate the drainage requirements related to the project size, location, type and the anticipated impacts to the local and regional surface water system:

- small project drainage review
- targeted drainage review
- full drainage review
- large project drainage review.

Every project that requires a drainage review must meet the core requirements that are laid down in the surface water design manual developed by/for each local authorised regulator.

The core requirements include analysis of the following:

- discharge at the natural location
- off-site analysis
- flow control
- conveyance systems
- erosion and sedimentation control plan
- maintenance and operation
- financial guarantees
- water quality.

In addition to the core requirements, there are also special requirements that may apply to a proposed project. These are documented in the municipalities' surface water design manual and relate to:

- area specific requirements
- floodplain and flood way delineation
- flood protection facilities
- source control
- oil control.

#### *2.1.2.6 Master drainage plan process and components*

Planning as early as possible is the key to establishing a good project plan and to ensuring an understanding of the applicant and local authority needs and requirements. As part of the permitting process, a master drainage plan (MDP) is required. This generally follows a sequential 10-step process for urban development proposals. An urban planned development (UPD) permit gives broad approval of the overall site plan, project phasing and development standards that are to be applied to all future developments on the site, together with conditions that will mitigate any impacts upon the environment, public facilities and services. The plan identifies the particular locations, uses and density of proposed development.

The UPD permit becomes the mechanism by which the development is implemented and establishes conditions that are to be complied with by all subsequent land use approvals. The necessary requirements to mitigate any adverse impacts that are related to surface water management would be included within the UPD permit conditions of approval.

The recommended sequence of events to develop MDPs is as follows:

1) Pre-application meeting with local authority engineers
2) Preliminary application submission
3) MDP and baseline studies scoping
4) Preliminary draft MDP (conceptual drainage plan)
5) Draft MDP
6) Recommended MDP
7) Hearing examiner process
8) MDP finalisation
9) Construction monitoring
10) Post-development monitoring

The above process, if correctly followed, promotes dialogue between the applicant and the local authority that will provide advice and approval for each stage of the process, thus limiting time delays and costs. The purpose of the post-development monitoring is to determine whether the level of protection anticipated in the master drainage plan has been achieved.

In addition to tracking the efficacy of the mitigation measures, post-development monitoring can be a useful tool for decreasing uncertainty with respect to resource management issues and allowing the potential for modification of the regulations and policies. The approach is ideally suited to address uncertainty, when potential impacts may only be qualitatively estimated and the magnitude of the impact is unknown. This process allows for adjustments to be made, which may be structural and/or procedural, that will improve performance and mitigation measures.

#### *2.1.2.7 Public engagement (outreach)*

The stakeholder groups that need to be engaged vary depending on the local issues or problems. A stormwater public education programme (SPEP) is a requirement under the CWA and implements activities that are most likely to reach the identified target groups. Wherever possible, outreach activities are developed in order to reach residents to influence their behaviour as they engage in activities related to the target pollutants.

Messages for most target audiences concentrate on simple 'how-to' tips for preventing pollution and are generally pollution specific, for example, identifying the harm of target pollutants on the community or neighbourhood and tips to prevent or reduce consequent stormwater pollution.

The target pollutants for the SPEP are identified in the NPDES permits.
The NPDES permit, which includes the requirement for the implementation of an education programme, generally has the following three main goals:

- increase knowledge and awareness
- change behaviour
- reach a diverse audience.

The SPEP is a pollutant specific outreach effort designed to reach the polluters or potential polluters through a variety of outlets with similar messages to ensure exposure and to increase behaviour change. Within this integrated programme each activity is mutually supportive by building a network of public education and reaching many target audiences with pollution prevention tips.

The target pollutants for the SPEP are identified in the NPDES permit requirements. These include the following topic areas. This information is provided to the general public and associated industries free of charge via printed leaflets and internet:

- **Trash (litter)** – main target areas are restaurants and customers of fast food outlets
- **Indicator bacteria** – advice to owners of pets – including horses – and septic sewer systems
- **Nutrients** – advice to gardeners and owners of pets and septic sewer systems
- **Pesticides** – advice to pet owners, gardeners and DIY enthusiasts
- **Hydrocarbons** – most municipalities have a used oil recycling programme. DIY mechanics and the motor repair trade are both targeted.

### 2.1.3 Champions and sources of assistance

It is important to appoint or engage champions for stormwater innovations to be successful. Champions are, or become, leaders that can help spread the word and support innovative surface water drainage systems. Strong champions are needed and these are particularly important in the key stakeholder groups, which include the environmental organisations. It is important for the nominated or self appointed champions to have good knowledge and understanding of the issues and to ensure integration across disparate groups to create a strong commonality of purpose.
Where practicable, the 'adoption' by communities or stakeholders of stormwater facilities, such as ponds, is an opportunity that needs to be exploited to ensure long term success.

There is a need for the right champions with good knowledge to be engaged in the process to assist in the selection of the most sustainable solutions, and to ensure the water quality and other performance aspects, including flooding, are appropriately joined up.

Innovative funding schemes can be useful in promoting and raising awareness and encouraging stakeholder engagement, including champions. One example of a 'champion' organisation is the Center for Watershed Protection (CWP). The CWP was founded in 1992 and is classified as a not-for-profit organisation. It is dedicated to protecting and restoring watersheds (ie river catchments) through effective land and water management. It is considered to be the foremost authority in the development, application and dissemination of stormwater and watershed protection management techniques. It provides practitioners with real world solutions and believes that individuals, particularly within local governments and watershed groups, hold the key to protecting and restoring watersheds.

The centre undertakes and translates research mainly produced by others into practical tools so that the non-technical public, as well as experts, can understand and act upon the emerging guidance and recommendations. Activities are aligned to five main programme areas:

- research
- practice
- implementation
- learning
- education and outreach.

The development of BMPs and guidance for design and use by the centre have assisted municipalities in meeting the EPA requirements to minimise stormwater pollution entering water bodies by the reviewing of existing codes and the development of new manuals and best practice guidance.

The centre is financed from a number of sources, which include federal funds from the EPA and the undertaking of contract work for private consultants and local authorities (cities and municipalities). Outputs from research are turned into applicable and accessible guidance manuals and handbooks, and this information is also provided via its website, where extensive resources are available free of charge. The centre currently has 21 staff that have produced over 30 manuals and reports relating to urban watershed protection and restoration, developed extensive resources for the EPA and has conducted over 350 training workshops over the past 10 years.

The centre provides local governments, environmental groups and watershed organisations around the country with the technical skills to help protect and restore rivers, streams and lakes. This is done via a multi-disciplinary strategy to watershed protection, which includes research, developing watershed management practices, encouraging watershed planning and implementation, fostering learning, and building the capacity of local watershed organisations.

Stormwater management is an essential part of the work undertaken by the centre since it has recognised that untreated waters discharging to the environment present one of the greatest threats to water quality.

## 2.2 Treatment and management of urban stormwater runoff

Many cities across the US are looking for creative ways to treat and manage their stormwater. Different approaches are used if the stormwater is included in a new development or exists as runoff from already developed urban areas.

### 2.2.1 Best management practices (BMP)

The USEPA defines two types of BMP that are used to reduce the threat of stormwater runoff pollution from construction and development in urbanising areas: (i) non-structural or source control BMPs, and (ii) structural or treatment BMPs. A recent list of types of non-structural BMPs is given in

Table 2.3 and structural BMPs in Table 2.4.[8] LID is considered as a combination of both non-structural and structural BMP.

Non-structural controls that rely more on natural approaches – with limited construction – seek to minimise runoff or the introduction of pollutants. Structural controls involve 'engineering principles', designed to provide temporary storage or treatment of runoff in their delivery.

| Major categories | Non-structural practice |
|---|---|
| Public education | Public education and outreach |
| Planning and management | Better site design.<br>Vegetation controls.<br>Reduction/disconnection of impervious areas.<br>Green-roofs (also a structural control).<br>LID (combination of non-structural and structural). |
| Materials management | Alternative product substitution.<br>Housekeeping practices. |
| Street/storm drain maintenance | Street cleaning.<br>Catchbasin cleaning.<br>Storm drain flushing.<br>Road and bridge maintenance.<br>BMP maintenance.<br>Storm channel and creek maintenance. |
| Spill prevention and clean up | Above ground tank spill control.<br>Vehicle spill control. |
| Illegal dumping and controls | Illegal dumping controls.<br>Storm drain stencilling (labelling).<br>Household hazardous waste collection.<br>Used oil recycling. |
| Illicit connection control | Illicit connection prevention.<br>Illicit connection – detection and removal.<br>Leaking sanitary sewer and septic tank control. |
| Stormwater reuse | Landscape watering.<br>Toilet flushing.<br>Cooling water.<br>Aesthetic and recreation ponds. |

*Table 2.3 Non-structural BMPs for urban stormwater runoff*

| Major categories | Structural BMPs |
|---|---|
| Ponds | Dry retention ponds.<br>Dry-extended detention ponds.<br>Wet (retention) ponds. |
| Stormwater wetlands | Constructed wetlands. |
| Vegetative biofilters | Grass swales (wet/dry).<br>Filter strips/buffer.<br>Bioretention cells. |
| Infiltration practices | Infiltration trench.<br>Infiltration basin.<br>Porous pavement. |
| Sand and organic filters | Surface sand filter.<br>Perimeter filter.<br>Media filter.<br>Underground filter. |
| Technology options and other | Water quality inlets.<br>Multi-chambered treatment train.<br>Vortex separation/continuous deflection systems. |

*Table 2.4 Structural or treatment best management practices for urban stormwater*

### 2.2.2 Low impact development (LID)

The US goal of an LID is to mimic site pre-development hydrology by using design techniques that maintain the original infiltration, filtering, storage, evaporation, recharge and detention of runoff as close to the original condition as possible. Techniques are based on the premise that stormwater management should not be seen as stormwater disposal. Traditional techniques convey, manage and treat stormwater in large, costly end-of-pipe facilities (regional) located at the bottom of drainage areas, whereas LID addresses stormwater through small, cost-effective landscape features located ideally at the house plot level.

8 Water Environment Federation (WEF) and ASCE. (1998) Urban Runoff Quality Management. ISBN 1-57278-039-8. WEF, Alexandria, VA.

These landscape features, also known as LID integrated management practices (IMP)[9], are the building blocks of LID. Almost all components of the urban environment have the potential to serve as an IMP. This includes open space, rooftops, streetscapes, parking areas and pedestrian areas. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment and regeneration projects. Utilisation of LID practices can eliminate the need for centralised BMP facilities.

In the mid 1980s LID was pioneered to help Prince George's County, Maryland, to address the growing economic and environmental limitations of conventional stormwater management practices.

LID allows for greater development potential with less environmental impacts through the use of smarter designs and advanced technologies that achieve a better balance between conservation, growth, ecosystem protection and public health, and consequently quality of life.

Bioretention is seen as either a BMP facility (Table 2.3) or one of the many LID techniques that are available. Others include permeable paving, the use of street planters and swales and the disconnection of roof water down spouts. An LID site will incorporate a wide range of techniques that are designed to control pollutants, reduce runoff volume, manage runoff timing and address a number of other ecological concerns.

LID has numerous benefits and advantages over conventional stormwater management. It is a more environmentally sound technology and a more economically sustainable approach to addressing the adverse impacts of urbanisation. By managing runoff close to its source through intelligent site design, LID can enhance the local environment, protect public health, and improve and enhance visual amenity including the possibility of reducing project costs. To be successful, stormwater management programmes require that a wide array of complex and challenging ecosystem and human health protection goals be addressed.

Many of these goals are not, and cannot, be met by conventional stormwater management technology. Communities are struggling with the economic reality of funding the ageing and ever-expanding stormwater infrastructure. The challenge of how to restore stream quality in watersheds that have already been densely developed is daunting. Simply relying on impervious reduction and/or conventional detention ponds to address these issues is not feasible, practical or sustainable. LID provides the key in its emphasis on controlling or at least minimising the changes to the local hydrologic cycle or regime.

LIDs (or should these be re-named low impact designs?) are utilised to address a wide range of wet weather flow issues. These include combined sewer overflows (CSOs), NPDES stormwater phase II permits, TMDL permits, non-point source programme goals, and other water quality standards. The agencies responsible for permitting can use LID as a model to facilitate more cost-effective, ecologically sound development practices. Developers can achieve greater project success and cost savings through the intelligent use of LID, and designers can apply these techniques for innovative, educational, and more aesthetically pleasing sites.

A common concern is that LID-based projects will be more expensive because they could require higher design and construction costs and a longer period to receive project approval. This may or may not be true and will to a great extent depend upon the experience of the project consultants and contractors, and how receptive local government officials

9 Field R., Sullivan E. (Ed.) (2003) Wet weather flow in the watershed. Lewis pub. 1-56676-916-7. p281

are to innovative practices. Additional LID cost concerns include the potential for greater expense owing to the increased land take and landscaping requirements. Costs are very site specific and each project will be unique and be based on the site's soil conditions, topography, existing vegetation, land availability etc.

Despite these issues, experience in the US has indicated that LID still saves money over conventional approaches through reduced infrastructure and site preparation work. Case studies and pilot programmes indicate that there is a 25-30% reduction in costs associated with site development that use LID techniques. These savings are achieved by reductions in clearing, grading, pipes, ponds, inlets, kerbs and paving. By careful design, infrastructure reduction can realise savings that can enable developers to add value-enhancing features to the property or even to recover more developable space since there will be no requirement to utilise land for a stormwater pond.

Many LID techniques have nothing to do with, nor can they be, significantly influenced by the behaviour of the property owner. These include basic subdivision and infrastructure design features such as reducing the use of pipes, ponds, kerbs and gutters; maintaining recharge areas, buffer zones, and drainage courses; using infiltration swales, grading strategies, and open drainage systems; reducing impervious surfaces and disconnecting those that must be used; and conserving open space.

The long-term success of LIDs has much more to do with the knowledge, skills and creativity of the site designers than what the property owner does or doesn't do. However, the key factor in the success of LID is to ensure that the landscape practices (such as rain gardens) are attractive and perceived by the property owner as adding value to the property. If these LID practices are viewed as assets, the primary motivation for their long-term maintenance is that of property owners protecting their vested economic interests.

Additionally, experience has shown that educational efforts can successfully promote active public engagement in protecting waterways by the simple act of people maintaining their properties. Appropriate LID site source controls should significantly reduce maintenance burdens for property owners and municipalities (local authorities). The techniques are simple, need no special equipment or high costs to maintain, and encourage property owners to be responsible for the impacts associated with their land.

For preserving stream integrity, experience has demonstrated the importance of a stormwater system that specifically addresses the more frequent or micro-storms that can and do occur on a regular basis. By using decentralised site-based source controls, LID uses the stormwater from these more frequent events as a resource and is an effective ecosystem approach. Additionally, if the full suite of LID controls and site design practices is creatively used, LID is capable of automatically controlling the higher return period storms through its primary strategy of restoring the built area's natural rainfall-runoff relationship. The more techniques that are applied, the closer to the undeveloped hydrologic function the catchment will become, and where there are known flooding problems, a hybrid approach may be required.

Although the term LID can be loosely defined (much like sustainable development), the appropriate definition of LID is distinct and should not be confused with other stormwater management and development strategies. LID seeks to design the built environment to remain a functioning part of an ecosystem rather than exist apart from it.

The approach relies more upon smarter and advanced technologies than it does on conservation and growth management and is not to be regarded as a land use control strategy. LID is a balanced approach and is an advanced, ecologically-based land development technology that seeks to better integrate the built environment with the natural environment. LID principles and practices allow the developed site to maintain its predevelopment watershed and ecological functions. LID provides technological tools to plan and engineer any type of urban site to maintain or restore a watershed's hydrologic and ecological functions.

The LID approach includes five basic tools:

- encourage conservation measures
- promote impact minimisation techniques such as impervious surface reduction
- provide for strategic runoff timing by slowing flow using the landscape
- use an array of integrated management practices to reduce and cleanse runoff
- advocate pollution prevention measures to reduce the introduction of pollutants to the environment.

LID is relatively simple and can be very effective, therefore the long- and short-term costs and benefits are advantageous. Instead of large investments in complex and costly centralised conveyance and treatment infrastructure, it allows for the integration of treatment and management measures into urban site features. The promotion of sustainable development techniques may also attract financial incentives in the form of free consultations and application fee discounts.

### 2.2.3 Examples of application

#### *2.2.3.1 SMURFF*

Stormwater and urban runoff is considered the number one source of pollution in Santa Monica Bay, California. The Santa Monica Urban Runoff Recycling Facility, otherwise known as the SMURRF, is an example of how to deal with polluted stormwater and urban runoff to protect coastal waters and is illustrated in Exhibit 2.2.

The project to overcome the stormwater pollution issues was instigated by the city of Santa Monica, which also provided funding together with contributions from the city of Los Angeles, the State Water Resources Control Board, Metropolitan Water District and Federal funds. The SMURFF project is the first facility of its kind in the US. This state-of-the-art facility treats dry weather runoff water as a result of runoff from excessive irrigation, spills, construction sites, swimming pool draining, car washing, the washing down of paved areas and some wet weather runoff that currently discharges directly into Santa Monica Bay through storm drains. Prior to the construction of the facility, pollutants such as oil and animal waste or anything that finds its way onto a surface exposed to runoff were discharged into the bay.

An average of 2,300 cubic metres (approx 500,000 gallons) per day of urban runoff generated in parts of the cities of Santa Monica and Los Angeles are treated by conventional and advanced treatment systems at SMURRF. The runoff water is diverted from the city's two main storm drains into SMURRF and treated to remove pollutants such as trash, sediment, oil, grease and pathogens.

Treatment processes include:

- coarse and fine screening to remove trash and debris
- dissolved air flotation to remove oil and grease
- degritting systems to remove sand and grit
- micro-filtration to remove turbidity
- ultra-violet radiation to kill pathogens.

Once treated, the water is safe for all landscape irrigation and dual-plumbed

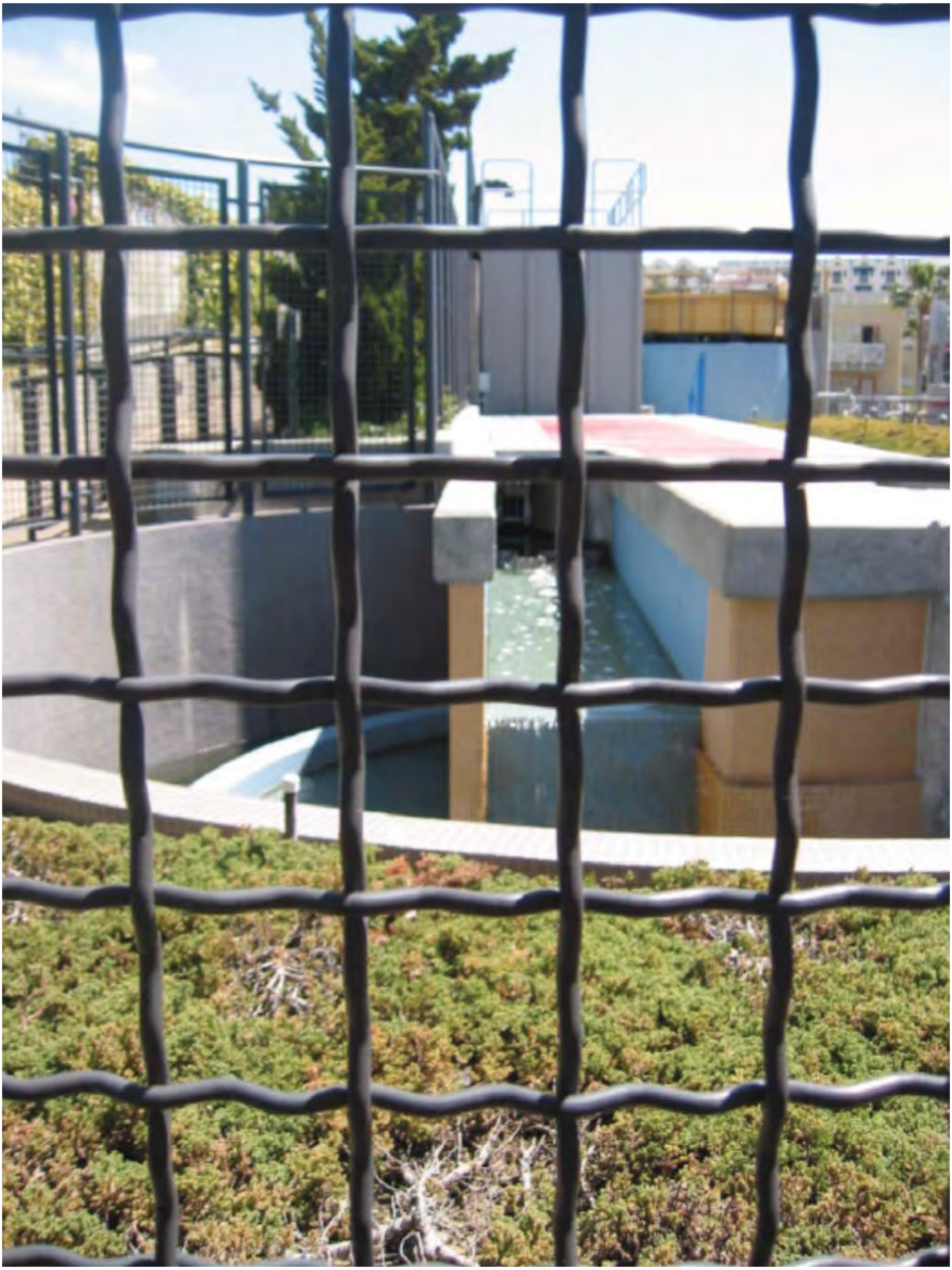

***Exhibit 2.2*** *The SMURFF unit in LA city designed to engage public interest in stormwater management*

systems (that is, buildings plumbed to accept recycled water for the flushing of toilets) as prescribed by the California Department of Health Services. The treated water meets the requirements as laid down by the city of Los Angeles and the county of California and is used for highway landscaping along the Santa Monica freeway, city of Santa Monica parks, cemeteries and school grounds.

As outlined in Section 2.1.2.6, dealing with stormwater pollution in the last decade has included education and the motivating of individuals and businesses to reduce their surface water runoff contributions. As part of the out-reach requirements, the SMURFF facility at Santa Monica is open to the public and has been designed with education in mind, having an elevated walkway that descends from one end of the site to the other. Visitors have a complete view of all of the equipment and processes that are used to purify the urban runoff. The siting of the equipment and the technology used has been considered equally with the need to make the process of runoff treatment understandable to visitors. The equipment is arranged in sequential order and oriented towards the viewer so that any visitors can follow the technology and the process visually. Each piece of equipment is placed on a prominent base and raised to an appropriate viewing level. In several locations the water moving through the system has been exposed to the open air to allow the process to be clearly seen by visitors.

#### *2.2.3.2 Downspout disconnection*

In several cities of the US that have a combined sewer network, a downspout disconnection programme is considered to be a key part of the effort to reduce combined sewer overflows (CSO). This disconnection reduces the overflow within the sewer system, which in turn helps alleviate the pollution of rivers, lakes and the ocean. Overloading of the system can also cause flooding, particularly in basements.

Examples of this were seen in Boston, Massachusetts and Portland, Oregon. The Environmental Services department in Portland, Oregon, encourages homeowners to disconnect their downspouts from the sewer system in targeted neighbourhoods. Not all downspouts can be safely disconnected and only those homeowners in targeted areas who have received written permission can be reimbursed for disconnecting.

Printed leaflets and on-line information provides the homeowner with information relating to the rationale behind the project, current targeted areas, consent application forms and a ‘do-it-yourself’ guide. Information is provided on creative landscaping techniques that can be employed to manage the runoff water safely and effectively.

The municipality will pay the homeowner to disconnect provided that the work has been consented and the works approved. The one off lump sum payment is currently around $50 (approx £27) per downspout disconnected, plus an annual charge reduction. This acts as an incentive for the homeowner to participate in this scheme. The local authority will also undertake this work free of charge, as a consequence the homeowner will not receive the one-off payment.

Around 44,000 homeowners in the city of Portland, Oregon, have disconnected their downspouts, which has resulted in the removal of approximately one billion gallons (4.5 million cubic metres) from the combined sewer system annually.

## 2.3 Stormwater control, operation and maintenance

The expense of maintaining most stormwater BMPs is relatively small compared with the original construction cost. Too frequently, however, BMP maintenance is not undertaken, particularly when it is privately owned. Improper maintenance decreases the efficiency of BMPs and can also detract from the aesthetic value of the installation. The operation and maintenance guidance/mandate within a stormwater ordinance can ensure that designs facilitate easy maintenance and that regular maintenance activities are completed.

The maintenance of stormwater BMPs includes the elements of design, routine maintenance, and inspections. Stormwater ordinance terminology regarding the maintenance of erosion control measures would differ slightly from a sediment and erosion control ordinance owing to the short-term nature of these measures. In addition, it is important to note that elements such as the process of applying for a permit would be included in more comprehensive sediment and erosion control or stormwater ordinances.

### 2.3.1 Legal issues

Many communities across the US are facing challenges associated with natural resource degradation due to rapid growth and development. Local governments need to have legal authorities in place to shape development and to protect resources. The EPA helps local governments by providing the information necessary to develop effective resource protection ordinances.

The EPA includes model ordinances to serve as a template for those charged with making decisions at state or county level concerning growth and environmental protection. For each model ordinance there are several real-life examples of ordinances used by local and state governments around the nation. The ordinances address matters that are often forgotten in many local codes, including aquatic buffers, erosion and sediment control, open space development, stormwater control operation and maintenance, illicit discharges, and post construction controls. There is also a miscellaneous category containing ordinances that do not fit into these categories.

In addition, there are materials that support particular ordinances, such as maintenance agreements and inspection checklists.

Some important elements of effective stormwater operation and maintenance ordinance terminology are the specification of a specific entity responsible for long-term maintenance and reference to regular inspection visits. The ordinance should also address design guidelines that can help ease the maintenance burden, such as the inclusion of maintenance easements. Although language that legally requires operation and maintenance of stormwater BMPs is important, there might be a disjoint between the ordinance language and what happens ‘on the ground.’ The information provided in support of the ordinance, such as maintenance agreements and inspection checklists, is as important as the ordinance to ensure that stormwater BMPs perform efficiently over time.

### 2.3.2 Observations on operation and maintenance

The authority charged with issuing the NPDES permit is also automatically responsible for the maintenance of the system, be it municipality, county or state level. Construction is a major factor in the successful implementation of the structures and regular inspections during the development are an important feature. Funding of the process is discussed further in section 2.3.4.

The public are also involved in the maintenance of BMPs. In Seattle, for example, the SEA streets project requires direct involvement from the public. Although the construction is of a very high standard and the systems are low maintenance with carefully selected vegetation and plants, low maintenance does not mean ‘no maintenance’.

*Exhibit 2.3* *Maintenance and cleaning*

The natural drainage systems are maintained by the city and in this the municipality undertake to:

- check and clean the structures periodically
- maintain plants as required to ensure effective storm drainage system performance
- perform other unscheduled maintenance as required due to unforeseen circumstances such as damage from storms or accidents etc
- look after the underground drainage sewer network to cope with the natural drainage systems.

In the majority of cases infiltration is expected to take place within 24 hours of a storm occurring. If after three days the system has not drained down a maintenance response is triggered from the city. The city has a 'no ditch filling' law which means that should a resident decide to fill in their ditch, the city authorities will return to re-excavate and replace it at the resident's expense.

It was noticeable that there is relatively high affluence in the areas in Seattle where the SEA streets have been retrofitted. This also indicates a reasonable standard of education and community interest, which helps with public engagement with environmental concerns. Maintenance processes in the heavily built-up Los Angeles areas are considerably different. Sediment entrapment facilities are the most used and the mission witnessed the annual cleaning of one such process.

*Exhibit 2.4* *Maintenance and cleaning*

As can be seen from the exhibits, the cleaning required considerable plant and manpower. Safety was clearly less of a consideration than in the UK – notice the lack of hard hats and safety harnesses, as well as lack of interest in the protection of bystanders.

However, despite over-manning, this was only an annual operation. Hence, despite its apparent over-use of manpower and questionable safety procedures, one could not question its effectiveness or the amount of pollutants that had been removed by the device. In the right context therefore, this is a procedure (and use of proprietary equipment) that is appropriate and worthwhile.

The mission made several visits to organisations with direct responsibility for both stormwater management and the maintenance of BMPs. At times the viewpoint expressed in the office was not so keenly observed in practice.

Whilst there are wonderful examples of design, construction, maintenance and control, such as in Portland, Oregon, and Seattle, there were occasions when the site experience did not bear out the enthusiastic oratory of the municipal officers. One such example was where the key points of the maintenance crews were prioritised as safety, function and aesthetics.

***Exhibit 2.5*** *Example of poor maintenance*

The location of Exhibit 2.5 has been deliberately withheld. Note the steeply sloping sides of these ponds, making egress difficult when any water is present in the structure. The control structures were of poor design and this one was blocked by leaves. There seemed little consideration for how the control is cleared should it become blocked. The site is also protected by a small fence that is very easy to climb over.

The same authority indicated that four drownings had occurred in the past year in ponds where there had been no fences.

The optimum solution was seen to be plastic covered chain link fences 42 inches high. The fact that the BMP was poorly designed and constructed and therefore necessitated a fence seemed lost. The same individuals congratulated themselves on the fact that because of their experience they knew more about the design and operation of BMPs than the consultants submitting designs for municipal approval!

However, despite the negatives, one cannot criticise the enthusiasm of the officers to improve the environment by controlling stormwater run-off and removing pollutants. It is important to learn from poor design and construction as well as good.

### 2.3.3 Public engagement

Public engagement was a recurring theme of all locations visited in the US. This will be further discussed under funding issues, but the role of the general public in successful implementation of BMPs and LIDs cannot be overestimated.

The public are aware that effective control of stormwater can be of major importance to their lives and environment. Direct citizen involvement on managing boards for water resources and drainage improves engagement and commitment. Strong drivers such as the high awareness of environmental impacts on Chesapeake Bay and its historically poor condition due to polluting inputs has promoted an awareness of the financial implications to local livelihoods, and can deliver support for innovative surface water solutions.

In the Boston area the public are aware of the need to keep groundwater levels high. A dam maintains groundwater levels and protects the wooden piles that support much of the city of Boston from drying out. This has a knock-on effect of 'backing up' the drainage systems in Cambridge (Harvard) County, Massachusetts, and causes flooding of basements, which owing to the very expensive land costs have become converted living quarters. The public in Cambridge, Massachusetts, have become very supportive of the innovative use of stormwater, as they realise the direct impact and consequence.

It was made clear that water quality improvements (of the combined sewerage system) and innovation has led to a major economic boom around the harbour (>$1 billion) and a general increase in city property values.

In Seattle, community and local 'stakeholder' adoption of stormwater facilities is a major buy-in and opportunity.

### *2.3.3.1 Getting the message across*

Public facilities (such as Sea Life Centers), with special links to stormwater are very strong vehicles for raising awareness. School education is another example. It was evident that public engagement was the responsibility of an individual within each of the organisations visited, the sole purpose of which was to ensure that education in many forms was effective.

There were few locations where a BMP or natural drainage system did not have a sign telling the public exactly what it was and its purpose. This even extended to the development of viewing platforms and walkways around the SMURFF UV stormwater treatment plant at 'Muscle Beach' in Los Angeles, described in Section 2.2.3.1 (See Exhibit 2.6).

Professionals living in local neighbourhoods believed it was their public duty to inform their communities of any new facilities for stormwater management.


***Exhibit 2.6*** *Signage explaining purpose of natural drainage systems*

### 2.3.4 Maintenance and adoption of stormwater facilities in US practice: utility types and delivery mechanisms

Most stormwater control mechanisms are funded from what is termed the 'general fund'. This can be apportioned at state, county or municipal level. In the same way that the responsibilities are delegated in regard to adoption and maintenance, so also are the funding mechanisms. In the US, local taxes, in addition to state and federal taxes, can be made in a number of ways, such as local taxes paid over the counter on all purchases. This varies from state to state, with high purchase taxes in some states and none in others. For example, Portland, Oregon, has no local purchase taxes and revenue is raised directly from home owners and companies.

Funding for stormwater is set at a level that is most appropriate for the successful management and delivery of the process. Whilst the above are fairly general in the application of funding mechanisms, the following are examples of variations.

#### *2.3.4.1 Seattle, Washington*

This city has achieved an apparent appropriate balance in terms of apportionment of responsibility for stormwater management. The stormwater budget is calculated directly from contributing roof area and plot size. This presumes that the amount of water landing on a roof is directly proportional to the use requirement for stormwater disposal. Hence charges are directly apportioned. This seems simple to apply and equitable.

#### *2.3.4.2 Massachusetts Water Resource Authority (MWRA)*

MWRA in Boston has a high degree of autonomy, but as it has to raise capital. A major concern is credit rating; hence it has to be seen to be efficient and open to stakeholders. Stormwater is the responsibility of the local communities in Massachusetts, but MWRA can design, maintain, construct and operate these. Some communities do not undertake their stormwater responsibilities with sufficient diligence and in cases where this happens MWRA will intervene.

In Boston all other utilities (than stormwater) have to pay for their own re-routing when storm sewer facilities are built. This indicates the hierarchy of the varying utilities and the priority assigned to stormwater management.

Because of its autonomy, MWRA has been able to consider a more integrated approach to stormwater management in the city and surrounding area. Accurate stormwater maps are essential for planning, and MWRA has shown that limited investment in relation to ensuring good understanding of stormwater systems and hydraulic performance – when well planned and targeted – can produce big benefits. MWRA has backtracked from a large scale storage CSO management solution ($1.3 billion in 1993). It now prefers the provision of a large number of smaller dispersed projects locally targeted and delivered at much lower cost. ($835 million at today's prices). These solutions are seen to be more flexible and involve new storage, stormwater disconnections and other approaches, even in densely populated areas.

MWRA has established sustainable success in rainfall runoff control by combining source control, LID, in situ control and central control. It has also successfully negotiated multi-tasking with its employees to lower costs. It has embraced new technology and utilises roving crews without demarcation.

#### *2.3.4.3 Los Angeles*

The city and state of Los Angeles have a combined population larger than most countries. The city has developed in the coastal plain below the mountains and covers a vast urban 'sprawl' with huge demographic and cultural spreads. The most endearing geographical feature of the city (apart from the weather) is its beaches on the west coast. However, the beaches are under enormous environmental strain from stormwater runoff pollution. The stormwater carries a high sediment load which contains a variety of gross pollutants including: large organic litter, smaller granular solids, heavy metals and hydrocarbons; faecal and other coliform bacteria from human and animal activity within the catchments.

The continuing degradation in the environment led the population to demand a clean up (litigation) and it was decided that water quality improvements amounting to some $0.5 billion of expenditure were necessary. A two thirds majority was required to create this law and it was carried by over 70% of the citizens by selling it as a 'bond issue' rather than as a new tax. The expenditure budget has been broken down as follows:

| | |
|---|---|
| • rivers, lakes, beaches, bays and ocean water protection projects | $250 million |
| • water conservation, drinking water and source protection | $75 million |
| • flood water reduction, river and neighbourhood parks | $100 million |
| • stormwater capture, clean-up and re-use | $75 million |
| | $500 million |

By raising this in the form of a bond, the money is ring-fenced and ensures that none of the funding on water quality can be siphoned off to other projects.

#### *2.3.4.4 Construction bond*

A feature of BMP and LID funding is the use of up-front construction bonds in some areas of the US, such as Baltimore County, Maryland. A bond is paid to the permitting authority equivalent to the cost of construction of the BMP to ensure that the construction regulations and standards are rigorously applied. If the standards are not properly applied, the permitting authority has the power to retain this money to put right any substandard work. This power ensures that the developer is careful during construction and may also include such things as a tree protection policy, as in Seattle, Washington state.

#### *2.3.4.5 Research and development (R&D)*

Investment in R&D in the area of stormwater management in the US appears substantial and this benefits the public domain. R&D is a federal funded initiative and there appears to be no shortage of funding, although USEPA budgets are subject to political whims and hence are reduced when administrations are anti-environment. Most software and stormwater manuals are freely available and are extensively peer reviewed to ensure consistency on a national level. The models developed are both comprehensive in scope and detail. Of particular relevance is the 'SUSTAIN' tool (system for urban stormwater treatment and analysis integration) for BMP selection and cost optimisation, which is under development by the EPA. It is expected to become a main decision support tool for stormwater management in the US when released in 2008.[10]

10 Lai F. –h et al. (2003). Development of a decision-support framework for placement of BMPs in urban watersheds. In: National TMDL Science and Policy Speciality Conference, Chicago Il. WEF.

### *2.3.4.6 Public engagement*

The role of the public has been discussed with regard to adoption and maintenance issues in Section 2.3.3 and, in particular, its role in funding the Los Angeles stormwater management programme. Public awareness initiatives and the public role in funding is a key aspect in stormwater management in the US.

It is apparent that direct citizen involvement in stormwater management boards improves engagement and commitment, and this includes the allocation of funds. In Massachusetts local communities decide individually if tariffs should be rising, declining or fixed for both water and sewage. This has resulted in communities in the MWRA area competing with each other to be more efficient and water, sewage and stormwater are locally politically-controlled functions within the community. Hence, politicians are seen as accountable for efficient services.

Further gearing of public engagement incentives to companies and retailers is another way of supplementing expenditure and raising awareness (eg in tree planting subsidies). Promoting innovative funding schemes also enhances awareness and engagement.

## 2.4 Performance and design of the systems used

The mission visited the EPA Office of Research and Development, Urban Watershed Branch in Edison, New Jersey. The EPA staff gave a comprehensive series of presentations covering BMP R&D, including swales, green roofs, design guides, BMP placement, design tools and creek restoration (Appendix C4). Further information about performance was provided by Eric Strecker and Wayne Huber in Portland, Oregon (Appendix C10).

***Exhibit 2.7*** *EPA best management practice research and development in New Jersey*

### 2.4.1 Overall effectiveness for health, safety, environmental quality and amenity in the US

There are a large number of BMPs to choose from. The USEPA menu[11] lists some 130 separate BMPs. These are categorised into the six minimum requirements, elements from each of the six categories must be included to comply with the NPDES stormwater phase II regulations:

1. Public education and outreach
2. Public involvement and participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post-construction stormwater management in new development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations.

New BMPs are continually being developed especially in the first two areas above.

Some estimates indicate that pollutant load reductions of 25-40% will occur where NPDES permitted stormwater management programmes are fully implemented. However, full implementation does not occur everywhere because of resource limitations. Evidence suggests that in some instances compliance may build up gradually with time, taking a decade or so to reach 90%.

11 USEPA (2003). National menu of best management practices for stormwater Phase II. http://cfpub.epa.gov/npdes/stormwater/swphases.cfm

Enforcement also increases compliance but requires resources. Compliance should be better where there are impaired water bodies and TMDLs are required for outfalls, with assigned maximum waste loads. Even if a stormwater outfall is not subject to an NPDES permit it may still be addressed under a TMDL load allocation if the receiving water requires a TMDL.

Coastal zones are also subject to the coastal zone reauthorisation amendments (CZAR), Section 6217 regulations. This specifies additional stormwater regulations for coastal areas. For new developments the post-construction TSS load must remain at re-construction levels or at least an 80% reduction on annual TSS loads in stormwater runoff following completion and site stabilisation. This is often the main requirement in BMP selection for coastal sites. Typically the 80% reduction can only be achieved using a treatment train of BMPs.

Of all the BMP options, only a few are suitable for stormwater quantity control. These include the various pond options and wetlands. These are usually provided as regional control measures. Other BMPs can help reduce peak flows but, for example, bioretention, infiltration systems etc do not deal very well with high volumes and thus do not provide flood protection for longer return period storms. However, they are useful for reducing the erosion impacts on receiving waters. Some systems aid groundwater recharge, with the BMP database showing that vegetative filter strips and dry detention ponds can add some 30% of inflow volumes to groundwater.

Stormwater reuse is promoted in many of the driest states. In Florida, uses include: golf course irrigation; toilet flushing; and industry. Retention BMPs are generally the most useful for these purposes.

Pollutant removal is now probably the most important use for BMPs in the US. The NPDES regulations specify pollutant reduction 'to the maximum extent practicable'. A lot of information is presented about pollutant removal efficiency of BMPs, but this is not readily transferable from one site to another. Hence BMP selection based on removal efficiency is not likely to produce expected results. There are a number of factors that influence structural BMP pollutant removal efficiency:

- active pollutant removal mechanisms, such as sedimentation
- BMP design characteristics as selected and used for the particular application
- influent pollutant removal properties and concentrations, such as particle size distributions
- conditions within the BMP, such as dissolved oxygen levels.

Although the presentation and selection of BMPs using percentage pollutant removal is widely criticised, there is as yet no alternative approach, although the observed final effluent quality is an approach promoted as an alternative. Table 2.5 illustrates the performance of the commonest structural BMPs.

Non-structural BMPs primarily remove pollutants by source reduction through better personal decisions. However, their effectiveness is difficult to assess, although dynamic and participatory activities will produce better results than passive measures such as advertising.

The other major non-structural BMP that can be very effective is I/I detection and reduction (Section 2.7.3). It was reported that in Wayne county, some 1,000 kg of solids were prevented from entering the stormwater system over a period of four years by I/I elimination.

| BMP | Percentage removal | | | | |
|---|---|---|---|---|---|
| | TSS | TP | TN | NOx | Metals |
| Dry extended detention pond | 61 | 19 | 31 | 9 | 26-54 |
| Wet retention pond | 68±10 (min -33 to max 99) | 55±7 (12 to 91) | 32±11 (-12 to 85) | 34±21 (-85 to 97) | 26-65 (-97 to 96) |
| Infiltration trench | 75 | 60-70 | 55-60 | – | 85-90 |
| Porous pavement | 82-95 | 65 | 80-85 | – | 98-99 |
| Bioretention | 80 | 65-87 | 49 | 15-16 | 43-97 |
| Sand or organic media filter | 66-95 | 4-51 | 44-47 | -95 to 22 | 34-88 |
| Stormwater wetland | 71±35 | 56±35 | 19±29 | 40±68 | 0-57 |
| Grassed swale | 38±31 (-100 to 99) | 14±23 (-100 to 99) | 14±41 (-100 to 99) | 13±31 (-100 to 99) | 9-62 (-100 to 99) |
| Vegetated filter strip | 54-84 | -25 to 40 | 20 | -27 to 20 | -16 to 55 |

*Table 2.5 Range of percentage pollutant removals using certain structural BMPs*[1]

Construction site controls are essential and well developed in the US (section 2.6). These typically reduce solids inputs to the stormwater system by up to 85%.

The reliability of particular BMPs is important when considering their use, as this can also relate to maintenance needs. Certain BMPs such as ponds need regular cleaning in order to maintain their performance.

Effectiveness in terms of social, health and amenity considerations will dictate whether or not a BMP can be used and where. Important factors are:

- mosquito breeding
- provision of wildlife habitats
- other community acceptance factors
  - safety issues
  - aesthetics.

Open water bodies are the most significant for mosquito risks and the link to West Nile virus has made this issue more important recently. Under-performing infiltration systems where standing water is visible are typically visited after 72 hours and the top soil layer replaced to improve infiltration capacity.

Safety is a major issue and is viewed as a priority in many regulatory areas. Risk of drowning in open water bodies is addressed, for example, by permanent fencing around ponds in Maryland. However, in Los Angeles city the very large gully inlets in highways (up to 6 metres long and with openings some 300 mm wide) and in use for almost a century did not appear to cause concern for drowning risks.

Many of the BMPs visited in the mission were aesthetically attractive; however, some were not, particularly the fenced dry and wet ponds in Maryland. In Seattle and Portland, Oregon the SEA streets and rain gardens were attractive, although the latter did collect litter. Aesthetic value requires maintenance if it is to be sustained. None of the visited sites had BMPs that in themselves provided amenity value, such as water sports or other recreation.

### 2.4.2 Examples of technologies (new and retrofit) and testing

The following sections provide examples of the technologies seen during the mission. There are many others available and those illustrated are not presented as necessarily the best technologies.

#### *2.4.2.1 Bioremediation as a sustainable drainage BMP*

The mission viewed a number of bioremediation examples during the site visits, principally in Baltimore, Portland, Oregon, and Seattle. These structures included bio-swales, eco-roofs (green-roofs), bio-detention basins, street planters and rain gardens. In many instances these were aesthetically incorporated into the urban landscape. Their role and performance is not only directed towards improving surface water quality; they also serve to attenuate and control the quantity of runoff.


***Exhibit 2.8*** *Bioremediation*

Bioremediation is a 'natural' surface water cleansing method utilising the biological and biochemical processes available from flora (fungi, plants, trees etc) to remove levels of contamination associated with urban pollution, diffuse or otherwise.
Bioremediation has been successfully used in the clean up of American brownfield sites. Certain plants have the ability and tolerance to take up high concentrations of toxic chemicals, including hydrocarbons, and in certain instances processing some of these chemicals to less toxic derivatives. The same natural cleansing principles can be applied as source control treatment to the polluted load of surface water runoff sources. A typical bioswale will provide 30-80% pollutant removal, including reductions in total suspended solids, total phosphorous, total nitrogen, floating trash, heavy metals, biological oxygen demand, bacteria, greases, oils and turbidity. These systems are suitable for compliance with the CWA to clean surface water runoff to specified TMDL levels.

#### *2.4.2.2 Low Impact Development (LID) in Baltimore, Maryland*

LID techniques were the initial focus of the mission, by way of the meeting and site visits with Baltimore County Department of Environmental Protection and Resource Management at its Towson office. Surface water management has been a key issue in Maryland since the mid 1970s with commitment at all administrative levels, so BMP technologies and public engagement issues are well advanced. The key driver for improvement and change has been environmental, with strong media pressure to clean up Chesapeake Bay.

At the LID sites visited the vast majority of BMPs viewed were natural bioremediation structures such as detention basins and filter strips incorporated into landscaping. In terms of the natural BMPs viewed in Baltimore, the techniques observed by the mission in Portland, Oregon, and Seattle may have greater value in terms of relevance and innovation to the UK as they were smaller scale and many were retrofitted into dense urban areas.

***Exhibit 2.9*** *Bioremediation filter strip and detention basin*

### *2.4.2.3 Bioremediation filter strip and detention basin*

Key BMP design parameters from Baltimore claim to use a single 1% return period design storm, over a 24-hour duration with intensity peaks. Freeboard for storage systems is between one and two feet (0.3-0.64 metres). Treating surface water quality is as important as controlling quantity in accordance with the CWA. There was some debate with regard to the long-term effectiveness of infiltration techniques and many of the BMPs were fitted with sacrificial sand filter layers (typically 600 mm thick).

Sample collection during some of the NPDES MS4 phase I permits required a grab and a composite sample to assess compliance. A grab sample was normally taken during the first 30 minutes of discharge, and a flow-weighted composite sample for the entire time of discharge. The initial grab sample was used for the analysis of the 'first flush effect,' assuming that most of the pollutants are discharged during the first period of runoff. The composite sample was obtained with aliquots collected about every 15-20 minutes for at least three hours, or until the event ended.[12]

A recurring technical theme across many of the US meetings from the mission (Baltimore, EPA, Hydro International Conference, Professor John Sansalone), was that the first flush theory, which presumes that the majority of pollutants are washed from urban surfaces in the first stages of runoff, is flawed as flushes can be observed, but are not predictable in terms of flush load or timing within a storm event.[12] Hence, techniques for quality control should not be based on the presumption that these flushes occur at the start of storm events. Evidence suggests that typically the first 5 mm of rainfall-runoff is insignificant in terms of total pollutant loading. It was recommended that for design purposes of surface water BMPs, runoff should be evaluated not in terms of the discredited 'first-flush' but rather as a series of a 'pulsed-flush profiles' for pollutant loading.

All natural BMPs are inspected at least once every three years and Baltimore County owns and maintains the majority of the structures. As the mission went on to learn from the USEPA Office of Research and Development Urban Watershed Branch in Edison New Jersey the following best practice guidelines for increased detention are also valuable to note:

- typical detention basin design provision should be a minimum six hours of storage time for the first 0.5 inches (12 mm) of runoff
- longer retention times of 24-48 hours are required for the effective treatment of surface water runoff
- outlet controls need to be properly sized; they are typically designed for peak discharge, but they should be installed (new build or retrofit) to slowly release smaller storm events that would otherwise pass through with little or no attenuation.

***Exhibit 2.10** Detention basin landscaped into public open space*

12 Maestre, A., Pitt, R. E., Williamson D. "Nonparametric statistical tests comparing first flush with composite samples from the NPDES Phase 1 municipal stormwater monitoring data." Stormwater and Urban Water Systems Modeling. In: Models and Applications to Urban Water Systems, Vol. 12 (edited by W. James). CHI. Guelph, Ontario, pp. 317-338. 2004

Another recurring theme, which was first encountered in Baltimore, was a levy on the amount of impermeable area within the boundary of a property and contributing to the storm drainage system – domestic, commercial or industrial. As surface water runoff from infill and micro development is becoming a significant issue in the UK, this impermeable area charge has great potential. With the levy of a surface water charge there is an opportunity to offer a discount for reducing the amount of impermeable area and consequently the amount of surface water runoff being positively drained.


*Exhibit 2.11 The importance of trees*

Some of Maryland's 'soft' BMP techniques are worthy of note. For example, the importance of flora for bioremediation and mature trees for evapotranspiration was another crucial BMP theme repeated in a number of places. Baltimore has successfully employed the following two techniques. The first is establishing protected 'forest buffer' zones, especially around creeks where water quality is improved. Maryland itself has a mandatory forest conservation act and restoration has been very successful leading to increased forestation and buffer zones. The second was the 'Growing Home Campaign' that afforded home owners a $5 (£3) tree voucher from the county and fostered greater public awareness. This initiative was backed by a further $5 (£3) discount from the retailer, leaving the homeowner to find the $15 (£8) shortfall for a tree. The campaign was a great success and it is worth noting that the county viewed the initiative as raising $20 (£11) capital expenditure per dwelling and not spending $5 (£3).

A follow-up meeting at the Center for Watershed Protection in Ellicott City served to underline many of the technology messages received from the previous day with the county. The value and contribution of trees within a watershed was reiterated as a valuable process in the treatment train of rainfall, interception, evapotranspiration, infiltration (refer to the centre's 'Urban Watershed Forestry Manual, Methods for Increasing Forest Cover in a Watershed). In terms of BMP design for infiltration techniques, the following were recommended:

- use a conservative infiltration rate
- infiltrate shallow depths in small areas close to source
- understand future land use
- control construction operations, both in terms of residual compaction and poor quality control
- use two levels of pre-treatment
- do not use a bottom liner
- restrict the amount of impermeable area draining to an infiltration device to limited realistic levels
- set a realistic design life in accordance with each structure type.

#### *2.4.2.4 'Smart sponge' advanced technology in Norwalk, Connecticut*

'Smart sponge' is a proprietary advanced polymer technology that removes pollutants from surface water runoff and holds potential for use in the UK as the WFD is implemented and the water industry strives to meet the 2015 water quality requirements. Patented by AbTech Industries based in Scottsdale, Arizona, the technology claims to have a unique molecular structure based on innovative polymer technologies that are chemically selective to hydrocarbons. Traditional absorbent technology when saturated often leaks oils and other pollutants back into the water if mishandled. However, this technology fully encapsulates recovered hydrocarbons, resulting in a substantially more effective response that prevents leaching.

There are other similar advanced polymer products being marketed in the US, however, smart sponge is claimed to be unique in that its porous structure allows water to pass through it and not simply pass over the surface area. This porosity affords a greater level of performance towards contaminant capture. It is also capable of removing oil from water, thereby successfully removing sheen. In addition, it remains buoyant in calm or agitated water, permitting it to remain in place until fully saturated and resulting in no wasted product. Once oil is absorbed, the pollutants are transformed into a stable solid, providing a 'closed-loop' solution to water pollution.

As this technology has evolved, a 'smart sponge plus' has been developed that is claimed to incorporate an anti-microbial agent structure that captures harmful bacteria (including Escherichia coli and other pathogens) frequently found in stormwater and other water streams. In this product an anti-microbial agent is bound to the proprietary polymers, thereby modifying their surface and adding microbiostatic features while maintaining their oil absorbing capabilities. A patent is pending on this product in the US. The presence of bacteria in surface water runoff is a serious problem in the US that poses significant health risks and increasingly results in the contamination of water bodies. In Europe and the UK, bathing waters are subject to strict bacteriological standards and such removal techniques may be useful. Water quality standards for bacteria are very strictly monitored in most coastal areas and small increases in bacteria counts can trigger US beach closures.

*__Exhibit 2.12__ AbTech's 'Smart sponge' demonstration to the mission*

AbTech believes that this breakthrough is highly significant in the surface water market. However, in the US there is a tendency for manufacturers to claim that their stormwater control products can solve a wide variety of pollution problems. Independent third party research and testing to accredit performance has traditionally been undertaken in the US by NSF International as part of stormwater treatment technology verification testing (ETV), but funding for this is a significant burden on some smaller companies. Nonetheless, independent verification of performance is an advantage to all new technologies and one approach is to use effective R&D from studies in the field, such as the smart sponge performance evaluations underway in Norwalk and Los Angeles described below. With the impending WFD, UK industry should be looking to emulate this to evaluate the long-term viability of such technologies.

Smart sponge advanced polymer technology can be pre-installed or retrofitted into a range of applications. These are usually non-mechanical in the US, although the installation is also used in a range of water industry proprietary products. The following applications may have UK potential:

- 'ultra-urban filter' is a proprietary insert fitted into urban catchpits (basins or gullies) that serve to both collect trash/sediment and filter surface water runoff. This application may not be feasible in the UK, as our catchpits are much smaller than those found in the US. A single point, end-of-pipe application, perhaps coupled with another proprietary product, may well be the solution for the UK
- 'passive skimmers' remove pollutants and oil sheen in catch basins, sumps and proprietary separators
- 'line skimmers' encapsulate hydrocarbons and oil sheen in non-confined water flows such as ponds, streams, clarifying wells and marinas
- 'bilge skimmers' control hydrocarbon contamination that occurs from the normal operation of boats and marinas. As the UK inland waterways industry is viewed as a key WFD stakeholder, such technology may be very applicable to its environmental targets.

The mission visited the Norwalk storm drain filter project. The project is funded via an EPA grant of $397,000 (£215,000) with some local additional support. It is a collaborative project between the EPA, City of Norwalk, AbTech Industries, Longo & Longo and The Long Island Soundkeeper (an environmental education and advocacy organisation). Other project partners are the Maritime Aquarium (one of the largest attractions in Connecticut) and the Norwalk River Watershed Initiative (since 1995 a unique partnership of seven watershed towns to address local water quality). The key project driver is to improve the quality of surface water draining from the watershed and into the Norwalk River, Norwalk Harbor and Long Island Sound.

The mission team was shown an example of the AbTech trash baskets and smart sponge ultra-urban filter inserts installed into the 275 storm drain catchpits (gullies) in the watershed, adjacent to the Aquarium and draining out to the Norwalk River; the basket insert was raised onto the sidewalk for inspection. All of the other catchpits in the vicinity also contained the AbTech dual filter system. This is a dual filter system because the proprietary collar and basket collects all trash entering the catchpit, while the smart sponge insert filters the surface water runoff, permanently adsorbing harmful pollutants.

***Exhibit 2.13*** *Sustainable drainage BMPs protecting the Norwalk River*

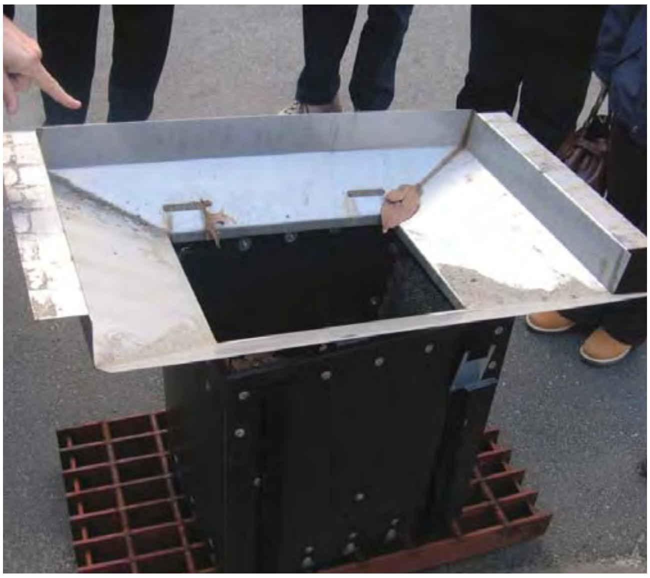

***Exhibit 2.14*** *AbTech's ultra-urban catchpit insert*

The 275 unit installation is claimed to be a unique project involving private and public bodies, including the local aquarium, which serves to incorporate considerable public engagement. It has also included contrasting catchments without the filtered outlets for comparison. There is a 12-month monitoring period to assess improvement in runoff quality, with a target removal of hydrocarbons, a range of bacteria (including Escherichia coli), total suspended solids, heavy metals and trash. Of the 275 trash screen collectors cleaned and weighed, 10 are taken away to be analysed for contaminants; it is estimated that there will be 50 lbs (23 kg) of trash per drain per annum. Locally, dredging in the Norwalk River has a significant cost associated with sludge disposal, so a reduction in dredged volumes is economically valuable. The catchment has some 84,000 people and 27 square miles (70 square kilometres). Modification costs are under $1,000 (£540) per catchpit in total. An effective and proactive maintenance programme will always be a key issue; these inlets should be cleaned once a year, but potentially once in three years is considered more likely, which may compromise the system performance.

The EPA has included AbTech's ultra-urban filter product incorporating smart sponge technology in the BMP listing under federal environmental guidelines that apply to local and state legislators.

The spent smart sponge is either disposed of to landfill or burnt as a fuel source in the US. A potential problem for UK application is the classification of the spent product; it is likely to be classified as special waste, making UK disposal costs potentially prohibitive. In addition, with tighter UK emissions control, incineration may not be a feasible option. Coupled with the lack of third party performance accreditation, there are seemingly intractable barriers to UK implementation, despite the technology having great potential for improving surface water runoff quality.

Smart sponge has been available in the UK for sometime through licence holders Source Control Systems. The industry's key stakeholders may need to collectively adopt a pioneering, pragmatic approach if the UK is to realise the benefits that these advanced technologies may yield. During the GeoSyntec workshop in Portland, Oregon (Strecker and Huber), it was stated that these types of proprietary products are expected to 'do-all' and that isn't really fair; because there is no 'silver bullet', but as a component in an effective treatment train, they do have a key role to play.

#### *2.4.2.5 Up-Flo filter technology in Portland, Maine*

The mission visited a stormwater conference hosted at the American headquarters of UK based company Hydro International, in Portland, Maine. Hydro offers innovative products for the cost effective control and treatment of stormwater and wastewater, and the visit included a tour of its Portland R&D and testing facilities specifically to coincide with this mission.

The main focus of the Hydro visit was its Up-Flo filter, which is claimed to be a novel solution for managing pollutant loaded surface water runoff. This proprietary product is marketed as the first high-rate, modular, upflow filtration system and bespoke design to meet stringent treatment regulations. The compact surface water treatment train capabilities were developed through extensive full-scale laboratory and field-testing, CFD modelling, and more than 30 years of stormwater treatment research by Hydro. The unique modular design – small footprint, upward flow path and drain-down mechanism – distinguish the Up-Flo filter from conventional radial or down-flow stormwater filtration devices. The system adopts a treatment train concept by integrating highly efficient screening, sedimentation and filtration technologies to eliminate the need for multiple treatment devices. The company claims that this treatment train design, together with its high treatment capacity and easily retrofitted components make the Up-Flo filter the most economic filtration device available for stormwater treatment.

*Exhibit 2.15* *Hydro's Up-Flo filter during field pilot testing and verification*

Hydro's laboratory and field data from pilot studies have indicated that the Up-Flo filter has a total suspended solids (TSS) removal efficiency of over 90%. These data are currently being independently confirmed under the protocols of the USEPA Environmental Technology Verification Program. The applications for removing gross debris, fine sediments, metals, organics and nutrients from stormwater runoff are immediate and widespread. A highly efficient, highly adaptable and low maintenance proprietary BMP such as the Up-Flo filter could potentially provide significant levels of economic surface water treatment both in the US and in the UK to help meet the stringent water quality requirements of the WFD.

### *2.4.2.6 The green streets of Portland, Oregon*

Portland's green streets were very much a 'watershed' destination for the mission in terms of evaluating the implementation of LID. The City of Portland, Oregon, receives an average annual rainfall of 37 inches (940 mm) that generates some 10 billion gallons (~45 billion litres) of urban surface water runoff per year. Not only does this runoff lift and wash pollutants from a raft of urban impermeable surfaces, but it also engulfs the sewerage infrastructure, increasing the number of CSO spills. In fact, the detrimental environmental impact on the local Willamette River from frequent CSO spills in the past was considerable. This has been a key local driver for not only extensive 'big pipe' sewerage improvements, but also the widespread implementation of contemporary sustainable drainage techniques and significant public engagement. This LID is known locally as 'green streets.' By encompassing these natural sustainable drainage techniques, the environmental message from the city of Portland, Oregon, remains: 'working for clean rivers, healthy watersheds and a liveable sustainable community.'

*Exhibit 2.16* *An impressively vegetated green street eco-roof*

Working from the highest level down, the green streets' BMPs include vegetated roof systems in the form of eco-roofs and roof gardens. Utilising the benefits of bioremediation, an eco-roof is a composite structure comprising proprietary waterproofing overlaid with an optional drainage layer, a natural layer (growing medium) and finished with a vegetative cover. The vegetation is not just limited to grass, which seems to be a common UK misconception. The mission visited examples which utilised a range of plant species that were not only very performance effective, but were also aesthetically pleasing. Typically eco-roofs may be planted with up to 10 different species for performance and optimum survivability, with variety also helping to maintain aesthetically pleasing, continual blooming flora as long as possible.

***Exhibit 2.17*** *Various species of plants aids survivability and enhances aesthetics*

As well as bioremediation, eco-roofs will also cool roof temperatures during summer (and hence reduce air conditioning usage), insulate during winter (reducing heating costs), and are effective evapotranspiration devices; the performance range is 10-100% precipitation removal (from runoff) dependent upon antecedent conditions and seasonal changes. This is a BMP often mooted in the UK but rarely used because of concerns over cost, longevity, roof maintenance etc, some of which may be unfounded. Maybe an economic inducement needs to be introduced. For example in Portland, Oregon, if a green roof is constructed on a commercial building, local planning conditions may permit an additional floor (storey) to be added. The use and performance of vegetated roof systems on commercial buildings in Portland, Oregon, emphasises the potential of the technique as a key link in the surface water management train.

Downpipe disconnection is a very simple BMP technique, either as new build or retrofit, and has been around as a drainage option for quite a while. While there are many older UK downpipes connected to a sewer, the vast majority of these are connected to a bespoke surface water sewer. However, in many instances these downpipes connect to a combined system, which in turn leads to increased CSO spills downstream. Surface water sewer connected downpipes add pollutant loading and flood risk that stresses receiving water systems and will need to be better controlled to meet the requirements of the WFD. Strategic downpipe disconnection is a valid BMP that reduces the amount of surface water runoff positively drained, and examples were seen in Boston, Massachusetts and Portland, Oregon.

With a surface water charging system based on the amount of impermeable area connected to the drains, the city of Portland, Oregon, offers a discounting system for a reduction of this impermeable area through retrofit downpipe disconnection of about $50 (£27) per downpipe, a one off payment plus an annual reduction in charges. Homeowners are even encouraged to 'do-it-yourself', and there is significant public engagement to educate and

*Exhibit 2.18 A rainwater downpipe draining to an open landscaped surface water box*

*Exhibit 2.19 Downpipe disconnection is simple, cost effective and it works*

get the message across in a comprehensible manner. This includes a number of clear and informative leaflets and brochures that not only explain how to disconnect, but also promote the benefits, not only for the wider Portland environment, but also to the property itself. Indeed, many residents proudly display downpipe disconnection message boards in their gardens and it is clear that because of informative promotional marketing many of the general public have subscribed to this initiative and 'disconnected'.

With over 47,000 properties either completely or partially disconnected in Portland, Oregon, the reduction of surface water flows reaching the sewerage network is substantial, with positive environmental benefits for the Willamette River. This BMP also has great UK potential, either for new build or retrofit. Nonetheless, surface water overland flows need to be controlled, for example, in terms of freezing in pedestrian areas. With a climate not too dissimilar to the UK's, Portland, Oregon, has managed this effectively. The stormwater source control systems were designed for two year return period storms, with excess flows passing into the main sewer network. These systems were also tested using a fire hydrant up to an equivalent of 25 year event, with a volume reduction of 82% and 81% in peak flow.

The City of Portland, Oregon, is very proud of its 'green streets' and rightly so. Owing to an understanding of the detrimental environmental effects of surface water as a result of runoff pollutants and CSO spills, Portland is constructing 'sustainable streets' around the city to mitigate the effects. Green streets use BMPs to mimic the natural site conditions by managing surface water runoff in a sustainable manner in terms of both quality and quantity. The BMPs used include porous pavings, bio-swales, bio-detention basins, street planters, rain gardens and are all aesthetically incorporated into the urban landscape. In terms of BMP performance towards controlling surface water runoff quantity, these utilise attenuation, infiltration and evapotranspiration. In terms of improving runoff quality the processes include bioremediation and natural filtration. There is a strong apparent aesthetic value of such landscape in the urban environment.

***Exhibit 2.20*** *A green streets planter incorporated into the urban landscape*

There is a comprehensive public engagement and marketing campaign towards education associated with the green streets project. There is even a 'stormwater cycling' tour map available, where cyclists are given a suggested route to visit a portfolio of local BMPs including eco-roofs, bio-swales, planters, rain gardens and 'naturescaping' (landscaping with native plants that require less water and no fertilisers or pesticides). A well marketed example of a successful green street is NE Siskiyou; traffic calming kerb extensions into the carriageway (to reduce the street to one lane at one end) are infilled with soft landscaping and converted into mini bio-detention basins for controlled quantity and improved quality of surface water runoff. The street runoff enters the planter via gaps in the kerbs and is attenuated and naturally treated before infiltrating or evaporating; there is no positive sewer connection, as a key driver is to reduce flows into a nearby combined sewer. Costing only a reported $15,000 (£8,100) to construct, the long term maintenance issues were resolved as a result of positive public engagement; local residents maintaining the planters as they add amenity and economic value to the green street they live in. There is a clear lesson to be learned for the UK from this US success story.

***Exhibit 2.21*** *An inlet to the street planter and note integration with pavement*

### *2.4.2.7 SEA streets in Seattle, Washington*

The Seattle street edge alternatives (SEA) streets were a similar use of BMP technologies to achieve LID to those seen in Portland, Oregon. The SEA streets' technologies include bio-swales, bio-detention basins, street planters, rain gardens and porous pavements, and are aesthetically incorporated into the urban landscape. Their role and performance is not only directed towards improving surface water quality; they also serve to attenuate and control the quantity of runoff. The main drivers for the sustainable drainage approach are to improve the quality of the Puget Sound, Elliot Bay and Seattle's many creeks by reducing the number of CSO spills and improving the overall quality of surface water runoff.

With an average annual rainfall of 39 inches (990 mm) and a climate not dissimilar to the UK's, the application of BMPs in Seattle held great interest for the mission. One of the key reasons for the terminology 'street edge alternatives' and a marked difference with

Portland, Oregon's green streets, is that these BMPs are not only designed to drain the highway and pavement, but the whole urban sub-catchment behind it, including the dwelling. This means that while Seattle does not have such a sizeable downpipe disconnection programme as Portland, Oregon's (neither does it have a surface water charge based on impermeable area; although it is being considered), it is a key BMP. Many of the residential downpipes are not connected into a below ground system from new, and simply drain to ground, or overland to the street edge BMP during high levels of precipitation. Downpipe disconnection is also undertaken as a retrofit on combined sewers when a new surface water sewer is constructed.

***Exhibit 2.22*** *A SEA street bio-swale edged with porous road and pavement*

The mission visited two SEA street sites; the first was the High Point new-build development employing an extensive use of bio-swales, traditional (grass lined) swales, porous paving and disconnected downpipes. Interesting permanent signage informed: 'Natural Drainage. Natural plants and grasses on gently sloped parkways cleanse rainwater from streets and sidewalks.' With the quantity and quality source control largely managed at the street edge in the surface water management train, site control was provided in the form of a balancing pond, as each train of swales had a high level overflow system to a below ground surface water sewer. From the High Point balancing pond the controlled and cleansed outflow drains to the Longfellow Creek. As with the majority of US developments seen during the mission, the completed High Point development permissible surface water discharge was the equivalent pre-development greenfield rate.

Once again, the importance of mature trees to the general environment and the surface water management train were evident in Seattle. This included 'tree protection fences' that were effective exclusion zones for the critical root zone around any mature trees on construction sites. The signage on the fencing also carried an appraised tree value as a warning of a resultant fine should the tree be damaged. These valuations were always in the $1,000s (£550+). Another very important construction issue that was being effectively managed at High Point was silt control of exposed soil areas. This can be a major source of pollution during precipitation if not controlled, as heavy downstream siltation can occur as a consequence. Mitigation measures observed included covering exposed soil areas between construction activities and blocking inlets and outlets to prevent the movement of silt.

The second site at the Broadview Green Grid was a well established 15-block housing development example of SEA streets. It showed no signs of redundancy as a result of poor maintenance, despite the majority of the BMPs being street edge bio-swales, although the Seattle Public Utility (SPU) does carry out regular light maintenance and inspection. The whole SEA streets catchment, including Viewlands and Carkeek Cascades, drains to the nearby Piper's Creek. While each resident is not compelled to maintain their street edge

*Exhibit 2.23 A familiar grass lined bio-swale*

BMP (although they cannot infill or remove), the majority do and have turned them into very aesthetically pleasing landscape features. Again, the importance of public engagement and the education process was clear. Due to local health concerns regarding mosquito breeding in still waters, any street edge BMP that does not drain-down within three days (there is a five day breeding cycle for mosquitoes), is excavated and the filtration layer replaced.

*Exhibit 2.24 A well established SEA streets landscape; drainage BMPs perfectly integrated*

Part of the success of SEA streets can be credited to public engagement and awareness campaigns. For example, the SPU Creek Steward Program seeks community volunteers to become stewards for the care and upkeep of the local creek. Whilst educating the community with the benefits to the environment from healthy river and environmental systems, this also includes the impact of surface water runoff from local houses and businesses within the catchment and promotes changes that can improve the quality of water draining from a property. Established Creek Stewards can even apply for city of Seattle grants to further improve the local watershed.

*Exhibit 2.25 A typical bio-swale located in a residential garden*

### *2.4.2.8 Application of proprietary techniques in Los Angeles, California*

The city of Los Angeles not only has a problem with the quality of surface water runoff, but at times also experiences major impacts regarding trash pollution on its justifiably prized beaches. Whenever there is significant rainfall the volume of trash that is washed into the sea via the Los Angeles

River (which has a daily TMDL) is substantial. Much of this trash is subsequently washed onto the resort and highly used recreational beaches, which can result in closures for health and safety precaution. As well being unsightly and a significant polluter, trash-induced beach closures impact upon the tourist industry and hence the local economy. The mission visited two sites in Santa Monica where proprietary techniques are being implemented to address the problem.


***Exhibit 2.26*** *The mission visiting the AbTech Los Angeles field study*

'The city of Los Angeles field study on smart sponge,' is in the Santa Monica Bay area and incorporates the advanced polymer technology discussed in Section 2.4.2.4. Essentially the same reasoning for the technology and a similar application to the Norwalk project, there is a greater emphasis in LA on the capture of trash. A trial field study, fully funded by AbTech Industries, is being undertaken in collaboration with the city of Los Angeles (CLA). The surface water discharges into Santa Monica Bay, which has gradually been cleaned up since the early 1980s through the CWA and strong environmental groups (litigation) providing public engagement, including the Santa Monica Baykeeper and Heal the Bay.

***Exhibit 2.27*** *A line of ultra-urban filter inserts in an LA catchpit*

The mission team was shown examples of the trash baskets and smart sponge ultra-urban filter inserts installed into 80 storm drain catchpits (gullies) in the watershed around Thornton Avenue and draining to Santa Monica Bay. CLA officials accompanied the mission during the visit and confirmed that independent testing was being carried out to verify the performance of the units. The results from this trial will be available in around twelve months, although unfortunately they will not be published and will be used only internally for CLA purposes. Income for the Bay clean-up was confirmed as bond funds paid for by property taxes, with an average estimated tax increase on a $350,000 (£190,000) home of $35/year (£19/year) for a period of 24 years. The expenditure breakdown is shown in Section 2.3.4.3. Project funds can be used for project planning, design, advertisement, bid and award, construction, construction management and inspection. There are also business improvement districts (BID) where companies are eligible for tax relief to assist in the clean-up.

Another proprietary technique demonstrated in Santa Monica was the CDS Technologies 'continuous deflective separation hydrodynamic separator' (CDS unit), installed and maintained by the city of Los Angeles. These separators can be installed in-line or off-line, depending on the hydraulics, and can also be end-of-pipe solutions. The CDS unit

*Exhibit 2.28* *Essential cyclic maintenance on a CDS Technologies installation; removing LA's trash*

was installed on the main storm drain within one chamber and the configuration meets multiple engineering objectives by combining both treatment and bypass capabilities in one structure. By utilising the CDS patented screening technology which is claimed to be non-blocking, the unit ensures removal of both fine and suspended solids along with oil, grease, trash and debris. The sump is an important design feature of the CDS unit, as the sumps prevent scour because deposited material is not stored within the treatment flow path.

The entrapment of hydrocarbons within the unit is effected by a secondary technology; advanced polymers similar to the AbTech product range. With a relatively small footprint, this system can be incorporated into new build projects or retrofitted into existing stormwater collection systems. There are no moving parts to maintain or replace and the unit requires cleaning out by emptying at least once a year, which will require plant such as a crane and jetvac.

The conclusions and observations drawn from this part of the mission, from the Norwalk demonstration site and Hydro International visit are that proprietary techniques have their place, but these systems require independent accreditation to be widely accepted and they should not be expected to perform too many 'multi-tasks'.

There did appear to be mixed approaches to public engagement in the places visited. For example, trying to influence behaviour for litter and pollutant sources in parts of Los Angeles. There was some evidence of this with warning signage well distributed around the neighbourhood. However, the significantly high number of homeless 'street-dwellers' in the city exacerbated the source of the trash problem due to bin raking. Also, the city only requires commercial areas to have trash bins, which means they are noticeably absent elsewhere. An effective method of source control to reduce trash could be to provide more bins on the streets and engage the public in using them responsibly. There were better examples, such as the SMURFF project (see Section 2.2.3.1) and the plebiscite for the stormwater bond. Efforts at greater public engagement with stormwater management may yield further improvements.

## 2.5 Design and selection of systems

Few watershed management practices simultaneously reduce pollutant loads, conserve natural areas, save money and increase property values. Fortunately, such practices have been developed. By designing and selecting the best stormwater management techniques that suit the site and environmental characteristics, the overall site design aims can be achieved through the implementation of appropriate BMPs, LIDs and traditional piped drainage methods.

The design manuals and guidance demonstrated during the mission varied in content, style, level of guidance or specific criteria to be achieved. A brief summary of the manuals that were encountered during the visits is provided in the following sections. Overall, the Center for Watershed Protection provided the most comprehensive set of resources for stormwater management planning, design and delivery.

### 2.5.1 Center for Watershed Protection, Ellicott City

The Center for Watershed Protection (CWP) provides a range of resources relating to design. The development of BMPs and guidance for design and use by the centre have assisted municipalities in meeting the EPA requirements to minimise stormwater pollution entering water bodies by reviewing existing codes and the development of new manuals and best practice guidance. Stormwater management is an essential part of the work undertaken by the centre since it is recognised that untreated waters discharging to the environment present one of the greatest threats to water quality.

The CWP provides local authorities, environmental groups and watershed organisations around the country with the technical skills to help protect and restore rivers, streams and lakes. This is done via a multi-disciplinary strategy to watershed protection, which includes conducting research, developing watershed management practices, encouraging watershed planning and implementation, fostering learning, and building the capacity of local watershed organisations. The CWP website has resources for the drainage engineer and provides an abundance of information regarding not only design criteria, but also relating to NPDES.

Whilst at the CWP a meeting took place with Neil Weinstein from the Low Impact Development Center. He has recently produced a disconnection guide, published by WERF/IWA.[13]

#### *2.5.1.1 Urban sub-watershed restoration manual (http://www.cwp.org)*

This composite manual provides a framework for small urban watershed restoration, comprising 11 individual manuals that include assessment methods and design tools for riparian and upland watershed restoration.

On-Site Non-Residential Retrofits

19 INFILTRATION TRENCH

Description

Feasibility

Figure 1: Infiltration Trench
Source: City of Portland, OR

Stream Repair: Grade Control

20 STEP POOLS

Description

Feasibility



Figure 1: (a) A Series of Step Pools Below a Road Culvert
(b) A Series of Step Pools Used to Halt Nick Point Migration

*Exhibit 2.29* *Examples of guidance from CWP manual for urban sub-watershed restoration manual*

13 Weinstein N. et al (2006). Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow
The Low Impact Development Center, Inc. MD 20705, USA. IWA Publishing. ISBN 1-84339-748-x

### 2.5.2 Baltimore County, Maryland (http://www.mde.state.md.us)

The CWP features in the design standards imposed by Baltimore County as it helped the state to write the stormwater design manual currently in use.

Maryland has a comprehensive stormwater design manual available on the internet. The basic principle of the manual relates to the experience that the state has gained since the 1980s. Title 4, subtitle 2 of the Environment Article Annotated Code of Maryland states that *'…the management of stormwater runoff is necessary to reduce stream channel erosion, pollution, siltation and sedimentation and local flooding, all of which have an adverse impact on the water and land resources of Maryland.'* Early programmes focused on addressing this article primarily by controlling runoff increases and mitigating water quality degradation associated with new development.

The counties and municipalities in Maryland have been responsible for the administration of effective stormwater management programmes that *'…maintain after development, as nearly as possible the predevelopment characteristics…'* The localities have performed well in establishing Maryland as a national leader in stormwater management technology. Maryland has experience of tens of thousands of BMPs that have been constructed to achieve the requirements of the article mandate. It is also fortunate as it has a relatively wealthy community.

However, the experience gained since Maryland's stormwater statute was enacted has allowed it to identify necessary improvements and revealed a need to refocus the approach to fulfil the original intent of this essential water pollution control programme. Increased emphasis on water quality, resource protection needs, increased BMP maintenance costs, and identified shortcomings in Maryland's programme have all contributed to basic philosophical changes regarding stormwater management. The updated 'Maryland stormwater design manual' was produced in an effort to incorporate the significant experiences gained by the state's stormwater community and accommodates much needed improvements for managing urban runoff.

The design standards and environmental incentives provided in the manual have been developed with the aim of producing better methods and advancing the science of managing stormwater by relying less on single BMPs for all development projects and more on mimicking existing hydrology through total site design policies. This is similar to the current philosophy in the UK where the 'treatment train' approach is frequently recommended. Additionally, the design standards have been developed to ensure that inherent philosophical change should produce smaller, less obtrusive facilities that are more aesthetic and less burdensome on those responsible for long-term maintenance and performance.

The main purpose of the manual is threefold:

- to protect the waters of the state from adverse impacts of urban stormwater runoff
- to provide design guidance on the most effective structural and non-structural BMPs for development sites
- to improve the quality of BMPs that are constructed in the state, specifically with regard to performance, longevity, safety, ease of maintenance, community acceptance and environmental benefit.

The 'general performance standards' outlined in the manual specify criteria used to create runoff control options that would perform equally well. The BMPs contained in the manual are by no means exclusive. The state of Maryland actively encourages the development of innovative practices that meet the intent of Maryland's stormwater management law and can perform according to the standards in the design manual.

One interesting fact that is in contrast to the current UK philosophy concerns the consideration of retrofit on redevelopment/ regeneration of brownfield sites. The state has a policy to actively encourage the redevelopment of brownfield land. While certainly recommending the BMPs listed within the manual, it is emphasised that these BMPs may not be appropriate for redevelopment areas where site size is constrained, and existing infrastructure prevents the use of conventional BMP technology. Therefore, redevelopment projects are not necessarily required to meet the design standards and performance criteria established in the manual.

The state of Maryland has developed 14 performance standards that must be met at development sites to prevent adverse impacts of stormwater runoff. These standards apply to any construction activity disturbing 5,000 or more square feet (465 square metres) of earth. However, the following development activities are exempt from these performance standards in Maryland:

- additions or modifications to existing single family structures
- developments that do not disturb more than 5,000 square feet (465 square metres) of land
- agricultural land management activities.

The following performance standards are outlined in the manual and must be addressed at all sites where stormwater management is required:

- **standard no. 1** site designs shall minimise the generation of stormwater and maximise pervious areas for stormwater treatment
- **standard no. 2** stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the state of Maryland shall be adequately treated
- **standard no. 3** annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods. At a minimum, the annual recharge from post-development site conditions shall mimic the annual recharge from pre-development site conditions
- **standard no. 4** water quality management shall be provided through the use of structural and/or non-structural practices
- **standard no. 5** structural BMPs used for new development shall be designed to remove 80% of the average annual post development total suspended solids load (TSS) and 40% of the average annual post-development total phosphorous load (TP). It is presumed that a BMP complies with this performance standard if it is:
  - sized to capture the prescribed water quality volume (WQv)
  - designed according to the specific performance criteria outlined in this manual
  - constructed properly
  - maintained regularly
- **standard no. 6** on the eastern shore (a specific area of the state of Maryland), the post development peak discharge rate shall not exceed the pre-development peak discharge rate for the two-year frequency storm event. On the western shore, local authorities may require that the post-development ten-year peak discharge does not exceed the pre-development peak discharge if the channel protection storage volume (Cpv) is provided (see standard No. 7). In addition, safe conveyance of the 100-year storm event through stormwater management practices shall be provided
- **standard no. 7** to protect stream channels from degradation, Cpv shall be provided by 12-24 hours of extended detention storage for the one-year storm event. Cpv shall not

be provided on the eastern shore unless the appropriate approval authority deems it is necessary on a case-by-case basis
- **standard no. 8** stormwater discharges to critical areas with sensitive resources eg cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs, Chesapeake Bay Critical Area may be subject to additional performance criteria or may need to utilise or restrict certain BMPs
- **standard no. 9** all BMPs shall have an enforceable operation and maintenance agreement to ensure the system functions as designed
- **standard no. 10** every BMP shall have an acceptable form of water quality pre-treatment
- **standard no. 11** redevelopment, defined as any construction, alteration or improvement exceeding 5,000 square feet (465 square metres) of land disturbance on sites where existing land use is commercial, industrial, institutional or multi-family residential, is governed by special stormwater sizing criteria depending on the amount of increase or decrease in impervious area created by the redevelopment
- **standard no. 12** certain industrial sites are required to prepare and implement a stormwater pollution prevention plan and file a notice of intent (NOI) under the provisions of Maryland's stormwater NPDES general permit. The requirements for preparing and implementing a stormwater pollution prevention plan are described in the general discharge permit available from MDE and guidance can be found in the USEPA document entitled, 'Stormwater Management for Industrial Activities, Developing Pollution Prevention Plans and Best Management Practices' (1992). The stormwater pollution prevention plan requirement applies to both existing and new industrial sites
- **standard no. 13** stormwater discharges from land uses or activities with higher potential for pollutant loadings, defined as hotspots, may require the use of specific structural BMPs and pollution prevention practices. In addition, stormwater from a hotspot land use may not be infiltrated without proper pre-treatment
- **standard no. 14** in Maryland, local governments are usually responsible for most stormwater management review authority. Therefore, prior to design, applicants should always consult with their local reviewing agency to determine if they are subject to additional stormwater design requirements. In addition, certain earth disturbances may require NPDES construction general permit coverage from Maryland state.

The six groups of acceptable BMPs that can be used to meet recharge and water quality volume sizing criteria in the state of Maryland are:

- stormwater ponds
- stormwater wetlands
- infiltration practices
- filtering systems
- open channel practices
- non-structural practices.

Specific performance criteria and guidelines for the design of five groups of structural BMPs are outlined in the manual. The performance criteria for each group of BMPs are based on six factors:

- general feasibility
- conveyance
- pre-treatment
- treatment geometry
- landscaping
- maintenance.

The manual also provides the user with a selection section that outlines the best BMPs for a specific site based on environmental and other site characteristics. This section has been designed so that the reader can use the tables in a step-wise fashion to identify the most appropriate BMP or group of practices to use at a site.

### 2.5.3 Seattle – Washington state design criteria *(http://www.ecy.wa.gov/programs/wq/stormwater/manual.html)*

The stormwater management advocated in the Washington state stormwater manual involves careful application of site design principles; construction techniques to prevent erosion and the discharge of sediments and other pollutants; source controls to keep pollutants out of stormwater; flow control facilities to reduce discharge flow rates; and treatment facilities to reduce pollutants. The current version was updated in 2005 following a public review draft prepared and presented at three public workshops. Ecology staff reviewed public comments and incorporated many of those comments into the final document.

The application of specific design standards and minimum technical requirements that any stormwater management facility (including BMPs) should achieve are outlined within the manual. The manual specifies a number of flow diagrams to guide the user to specific technical requirements that the developer should achieve for new development and redevelopment.

The retrofit design requirements stipulated by Washington state differ from those stipulated by Maryland state. Seattle requires redevelopment land to include appropriate BMPs. Compliance is required regardless of the type of redevelopment, and regardless of whether or not a permit is required.

A maintenance manual is available on the Seattle SEA streets. This will not be discussed in detail in this section as the focus is on design manuals and selection criteria.

### 2.5.4 Portland, Oregon *(http://www.portlandonline.com/bes/index.cfm?c=35117)*

The purpose of the stormwater management manual developed by Portland, Oregon is to provide stormwater management principles and techniques that help preserve or mimic the natural hydrologic cycle, minimise sewer system problems and achieve water quality goals. The manual provides developers and design professionals with specific requirements for reducing the impacts of increased stormwater runoff flow quantity and pollution resulting from new development and redevelopment.

The requirements of stormwater management apply to all projects within the city of Portland, whether public or private:

- projects of any size are required to comply with stormwater destination/ disposal requirements as identified in the manual. Specific facility designs that meet these requirements are presented throughout
- all projects developing or redeveloping over 500 square feet (55 square metres) of impervious surface, or existing properties proposing new stormwater discharges off-site, are required to comply with pollution reduction and flow control requirements presented in the manual. Specific facility designs that meet the stipulated requirements are outlined in the manual
- all projects constructing destination/ disposal, pollution reduction or flow control facilities are also required to comply with operations and maintenance requirements
- projects that are classified as high risk because of certain site characteristics or activities must comply with the source control requirements identified.

The manual is easy to use as it provides a flow chart for the navigation of projects of all sizes and types. It also takes a number of example projects step-by-step.

Stormwater destination/disposal hierarchy must be used to determine the ultimate discharge point for stormwater from a development site. The hierarchy is set up to protect watershed health and mimic pre-developed hydrologic conditions by requiring on-site infiltration wherever practicable. This also serves to protect the capacity of downstream infrastructure and minimise the occurrence of combined sewer overflows and basement sewer backups in the combined sewer system. The hierarchy is also intended to protect groundwater resources by limiting the use of infiltration in some cases. It requires infiltration at the ground surface where practicable, and pollution reduction where it is not. Where on-site infiltration is not practicable, the hierarchy dictates the use of off-site storm-only systems for stormwater discharge if feasible, before discharge to combination sewer systems can be considered.

At the meeting with Eric Strecker and Wayne Huber in Portland, Oregon, a new design guide was introduced, published by WERF and IWA: 'Critical Assessment of Stormwater Treatment and Selection Issues'[14], based on two research projects: 'Development of a BMP evaluation methodology for highway applications' funded by the US National Cooperative Highway Research programme; and 'Critical assessment of stormwater pollution control selection issues' funded by WERF.

### 2.5.5 Education of the key stakeholder groups

Selection of a BMP or LID is influenced by the ability of the stakeholders to use or maintain the systems; hence education and capacity building are key elements in the CWA.

The primary goals of education in relation to stormwater in the US includes: increasing community awareness; preserving local water resources; and gradually changing user behaviours to reduce the amount of pollutants from stormwater runoff. Education programmes may focus outreach on a single behaviour on a broad basis, or concentrate their efforts at the sub-watershed level. The most effective education programmes focus on key pollutants or behaviours, carefully target their audiences, and survey residents to understand their attitudes before designing education campaigns.

The CWP website provides free material providing technical guidance and help to generate project and training ides for small watershed organisations (primarily local residents and commercial/retail establishments). The website also provides free material that may be used in educating local stakeholders on the impacts of watershed related behaviours and the usefulness of BMP and LID techniques to manage stormwater.

The CWP material is used to target homeowners to help strengthen education programs; specifically a series of Homeowner Association slideshows on suburban impacts to water resources is available. The centre also encouraged the local paper to publish related articles, and initiated demonstration projects to educate watershed residents on voluntary 'back yard' practices to minimise residential impacts.

## 2.6 Construction

### 2.6.1 Introduction

The typical levels of earth disturbance that occur during land development are substantial; hence the construction process is widely identified as a critical time for the prevention of siltation and pollution due to stormwater runoff from sites under development. Traditional construction techniques involve levelling the site and installing the primary stormwater drainage as

14 Strecker E. (2006) IWA publishing, January ISBN: 1843397412

one of the first priorities, thus utilising the drainage to stabilise the site for construction. In an ideal situation the primary drainage would be constructed at the end of the development with a temporary or secondary drainage system installed to service the site during the construction process, however, the financial sense of this relies on predicting the cost of a clean up of the primary drainage system caused by bad management practice (BaMP) during the construction process.

During the mission each of the cities and states visited had, and were expected to administer, construction site stormwater runoff preventative measures. On the whole, the US has identified the need to legislate in this area and developed regulations to allow the enforcement and management of construction site pollution in general. The following sections provide an overview of the findings in this area.

### 2.6.2 Rigorous controls – construction site regulation

With the introduction of the CWA came the basic overriding, though not limiting, regulations for construction site runoff. These fundamental controls on construction activity are channelled through the EPA Water Permits Division and administered through the NPDES. Obtaining a permit requires control of stormwater discharges associated with industrial activities, which includes construction activities, thus limiting any negative impact on the environment. Land developers/construction site operators are expected to adhere to a set of preventative measures aimed at reducing construction site erosion and the discharge of contaminated construction site runoff.

The NPDES was introduced as a federal regulation so that the US as a whole was required to act on the problems created by construction site discharges. Prior to this, certain states already had in place state laws that required land developers to control their construction site discharges. These laws come with the requirement of a soil erosion and sediment control plan approved from the local soil conservation district (SCD), representing the approval process.

The visit to the county of Baltimore and its ‘Department of Environmental Protection and Research Management’ (DEPRM) offered perhaps the best example of the controls and structure in place for construction site sediment and erosion control, including the practicalities of enforcing the laws, along with financial aspects. Along with and prior to the NPDES permit system, the state of Maryland, and subsequently the county of Baltimore, had developed a separate ‘sediment control law’ (passed in 1970) which requires the approval of an ‘erosion/sediment control and stormwater management plan’ before the issuing of a building permit and any grading permit. This was seen by the county and others to be somewhat innovative compared with elsewhere in the US. It is worth noting that the county of Baltimore is well funded due to the relative affluence of its citizens and as such may not represent a majority view, although it provides a good example of what is possible.

### 2.6.3 Inspection and enforcement

Enforcement of the regulations relating to construction site runoff is primarily subject to resources the controlling body has available to carry out inspections. In practical terms the NPDES requires that a developer wishing to disturb more than 5 acres (2 hectares) of land has to apply for a NPDES permit. The developer will need to demonstrate that an approved soil erosion and sediment control plan is in place along with records showing that a weekly inspection of erosion and sediment controls, plus an inspection the day after any storm event, has been carried out. They will also be expected to keep a record of any subsequent maintenance.

Where a developer is found to be in contravention of its NPDES general construction permit, or has disturbed earth as part of a construction activity without notification of intent, it can be prosecuted under federal law and specifically the CWA. Additionally, if a developer is found to be in contravention of the governing environmental regulations of the relevant state it is liable for any number of penalties which can range from the following:

- issue of a correction notice
- shut down of the site either in its entirety or in the specific location of any infringement
- wide ranging fines: eg Seattle has examples of contractors being fined in excess of $1 million (£550,000) for not controlling solids runoff during construction
- prosecution penalties for contravention of the NPDES permit and the CWA can range in severity from a maximum fine of $2,500 (£1,350) per day and/or imprisonment for not more then one year for negligence, to a fine of $25,000 (£13,500) and/or imprisonment for a maximum of 15 years.

### 2.6.4 Fees and discounts

Fees are generally payable for permits such as an NPDES general construction permit, grading permits, etc, but will vary depending on the state regulations as to how or if they manifest themselves. For example, in Baltimore there is a one-time application fee to pay based on the size of the planned disturbance. This is described as a 'grading security' based on a rate of five cents per square foot, (3p/0.1 square metre), up to a maximum of $30,000 (£16,275). The size of the planned disturbance is provided by the developer upon submission of a notice of intent, from which the authorising engineer will decide the fee payable. It is possible to get a discount on the up-front fees payable in Maryland by demonstrating that certain criteria can be met, such as the intention to convert a construction BMP such as a sediment pond into the primary drainage BMP once construction is complete. Another important consideration is that reduction of construction site pollution in the natural environment can be the cost-effective alternative to cleaning up the environment post construction.

The overriding impression is that fees are used to control the construction practices of contractors, with the onus put on the contractor/developer to ensure that development sites are as environmentally friendly as possible, thus enabling the contractor to limit the up-front financial burden placed upon it. The effectiveness of this type of incentive to a developer is hard to determine from the visit, but from the sites visited and general observations, some of the more obvious control methods adopted by contractors are highly visible and in abundance.

### 2.6.5 Effective contractors – construction process

The process involved in acquiring all permits and permissions to construct will vary from state to state and city to city. The process for Baltimore County is shown.

#### *2.6.5.1 Baltimore – Maryland*

- The first step is to have the relevant stormwater management plan and erosion and sediment control plan approval in place. This plan is a requirement where developments will disturb land greater then 50,000 square feet (4,645 square metres), or move more then 100 cubic yards (76 cubic metres) of fill material. The aforementioned plans will require the approval of soil conservation districts (SCD) and any other affected parties (such as utilities etc).

- A grading plan, a sediment and erosion control plan, stormwater pollution prevention plan etc are produced and submitted for approval.

- Financial securities are paid up-front of approvals and issuing of permits.

- If an area greater then five acres (two hectares) is going to be disturbed then an NPDES permit will be required and a notice of intent needs to be submitted with a fee.

- Before the construction can begin a pre-construction meeting will be conducted with all of the parties involved, including a representative of the community.

- The developer may then be required to put in place the sediment control measures and have them inspected before the permit is issued. Sediment control is required to be carried out by a trained contractor.

- Once construction activity is finished and the site has been 'finally stabilised', the developer will have to issue a notice of termination and must have or be imminently removing all temporary control measures.

- Only once the site has been inspected and approved will the stormwater/grading bonded security be released. A suitable amount is kept back to cover any unconformities as a leverage to make sure the work is finished to a satisfactory standard. The money that is held back will be used to carry out any remedial measures that the contractor/developer fails to carry out. A certain amount will then be kept for a year after the site is approved as a maintenance bond.

### 2.6.6 Good construction practice (GCP)

The example of Baltimore County (2.6.5.1) showed how a formal structure is in place to apply and enforce the regulations relating to construction site stormwater runoff. Seattle, Washington state, provides an equivalent example of a practical application where a range of controls has been applied to a construction site; a new housing estate that had been constructed entirely utilising BMP/LID drainage.

During the tour of the site in Seattle (along with observations from other visits) the mission delegates were provided with examples of construction practices geared towards reducing contamination of the environment and the primary drainage system, which are summarised below:

- covering recently disturbed soil during a storm event to alleviate the eroding effect of stormwater flowing across its surface

- laying turf over areas instead of seeding the ground and waiting for it to grow stabilises areas of soil quickly, as opposed to seeding. There are obvious cost implications to this but if the intention is to turf the area (landscaping traditionally being the last job), then planning as early as possible will provide soil erosion protection at no extra cost

- suitable biodegradable geotextiles can be laid on regraded areas where they can provide support and binding for the soil, growing plants and seeds

- construction of a temporary sediment basin or underground storage structure on site to receive construction site stormwater for silt settlement and attenuation of flow. This can then be converted into a permanent feature or removed post-construction

- managing the regrading of the site during the construction process to reduce exposed areas that are susceptible to erosion during storm events. Also known as construction sequencing, this was very evident in that large blocks of the Seattle development were completed, with construction elsewhere still at an early stage on other parts of the site

- the use of silt fences to alleviate stormwater runoff is a simple but relatively effective way to contain sediment on the site. Silt fences are a minimum requirement of the NPDES permit and were perhaps the most visible of control measures present on the construction sites visited. This was because of their ubiquity and location around defined construction site perimeters

*Exhibit 2.30* Silt fences in use

- covering and protection through the diversion of stormwater away from sensitive drainage features that could be badly affected by siltation, and contaminated stormwater such as porous pavements, biofilters, swales etc

- the use of filtration baffles in front of catchbasins and access points that lead into piped drainage systems provide protection from silt. A variation observed in Seattle was a silt sack installed in catchbasins to provide a primitive form of silt filtering device

*Exhibit 2.31* Covering and protection

*Exhibit 2.32* Filtration baffles

- using contractors with required training in the area of construction site pollution management termed as 'responsible personnel.' This was a common theme highlighted in Baltimore and Seattle where it was a requirement for a qualified contractor to install the sediment and erosion controls on site. In the county of Maryland, the Maryland Department of the Environment offers a training course entitled 'responsible personnel training for erosion and sediment control' to contractors in order to meet these requirements

- the addition of mulch amongst recently constructed drainage features or recently disturbed soil provides a certain amount of soil stabilisation, although it lacks robustness. This is the practice of laying a carpet of loose clippings, typically biodegradable waste products (eg straw) over the top of the surface


***Exhibit 2.33*** *Protecting established trees*

- the practice of protecting established trees and their roots by giving them a price which will be payable as a fine if they are removed illegally. Signs are prominently displayed on the construction site at each of the specific trees warning against accidental removal and discouraging intentional or unintentional removal by providing a sense of worth (expressed in $) to the existing environment through education.

There are many more techniques available for use on construction sites which were not directly observed during the mission. Further information can be found on the internet on the EPA web-site (www.epa.gov) or the individual states or municipality websites.

### 2.6.7 Construction – summary

To ensure the effective reduction in construction site pollution within the US, the Federal Government and State Governments have created legislation that provides a minimum requirement to mitigate any potential pollution and erosion created by construction site stormwater runoff. Alongside the regulatory aspects there are well developed systems of control and inspection, financing, incentives, permitting and penalties, all aimed at encouraging compliance by the use of stormwater management techniques identified as being effective means of silt and erosion prevention.

Notwithstanding the above, it must be acknowledged that the mission did not have the opportunity to engage with contractors or developers to ascertain the views of the construction industry in controlling construction site runoff. Nonetheless, although these views are largely missing it is clear that there is a tangible required and demonstrable effort by all parties to address the problems associated with construction site stormwater runoff. Despite the undoubted problems in applying the practical solutions associated with construction site stormwater runoff, it is still fair to say that the first steps have been taken on a metaphorical road that is undoubtedly having, and will continue to have, a positive effect on the environment that the American public live in.

## 2.7 Monitoring of performance

There are two important aspects here; one relates to compliance monitoring and the performance of BMPs and LIDS, the other to the continuing performance of stormwater drainage systems in relation to the wastewater system as a whole. The latter requires an understanding of the unwanted inputs to these systems, known as I/I in the US.

### 2.7.1 Introduction

Stormwater standards in the US are generally delivered using technologies that are 'deemed to comply' with pollutant removal efficiencies, but in reality it is almost impossible in many cases to design systems deterministically to achieve these standards.

US stormwater regulations have six minimum operational requirements for compliance/permitting:

- public education outreach – to raise awareness and support
- public involvement – to meet notification requirements
- illicit discharge detection and elimination – remove cross connections

- construction erosion control – for new development and redevelopment
- post–construction management – must be reviewed for compliance
- pollution prevention – municipally owned BMP maintenance schedule.

It was clear from the visits that the implementation of an effective SUDS/BMP monitoring programme, whether pre-, post-, or during construction, is not a straightforward task. A one-size-fits-all approach is very unlikely to succeed owing to the widely varying techniques and methods adopted in designing, installing and maintaining a project.

The term BMP tends to group together a massively varying range of techniques, from source control approaches such as street sweeping and green-roofs (Exhibit 2.34), local schemes incorporating proprietary devices (Exhibit 2.35) for treatment and control, swales, bio-retention areas, through to large regional structures such as large detention ponds, each with their own peculiarities, technical difficulties and challenges (Tables 2.3 and 2.4).

*Exhibit 2.34* *Green-roof in Portland, Oregon*

Coupled with this wide range of BMP options (which is growing), the large variations in weather patterns, geography, land use etc. across the US complicates the problems of monitoring even further. If a BMP monitoring programme is to be effective, it must deal with this variability to produce reliable and meaningful information.

*Exhibit 2.35* *Proprietary Up-Flo filter system from Hydro International*

With all these difficulties to overcome it is understandable why a US Government Advisory Committee produced a report in 2002[15] on current monitoring practices in the US, noting that data gaps are prevalent and 'particularly serious for non-point sources'.

Monitoring data from the EPA compliance with the NPDES requirements programme have been included in some databases. The CDM national stormwater quality database included 816 NPDES storm events in a database that includes approximately 3,100 total events. The Rouge River National Wet Weather Demonstration Program office in Detroit included its NPDES data in its database. Recently, the EPA granted the University of Alabama and the CWP protection funding to collect and evaluate NPDES MS4 municipal stormwater permits. By the end of 2002 this project had collected 3,757 storm events from 66 agencies and municipalities in 17 states. This database includes geographic and seasonal information that can be useful for various analyses.

15 United States Environmental Protection Agency (U.S. EPA). Environmental monitoring and assessment program – research strategy. EPA 620/R-02/002. – July 2002

### 2.7.2 Main findings relating to monitoring and compliance

It is evident that any performance monitoring procedures currently in place relating to investigations, studies and compliance evaluation can vary greatly from state to state. The success or efficiency of monitoring systems can rely, in many instances, although not exclusively, on issues such as the presence of a 'champion' or 'champions' within the relevant organisation with the right knowledge and experience (Section 2.1.3), or on the existence of dedicated funding allocated specifically to deal with stormwater issues.

*Exhibit 2.36 Sediment control on a construction site in Portland, Oregon*

A typical example of the disparity in approach between one state and another and how individual states deal with stormwater in different ways, is highlighted for LA, California where the main approach is to obtain wider improvements in stormwater quality management is through additional requirements imposed on redevelopment projects. The assumption is that over time this approach will lead to the entire stormwater system being improved.

In California, the Department of Transportation carried out a $30-40 million (£16-24 million) study on BMP performance and found that the performance of these systems was inadequate. The major effort in terms of stormwater for these projects was really focused on the 'during construction phase'.

It is widely accepted in some states that it is essential to control catchment sediment during construction upstream (which may not be within their personal jurisdiction) and there are excellent examples of sediment control during construction, which crosses municipal and management boundaries.

Another example of monitoring relevant to a particular state or city is in Baltimore County where the municipality does not maintain 'underground structures', ie storage chambers etc, but they do monitor performance using remote cameras. Also, all private stormwater facilities are inspected every three years. These must have agreed maintenance rules when built (stated in the NPDES permit) with the plans being equivalent to a contract between the county and the developer.

Some other counties in the state of Maryland have made sure all stormwater facilities are privately owned and maintained. Maryland as a state seems to be ahead of the rest of the US in a lot of respects, and environmental concern is strong amongst the public due to awareness of the need to clean up Chesapeake Bay, as it has an impact on the tourism and leisure industries. High levels of taxation evoke public interest and the population of Maryland is generally quite wealthy.

In the US there is local state interpretation of federal watershed protection requirements (in many ways equivalent to member states in the EU and the WFD). Individual states then pass standards to communities for compliance (the state generally produces a stormwater manual). It is evident that some states and communities are not dealing with this. Phase II compliance of the CWA is required by 2008, but many states have not even achieved phase I compliance as yet

(See Table 2.1). There are some excellent examples of stormwater manuals within certain states and municipalities, but the content and structure varies a great deal from one manual to the next. A good source of many such manuals can be found on the website created and maintained by the CWP (http://www.stormwatercenter.net/). Another good example is the 'stormwater management manual for western Washington' (http://www.ecy.wa.gov/biblio/ 0510029.html).

Many types of monitoring exist, such as pre-BMP monitoring to establish design, implementation monitoring and performance compliance monitoring. It would appear that until recently the most prevalent type taking place was the pre-BMP during the design evaluation stage. However, there does seem to have been a steady increase, in many areas of the US in compliance monitoring.

There are many examples of proprietary systems available in the US with varying ranges of data relating to performance. CFD modelling is a very effective method for assessing the performance of settling systems, but should be linked to pilot studies. It is clear that the development of any product leading to satisfactory up-take requires a number of steps to be followed from laboratory through to pilot testing, and finally field scale and independent verification. An illustration of such data and examples of systems that have followed this route can be found on the Department of Ecology for Washington state website (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/). Evaluation of a range of emerging stormwater treatment technologies is covered detailing the use level categories for a list of proprietary systems currently available in the US for which satisfactory data has been provided and subsequently approved by the Department of Ecology.

Various methods exist for monitoring BMP effectiveness including input/output sampling,


***Exhibit 2.37** Hydro International's Up-Flo system during on-site pilot testing and ETV verification by Penn State University*

before/after sampling, and upstream/downstream monitoring. Errors and ineffective data are often prevalent because of incorrect flow measurements and sample collection problems. For example, automatic sampling was found to be ineffective for assessment of stormwater control systems as large and whole cross-sectional sampling is required. Some BMPs do not have clearly defined inflow and/or outflow (vegetated filter strips and green-roofs, for example), which presents great difficulties in collecting meaningful representative samples and data. However, it was shown that these barriers can often be overcome in some instances if the desire or need is strong enough.

*Exhibit 2.38* *Monitoring equipment on demonstration green-roof site in Portland, Oregon*

The USEPA and ASCE's Urban Water Resources Research Council has compiled a national stormwater best management practices database (http://www.bmpdatabase.org/), the purpose of which is to develop a more useful set of data on the effectiveness of individual BMPs used to reduce pollutant discharges from urban development. A review of the information contained in this database as well as the data that is required is useful to determine precisely what information should be collected as well as how.

Care must be taken, however, when considering the use of data collected elsewhere, particularly relating to any differences that may lead to incorrect conclusions (eg weather, geography, sources of pollutants). Assumptions that certain pollutants are associated with certain sediment fractions may lead to errors.

Another example of effective monitoring is in the city of Seattle where inspectors visit sites to check compliance and occupancy certificates are not issued if the system does not meet the requirements. There is some concern at the moment that this process can take too long, but work is being carried out to streamline and speed up certificate issuing.

Post-construction monitoring is also seen as essential to show compliance in order to avoid litigation, amongst other things, and it is vital that this type of monitoring should be built into the system and considered during the design phase. It would seem that monitoring can be either visual or detailed but not prescriptive. It is also recognised that some methods for field performance evaluation are expensive and only effective with very great care.

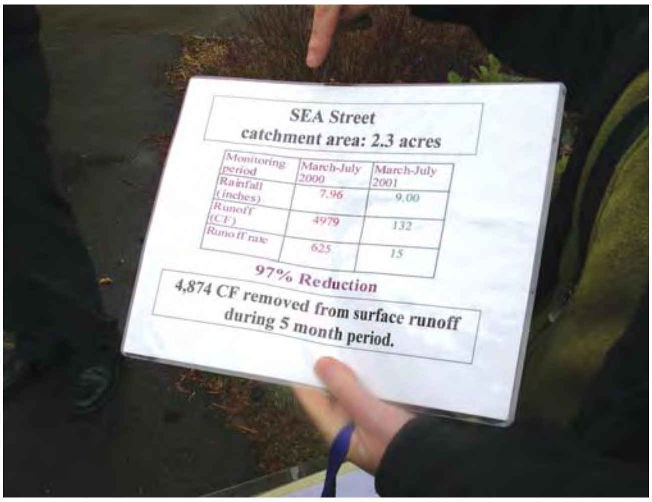


*Exhibit 2.39* *Runoff reduction data from Seattle's SEA street monitoring scheme*

A great deal of post-construction monitoring, particularly with proprietary systems, tends to take place during the planned maintenance programme activities (provided they have been instigated in the first place). If a device is being cleaned or emptied at set intervals,

*Exhibit 2.40 Temporary monitoring equipment in place at SEA Street development*

*Exhibit 2.41 The captured contents of a CDS separator prior to annual clean-out*

this is the ideal time to carry out any ongoing monitoring requirements, whether simply visual or using more detailed sampling.

Despite the prevalence of pre-BMP monitoring, many areas remain where performance is poorly understood, such as stormwater pollution from agricultural run-off, despite the fact that this is known to be important particularly for background concentrations in urban area watercourse (Section 2.1.1.3).

A recently published report produced for The National Cooperative Highway Research Program, Transportation Research Board and National Research Council[16] focuses on improving the scientific and technical knowledge base for the selection of BMPs predominantly for highways projects, and on the improvement of the decision-making process through a better understanding of BMP performance and application. The report recommends that drainage engineers should use fundamental unit operation and process (UOP) principles to guide their selection of treatment systems for control of stormwater with UOP selection based on specific targeted pollutants, as opposed to the 'one-size-fits-all' with typical BMP performance data. It is also recommended that guidance and requirements for stormwater BMPs based upon UOP approaches are combined with empirical approaches based on performance databases. Simple design rules based, for example, upon a 24-hour precipitation analysis for sizing and considering all BMPs equally will not produce designs meeting water quality goals. There is evidence to suggest that 80% of US BMPs have delivered less than desired results.

Infiltration systems in general may not be robust in a lot of cases due to clogging, groundwater contamination or poor construction. However, if they can be linked better to groundwater recharge, with quality control, they may be useful. More investigations may be needed to ensure infiltration performance problems are not due to bad construction and/or maintenance needs. It is clear, however, that infiltration BMPs have a place if properly engineered (and constructed) and used appropriately – but generally not on a large scale (Baltimore County experience). Pre-treatment is an essential component (particularly for sediment removal) of infiltration in the treatment train. This is also true for storage systems.

16 Project 25-20(01) – Evaluation of Best Management Practices and Low Impact Development for Highway Runoff Control. http://web.engr.oregonstate.edu/~huberw/25-20/March06Final/ResearchReport/FinalReport3-13-06.pdf

There needs to be more recognition about the limitations of knowledge and the complexities related to rainfall-runoff and diffuse pollution processes. Acknowledgment of the uncertainties should be made explicit in regulation and the delivery of solutions.

### 2.7.3 Illicit discharge and infiltration (I/I)

In the US the terminology for I/I is slightly different to that of the UK. The term I/I in the UK normally refers to 'inflow and infiltration'. Nevertheless, they are essentially identical, refering to flows that are entering the sewer which should not really be there.

In the US the presence of I/I is generally targeted at illicit discharges into storm sewers as most sewer systems are separate, not combined. The CWP, in conjunction with Robert Pitt, University of Alabama, has developed a 'guidance manual for program development and technical assessments', which deals directly with illicit discharge detection and elimination. Some of the text below is taken directly from this comprehensive document and illustrates the importance of this in a holistic strategy towards a 'sustainable' drainage system. It would appear axiomatic that unless the effects of unwanted discharges are removed from drainage systems, it will be impossible to achieve a sustainable solution. Unfortunately this is often not tackled in either the US or UK.

Provision of the CWA requires NPDES permits for stormwater discharges. Section 402 requires that permits for municipal separate storm sewers include a requirement to effectively prohibit problematic non-stormwater discharges into storm sewers. Emphasis is placed on the elimination of inappropriate connections to urban storm drains. This requires affected agencies to identify and locate sources of non-stormwater discharges into storm drains so that they may institute appropriate actions for their elimination.

Detection and eliminating these illicit discharges involves complex work that makes it hard to establish a rigid prescription as to how to 'hunt down' and correct all illicit connections. Frequently there is no single approach to take, but rather a variety of ways to get from detection to elimination. Local knowledge and available resources can play significant roles in determining which path to take. At the very least, communities need to systematically understand and characterise their stream, conveyance and storm sewer infrastructure systems. When illicit discharges are identified, these need to be removed. The process needs to be ongoing and the effectiveness of a programme should improve with time. In fact, well-coordinated programmes can benefit from and contribute to other community-wide water resources-based programmes, such as public education, stormwater management, stream restoration and pollution prevention.

#### *2.7.3.1 I/I programme at MWRA*

The mission team saw an example of infiltration management that delivered excellent results for the overall management of the wastewater system at the MWRA in Boston. The city of Boston resembles a number of UK cities in its arrangement of sewer systems. Boston relies on an old combined sewer system serving a central city population of around one million with spurs that emanate out dendritically to the smaller townships that serve the outer lying areas and swell the total population to around two million. The trunk sewers which serve the outer lying communities can be up to 20 miles (33 km) long.

The Greater Boston system is subject to continuous flow monitoring at strategic positions in the network. This provides real value to the operation of the sewer network.

For example:

- any new illicit discharge is immediately picked up as it registers a change at low flows during night time. This enables MWRA to track it down and remedy it fairly quickly
- the effects of gradual downspout disconnection can be observed over time, providing clear evidence of its value
- the hydraulic computer models used (Infoworks) can be honed to a higher degree of accuracy (calibrated), thereby better targeting capital expenditure on the network in a more strategic and holistic way
- it targets and improves maintenance efficiency.

The use of the targeted flow monitoring and metering (of both water and wastewater systems) has resulted in water usage being reduced from 340 million gallons per day to 120 million gallons per day, which is the same as 1911 despite a much larger population.

#### *2.7.3.2 I/I programmes – relevance to the UK*

Many sewer network systems in the UK are subject to major inflow and infiltration problems. This is often seen as 'just one of those things' and it is therefore not allotted sufficient relevance. It seems incongruous to embark on the construction of bigger and bigger carrying sewers and storage structures without tackling the problems of getting unwanted water in its many guises (storm, groundwater infiltration, rivers and streams, leaking potable water etc) out of the system. The presence of I/I and its detection and removal should be part of any 'sustainable' holistic solution for UK drainage systems.

There is growing evidence of attempts at integrated management of wastewater systems and examples of these include the holistic approach being undertaken in Glasgow. Here 'communities need to systematically understand and characterise their stream, conveyance and storm sewer infrastructure systems'. In Cardiff there has been a 12 month monitoring programme on key sewers in the network to help understand how these Victorian systems actually work.

Programmes such as these should be extended and continuous, as the MWRA has shown that the results can be valuable for a comparatively limited investment.

The IDDE programmes of the US concentrate generally (Boston excepted) on illicit discharges into storm sewers whilst the problems in the UK are centred on combined systems. Nevertheless, much of the detection and elimination is of the same type of water, eg groundwater, leaky pipes etc. Hence a number of the procedures recommended in the CWP guidance manual are equally applicable to the UK.

## 2.8 Integrated management and stormwater as a resource

During the mission there was little evidence that significant interest existed in the use of stormwater as a resource, although the more enlightened, like John Sansalone, did indicate that there was an urgent need to start to consider stormwater as a resource. Direct use and reuse are recognised LIDs and BMPs, although so far mainly recommended for external uses. The limited evidence of stormwater reuse was probably because in the areas visited, perhaps with the exception of LA city, there is no apparent water stress. Also possibly because there is very little interest in the US in the future potential implications for climate change. Although in the LEED (leadership in energy and environmental design) programme of the US Green Building Council, rainwater harvesting plays a part in achieving building performance accreditation (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19). This has some equivalence to the UK 'Code for sustainable homes'

There were examples of direct water use for 'rain gardens' in Portland, Oregon and in garden watering using the treated stormwater from the SMURFF device in LA, but this had notices warning the public that the irrigation water was potentially hazardous (See Exhibit 2.42).

There were no examples of any explicit attempts at integrated water management by those visited.

Rainwater planters are regularly used in the city of Portland, Oregon, to manage disconnected flows. Exhibit 2.43 illustrates the use of rainwater planters and also the emphasis on public education.


*Exhibit 2.43* *Public information notice board providing information regarding roadside rainwater planters, Portland, Oregon*

*Exhibit 2.42 Re-used stormwater from the SMURFF in LA for irrigation carries a health warning*

Other examples of using rainwater at source include the use of rainwater in public areas to create communal recreational areas. This example (Exhibit 2.44) in Portland, Oregon, is a feature at the local university. The rainwater here is also recycled and used to flush toilets.

*Exhibit 2.44 Use of rainwater recycling to create recreational areas in Portland, Oregon*

At present annual water use in Portland, Oregon, is approximately 23 billion gallons (100 billion litres) and the annual yearly rainfall is approximately 91 billion gallons (400 billion litres). Stormwater reuse is not widely used in Portland, but is now starting to be explored as an option, although there are major difficulties in charging for services if the take-up rate is high because of the current form of institutional arrangements for charging for water supply, sewage and stormwater. A small direct water use project has been installed at the University of Oregon where 'treated' stormwater is used to flush toilets. Installation of this system was however, strongly opposed by certain regulators and by the city's plumbers.

# 3 CONCLUSIONS AND LESSONS FROM US STORMWATER MANAGEMENT PRACTICES

The mission produced a list of conclusions for each day of the visit. These have been collated and grouped into generic categories in the following sections.

## 3.1 Drivers, reasons and motives

- The drivers and motives for adopting particular stormwater management practices such as BMPs need to be understood if novel approaches are to be utilised. In the US, implementation since the CWA has often stemmed from environmentalists and the legal system that provides the means for citizens, NGOs and other interested parties to bring prosecutions against federal, state and other organisations where they are perceived not to be fulfilling their statutory duties. Environmentalists concerned with the obviously poor condition of many US waters have been able to readily mount legal action to force those responsible to address the problems by enforcing the requirements of the CWA, such as defining the water bodies that are impaired within a particular area. In LA, local environmental groups and the state both carry out tests at bathing beaches and can close them if the water is of poor quality. The success in implementing the CWA has been despite a long history of central government not being amenable to funding environmental improvements.

- There is a view from some of those visited that the environmental lobbyists are less interested in the actual outcome or resolution of impaired water body problems than in the process of litigation. Much of this activity by the environmentalists is also not as well-informed as it should be. Nonetheless, there are still states in the US, such as Texas, where the CWA has not been implemented. There is also a problem caused by the threat of enforcement and litigation, which can lead to over-regulation and delays in implementation of improvements.

- Similar attempts at prosecution of any of the various parties involved in stormwater management in the UK cannot be envisaged, owing to problems of obtaining suitable evidence, the opacity of the services provided and the relative secrecy and complexity of UK governance and institutional systems compared with those in the US.

- On a more local level, citizens and local agencies such as Baltimore County are highly conscious of the condition of its more prominent water bodies, such as in the Chesapeake Bay. Elsewhere, the citizens of LA city were prepared to pay higher (bond) taxes to improve the quality of their beaches. Whilst clean-up presents a challenge, it can also be an opportunity to ensure that all stakeholders buy-in to the need for additional resources and special measures for dealing with stormwater.

- In the Boston area high property and land values have forced people to convert basements to habitation and this has highlighted the problems of flooding risk. This has resulted in increased buy-in by property owners and dwellers. In the adjacent township of Cambridge, Massachusetts, the challenges facing the stormwater managers relate to sustained high river levels, which are maintained to ensure submergence of the timber piles supporting much of the city of Boston. This leads to frequent urban flooding and, as a consequence, community pressure to deal with the problems. Although many of the options selected to deal with the problems involve new in-sewer storage, utilisation of green-roof BMPs is expected to result in up to 100% reduction in local runoff volumes in selected areas.

- A major lesson for the UK is the need to determine and build on local drivers (issues and motives) when trying to implement innovative stormwater measures such as SUDS in the UK. It is unfortunate that the WFD does not appear to offer the same flexibility as the CWA in its implementation, particularly in relation to priority substances. Local needs and measures may therefore become 'lost' in European or UK nationally defined policies and standards. In the US, regulations that span across states possibly fit more easily than in Europe, as US culture is more coherent. What is different in the US is that local wealth and community attitudes determine to what standards, and how the CWA, NPDES and TMDLs, will be delivered via definition of impairment of water bodies and subsequent funding. For example, in LA city there were some 166 water bodies initially identified as 'impaired', ie not suitable for intended use. Although the WFD requires a proper cost-benefit assessment to determine whether or not particular measures are required. This in principle is similar to the position in the US. In the UK, a proper application of the WFD's river basin management approach by all stakeholders should avoid unrealistic standard setting and lack of community engagement, and ensure locally determined and appropriate solutions to stormwater management that are affordable.

- The knock-on benefits of improving water quality should not be underestimated. The economic benefits accruing from the clean up of Boston Harbor are estimated at some $1 billion (£550 million). These benefits have made the major investments required for the clean-up more palatable. Engagement of the public by direct involvement in the MWRA board and in determining charges for sewage and stormwater management has also ensured better community buy-in and public acceptance. This contrasts with the UK, where there is no direct public involvement or accountability of the main stakeholder groups; a major factor in public disinterest in wastewater management.

- Climate change is not as yet a driver in the US, in contrast with the UK where it is used perhaps too often as a 'threat' to the public. None of the design approaches used for BMPs reported any consideration of climate change over the typical 30-year lifetime expected, with even Strecker and Huber indicating that this was not a material consideration in their use of 20 or more years of continuous rainfall records for simulating storm drainage systems performance.

- Plumbing codes make the direct use of stormwater very difficult in Portland, Oregon. Hence direct use of stormwater is not significant. Although the relatively high rainfall does not make this a main driver at the moment, it may become important in the future.

### 3.2 Institutions, regulations and stakeholders

- Strong champions are needed in the key stakeholder groups if innovative and more sustainable management of stormwater is to be implemented. These champions must have good knowledge and well developed plans. By selection, the visit met a number of champions in the EPA, municipal and stormwater utilities, consultants and academics. In addition to champions, better integration across all stakeholder groups and a stronger commonality of purpose in delivery of innovative stormwater management needs to be in place.

- In England and Wales, the loss of a sewerage agency function by local authorities and the loss of experienced engineering staff has resulted in them being less capable of dealing with stormwater issues. A typical local authority will now only have highway engineers who are often inexperienced or too focused on the delivery of safe road transport to be interested in both the quality and quantity management of stormwater within a catchment perspective. This may lead to problems in the future when the WFD is being implemented as it will be important to ensure that highway drainage is properly integrated.

- From US experience it is apparent that a separate stormwater utility can be beneficial for managing longer term maintenance of facilities. Evidence from the visit also indicated that, despite decades of use, there is insufficient capacity in the US consulting and contracting service sector to design and implement innovative BMP systems. The situation in the UK is similar, although with a shorter history of use of BMP type systems. Current design and construction service capacity for innovative stormwater systems would be inadequate if these systems were to become more widespread in the near future. This lack of capacity is also in part responsible for a lack of take-up of SUDS due to the inability of consultants and others to assume an advocacy role for their use.

- Where there are a range of stakeholders involved in stormwater management, agreements need to be clear and robust. These may be between (adjacent) municipalities, those responsible for stormwater system construction and stormwater maintenance service providers. Where stormwater management is required across watersheds and municipal or state areas, this can become of major importance. For example, LA city officials reported that a recent change in engineering leadership in the adjacent county has resulted in a renouncing of previous agreements on cross-jurisdiction management of stormwater that will compromise in-city measures.

- Where practicable, community and stakeholder ‘adoption’ of stormwater facilities can raise awareness of environmental systems and help promote citizenship and strengthen communities. This was apparent in most places visited. However, community willingness to adopt is by no means universal in the US, with evidence that individuals and communities have not been willing to take on BMP maintenance responsibilities. This was evident for individual sites in Seattle and in Boston, where MWRA may have to intervene when some of these wide range and number of types of local communities in Massachusetts responsible for stormwater do not take their stormwater management duties seriously.

- The structure and way in which stormwater utilities operate is significant in terms of the services delivered and interaction with stakeholders. MWRA in Boston is a public body that has a high degree of autonomy. It also has to raise capital for investment and one of its main concerns is its credit rating. As a consequence it wishes to be perceived by all stakeholders as efficient and ‘open’ in terms of performance. Regulation of the MWRA is state controlled, although there is strong direct citizen involvement. There may be some analogy in the way in which MWRA and

Scottish Water operate, although the latter does not have to deal with the wide range of constituent stormwater service providers that exist in Massachusetts.

- Although there are already a number of 'trade-related' bodies involved in stormwater in the US, such as AWWARF, WEFTEC etc, there is still a need for a stormwater trade group to help with technology development and acceptability.

- There are a number of barriers to utilisation of innovative stormwater management systems in the UK. Partnering is needed to properly understand the issues and solve the problems. In addition, understanding needs to be improved as to the uncertainties and limitations of knowledge in relation to stormwater, stormwater management and what is realistic. Industry and regulators are often averse to utilising new knowledge where this is perceived as being 'too academic' – even where it may improve practice with often very simple changes. There is also a danger that educators (at all levels, especially professional) focus too much on traditional (engineering) solutions. To resolve this requires flexibility combined with 'fairness' in regulation, capacity building (education), and possibly institutional change to encourage greater innovation.

- The CWA states: 'develop and implement a stormwater management plan to reduce the discharge of pollutants to the 'maximum extent practicable'. Hence, the requirements and definition of TMDLs are open to widespread and uncoordinated interpretation resulting in differentiated standards across the US. This has led the USEPA to criticise certain local regulators for poor implementation. However, in certain states there is a view that some quality requirements have become too onerous, particularly those related to bacteriological and pathogenic indicators.

- Multi-disciplinary teams are required to deliver BMP and SUDS approaches to stormwater management in order to ensure proper account of the social, economic and environmental aspects. This means the involvement of planners, landscape architects and others is needed to properly fit the more 'natural' systems into the urban landscape.

- In many areas of the US, stormwater charges are based on the extent of the directly connected impervious area to the stormwater system, although in others (LA city), charges are based on property values. The former has allowed a variety of types of service provider to develop and also for these service providers to utilise differential charging systems, rebates, provide support for disconnections and/or develop innovative management systems. The current institutional arrangements in the UK militate against this type of approach. Although potentially feasible for new-build, in England and Wales there would be too many risks to both the EA, local authorities and the sewerage undertaker if existing stormwater system disconnection was encouraged. The EA and local authorities would be concerned about increased or transferred flood risk, whereas the sewerage undertakers would be concerned about both the loss of revenue and also the potential under section 106 for subsequent property reconnection to the main sewer network.

### 3.3 Development planning, funding and control of stormwater

- In the US there is local state interpretation of federal watershed protection requirements (equivalent to EU and WFD) – the state then passes standards to communities for compliance (usually producing a manual). For example, in California the main planning baseline is the 'basin plan', which designates the beneficial uses of waters. Some states/communities are not yet complying with this approach. Phase II compliance of the CWA is required by 2008 although many states (eg Texas) have not yet implemented phase I. It was suggested in LA that the main objective is to 'address' the 'pollutants of concern' identified in the TMDLs – not necessarily to effectively deal with them. Most proposals have been accepted when the developers have followed the guidance in the manuals and problems have been overcome by negotiation and refinement through partnership. Nonetheless, some stormwater management implementation does not follow the best practice specified in these manuals, but may nevertheless be accepted.

- In Massachusetts, the MWRA has re-planned the original large scale storage solution to manage CSOs (estimated as $1.3 billion (£700 million) in 1993). There are now a larger number of smaller dispersed projects (approx 100) underway. These are locally targeted, incremental and come at a much lower cost ($835 million (£450 million) at 2006 prices). These solutions involve new storage, disconnections and other local solution-based approaches and are seen to be more flexible and open to modification following experience in use. The solutions are also being used in the densest urban areas. Evidence from Portland, Oregon, suggests that downspout disconnections are not effective in all areas and may not be usable owing to a lack of suitable alternative outlets for the stormwater. In addition, most urban areas in the US have more open space than most conurbations in the UK. Hence, a key issue in the UK is the space to locate open 'natural' structures such as BMPs. As contemporary UK planning requirements (PPS3) demand ever denser housing, sometimes in direct conflict to other requirements for development and flood risk planning (PPS25), the premium on developable land area grows and the availability of 'soft areas' to implement natural BMPs reduces. The solution is a balanced urban landform approach developed by using a contemporary toolbox of drainage techniques. This includes both natural and proprietary BMPs and also piped systems. More R&D is needed in this area to determine under what circumstances there would be sufficient and robust benefits arising from the summation of lots of small responses such as widespread disconnections.

- A growing problem in the UK is infill and micro development, which lead to 'creeping' increases in surface water runoff. Downpipe disconnection is being used extensively in the US and may be a simple and effective way of not only mitigating the impact, but also reversing the increasing flows. However, disconnections should only be undertaken following flood risk assessments in accordance with standards such as PPS25. Without a surface water impermeable area charge, and hence the ability to offer incentives and discounts for disconnection, the UK stakeholder take-up may be less significant than in Portland, Oregon. In addition, the section 106 right to connect could mean that previously disconnected downpipes could be subsequently reconnected in future. This risk could be offset by implementing a similar charging system to the US in the UK, although it may not be attractive to the sewerage undertakers due to loss of revenue from the disconnected stormwater inputs.

- The most enlightened stormwater service providers in the US believe the right approach is to manage the problem and not simply meet regulations. This conforms to the approach taken in the UK, although there are instances where problems 'fall between' more than one main stakeholder. Where each stakeholder is more concerned with operating within strict legislative boundaries then problems can remain unresolved. Examples include whether or not a covered watercourse is actually a 'sewer'.

- Retrofit disconnection of stormwater, via downpipes or other inputs being removed from main sewerage networks, is an important option in the US for the management of CSOs. However, precise application and maintenance of disconnected stormwater systems in the US appears to be very variable, with certain municipal agencies assuming responsibility (eg Portland, Oregon) and others expecting local property owners to assume responsibility (eg Seattle). Disconnection has however, been shown to be acceptable and effective at removing stormwater from the system providing disconnection water does not discharge across pavements.

- Retained bond payments by developers/contractors for stormwater facilities prior to beginning BMP construction can be very effective at ensuring that specified standards are achieved during and after construction. In Seattle, one developer was recently fined around $1 million (£550,000) for contravening construction controls on stormwater pollution and all work on the site was stopped until the problem was rectified.

- In many places the stakeholders responsible for enforcing development regulations are not the same as those drawing up the specification or planning structure for stormwater management systems. In Baltimore County these functions are carried out by separate teams that nonetheless have established close working relationships. In the UK, building regulatory functions are typically carried out by different agents from those drawing up planning specifications (eg LDFs in England) or those with professional expertise in drainage, such as local authority engineers or the EA. Under current building inspection regimes in England and Wales there have been problems with stormwater systems once constructed. There is a need for better inspection processes with better qualified inspectors for stormwater assets, linked in future to the new 'Code for sustainable homes'.

- To be effective, any utilisation of sustainable drainage systems must include appropriate cooperation between all of the functions of regulation, building control and planning. This may also require better training of those responsible for building control.

- There are similarities in the delivery of US watershed management plans and what will be needed for the WFD in the UK. Conditions in LA: population, land values and rainfall variability resemble the southern parts of the UK, where lessons from LA may be applicable, particularly with regard to conditions under future climate change. States, counties and cities in the US have the ability to deliver a more joined-up approach than in the UK as they have more responsibility for the various parts of the water cycle (although these vary state-to-state and between communities), which is unlike England and Wales, where responsibilities are fragmented and more difficult to coordinate. Of particular importance will be better linking of the planning framework to stormwater management earlier in the development process. This has been recognised in 'Making space for water' and with more formalised and effective cooperation between the principal stakeholders should become more effective in the future.

- Land use management is the key to stormwater management within a basin perspective. Creating landscape can assist the disposal of stormwater and in the US redevelopment has to include new landscape in most cities. For new developments the CWP in Maryland suggests that the primary scale for stormwater management should be at the local level, rather than the larger catchment scale (ie 50 square kilometres not 250 square kilometres). Smaller scale approaches work better in engaging communities and can be used collectively to deliver solutions on a larger scale.

- In some areas of the US problems arise where different standards are used for potentially adoptable BMPs compared with privately operated and maintained systems. Because of this, Baltimore County stipulates identical standards for both private systems and those intended to be adopted. In England and Wales, differing standards apply for private stormwater systems (Parts G/H building regulations) and for adoptable systems (Sewers for adoption). The latter does not include SUDS systems although there is an EA SUDS for adoption document.

- In many stormwater service provisions in the US the separation of the stormwater charge from that for other water streams provides new opportunities for institutional arrangements and imaginative fund raising and investment via the clearly earmarked specific revenue stream. However, in a number of areas there are problems with charging for sewage where the sewage arises from direct stormwater use, as there is no metered water consumption. Such an arrangement may be worth considering in the UK, although the institutional arrangements in England and Wales may preclude it.

- Arrangements with other key stakeholders are important. For example, a historical agreement does not allow Portland, Oregon, to charge the transportation department and main highways agency for stormwater management.

- The whole catchment should be managed (eg regionally). In some instances it may be more effective to invest in managing the downstream watercourse into which stormwater is discharged, rather than in refinements to the BMPs in the upstream catchments. This approach is only feasible where the major stakeholders can agree and budgets can be allocated appropriately. In the UK, it is probable that the WFD will prevent this approach being taken.

- In the US it is essential to get public support for new taxes. Raising specific revenue to manage stormwater requires public plebiscite with a 70% approval in LA city. Re-packaging the message as 'bond-raising' instead of 'tax', led to a successful vote for water quality improvements in LA city (79% in favour of $500 million (£270 million)). This income is to be raised as $100 (£55) per year added to each property tax for 20 years, but spent in the next 10 years. Perhaps better differentiation of water, stormwater and sewage charges could help to engage the UK public in dealing with the stormwater challenges.

- The vision for improving stormwater management in California is to incrementally ensure improvements in stormwater systems through redevelopment projects, which it is assumed over time will eventually lead to the entire stormwater system being improved. State grants are typically inadequate for what the state expects to be done. This is being achieved by passing costs on to developers and requiring stormwater permits for development projects that disturb one acre or more of land. Such an approach can only be taken where the timescales are open-ended enough to accommodate prolonged clean-up over time.

### 3.4 BMP planning, forms and performance

- Sustainable success in rainfall-runoff control will require a combination of source control, LID, in situ control and central control. Even in the US there is inconsistency in usage of the terms for stormwater management systems. Evidence has been provided that in some instances BMPs are considered as part of LID, and in other instances LIDs are considered a form of BMP. Confusingly, there are also LID integrated management practices, which are a component of the LID approach. Despite the unfortunate terminology used in the UK, SUDS, which are not a priori necessarily 'sustainable', there is a strong case for a single term. Views were expressed in the US that in some instances there needs to be a little less 'religion' and more science in LIDs. When viewed within a wider planning context, SUDS, BMPs and other stormwater management approaches may be considered to be but one part of a design process that includes all aspects of water within the planning process. Because of this, Australia and much of the Far East use the term 'water sensitive urban design' (WSUD) which means all aspects of water within the planning process. WSUD encompasses both LID and BMP as well as SUDS concepts. There is therefore still a need for a clearer definition of terms, ideally internationally. The IWA urban drainage glossary, published in 2004, includes definitions for BMPs, and source controls, but does not mention LID, SUDS or WSUD.

- Although much of the emphasis in stormwater control in the US is on quality management, with LID concepts assisting significantly the management of smaller storms, it is possible that these may not be as effective for larger runoff events. It is therefore recognised that flow-duration control is important for downstream watercourse erosion prevention. Much design now uses long-term continuous simulation, which makes it easily possible to analyse flow-duration and control the impact on receiving waters.

- There is a gradual transition in assessment of performance by regulators that steadily become interested in increasing numbers of pollutants (although this is not an application of the precautionary principle), with the main interest in impairment of water use. There are reportedly irreducible background concentrations (eg Cd 3 μg/l) in diffuse stormwater runoff in the US. Regulations require there to be zero litter in stormwater discharges in Los Angeles by 2013. This is another example of unrealistic targets given the multiple (diffuse) inputs of litter to the stormwater systems. Paralleling this, the WFD priority hazardous substances directive to remove all traces of certain defined substances is also unrealistic, and de minimis levels for these substances need to be defined.

- Notwithstanding the difficulties that arise in defining these de minimis levels, there is a need for environmental requirements to be both prescriptive and performance based, ie there should be fixed emission limits for acute, toxic and bioaccumulative substances, whereas substances that may be assimilable more readily in receiving watercourses should be managed by the setting of local standards. This is the approach taken in defining TMDLs in the US. However, stormwater standards in the US are delivered using technologies that are 'deemed to comply' by achieving defined pollutant removal efficiencies. Currently it is virtually impossible to design these systems deterministically to achieve defined quality standards.

- Responding to current and future drivers will require flexible and adaptable solutions that may not be apparent with current knowledge. Therefore a range of types (portfolio) of solution should be utilised, some of which may include piped or sewered systems. There is no 'magic bullet' solution that can deal with all challenges now and in the future. Solutions should also include non-structural as well as structural solutions, which may cross boundaries between the main stakeholder groups under current UK institutional and regulatory regimes.

- Investments need to be made in the most appropriate part of the system to achieve the most efficient and effective outcome for stormwater management, irrespective of which stakeholder has the primary responsibility. There is also a need to better engage the public and wider community, although considerable difficulty exists as to how best to do this in the UK. However, this is a major aspiration of the current 'Making space for water' initiative.

- There is a perceived priority order for stormwater management in the regulatory areas where there is long experience in implementing the requirements of the CWA. These are: public safety, followed by utility, then aesthetic benefits. For this reason certain areas, such as Baltimore County, utilise permanent fencing around open water BMPs.

- There is considerable reliance in the US on experts as they are considered to be effective as overview project or watershed managers. Hence the CWP is playing a major role in delivering effective stormwater management across the US. This has shown that strong guidance via clear manuals for professional and other stakeholder use and good practice are needed, often with experts acting as the interface between research and practitioners. Manuals and guidance etc should show examples and illustrate choices, but should not limit innovation. It is not clear whether or not CIRIA (which may be the UK equivalent to the CWP) is independent enough to deliver this function and whether UK guidance is actually being provided at the appropriate levels and format for each of the stakeholder groups.

- There is variability in use of types of BMP, for example, in Portland, Oregon, large detention basins or wetlands are not promoted, whereas they are used extensively in other parts of the US. Experience in Maryland has shown that on-line (on-stream) storage systems are not easy to maintain in terms of sediment removal and offline, in terms of the stream, are preferred (these would still be on-line as part of the drainage system).

- US experience has shown that funding for stormwater management should be at the level and location at which it is most appropriately managed and delivered. It should not be fixed so that the service provider is constrained to deliver particular types of solution. The sewerage undertakers in the UK cannot utilise sustainable drainage systems as these are not legally definable as 'sewers'.

- Although much quoted, the first flush concept is not good. It has been shown in US (and French) studies not to be statistically valid for smaller particulates and other pollutants. This is because flushes may not occur at all, or occur throughout the storm in 'pulses'. However, evidence from LA city suggests that there may be first flushes of larger 'trash' litter. Notwithstanding, in Massachusetts the first flush concept is used to control finer sediments based on retention of half an inch (12 mm) of rain (runoff). In British Columbia and many other places in the US, stormwater pollution control standards are based on the capture by BMPs of 90% of runoff for a one year storm. The precise stormwater storage volume needed depends on the wetted surface area and also on the nature of the surface (grass type etc) as this will control the likely pollutants. In the UK, capture is typically of the first 5 mm of rainfall-runoff which is inadequate by US standards. UK approaches should be modified to achieve at least 25 mm capture if the expected WFD water quality standards are to be met in the future.

- Regulators such as the EPA invest substantially in R&D in the US and this clearly benefits the public domain; the outcomes are open, transparent and freely available, with key software and manuals being extensively peer reviewed. This is a clear route to consistency on a national scale. The situation in the UK is very different. Commercialisation has led to secrecy, opacity and the exclusion of key stakeholders from access to information, guidance and support for implementing sustainable drainage systems. The lack of peer review of key UK computational models and secrecy about the processes used in the models stifles effective debate and scrutiny and leads to poor usage and unquestioning belief in outputs by modellers who do not understand the processes used in the computer models. Ironically, the US is arguably the most commercial country in the world, and yet access to information in this area is much more readily available than it is in the UK.

- In Baltimore County there are six operational requirements in relation to stormwater management:
  - public education outreach
  - public involvement
  - illicit discharge detection and elimination
  - construction erosion control
  - post-construction maintenance
  - pollution prevention.

- Demonstration projects are important and also facilitate access by others for dialogue and in-depth contact with those already using or responsible for them. Trying and testing stormwater innovations is important as this provides opportunities to learn by doing and even from mistakes. Prior to applying regulatory controls to development proposals, municipalities and other regulators should firstly manage their own premises' stormwater problems to demonstrate good practice. In order to do this an accurate storm sewer map of any existing system is essential. As part of this approach it is important to implement quick-wins in a staged stormwater management improvement programme. The MWRA has illustrated this approach by making staged and initially limited but well targeted investment in stormwater management, producing large economic benefits and convincing stakeholders to provide further resources and support to implement further improvements.

- The use of traffic calming areas in streets for stormwater management is growing in the US (also in Australia). There could be more imaginative use of the space in traffic calming measures in the UK to include stormwater facilities, such as street gardens. However, even in the US there is only limited cooperation between highway and traffic managers and those responsible for overall stormwater management. This often restricts usage of the most appropriate solutions.

- The utilisation of typical BMPs in the US will have a greater effect on stormwater quality rather than on controlling quantity in terms of flood risk.

- There are problems of application of BMPs and LIDs in some areas due to tradesmen and trade associations. Plumbers, for example, in California. This may be because of the need to re-train or of perceptions of increased costs of these systems. There may also be correctly perceived grounds to question the safety of certain BMP systems, particularly those that recycle or make direct domestic use of stormwater. There are examples in the US where BMP solutions have been shown to be cheaper in terms of capital investment than pipes. A BMP system in Davis, California was installed at less cost than the equivalent piped system and has reportedly performed well for 30 years.

- Bioprocesses are important for quality related performance, and plants and trees are considered essential for effective BMPs across the US.

### 3.5 BMP construction and maintenance issues

- The impact of practices and construction on the community needs to be addressed and taken seriously into account.

- Ownership and maintenance of the above-ground BMPs is another key UK issue. This was not entirely resolved across many of the similar US sites visited because in some areas municipal responsibility is assumed, whereas elsewhere it is left to the developer or property owners. However, in the US, barriers such as responsibility for maintenance did not appear to prevent these systems being used as maintenance responsibility was deemed resolvable. It was contended that many of these street BMPs are only marginally more expensive to maintain than a standard landscape feature and the benefits of having the BMP performance far outweighs the small cost increase. As planning deems it essential to incorporate landscape features in UK development and modern urban streetscapes, many of these features could multi-task using sustainable drainage BMPs.

Construction methodologies for BMPs are still a problem in many parts of the US. However, they are essential in controlling catchment sediment during construction. The US has sophisticated and very detailed techniques to control construction sediment runoff and plans have to be certified by the SCS.

- There is a tendency to only use reactive maintenance in the UK, but there is a need to see proactive maintenance as perfectly valid within the whole life performance of the BMP.
- BMP construction. In Boston the other utilities have to pay for their own re-routing when storm sewer facilities are built.
- Effective, planned and accepted maintenance strategies are essential within a whole-life costs framework. There is a critical link between operation and maintenance.
- Post-construction monitoring is essential and designed into the system.
- In Portland, Oregon, maintenance arrangements are inconsistent and tackled case by case.
- Random policing of continuity of downspout disconnections is made in Portland, Oregon, (not clear what happens if these are reconnected) – tax reductions accompany disconnections.
- Householders are responsible for the maintenance of stormwater structures where these are on the sidewalk up to the roadway, although the city will step in where necessary.
- Maintenance for BMPs is really identical to what it would be if these were a landscape feature anyway (parks and landscape departments in the UK could become responsible for the quality control of BMPs, but flood control may be too important at this time to leave it to these groups, but this capacity could be built).
- Below ground solutions are 'out of sight, out of mind'; above ground it is (usually) obvious when maintenance is needed.
- Portland, Oregon, is not too worried about maintenance and is keen to 'get systems

in' in the expectation that it will work out as communities seem to be more committed to engaging in this.

- Maintenance by property owners is more likely where this influences property values – however, where BMPs are considered to be aesthetically or otherwise unappealing these may be abused.
- The classification of pollutants removed from stormwater as 'hazardous' makes their removal less attractive as the 'new owner' then has a difficult job of disposing of them.
- Of 1,000 CDS units in the ground in southern California, only some 30% are being properly maintained.
- There is no definitive agreement on maintenance responsibilities and payments – LA County is adopting more of these to ensure compliance is achieved by maintaining and using developer commuted sums and units built on public land.

### 3.6 Performance of BMPs

- More BMP performance data needs to be routinely collected and the monitoring and maintenance systems should be designed into these systems. Predictions of pollutant loads and hence removal efficiency require highly site-specific empirical data fractionated for model calibration. However, methods for field performance evaluation of BMPs are expensive and only effective with very great care. Automatic sampling is often ineffective for the assessment of stormwater control systems as large and whole cross-sectional sampling is required. Pilot scale testing of BMPs is preferred where possible, rather than full-scale testing due to the controllability of the parameters and the large number of storm events required at full scale.

- Flood risk management in the US typically controls 25 year events and also some 100 year events – there is a similar perspective for pollution control, although pollution from the smaller more frequent events may be the most significant. It is not clear how the excess flow is managed. Using typical US design rules, BMPs can only be effective at improving water quality for smaller and more frequent events. However, design should be based on flow volume and mass transport simultaneously.

- Transport and pollutant yield in runoff can be characterised by either flow limited (zero order) or mass limited (first order) resulting in significantly differing volumetric criteria for the design of controlling structural BMPs. When using treatment trains, 'daisy-chaining BMPs', it is wrong to assume a similar performance at each step of the train as for a single unit process, as this will over-predict the performance. Water quality modelling for the design of BMPs should be long-term continuous simulation in order to account properly for the various storage elements.

- As foul flushes cannot be defined a priori – as they may or may not exist under different circumstances – there is a need to improve regulations or standards that include the need to capture the 'first flush'. Percentage pollutant removal is not a sensible design standard, although it is invariably specified in the TMDL; the use of an EIA or equivalent based approach is more sensible.

- Many of the lessons, tools and solutions from experiences gained in the long history of wastewater treatment are not readily transferable to stormwater – for example, the effectiveness of end-of-pipe compared with distributed systems (see 3.6.1). Also, for the management of residuals as this will become a big industry for stormwater management in the future. Even in the US, treatment processes for managing particular pollutants in stormwater have not yet been developed.

- More recognition is needed of the limitations of knowledge about stormwater system performance and the complexities related to rainfall-runoff and diffuse pollution processes. A tacit acknowledgement of the uncertainties needs to be made explicit in regulation and delivery of solutions.

- There is a need for more engineered development of structural BMPs, with design and operation that should be open and transparent and that includes better and independent testing and verification of performance of components. Proprietary systems (widgets[17]) do have a place where they are targeted in terms of particular pollutants or process, but cannot be expected to do too many things. Certification for conditional use (with a view to future unconditional use) has to be applied for each proprietary system from stormwater regulators. Unfortunately in the US manufacturers of these systems believe that they are forced into mis-representing performance as users want a 'magic-bullet' device that will remove all pollutants. Certified equipment is often substituted by similar but inferior sources (cowboys and garage manufactured) that is cheaper, but does not perform adequately. Users need to be better informed to make them realise that this is not realistic and to understand how complex the stormwater management area is. In the UK it is most likely that the take-up of 'widgets' can be more easily effected at the 'end-of-pipes'/single points than at inlets, as is being done in LA city. The visit to the trash screen near the beach in LA showed how devices located at the ends-of-pipes can localise maintenance.

- Encouraging evapotranspiration is typically an under-rated means of stormwater management. As a first step it is important to manage the 'sponge' (soil and flora) before anything else. Soils should also be engineered to manage key nutrients such as phosphorus. As nitrogen is very difficult to remove from stormwater, there is a need to use plants in every above-ground structural BMP.

- Some 80% of US BMPs studied have delivered less than desired results. For example, CalTrans undertook a $30-40 million (£16-24 million) study on BMP performance and did not find satisfactory performance. However, the major effort in terms of stormwater management for highways is focused on the 'during construction phase'. A lot of schemes, such as road widening, are exempt from stormwater regulations.

### 3.6.1 Infiltration systems

- Infiltration systems have their place if properly engineered (and constructed) and used appropriately – but not at large scale, as they may suffer from clogging. However, there is a need for more investigations to ensure infiltration performance problems are not because of bad construction and/or maintenance needs. It is possible to return the effectiveness of infiltration pavements to almost 100% by both vacuuming and sonication.

- If infiltration systems can be better linked to groundwater recharge, with quality control, they may be useful in water stressed areas. In Oregon, state regulators are concerned about the polluting impacts of stormwater on groundwater and have required special permits for any new infiltrating BMPs. There is little knowledge about the adsorption processes that occur in media or soils in infiltrating systems, although these are the key to dealing with metal removal from stormwater.

- Pre-treatment is an essential component (sediment removal) before infiltration in the treatment train and it frequently may be

17 Water Integrated Device Giving Effective Treatment (Bob Pitt)

achieved using buffer strips. Engineered 'smart' media are required in infiltration systems in order to remove both metals and nutrients as the use of natural media such as sand is ineffective. Although stormwater infiltration systems may have a lot to learn from water treatment experience and research. There is a range of smart media or infiltrating surfaces now beginning to emerge, such as cementitious permeable pavement (CPP). However, until these are taken up by manufacturers they are not likely to be widely available or economic to use.

### 3.6.2 Storage systems

- Storage is one of the most common forms of BMP and can be very effective at both quantity and quality control. Ponds in series are better than a single pond of the same surface area, but the removal performance efficiency of each pond is not the same as for a single pond alone. Unfortunately, some BMPs are simply 'HIGS' –holes-in-ground that are not maintained or perform according to design. Unless effective controls of sediments in inflows to constructed wetlands are utilised, then facilities can become depositories for hazardous pollutants. Pre-treatment is an essential component (sediment removal using, eg a sediment trap prior to large scale storage. Hydraulic loading appears to be the only controlling factor for solids removal in ponds and planted wetlands.

- Retention times need to be at least 24-48 hours, preferably 72 hours. Pond size should be able to cope with 90% of the annual storm. When assessing performance conductivity appears to be a good correlator of pond quality parameter variability. There is a byelaw requirement in Cambridge, Massachusetts, for developers to store between the two and 25 year storm and also to provide 25% impermeability. In this example, and elsewhere, multiple outlets are needed to ensure appropriate capture and release of different types of event. The city of Cambridge, Massachusetts, has developed demonstration examples of how to best manage stormwater (to be applied as an example to the new police headquarters) and shown as part of the recommendations for use by developers.

- Steel corrugated pipes should not be used to store stormwater unless the frequency of their replacement is built into maintenance programmes.

- The maintenance of ponds in which deposited sediments are removed typically has no effect on stormwater sediment removal efficiency. Sediment removal does improve COD concentrations as most COD loads seem to be as a result of decomposing leaves, depending upon the season. Classification of residual arisings is an important consideration in the ability to utilise innovative approaches to stormwater management – as disposal may be costly and difficult.

- CFD modelling is very effective at assessing the performance of settling systems, but should be linked to pilot studies.

### 3.6.3 Green-roofs, trees, street gardens and inlets

- Green-roofs can be very effective, with a runoff coefficient of 0.1 likely from a green roof compared with 0.9 from a conventional roof. Green roofs can also significantly improve water quality and benefit the usage of energy over the life of a building through helping cooling in the summer and heating in the winter. Other benefits accruing to users of green-roofs include a gain in planning benefits, such as an allowance to construct an extra storey on buildings in Portland, Oregon, where a green-roof has been used.

- Some of the demonstration approaches in Cambridge, Massachusetts, are innovative, particularly in showing how effective green-roof storage can be. These use a combination of both green-roof surface and on-roof storage.

- Stormwater planters and water garden design can be effective and these systems have been well developed in Portland, Oregon. Trees older than 10 years are very effective at managing stormwater quantity and quality. However, Portland street garden systems are not viable in areas where there is pressure on car parking on streets.

### 3.6.4 Other BMPs, stormwater management and related issues

- There appears to be promising proprietary systems for a range of pollutants, including for inlet controls for solids and bacteria; however, there is as yet insufficient independent evidence to confirm this. Product development and take-up requires a three stage process: lab-pilot-field scale and independent verification. Because of this various full-scale trials are underway across the US, partly funded by manufacturers and partly by regulators to assess the effectiveness of a range of types of system.

- As yet there are too few US applications to give credibility to the new generation of Up-Flow filter technology to UK applications.

- In Massachusetts, plumbing codes now require low flush toilets. There is also a requirement to modify these and ensure that there is no risk of backflow siphonage when there is major building refurbishment.

### 3.6.5 Non-structural BMPs

- Effective public and stakeholder engagement is the most important aspect of non-structural BMPs (see 3.8). This is recognised as an essential component of the CWA which seems to be much clearer in this regard than the WFD.

- The lesson that non-asset based approaches (non-structural) can be more effective than building yet more assets needs to be emphasised for UK applications. Current institutional boundaries also need to be addressed to make the use of these systems more viable. For example, a series of small contributory schemes may be as effective as and more sustainable than one single large additional asset.

- Control at source is the most effective BMP and as part of this a new generation of US street cleaning machines can now remove up to 80% of all sediment particle size fractions.

## 3.7 Sewer related issues

- There are similar issues in the US as in the UK related to a mixture of combined sewerage (mainly in the denser urban conurbations) and separate stormwater and sanitary sewerage. CSO control is as important for the combined sewers in the US as it is in the UK. They have similar problems related to separate stormwater control, although there are additional problems in the US because of overflows on sanitary sewers (these are not dealt with in this report). Infiltration and inflow (I/I) is a major problem across the US and it is extensive in all types of sewerage system. This includes not only infiltration, but wrong connections between storm and sanitary systems. For example, I/I is typically 50-60% of the flow even in notional sanitary sewers in the MWRA area.

- The continuous measurement of flow in sewer networks is considered essential to: (a) understand performance and I/I; (b) target and improve maintenance efficiency; (c) optimise performance; and (d) allow proper calibration of computer models (quality modelling is not done, except for receiving water coliforms FCs/EC). In the MWRA area charges are based on measured sanitary sewage flow. There is a substantial I/I control programme working right across the catchment in Boston (with the remotest areas being some 20 miles (33 km) away from the city centre).

- Any new developments in the MWRA area which will add additional flows to the sanitary sewer network have to provide compensatory reductions elsewhere in the network of between 3-15 times the proposed new inputs.

- Studies in Cambridge, Massachusetts, by MWH have shown that rain caught in catchbasins can be used locally to effectively flush sanitary sewers to keep them clean of sediment. Daily in-sewer flushes can also control fats, oils and greases in sanitary sewers.

- There has been a number of large sewer storage tunnels proposed to deal with CSO problems. For example, the 'big pipe' in Portland, Oregon. This is, however, now smaller than first envisaged due to the effectiveness of a stormwater disconnection programme. However, despite evidence that the 'big-pipe' may no longer be needed longer-term, it is going ahead anyway because of the short timescale for implementation of the CSO clean-up programme (2011).

- One innovative proposal in Portland, Oregon, is that during dry weather it may be useful to divert separate stormwater from 'nuisance flows' (such as baseflow from irrigation and other domestic inputs, which is up to 150 gallons/house per day) into the sanitary system, which will have spare capacity and hence allow these flows to be treated.

## 3.8 Public engagement

- Gearing of public engagement fiscal incentives from stormwater service providers to also include retailers can help supplement expenditure and also raise awareness. For example, from targeted tree planting subsidies for householders linked to discounts from retail outlets in Portland, Oregon. In the UK, subsidies for rain water barrels from sewerage undertakers experience high levels of uptake, but cannot cope with demand at times of drought.

- Innovative funding schemes can be useful in promoting awareness and engagement and there should be more national subsidy options for engaging householders in stormwater management. Unfortunately, the enhanced capital allowance (ECA) scheme applies only to industry. More UK government efforts via subsidies, grant schemes and other means are required, along the same lines as energy efficiency promotion.

- School education is a major opportunity to raise awareness in stormwater management. Sea Life Centers and equivalent public facilities, with special links to stormwater as at Norwalk, are very strong vehicles for raising awareness, engagement and thence improving water quality in coastal areas through education and encouraging more willingness to pay for better stormwater facilities. Unfortunately, in the UK the national curriculum may be a constraint to using these approaches to improve awareness and responsibility in schools.

- Across the US, direct citizen involvement in managing boards for stormwater utilities improves community engagement and commitment. For example, in Massachusetts local communities decide individually if tariffs should be rising, declining or fixed for both water and sewage. Communities in MWRA competed with each other to be more efficient and water, sewage and stormwater were politically controlled functions within the community. Hence politicians are seen as accountable for inefficient services.

- Public choice about expenditure on stormwater management is part of decision making in Cambridge, Massachusetts. The high proportion of intellectuals living in the city are strongly engaged in the decision making processes and their views need to be taken into account. The use of professionals living locally (eg architects) in design details can help keep the local community on board with new facilities for stormwater management.

- In LA city, community representatives have also been directly involved in determining where the funds raised by the stormwater bond should be spent; although there is some concern that the funds raised will be misappropriated for uses other than stormwater improvements. Unlike the US, the distance of UK consumers of stormwater services from decision making processes is a major barrier to their effective engagement and better stormwater management. It is unlikely that the new CCW will be able to bridge this gap.

- Unlike the UK there is no public warning system for flooding risk in Cambridge, Massachusetts, despite frequent (one-to-two year) flooding.

- Metering of sewage from connected communities into the wastewater networks operated by MWRA is universal and encourages the control of I/I by communities themselves. This is despite there being no reduction in charges for more efficient households, as capital investments in the sewerage and stormwater networks needs to be repaid over 25 years. In the same area, water usage of 340 million gallons (1,530 Ml) per day has been reduced by 120 million gallons (540 Ml) per day as part of a distribution system leak detection programme (also an I/I programme). This has resulted in water usage returning to 1911 levels despite an increase in population in the Boston area.

- Effective engagement is also required with the service deliverers and in MWRA, employees have embraced new technology and multi-tasking with roving crews with no job demarcation.

- The most effective ways of communicating with the public in relation to stormwater systems have to be appropriate and directly relate lifestyle improvements and recreational benefits to costs and investments.

- Stormwater disconnection incentives need to be communicated effectively and pitched at a level to make these worthwhile to householders. In Portland, Oregon, total stormwater charges (which are separately billed) can be reduced by a third by disconnections. Public awareness can be heightened about water systems in general with specific campaigns aimed at, for example, disconnections. The use of posted 'my stormwater is disconnected' signs on property as seen in Portland, can encourage wider community take-up.

- Changing existing stormwater systems to those that are more effective and sustainable takes a long time, and keeping communication working for such long periods can be challenging. 'Public agencies' have a duty to ensure proper stories are told to ensure continuing support over lengthy periods of change. This also requires trust in these agencies by service users. Continuing messages using permanent displays at stormwater treatment facilities can be used to promote and maintain public awareness by making these a public feature, as illustrated by the SMURFF facility in LA city.

### 3.9 Sources of diffuse pollution

- Stormwater pollution arising from agriculture is poorly understood in the US, although it is known to be important. The difficulties of controlling diffuse pollution arising from agricultural runoff are similar in the US to the UK and there are no obvious solutions to deal with this.

- In urban areas the majority of pollutants are transported by the most frequent but smallest storms with less than one year return period. 75-80% of all pollutants occur in only one-tenth to two-tenths of an inch (2.5–5 mm) of runoff. The main sources of problematic pollutants that find their way into stormwater runoff are from older neighbourhoods and where cars owned by the poorest inhabitants drip most oil. Other problem areas include where there are vehicle stop-start movements, eg supermarket car parks.

- Diffuse pollution can arise from water solubility of building materials such as the copper pipes used in domestic plumbing. These materials should be inert to water solubility.

- Property owners and users may be irresponsible in their domestic use of pesticides.

- In LA city there is a huge homeless community that creates a lot of trash in particular areas. Because of this 'bin-raking', the city cannot provide trash bins as rubbish is thrown all around the streets; hence they are only being provided in commercial areas. Street sweeping and gully cleaning occurs once a week and cars parked in the way are fined. Current strategy for managing litter and trash entering stormwater systems is in tackling high trash areas first and intensively, sometimes hourly. This is in addition to extensive trials using catchbasin inlet screens.

# 4 RELEVANCE TO UK PRACTICE

## 4.1 Water Framework Directive (WFD) and other standards

The CWA has a number of similarities to WFD. However, the CWA has now been around for 30 years with a target of final phase II implementation of 2008. The WFD encapsulates a lot of similar concepts to the CWA, but WFD implementation is expected over a much shorter time frame (approximately 10 years from now). In addition, the CWA is delivered through an NPDES system and specified TMDLs, whereas the WFD is expected to result in a so-far undefined 'good ecological status' for water bodies. The latter also requires the 100% removal of certain priority hazardous substances such as cadmium and nickel.

Many of the water quality standards that are enforced in the UK, such as the urban waste water treatment directive (UWWTD) have focused on the quality issues relating to foul/combined sewer pollution. Surface water has not been subject to the same degree of quality control. Apart from the imposition of petrol/oil interceptors when high levels of pollution are expected, there is little to be found in the form of treatment other than in Scotland where there has been a greater interest in treating stormwater. It is often the case that surface water runoff arrives untreated at the watercourse or into tidal waters. The US evidence shows that wet weather runoff can contain high levels of contaminants and often the most persistent and bioaccumulative substances such as heavy metals. Treatment in the US can take many forms, such as bio-swales, filter media and bespoke commercial devices. Unfortunately, the standards set for TMDLs, for example, may not be easily applied or realistic as illustrated in the extract from the EPA website in table 2.1.

Some of the requirements to remove pollutants from stormwater can be overly onerous. This is true of both the CWA and WFD. There is a need to be cautious when expecting the removal of 'all' (no de minimis concentrations) of a certain pollutant such as cadmium or nickel as these, and other priority substances, are naturally occurring in the environment, come from sources other than wastewater emissions and in any case, total removal from stormwater is actually not possible with current technologies (see also House of Lords inquiry report on Water Management, June 2006).

Additional difficulties relate to monitoring and compliance testing. It is clear that full scale sampling requirements to ensure compliance can be substantial and hence costly. There is a need to be realistic in the approaches taken; solutions should be provided to satisfy value for money, as well as environmental concerns and not just arbitrarily set 'technical' standards.

## 4.2 Institutional similarities

The biggest difference in issuing permits between the US and UK is in the use of NPDES. In the US the issuer of the NPDES will generally be the organisation charged with adoption and maintenance. It is therefore in its own interest to get the structures constructed well and to regulate these appropriately. Where management companies have been used, the legal frameworks controlling them have to be very tight to ensure that responsibilities are clearly defined. The use of stormwater management companies is now emerging in the UK – such as the 'Green Belt Company', but this can only be described as 'early days'.

In the US there is a wide variety of responsible bodies for managing stormwater and delivering the requirements of the CWA. The Federal and municipal sectors are heavily involved in regulation and delivery of good practices and even in managing stormwater systems. This diversity has both good and bad aspects. It is good in that municipal delivery seems to be very effective at stakeholder engagement and promotion of individual responsibility. Disadvantages include the lack of consistency between stormwater service provision and lack of nationally agreed design and operational standards. In the UK it would appear that in many cases the most appropriate and responsible body for the adoption and maintenance of SUDS is the sewerage undertaker. However, delegating powers to others such as local authorities could be considered, particularly in large towns and cities. Alternatively, separate stormwater management utilities/companies could be established.

The closest example to the UK model witnessed in the US was the MWRA, although this is entirely state owned. However, there are many differences in the way it operates, the most important of which is its direct funding from taxes and charges based on measured sewage flow rates; with each municipal area being responsible for its own sewage and stormwater systems up to the point of connection. Other major advantages are that citizens have direct involvement in funding decisions and the organisation is non- profit making.

### 4.3 Stormwater Profile and Public Engagement

The revision of PPG25/PPS25 and the consultation and delivery of 'Making space for water' are probably the biggest incentives so far in England and Wales to engage the wider stakeholder community in an understanding of surface water runoff, climate change and their place in the planning and development process. The development of flood maps and their effect on insurance premiums has also helped concentrate thinking; however, these relate to main rivers and coastal flooding and are of less significance for local pluvial flooding of the type caused by stormwater.

Much of the planning guidance on PPG25/PPS25 relates to the precautionary principle and great weight is given to flooding aspects and the control of flood water. Unfortunately, the implementation of the flood maps can be over-zealous by officers who have little experience or knowledge of the development process. It has been known for developers to be asked by planners (and the EA) to specify exactly which SUDS device will be implemented before site investigation and soil conditions are known. The developer can feel hampered by this approach and often reverts to known parameters with less risk and uncertainty such as pipes and underground tanks. This is often not the sustainable answer and perhaps there needs to be a 'commitment' toward appropriate SUDS techniques and understanding of flood risk at the planning stage, rather then focusing too much on 'exact' engineering design.

There needs to be a certain amount of mutual trust on the part of planners (and the EA) and designers/developers and this could be accounted for within the text of the planning approval. EA is looking to remedy some of these difficulties by improving the training on SUDS to its officers and this is to be commended.

### 4.4 Planning and the water company perspective in England and Wales

Typically, UK planning documents and policies have not accounted sufficiently for the importance of water within developments, although this is now changing with RSS, LDFs, the SEA and WFD directives. Nonetheless, problems still remain including the growth in hard surfaces that occurs due to creeping urbanisation – in which lawns are converted to driveways and patios.

As sewerage undertakers the water companies in England and Wales have a role in the planning process, but this generally extends only to whether there is sufficient sewer capacity. 'Right to connect' under section 106 is a big issue militating against the use of SUDS systems and water companies quite often have to rely on the building regulations to force developers away from connecting surface water into their sewers. In any case, it is then possible for future property owners to subsequently invoke section 106 to disconnect a SUDS system and connect into the sewer network if so wished.

The 'definition of sewer' also precludes adoption of many types of natural drainage systems as the sewerage undertaker only has a right to adopt a 'sewer' which has a proper outfall.

Primary legislation is required to enable water companies in England and Wales to properly fund SUDS so that they can arrange adoption and maintenance standards. The Seattle model is an excellent example of stormwater funding. The only other alternative in a lot of cases is the use of 'management companies' – but this is not ideal because of wider legal difficulties and problems of long-term ownership.

There are known difficulties with off-site ponds with legislation relating to groundwater infiltration. This makes adoption and maintenance very difficult. Until the government acknowledges and addresses the problems associated with the legislation there will be continuing problems in relation to the types of system that can be built. As it is likely that SUDS may be the only way in which WFD compliance can be achieved in the future, these problems need to be addressed with some urgency.

'One size does not fit all' and the current plethora of organisations responsible for stormwater (as recognised in making space for water) require greater freedom to develop cooperation, appropriate and agreed standards, and also raise and allocate revenue appropriately to deliver the best solutions. In order to do this the organisations need to be held more accountable to their stakeholders. One way of doing this is by direct engagement of the public in the decision making boards to ensure transparency and clarity.

## 4.5 Redefining UK sustainable drainage

The precise terminology relating to sustainable drainage systems varies around the world. There is even confusion in the US between BMP and LID. In the UK there has been a belief for some time that the term 'SUDS' is confusing, misused and potentially redundant. It has for too long conjured up a misplaced belief that all SUDS should be a 'natural BMP', but this is inaccurate. The contemporary balance for a surface water management train must surely lie in a toolbox of sustainable drainage techniques that includes both natural and proprietary BMPs as well as piped systems where appropriate, set within the concept of LID. The sustainable drainage mission to the US has only served to reinforce this view and 'sustainable drainage BMPs' may be a more appropriate definition, incorporating natural, proprietary and traditional drainage techniques.

It is also clear that the selection of contemporary sustainable drainage techniques goes beyond the key definition tenets of quality, quantity and amenity, although all three are all still authentic and valid. The US mission underscored the importance of construction and maintenance towards successful implementation and longevity; and there is an overriding need to understand the whole life costing of sustainable drainage BMP selection for the

UK water industry (see Anglo-US project 'Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems' (05/WW/03/6)). If an analysis of this ideology, including the importance of applying whole life costing results in an oversized concrete pipe with a flow control as the preferred solution for a given context and set of implementation parameters, then that by definition is nonetheless a 'sustainable drainage system'.

# 5 TOP 10 CONCLUSIONS AND RECOMMENDATIONS

These are selected as those of most potential significance to the UK and in many cases reinforce what is already known.

## 5.1 Conclusions

### Drivers/reasons

1 The perceived need to clean up the environment, reflected in increasingly stringent environmental legislation and regulation as specified respectively in the CWA and the WFD, is the main driver for tackling stormwater in the US and UK respectively. In the US, flooding and climate change are not as significant drivers as they are in the UK. In addition to the threat of prosecution, a significant US driver for the better management of stormwater is also the nature and use of the water body being discharged into (eg ocean, fishing water, stream and amenity use), and the resultant negative impact from pollutants on every day lives. People recognise the benefits of living in a cleaner, healthier environment.

### Technology

2 Novel and more flexible approaches to stormwater management are becoming more important for addressing the drivers described above in the most sustainable way possible. The technologies to do this (such as BMPs, LIDs, SUDS and associated software and IT tools) are still emerging and developing an understanding of whole life performance. New ideas and versatile systems that will assist with particular applications in the UK are needed, such as high density housing, retrofitting to resolve existing problems and to meet the requirements of the WFD. Compared with the US, the UK has greater challenges as to how stormwater can be managed due to limited space, particularly in urban environments.

3 Proprietary systems are providing solutions for dealing with particular water quality or quantity problems. However, because of the way in which the industry is regulated in the US, manufacturers are being encouraged to make unrealistic claims with regards to the efficacy of proprietary systems. Although these systems are effective when applied appropriately and can provide some valuable solutions for removing contaminants, there is no evidence that there is a 'magic bullet' device that can provide all of the treatment needs in a single unit.

### Disconnection/stormwater removal

4 US experience has shown that the incremental and localised small-scale management of stormwater, such as: evapotranspiration techniques; green-roofs; bioremediation, water gardens and/or disconnecting existing inputs to major drainage systems, does collectively provide significant benefits to managing local and downstream water quality and quantity. These approaches can also provide other benefits such as local irrigation or opportunities for reuse as well as enhancing local amenity. In the UK, it is likely that stormwater disconnections (retrofit) as part of a portfolio of approaches will become increasingly important (if not essential) to meet the requirements of the WFD, as disconnections could potentially reduce both discharge volumes and

remove significant pollutants from discharges into natural water bodies.

## Funding

5 It is apparent from US practice that there are considerable benefits from providing greater incentives for the use of innovative stormwater management techniques. These are most effective when the stormwater costs are clearly identifiable within charging schemes. Incentives include charges (and discounts) based on directly connected impervious areas that include hard standing, highways and roads. Clearly identifiable costs and discounts or rebate opportunities can aid in engaging each of the stakeholders, including public, property owners, professionals and other utilities and service providers.

6 In many areas of the US, separate stormwater utilities (municipal or private) deliver a service associated with a defined income stream as above. These utilities also raise awareness of stormwater, help identify the better opportunities for innovative management and more effectively engage all stakeholder groups. There are clear advantages of such utilities; however, they need to be properly positioned within an integrated water management and planning system.

7 Whole life performance and costing of stormwater systems is needed to include construction, maintenance and the selection of the most appropriate sustainable drainage systems (this may include piped systems). Ensuring effective design and construction is challenging even in the US. The lodging of developer bonds (refunded on satisfactory completion) with the regulatory authorities before construction can ensure that good designs and construction are delivered.

## Public and other stakeholders

8 In the US the CWA makes clear recommendations about education and community participation. There is a need to build capacity (knowledge and competence) within the stakeholder communities and also to help stakeholders understand and accept innovatory approaches and technologies which may include the need for certain individuals or stakeholder groups to assume a more responsible role. There are a number of excellent examples in the US including publications and programmes offered by the CWP. Engagement is the key to gaining both momentum and support and should be clear and concise and at an appropriate level to each stakeholder community (including regulators and legislators).

## Planning, regulation, adoption and maintenance

9 The US regulatory framework – comprising CWA-NPDES-TMDL – definition that is devolved and locally determined appears to offer a flexible approach to the management of stormwater within context and region. With the future challenges of climate and environmental regulations, institutional and regulatory approaches need to be as flexible and adaptable as possible in order to be able to respond better to the uncertainties of stormwater management in the future. This includes ensuring that stormwater management is appropriately prioritised within town planning procedures, with flexibility for locally determined priorities and solutions.

10 There is a wide variety of approaches to the adoption and maintenance of BMPs and LIDs in the US, from municipal responsibility to individual householders. Within a particular regulatory area there is

a tendency to utilise one single approach, for example, in Baltimore County BMPs are almost entirely municipally managed, with inspectors assessing the few that are private. It is apparent that stormwater systems should be adopted and managed by a single appropriate agency (organisation or individual) within a local context. This may be a separate stormwater utility (See 6 above).

### 5.2 Recommendations in relation to more effective future stormwater management in the UK

1 It is essential to understand current and future drivers affecting stormwater management and plan for them. Where possible, the implementation of the drivers (eg the WFD, Daughter Directive on Priority Hazardous Substances and consequent impacts) should be influenced as they will have major implications for stormwater drainage systems in the UK. It will also be essential to consider stormwater management systems as one part of the water cycle and manage stormwater appropriately within an integrated context, and as a key part of the planning process based on, for example, the LID approach in the US or the WSUD approach in Australia.

2 Notwithstanding recent efforts in the UK, there is a need to invest more in developing and evaluating the performance of sustainable drainage systems via clearly defined and scientifically robust long-term monitoring. Protocols for monitoring from US studies and guidance will help to define investigation programmes. This will require significant investment and should be recognised by regulators and others as essential for the development of long-term and sustainable stormwater management systems. However, care should be exercised so that the implementation of innovative stormwater controls is not delayed unduly in the pursuit of certainty, ie risk assessment evaluations should be used in the decision making processes.

3 There are a number of innovative proprietary systems that deal with specific aspects of stormwater problems. It is recommended that these systems should only be used where their performance is proven by pilot and/or full-scale testing. Further development of new devices is needed to address particular challenges, such as controlling bacteria and pathogens and as much support as possible should be given to promising emerging technologies.

4 There is a need to better understand the effectiveness of dispersed solutions to the management of stormwater in the UK context. Particularly the position of, barriers to, incentives for, and effectiveness of, the various disconnection options utilised in the US and elsewhere. Costs, risks and institutional barriers need to be considered within a whole system performance context. Cross-regulatory and institutional barriers arising due to the mixed management responsibility for stormwater in England and Wales need to be exposed and eliminated where stormwater disconnection is identified as the best option.

5 An identifiable separate surface/stormwater charge should be apparent to bill payers in the same way that sewage and water charges are currently identified. Alternatives available for stormwater system users to, for example: disconnect; reuse; fit green-roofs; use alternative lawn fertilisers etc, should be made clear in information available from the EA, sewerage undertakers and others such as the CCW. This should be accompanied by clear indications of the financial support and

benefits (rebates and also benefits other than financial, such as waiving certain planning restrictions), available for alternatives, along with educational programmes aimed at enabling householders, facilities managers and others to take a more active role in local stormwater management. As the latter will not be in the interests of the sewerage undertakers in England and Wales (see recommendation 6) because it will lead to a reduction in income, Ofwat will need to review the incentives to the undertakers to promote these changes to current practice.

6 Although there is a risk of further fragmentation of the responsibilities for water management, the establishment of separate stormwater utilities may be useful in the UK. These have been shown to be very effective at ensuring the importance of stormwater in planning and management systems is given a high priority and also overcomes the problems associated with the responsibility for adoption and long-term maintenance. Such utilities may be attractive to existing sewerage undertakers if 'natural' sustainable drainage systems can be defined as assets, as this can increase the benefit to the water companies in England and Wales.

7 The limited experience of sustainable drainage systems in the UK means that better arrangements need to be in place to ensure good design and construction. This requires a whole life performance perspective and the education and training of all stakeholders, especially planners and building control officers. In addition, schemes, such as that in Baltimore in which up-front bonds have to be lodged prior to construction should be considered in order to ensure that these systems are properly constructed. This may necessitate the establishment of specialist sustainable drainage inspectors (this may be a service offered by established consultants as it is unlikely to be a local authority capability), who may also be trained in other stormwater management aspects such as local flood risk management advice to householders and property managers.

8 The capacity to understand and deal effectively with stormwater within virtually all stakeholder communities in the UK is limited. This is also true even in the US (although the CWA recognises and formalises the need for stakeholder education). With the changing drivers (and even current ones such as the WFD), this is no longer going to be acceptable in the UK. A more concerted and robust approach to the engagement and education of all stakeholders is essential in order to build the capacity to deal with the future challenges. Currently the EA has assumed the role of educating and building capacity in England and Wales to deal with stormwater amongst certain stakeholder groups. This has to be widened into a consistent national programme to include all the key stakeholders and all agencies engaged in any aspect of stormwater management. There is a clear need for a cross-institution stakeholder engagement and capacity building initiative; however, this is currently impossible due to the inflexibility and intractability of the existing regulatory and institutional arrangements that are restraining the opportunities for innovative stormwater management in the UK.

9 Currently the place of stormwater (and water) within formal UK planning processes is not considered to be very important, although in England various PPS (eg 11, 12, 25) are bringing water related matters more to the fore. However, other planning guidance (particularly PPS 3) is making the

implementation of sustainable drainage systems more difficult due to the requirement for high density development. In view of the future uncertainties from climate change and impacts from current legislation (WFD in particular), stormwater management will need to take a more central role in all aspects of planning. In addition, the regulatory system will need to become more flexible and adaptable to new knowledge, for example recognising the need for regionally based building regulation, including more performance related standards rather than prescriptive specifications for design details.

10 The case for a single agency to assume responsibility for all aspects of stormwater management is strong. This agency would facilitate SUDS adoption (and maintenance) and should also include responsibilities for flood risk management. This would have the advantage that one single agency would receive payment for the delivery and maintenance of the required infrastructure including public education and communication. Any agency in this role should not be constrained by the need to maintain and own assets, but rather to be able to operate across the whole range of structural and non-structural approaches to stormwater management, supporting other stakeholders where appropriate.

# Appendix A

## MISSION DELEGATE DETAILS

**Prof Richard Ashley**
University of Sheffield and Pennine Water Group (mission leader)
*R.Ashley@sheffield.ac.uk*

Richard is Profeesor of Urban Water at Sheffield University and Managing Director of the Pennine Water Group (PWG) which is a specialist centre for water and wastewater research. He is responsible for overall group operation, high-level R&D across the various areas of water management: wastewater; stormwater; and water supply.

University of Sheffield and Pennine Water Group (PWG)
*www.shef.ac.uk/p/pwg*

The PWG is a multi-disciplinary specialist centre for water and wastewater research, and is one of only four such international centres of excellence in water research in the UK. The PWG's primary mission is to develop improved procedures and support systems for the more sustainable management of water services, assets and their interactions.

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**Ian Pallett**
British Water (mission manager)
*ian.pallett@britishwater.co.uk*

Ian is the Technical Director at British Water. He coordinates members' activities via industry focus groups within the Technical Forum. The Forum facilitates the preparation of industry technical standards, best practice guidance and information documents and industry participation in the development and application of sound environmental policies.

British Water
*www.britishwater.co.uk*

British Water is the lead association for the UK water and wastewater industry representing all areas of the supply chain including contractors, consultants, manufacturers, equipment suppliers, and many specialist service providers. It lobbies government, regulators and major customers and provides vital information on home and overseas water and wastewater markets.

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**David Schofield**
Arup
*david.schofield@arup.com*

David was nominated by Arup as a Water Engineering Skills Network Champion for drainage and sewerage, providing technical expertise to a wide range of Arup projects. He has over 20 years' infrastructure and water engineering experience, including extensive work on master-planning, analysing, reporting, rehabilitating, designing and constructing sustainable drainage systems (SUDS) on foul and surface water networks.

Arup
*www.arup.com*

Founded in 1946, Arup is a professional engineering consultancy providing worldwide technical solutions. Arup's project portfolio includes the following key tenets; local knowledge and global expertise, creative business solutions, project creation and management, multidisciplinary design and planning and engineering consultancy.

**Richard Munden**
Copa Limited
*richard.munden@copa.co.uk*

Richard is the Business Development Director for Copa Limited, part of the CDS group. He has been in the water industry since 1989 and was responsible for the commercial introduction of the submerged aerated filter (SAF) for sewage treatment in small communities.

Copa Limited
*www.copa.co.uk*

Copa Limited is the European division of CDS Technologies, a multi disciplined company offering a comprehensive range of products, wastewater treatment technologies and processes along with storm water management solutions for attenuation, flow control and storm water overflow treatment. The products are focused on the municipal water treatment market.

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**Alan Rafelt**
Environment Agency
*alan.rafelt@environment-agency.gov.uk*

Alan is the Regional Strategic and Development Planning Team Leader within the Flood Risk Management Function of the Environment Agency. His principle responsibility is to lead the regional team to produce, develop, and maintain a long-term and integrated plan for sustainable flood risk management with a three to 50 year horizon.

Environment Agency
*www.environment-agency.gov.uk*

The Environment Agency is the principal environmental regulator in England and Wales. It was established in April 1996, and is the leading public organisation for protecting and enhancing the environment in England and Wales. The Agency's vision for the environment is 'a better place for people and wildlife for present and for future generations'.

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**Alex Stephenson**
Hydro International
*alex.stephenson@hydro-international.co.uk*

As Director of the UK Stormwater Division, Alex is responsible for the day-to-day running of the business based in the head office in Clevedon, Somerset, and liaises closely with the Wastewater division based in Ely, Cambridgeshire. Alex is also currently the convenor of the British Water SUDS Focus Group.

Hydro International
*www.hydro-international.co.uk*

Hydro International plc provides innovative products for the cost effective control and treatment of water. The group has developed technologies to control stormwater, combined sewer overflows and municipal wastewater and, in recent years, has developed considerable expertise in computational fluid dynamics (CFD) simulation.

**Stuart Ramella**
Polypipe Civils
*StuartR@Polypipecivils.co.uk*

Stuart manages set research and development projects, which predominantly involves the design and development of new products from beginning to end. Stuart has also had involvement in SUDS development, not only within Polypipe, but also through involvement with the CIRIA working group for document providing guidance sustainable drainage systems.

Polypipe Civils
*www.polypipecivils.co.uk*

Polypipe Civils Ltd belongs to the Polypipe Group of companies, which is one of the largest plastics manufacturers in Europe with products predominantly aimed at the construction/building industries. Polypipe Civils Ltd manufactures and supplies products into the civil engineering, construction, utilities and agricultural industries.

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**Kate Zabatis**
United Utilities North West
*kate.zabatis@uuplc.co.uk*

Kate is responsible for developing wastewater network policies and strategies and ensuring that all regional wastewater network expenditure projects are in line with these strategies. She represents the company on issues such as SUDS, first time sewerage and contaminated surface waters. Kate also delivers the company's response to national consultations such as 'private sewers' and 'sustainable drainage systems'.

United Utilities North West
(Subsidiary of UU Plc)
*www.unitedutilities.com*

United Utilities manages and operates the regulated electricity distribution and water and wastewater networks in north west England (UUNW). United Utilities PLC also owns two support services businesses: United Utilities Contract Solutions and Vertex. These businesses supply infrastructure management and business process management in the provision of service to others.

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**Jeremy Jones**
Welsh Water
*jeremy.jones@ntlworld.com*

Jeremy Jones is a specialist in the field of sewer and stormwater networks and treatment. He provides specialist advice on the implementation of SUDS and has been developing guidelines and procedures for tackling the key issues of adoption and maintenance. Jeremy is the Secretary of the SUDS Working Party for Wales.

Welsh Water
*www.dwrcymru.com*

Welsh Water (DCWW) is a company that supplies drinking water and wastewater services to most of Wales and western parts of England. It is the only utility company not owned by shareholders, being wholly owned by Glas Cymru, a single purpose company that exists only to provide better value services to Welsh Water's customers. It is top of the Government's 'Overall Performance Assessment'.

# Appendix B

## HOST ORGANISATIONS AND ACKNOWLEDGMENTS

| Date | Location/activity | Contact | Report responsibility |
|---|---|---|---|
| 13 March | **Baltimore County**<br>Site visits | **Al Wirth**<br>Supervisor, Storm Water Engineering<br>DEPRM<br>*rwirth@co.ba.md.us*<br><br>**Steven Stewart**<br>Natural Resource Manager<br>Watershed Management and Monitoring<br>*sstewart@co.ba.md.us*<br><br>**Scott Porter**<br>Baltimore County DEPRM<br>*sporter@co.ba.md.us*<br><br>**Tom Vidmar**<br>Baltimore County DEPRM<br>*tvidmar@co.ba.md.us*<br><br>**Dave Outen**<br>Baltimore County DEPRM<br>*douten@co.ba.md.us* | Richard<br>Ashley |
| 14 March | **Ellicott City, Maryland**<br>1. Center for Watershed Protection | **Jennifer Zielinksi**<br>*jaz@cwp.org*<br><br>**Tom Schueler**<br>*trs@cwp.org* | Richard<br>Ashley |
| | 2. Low Impact Development Center | **Neil Weinstein**<br>*nweinstein@lowimpactdevelopment.org* | Alan<br>Rafelt |
| 15 March | **Edison, New Jersey**<br>USEPA Wet Weather Center Urban Watershed Management Branch National Risk Management Research Laboratory | **Richard Field**<br>*field.richard@epa.gov* | Alan<br>Rafelt |
| | **Norwalk, Connecticut**<br>Site visit to Abtech smart sponge | **Rodolpho B Manzone**<br>Executive Vice President<br>Chief Technology Officer<br>*rmanzone@abtechindustries.com*<br><br>**Graham Martin-Loat**<br>Source Control<br>*grahamml@sourcecontrol.co.uk* | David<br>Schofield |
| 16 March | **Portland, Maine**<br>Hydro International conference – The Changing Face of the Stormwater Industry | **Prof Bob Andoh**<br>Hydro International<br>*bandoh@hil-tech.com* | Alex<br>Stephenson |
| 17 March | **Boston MWRA** | **Dennis Doherty**<br>Jacobs Civil Inc<br>*dennis.doherty@jacobs.com*<br><br>**Frederick A Laskey**<br>Executive Director<br>Massachusetts Water Resources Authority<br>*fred.laskey@mwra.state.ma.us*<br><br>**Michael J Hornbrook**<br>Chief Operating Officer<br>Massachusetts Water Resources Authority<br>*michael.hornbrook@mwra.state.ma.us* | Jeremy Jones<br>Kate Zabatis |

| Date | Location/activity | Contact | Report responsibility |
|---|---|---|---|
| 18 March | Boston<br>Morning seminar on John Sansalone's work on surface drainage in Florida and elsewhere | **John Sansalone**<br>Associate Professor<br>Dept of Environmental Sciences<br>*jsansal@ufl.edu* | Richard Munden |
| 20 March | Portland, Oregon<br>Morning seminar on regulations and rain gardens at Portland City offices, Bureau of Environmental Sciences.<br>Afternoon site visits arranged to ecobuildings and other sites. Evening working dinner. | **Tom Liptan**<br>Landscape Architect<br>City of Portland's Bureau of Environmental Services<br>*toml@bes.ci.portland.or.us*<br><br>**John Gardiner**<br>Suri Futures Inc<br>*johnpgardiner@cs.com*<br><br>**Dean Marriot**<br>Director of Environmental Services<br>*deanm@bes.ci.portland.or.us* | Stuart Ramella |
| 21 March | Portland, Oregon<br>West Coast applications of LID | **Eric Strecker**<br>GeoSyntec Consultants<br>*estrecker@geosyntec.com*<br><br>**Wayne Huber**<br>University of Oregon<br>*Wayne.huber@orst.edu* | David Schofield |
| 22 March | Seattle City Council<br>SEA streets | **Tracey Tackett**<br>Senior Civil Engineer<br>Seattle Public Utilities Drainage/Wastewater and Solids Waste Engineering Division<br>*Tracy.tackett@seattle.gov*<br><br>**Mara Rogers**<br>Seattle Public Utilities *mara.rogers@seattle.gov* | Jeremy Jones<br>Kate Zabatis |
| 23 March | Los Angeles<br>Site visits to see small and large storm systems being cleaned out.<br>Then session with municipal engineer on maintenance issues and afternoon workshop on six areas of interest. | **Richard Munden**<br>Business Development Director<br>Copa Limited<br>*richard.munden@copa.co.uk*<br><br>**Barry Febey**<br>CDS Technologies Inc<br>*bfebey@cdstech.com*<br><br>**Mark Cuneo**<br>CDS Technologies Inc<br>*mcuneo@cdstech.com* | Richard Munden |
| 24 March | Los Angeles<br>City of Los Angeles officials and roadway drainage.<br>Abtech – roadway catchpit inserts and smart sponge. | **Rodolfo B Manzone**<br>AbTech Industries<br>*rmanzone@abtechindustries.com*<br><br>**Duane E Cook**<br>AbTech Industries *dcook@abtechindustries.com* | David Schofield |

# Appendix C

## VISIT REPORTS

### C1 Baltimore County Council Offices, Towson, Baltimore County Dept of Environmental Protection and Resource Management, Maryland.

*(http://www.co.ba.md.us/Agencies/environment/)*

**Visited:** Steve Stewart (watershed protection, monitoring and management), Tom Vidmar (Deputy Director), Scott Porter (stormwater operations/capital and maintenance), Al Wirth (stormwater management planning), Don Outen (policy, education, research, GIS and community links).

**Date:** 13 March 2006

**Purpose:** To discuss and review (with site visits) drivers, delivery and current regulatory framework for BMPs, delivery of NPDES and TMDL programmes, performance, design and maintenance of BMPs and associated issues.

#### Information provided

There were no formal presentations; information was provided via dialogue between the mission and BCC staff. A visit was made to Owings Mills' high-density development.

#### Summary

Baltimore County is the third largest county in Maryland and nearly surrounds the city of Baltimore; 90% of the population is served by public water and sewers and drainage passes to the Chesapeake Bay. Baltimore County is a corporate and political body which performs all local government functions. Since the mid 1970s it has focused development within an urban growth boundary. Today, more than 85% of citizens live inside the growth boundary on one third of the land. The outlying areas have been zoned to protect agriculture, reservoirs, and forests. BCC Department of Environmental Protection and Resource Management (DEPRM) is the environmental focus for the county. It has developed an active programme for stream restoration (using Rosgen-based natural channel design) and stormwater BMPs. Restoration is driven by the more than 85% of development which pre-dated the environmental controls which were enacted after the 1980s. DEPRM has an educational specialist devoted to working with businesses, citizen organisations and home owners to provide education about alternatives for the use of non-structural BMPs. They have promoted the state of Maryland's Green Schools programme and have more certified green schools than any other county. The provision of water and treatment of wastewater are the responsibility of the city, and the county pays for these services under a long-standing intergovernmental arrangement enacted under law. Under recent state law changes, stormwater requirements for new development now require five discharge volumes to be accommodated (recharge, stream channel protection etc). BCC is a large investor in watershed planning ($2 million (£1.1 million) in local funds to complete plans for nine of 14 major watersheds). It conducts water quality modelling (SWMM) for pollutant runoff and channel stability assessments and has completed close to 30 stream restoration projects, restoring more than 53,000 linear feet (1,346 metres) of streams at more than $12 million (£6.5 million) investment. Many of these projects also incorporate stormwater improvements.

The CWP is located in Ellicott City (see separate visit report) and has helped the state to write the stormwater design manual. BCC owns most stormwater structures, whereas other counties in MD want to thrust responsibility onto the homeowners. BCC considers this problematic. In 2002 Montgomery County took ownership of 1,400 previously privately-owned structures as it was resulting in unreliable management. A developer wanting to build 30 houses on land between two communities would normally have to show a concept plan to the communities that shows the general location of any stormwater structures. However, the Baltimore County Code 1 states that this should also include preliminary hydrologic computations, type, size and location of structures, and verification of a suitable outfall. The outfall is crucial – the general public do not want a pipe pointing straight at their house. BCC looks at the existing drainage patterns on the site, and tries to encourage sheet flow to a wetland or the use of buffers to spread the flow. For the last 28 years there has been an attempt in the region to get stormwater utilities to deal with governance and to fund maintenance for overall stormwater problems. These utilities exist all over the US except in Maryland, where only Montgomery County has authored a statute. Baltimore County currently builds the bill for inspection and maintenance into the rest of the watershed programme that the citizens pay for in taxes.

## Conclusions and observations

- Chesapeake Bay 'critical area' designation and high public awareness are seen as the main drivers for getting politicians to introduce legislation and the public to be more interested in stormwater (quality).
- Wetland buffers, tree (re)forestation used to improve stream protection.
- Strong and well-developed controls on construction site runoff based on long experience of application.
- Priority for stormwater management is safety > function > aesthetics for maintenance. The state owns some 800 stormwater facilities and this will rise to 1,500 or so shortly. There are some 1,500-1,600 privately operated stormwater facilities. The county approves some 300-400 stormwater plan submissions each year out of a total of 1,500.
- All private stormwater facilities are inspected every three years by Baltimore County. These must have agreed maintenance rules when built (stated in NPDES permit).
- State of Maryland manual sets out quality standards, specifying the type of BMP to achieve standard – using a 'deemed to satisfy' approach. Currently, 80% removal of TSS and 40% of P.
- Capital costs of BMPs planned in a development are held up front by the county, then only returned to the developer once 'signed-off' as built and after one year of post-construction.
- Zoning regulations restrict creeping urbanisation in housing areas.
- Detailed development controls are used for stormwater where there is more than 5,000 square feet (465 square metres) of development.
- Typical designs from consultants are inadequate and because of the long experience in Baltimore County, the engineers have more extensive knowledge and hence are better able to judge (in)effectiveness of plans. Baltimore County engineers have delegated dam safety endorsement from US Corps of Engineers.
- Maryland County sees advantages in maintaining – as control and land ownership are seen as beneficially long-term.
- The site grading plan is the baseline – this is the maintenance of land form and layout to retain natural drainage characteristics as far as practicable.
- Stream erosion and sediment control is a major objective (was two year return period, Al Wirth thinks this should change to one year) and is regulated by the Soil

Conservation Service (SCS) for construction phase (also responsible for farm plans).

- Public awareness and behaviour is seen as essential in delivering an environmental improvement programme. Lots of initiatives: green schools; growing home ($10 (£6) toward new tree, with $5 (£3) payback from county to retailer).
- Most developments become maintained by the county – and the developer can decide that the Home Owners Associations will be responsible. No reductions in taxes where stormwater is privately managed and standards of construction must be identical to those adopted by the county.
- Baltimore County use 42 inch (1 metre) high chain link plastic covered fences. Margins typically slope at 3:1.
- Original state specifications stated that infiltration should be the first option. Problems were found with fine sediment clogging, and now infiltration is rarely used. Many early systems had no overflows or bypasses when blocked. Most facilities now use offline ponds.
- Largest facilities have 2 feet (610 mm) of freeboard for 100 year event and use roads as flow paths.
- Ten watershed management plans have been set up considering quality impacts and erosion of streams. Channel plans to take increased flows, but with natural form. Latest project is Gwyms Falls with 130 possible projects ($30 million (£16 million) estimate).
- So far these plans have not focused on TMDLs and need to be revised. Non-structural options seen as essential in delivery with strong community involvement.
- Some problems with convincing communities – eg West Nile virus has led to the shelving of plans for shallow marshes in one community.
- Now getting money into community Watershed Associations to help deliver on-the-ground solutions. This includes lots of new media outputs to change behaviour.

## Visit to Owings Mills development

Owings Mills is one of Baltimore County's designated growth areas with a population of more than 20,000 located within the fast-growing northwest section of Baltimore County, less than half an hour's drive from the city. The median household income is above state average as is the median house value. Hispanic race population percentage is above state average. Building density is from five and a half-up-to-16 units/acre. There is a lot of green space between the clustered developments, some of which comprises stormwater ponds (mainly dry). See below.

***Exhibit C.1*** *Owings Mills – apartment developments with detention pond in foreground*

***Exhibit C.2*** *Owings Mills – pond serving a retail and office cluster*

## C2 Center for Watershed Protection (CWP), Ellicott City, Maryland

**Visited:** Dr Jennifer Zielinski (Programme Director) and Professor Tom Schueler (Director of Watershed Research and Practice).

**Date:** 14 March 2006

**Purpose:** The CWP is one of the main champions for stormwater management within the context of watershed protection and has been responsible for a number of manuals and guidance documents now used across the US. The aim of the visit was to tap into this expertise and experience.

### Summary

Jennifer made presentations and Tom participated in discussion. Founded in 1992, the CWP is a non-profit corporation that provides local governments, activists and watershed organisations around the country with the technical tools for protecting streams, lakes and rivers. The centre has developed and disseminated a multi-disciplinary strategy to watershed protection that encompasses watershed planning, watershed restoration, stormwater management, watershed research, better site design, education and outreach, and watershed training. The centre is supported by five major revenue sources: state and federal grants, contracts with local governments, subscription and publication sales, workshop fees, and private foundations. Annual revenue climbed from $77,362 (£42,000) in 1993 to more than $1 million (£550,000) for the fiscal year 2001. The centre operates with a very low overhead rate; nearly 95% of all income is used directly for programme expenses. The centre has produced many of the design manuals (for LID and BMPs) and good practice guides for many states/counties/cities across the US (http://www.cwp.org/index.html).

The CWP's main goal is to translate R&D outcomes into practical tools. Major programmes include 'American Forests' – to better use cover in urban landscapes. The CWP has produced an urban sub-watershed (small catchment) manual and 11 manuals with all the details of watershed restoration (ie enhancing catchments). The CWP is mainly concerned with monitoring not modelling. Recommended scale of working is sub-catchment size of 100 square miles or less and preferably with one key stakeholder only at circa 20 square mile size. This gives better community engagement. The best examples of stormwater separation are in Milwaukee (USEPA mandated drivers) and to some extent Portland, Oregon. Most of the on-site facilities in Maryland are now inspected annually by specialist contractors that report to the municipality. There are complex and variable jurisdictions in the US for financing stormwater facilities. Andy Reece of AMEC has produced a recent report on this. In general property fees are based on amount of connected impervious area. Highway drainage is managed in each state and requires a USEPA permit. Many states suffer as there are few competent BMP construction organisations or designers. In the 1980s there was an apparent 50% failure of infiltration facilities; however, since then smaller (distributed) systems are used that function better. The CWP believes that it is impossible to meaningfully measure pollutant removal in infiltration systems and also that the perceived 'first flush' does not always occur. From monitoring it has been possible to establish that the typical treatment volume is from 0.9-1.5 inches (23-38 mm) of rainfall. Most good research has been done at the very local and detailed level, and recently good work has been carried out on bioretention. The CWP has developed methods to deal with local 'hotspot' problems. Most failures result from isolated extreme events like spillages. Each state sets its own standards in response to the CWA. USEPA did not want to overburden small communities; hence some of them are not complying. Some 15-20 US states have strong programmes, with the rest taking between five-10 more years. Many states have set up separate stormwater utilities which operate identically to any other utility and raise revenue.

### Conclusions and observations

- The CWP is not involved in brownfield sites, although there are major developments on these.
- Maryland as a state seems to be ahead of the rest of the US in many respects due to the unique driver. Environmental concern is strong due to awareness of Chesapeake Bay. High levels of taxation evoke public interest and the population is generally quite wealthy.
- Watershed areas are some 100 square miles and sub watersheds are circa 20 square miles and the latter are the primary planning level for stormwater.
- Separate systems have existed since the 1900s, but in the city of Baltimore there are now decay problems and a lot of I/I in the combined systems.
- Septic systems are a big problem in the Chesapeake Bay area as their locations are largely unknown.
- In five to 10 years it is expected that CWA standards will apply across the US.
- Limited numbers of consultants are capable of designing BMPs properly, or developers of constructing them.
- A lot of BMPs have been installed and details not recorded.
- Citizens rejected the responsibility to adopt and maintain ponds in Baltimore County
- The community was more interested in paying a stormwater charge to get Baltimore County to do the maintenance.
- Proprietary systems – no definitive standards to judge and lack of supporting data to demonstrate performance.
- Quality standards in MD relate to 'presumed compliance' and are based on advisory standards at federal level.

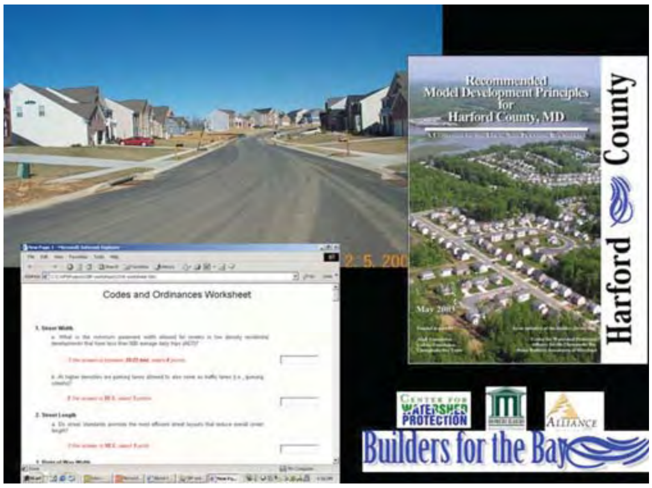



*Exhibit C.3 Examples of CWP activity*

## C3 Low Impact Development (LID Center)

**Visited:** Neil Weinstein (at the office of the CWP, Ellicott City)

**Date:** 14 March 2006

**Purpose:** To discuss and be appraised of the techniques currently available for inclusion within designs for LIDs and review their applicability to the UK.

### Outline of information provided

- Extensive discussion over lunch
- Location of websites

### Summary

This report is the result of a lunchtime discussion followed by research on return to the UK.

The LID Center was established to develop and provide information to individuals and organisations dedicated to protecting the environment and water resources through proper site design techniques. Neil Weinstein is the Executive Director and one of the founders of the LID Center, which is a non-profit research organisation based in Maryland dedicated to the advancement of LID technology.

Neil is one of the pioneers of LID and has helped create the initial planning, design and analysis tools that are the basis of LID strategies. He and his team have worked to develop stormwater policies and strategies at the national and local levels through research, development and policy analysis. The LID Center works on projects in many different areas, which includes design, ordinance development, outreach and master planning. clients have included the American Society of Engineers, USEPA, Federal Government departments as well as numerous community watershed organisations. The centre also works closely with the CWP, the EPA and various academic institutions.

## Conclusions and observations

- The LID approach includes five basic tools:
  - encourage conservation measures
  - promote impact minimisation techniques such as impervious surface reduction
  - provide for strategic runoff timing by slowing flow using the landscape
  - use an array of integrated management practices to reduce and cleanse runoff
  - advocate pollution prevention measures to reduce the introduction of pollutants to the environment.
- LID techniques are relatively simple and effective and address stormwater at its source.
- LID has numerous benefits and advantages over conventional stormwater management approaches since it is based on more environmentally sound technology and a more economically sustainable approach to addressing the adverse impacts of urbanisation.
- LID is flexible and offers a wide variety of structural and non-structural techniques to provide for both runoff quality and quantity benefits.
- LID works in highly urbanised constrained areas, as well environmentally sensitive sites.
- The key distinction of LID from other more conventional strategies is that it is essentially an ecosystem-based approach, and seeks to design the built environment to remain a functioning part of an ecosystem rather than exist apart from it.
- Opportunities to apply LID principles and practices are practically infinite since any feature of the urban landscape can be modified to manage runoff and reduce the risk of pollution.
- It is a comprehensive multi-systems approach that has built-in redundancy, which reduces the possibility of failure.
- By managing rainfall runoff as close to its source through intelligent site design, LID can enhance the local environment, protect public health, and improve visual amenity and reduce infrastructure costs.
- Most conventional techniques will require an off-site sewer to collect the stormwater from the on-site system, resulting in additional project costs for the enhancement of downstream sewers as the urban areas expand.
- LID techniques have been used to address a wide range of wet weather flow issues, including Combined Sewer Overflows (CSO), NPDES stormwater phase II permits, TMDL permits, non-point source programme goals, and other water quality standards.
- Case studies and pilot programmes have shown that as a result of employing LID techniques on residential developments capital costs can be reduced by around 25 to 30%.
- The techniques also provide additional benefits, such as groundwater recharge and cleaner watercourses, but they also increase the urban forest, reduce the urban heat island, improve air quality, reduce thermal stream pollution and enhance the visual amenity.
- LID practices such as rain gardens can usually be designed as part of the development's open space, without any loss of developable area.

- The key factor in the success of LID is to ensure that the landscape practices (such as rain gardens) are attractive and perceived by the property owner as adding value to their property.
- LID practices are viewed as assets and the primary motivation for their long-term maintenance success is that of property owners protecting their vested economic interests.
- LID maintenance burdens for property owners and local governments are simple and do not require specialised equipment.
- To assist in the preservation of stream integrity, experience has demonstrated the importance of a stormwater management system that specifically addresses the frequent micro-storms that occur on a regular basis (weekly or monthly).
- LID techniques can be successfully utilised in both retrofit and brown-field development areas.

Websites
- *http://www.lowimpactdevelopment.org/announce.htm*
- *http://www.larch.umd.edu/LIDSITE/judgin.htm*
- *http://www.psat.wa.gov/Programs/LID.htm*
- *http://www.toolbase.org/techinv/techDetails.aspx?technologyID=223*
- *http://www.nrdc.org/water/pollution/storm/chap12.asp*

***Exhibit C.4*** *Retrofit street edge alternatives (SEA) in Seattle*

## C4 US Environmental Protection Agency, Urban Watershed Management Branch

**Visited:** EPA staff included: Richard Field (chair and host) and Dennis Lai, Mike Borst, Tom O'Connor and Scott Struck (presenters).

**Date:** 15 March 2006

**Location:** Edison, New Jersey
*http://www.epa.gov/ednnrmrl/*

**Purpose:** To be appraised of the work being undertaken by the staff of the Office of Research and Development at the National Risk Management Laboratory.

### Outline of information provided

- Presentations on the current work related to stormwater management
- Tour of the laboratory
- CD containing presentations

### Summary

The EPA leads the nations' environmental science, research, education and assessment efforts and works to develop and enforce regulations that implement environmental laws enacted by congress. It advances educational efforts to develop an environmentally conscious and responsible public and to inspire personal responsibility in caring for the environment.

In recent years, approximately half of the EPA's budget has provided financial support to state environmental and research programmes. It is responsible for setting national standards for a variety of environmental programmes and has the power to delegate these responsibilities to the various states and municipalities for the issuing of permits and for monitoring and enforcing compliance.

The UK team was informed of the research and studies that are currently being managed by the Urban Watershed management team, which included the following:

Dennis Lai:

- Framework for the placement of BMPs in urban watersheds to protect source waters and meet water quality goals.
- Sanitary sewer overflow analysis and planning toolbox (SSOAP)
- System for urban stormwater treatment and analysis and integration (SUSTAIN)

Michael Borst:

- BMP performance: pilot-scale evaluation of wet ponds and constructed wetlands for solids reduction
- Pilot-scale evaluation of swale designs (test rig to be constructed at the laboratory)

Tom O'Connor:

- Stormwater best practice management guide
- Performance monitoring of a BMP pond on Staten Island
- Green-roof research

**Scott Struck:**

- Accotink Creek (City of Fairfax) Restoration Project: stream restoration techniques

### Conclusions

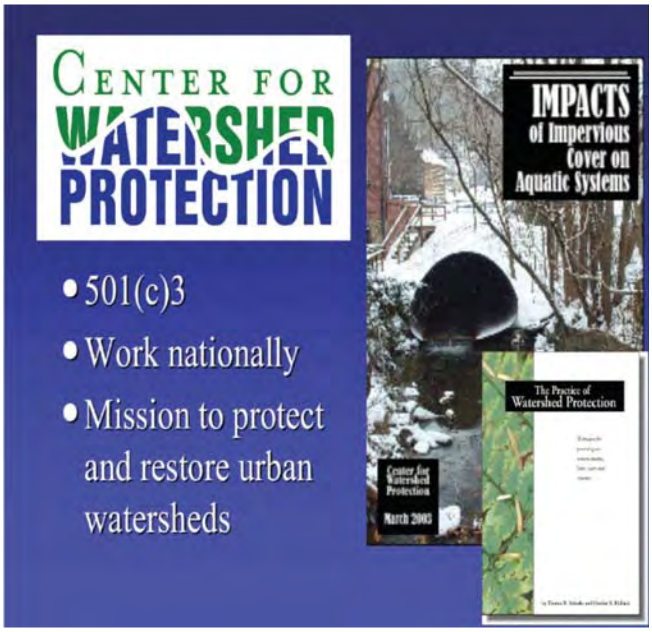
- Methodologies and decision support tools are required to help develop, evaluate, select and place BMPs in urban watersheds based on both sound science and a consideration of costs and effectiveness.
- Currently, the typical detention basin design provides for six-hour storage time for the first half inch (12 mm) of rainfall. Evidence has shown that longer retention times of between 24 and 48 hours are needed to treat stormwater runoff.
- Pond outlet controls need to be designed (and retrofitted where necessary) to slowly release smaller storms (higher frequency)

that may pass through the system with little or no attenuation.

- The incorporation of accessible and secure monitoring facilities should be incorporated into the BMP design.
- The collection and collation of long-term data sets will assist in better site design.
- Leaves from trees appear to be a major contributor to chemical oxygen demand.
- Pond maintenance regimes can adversely affect the chemical oxygen demand.
- The treatment capabilities of BMPs, and in particular ponds, may vary from season to season.
- There is a preference for actual data, such as rainfall, as opposed to a simulation of the hydrograph. Hence the need to ensure that monitoring is incorporated in the maintenance requirements.
- Watercourse restoration and the implementation of appropriate BMPs can assist the resolution of short and long term flow problems and provide an acceptable flow regime to achieve dynamic equilibrium.
- There is currently little knowledge on the performance capabilities of swales to deal with water quality issues; however, it is generally accepted, and this is mainly anecdotal evidence, that swales greatly assist in the reduction of run-off volume and may provide between 60% and 99% particulate reduction.
- The EPA is increasingly advocating the use of swales as an alternative to gutter and kerb drainage as part of the designs for LIDs.
- The US Department of Transport's expenditure on swale and pond systems is huge, but the performance results are regarded as being vague. These systems were originally designed and installed to remove water from the highway as quickly as possible for driver safety reasons.
- Green-roofs have numerous benefits and include:
  - o the control and management of stormwater
  - o reduction in the urban 'heat island' effect
  - o provision of additional and in some cases diverse habitat
  - o reduction in energy costs associated with heating and cooling
  - o can be more visually attractive.

Website

- *http://www.epa.gov/ednnrmrl/*



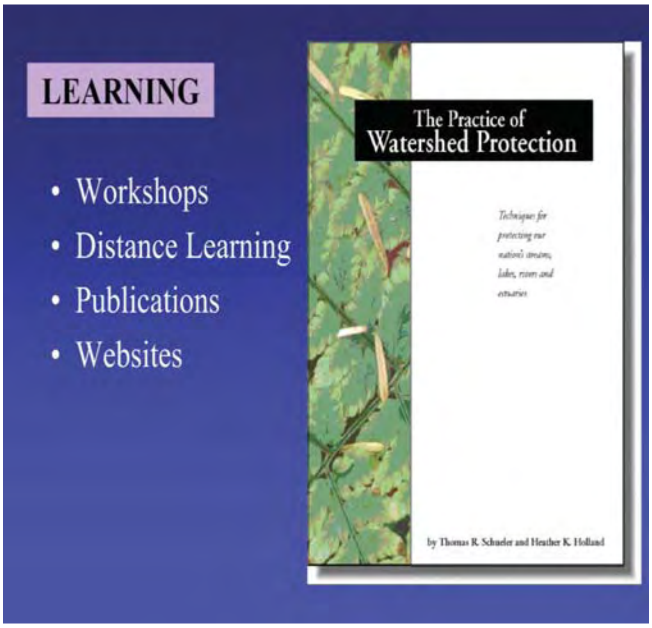




***Exhibit C.5*** *Examples of activities undertaken by the CWP*

## C5 Site visit to AbTech smart sponge

Organisation visited
AbTech Industries (Scottsdale, Arizona).
Source Control Systems (UK).
City of Norwalk (Connecticut).

**Location:** Norwalk 'Storm Drain Filter Project' site visit to the Maritime Aquarium and follow-up meeting at city of Norwalk Town Hall, Norwalk, Connecticut.

**Date:** 15 March 2006

**Purpose:** Evaluate the US advanced polymer technique (smart sponge) for cleaning surface water runoff with the manufacturer (AbTech) and project promoter (City of Norwalk). This technique may be significant for future use by the UK water industry for improving surface water runoff quality, in accordance with the requirements of the WFD.

Details of persons met:
- Rodolfo Manzone – Executive Vice President of AbTech Industries
- Graham Martin-Loat – Director of Source Control Systems
- Sal Longo – Contractor and Connecticut distributor of smart sponge
- Michael Yeostock – City of Norwalk Senior Engineer.

Information provided:
- The Norwalk Storm Drain Filter Project – presentation and accompanying handouts by AbTech Industries
- The Norwalk Storm Drain Filter Project – local information booklet by the city of Norwalk.

### Site visit to the Maritime Aquarium

The project is funded via an EPA grant of $397, 000 (£215,000) with some local additional support. It is a collaborative project between the EPA, City of Norwalk, AbTech Industries, Longo & Longo and The Long Island Soundkeeper (an environmental education and advocacy organisation). Other project partners are the Maritime Aquarium (one of the largest attractions in Connecticut) and the Norwalk River Watershed Initiative (since 1995 a unique partnership of seven watershed towns to address local water quality). The key project driver is to improve the quality of surface water draining from the watershed and into the Norwalk River, Norwalk Harbor and Long Island Sound.

The mission team was shown an example of one of the AbTech trash baskets and smart sponge 'ultra-urban' filter inserts installed into 275 storm drain catchpits (gullies) in the watershed, adjacent to the aquarium and draining out to the Norwalk River; the basket insert was raised onto the sidewalk for inspection. It was noted that all of the other catchpits in the vicinity also contained the AbTech dual filter system. It is a dual filter system because the proprietary collar and basket collects all trash entering the catchpit while the smart sponge insert filters the surface water runoff, permanently taking out harmful pollutants.

Presentation and discussion
(at the Norwalk City Hall):
- *www.abtechindustries.com*
- *www.sourcecontrol.co.uk*
- 'The Norwalk Storm Drain Filter Project': a unique project involving private and public bodies, including the Aquarium. Involved retrofitting 275 storm drains with smart sponge and included contrasting areas without the filtered outlets for comparison.
- There was a 12 month monitoring period to assess improvement in runoff quality. Includes target removal of hydrocarbons, a range of bacteria (including Escherichia coli), total suspended solids, heavy metals and trash.
- Of the 275 trash screen collectors cleaned and weighed, 10 are taken away to be analysed for contaminants. Estimated 50 lbs of trash per drain per annum.

- Dredging has a significant cost associated with sludge disposal, so a reduction is valuable.
- The project is aiming for 90% hydrocarbon removal and 80% bacteria.
- AbTech smart sponge technology is now at a 10 year evolution and the 'popcorn' can be manufactured into any shape or form. It is both porous and buoyant and uses absorption techniques to chemically select contaminants into the inner part of its structure. Standard capability is the capture of hydrocarbons, trash and sediment. It can absorb up to five times its own weight in contaminants. A recent upgrade has permitted the capture of some bacteria and the future capture of heavy metals is a possibility.
- There has been EPA collaboration in the Norwalk project.
- There is no release of by-products either during or after pollutant capture from the sponge. Typical lifespan is two-to-three years, dependent upon the amount of pollutants captured; at this time the sponge is saturated and must be changed ('jellification'). Other usage has included sports socks and medical gowns because of its anti-bacterial properties.
- This is a dynamic treatment of SW runoff. Bacteria capture efficiency varies, but it can be up to 75%. AbTech is now in generation four of smart sponge. Hydrocarbon capture is up to 95-97%. Development of the advanced polymer technique continues and the intention is for heavy metal capture. There will be a slight loss of hydraulic performance at each inlet from the 10-15% reduction in area.
- SCS commented that it has six UK test sites. 'Real world' applications for the UK are essential, as is the classification for the spent sponge; special waste? If special waste, the disposal costs may be prohibitive. Disposal may include landfill or incineration as a fuel. Another UK application may be in landfills.
- Maintenance will always be an issue; inlets should be cleaned once a year, but once in three more likely, when the sponge reaches saturation.
- The catchment has some 84,000 people and 27 square miles. Modification costs are under $1,000 (£550) per gully, total for all infrastructure.

## Conclusions

- A separate stormwater utility is beneficial for managing longer term maintenance. Also perhaps for installation and construction.
- Sea Life Centers and equivalent public facilities are very strong vehicles for improving water quality in coastal areas through education.
- Agreements between municipalities, maintenance companies and contractors need to be clear and robust.
- Community and stakeholder 'adoption' of stormwater facilities is a major buy-in and opportunity.
- School education is a major opportunity – in the UK the national curriculum may be a constraint to improving awareness and responsibility.
- Classification of residual arisings is an important consideration in the ability to utilise innovative approaches to stormwater management.
- Non-asset based approaches (non-structural) can be more effective than building yet more assets. A series of small contributory schemes may be as effective as and more sustainable than one single large additional asset.
- There is too much reactive maintenance in the UK. It needs to see proactive maintenance as perfectly valid within whole life performance.
- There appears to be promising proprietary systems for both inlet and single-point outlet controls for solids and bacteria. However, additional independent evidence to confirm this would be useful.

***Exhibit C.6*** *AbTech's ultra-urban catchpit insert*

***Exhibit C.6*** *AbTech's 'smart sponge' demonstration to the mission team*

## C6 Hydro International conference – The Changing Face of the Stormwater Industry

Visited: See Below

Location: Portland, Maine

Date: 16 March 2006

Purpose: This conference was intended to provide knowledge and offer a greater understanding of the stormwater industry in the US by bringing together regulators, consultants and academics to discuss the changing state of stormwater management.

Outline and programme for the day

- Welcome – Steve Hides, CEO and President, Hydro International
- 'Sustainable stormwater management – an international perspective' – Prof Richard Ashley, Professor of Urban Water, University of Sheffield and MD, Pennine Water Group
- 'Stormwater treatment at critical source areas' – Robert Pitt, PE, PhD, University of Alabama
- 'Implementation of stormwater treatment standards modelling program' – Jim Bachhuber, PH, EarthTech
- 'History and future of technology verification programs' – Tom Stevens and Pat Davison, NSF International
- 'Choosing appropriate stormwater treatment practices considerations for engineers, planners and regulators' – Richard A Claytor, Jr, PE, Principal, Horsley Witten Group
- 'Regulatory driven developments in proprietary stormwater treatment devices' – Dr Robert Andoh, Director of Innovation, Lisa Glennon, US Research and Development Manager, Hydro International
- Hydro International R&D facility tour

## Summary

Copies of all the presentations/papers can be viewed/downloaded at:
*http://www.hydrointernational.biz/us/docs/downloadpage.php*

During the day it was demonstrated that the drivers for stormwater management need to be fully understood to be effective and that champions within the industry should be looked for and encouraged.

A good example of a USEPA funded project was showing how the development of stormwater treatment control devices using filter media and a multi chamber treatment train approach resulted in the commercialisation of Hydro's Up-Flo filter system, which is currently being evaluated within the ETV programme. Extensive media research by Bob Pitt was also presented in detail showing all the early work that was carried out to develop the Up-Flo filter.

Experiences with the EPA's ETV programme were explained as well as some of the difficulties encountered with field testing procedures and how difficult it can be in achieving meaningful results in uncontrolled conditions. It was also explained that caution needs to be exercised especially when obtaining data in the field using automatic samplers and measuring devices.

A guided tour of the R&D facilities showed the in-house testing equipment available and demonstrated a lab based unit of the Up-Flo system used to verify the performance of the various filter media, as well as allowing ongoing development work to be carried out.

## Conclusions

- The six minimum requirements of US stormwater regulations are: 1) public education outreach; 2) public involvement; 3) illicit discharge detection and elimination; 4) construction erosion control, 5) post-construction maintenance; and 6) pollution prevention.
- Innovative funding schemes can be useful in promoting awareness and engagement and there should more national subsidy options.
- There needs to be more performance data collected routinely and monitoring and maintenance systems should be designed in.
- Irreducible concentrations, eg Cd 3µl may exist in stormwater.
- Majority of pollutants are transported in smallest storms.
- The impact of practices on the community needs to be addressed and taken seriously.
- Older and poorer cars drip most oil, and stopping/starting in supermarket, drive-in store car parks, for example, leads to high pollutants.
- Methods for field performance evaluation are expensive and only effective with very great care.
- Whilst there are some good proprietary systems available on the market and there are many cases where products can be used successfully, especially in conjunction with other devices, they should not be forced by the market to being sold as all things to all people.

***Exhibit C.8*** *Hydro International's R&D facility – Portland, Maine*

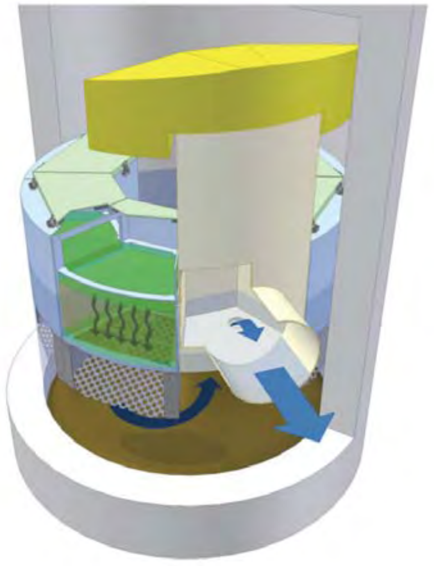


*Exhibit C.9 The Up-Flo filter system from Hydro International*

## C7 MWRA Boston

**Visited:** Fred Laskey (Executive Director) MWRA, Michael Hornbrook (Chief Operating Officer) MWRA, Massachusetts Water Resources Authority (MWRA), Dearden Cambridge City Council, Dennis Doherty (Jacobs Civils Inc)

**Date:** 17 March 2006

**Boston:** Population 590,000, land area 48 square miles, water area 41.21 square miles, annual precipitation 41.5 inches (1 metre)

**Cambridge:** Population 101,000, land area 6.43 square miles, water area 0.7 square miles

**Purpose:** Presentation from MWRA on CSO programme in Boston, meeting with Cambridge City Council (Department of Public Works). Site visits.

### Outline of information provided

- Massachusetts Water Resource Authority five-year progress report 2000-2004
- 'The State of Boston Harbor. Mapping the Harbor's Recovery' Massachusetts Water Resource Authority 2002
- 'Your Drinking Water Test Results' Massachusetts Water Resource Authority 2004
- Cambridge Department of Public Works – www.cambridgema.gov/TheWorks/storm water/index.html

### Summary: Massachusetts Water Resources Authority (MWRA)

In order to fulfil its mission of providing quality water and sewerage services to its communities, the Massachusetts District Commission (MDC) needed to raise sufficient revenues to hire adequate staff, properly maintain plants and equipment, to finance major capital programmes, and to develop operating budgets that were responsive to existing and future needs. MWRA was developed in order to fulfil the goals of provision of quality water and sewerage services to customers. In 1984, legislation was enacted to create the MWRA, an independent authority with the ability to raise its revenues from ratepayers, bond sales and grants. The primary mission of the department was to modernise the area's water and sewer systems and clean up Boston Harbor.

Boston Harbor was previously considered one of the dirtiest harbours in the US. However, in 1985 a federal court order set an ambitious schedule for the newly formed MWRA to plan and construct new sewage treatment facilities that would end the discharge of untreated and partially treated sewage to Boston Harbor.

Four major construction projects were completed:

- cessation of sewage sludge disposal to river via new facility development to produce commercial fertiliser pellets
- a new secondary wastewater treatment facility at Deer Island
- a tunnel from Nut Island to Deer Island Treatment Plant to capture CSO for secondary treatment
- an outfall diffuser system that discharges treated effluent 9.5 miles offshore into Massachusetts Bay.

Harbour water quality improvements in the last 10 years have led to a major economic boom around the harbour to over $1 billion (£550 million) and a general increase in property values.

The final stage of the clean up programme relates to the removal of CSO discharges to the Charles River.

Originally CSO resolution was to have one large interceptor project. Following detailed planning that considered sites and effluent issues, 29 smaller projects have been developed and are in the process of being implemented. These include sewer separation, interceptor improvements, new CSO treatment facilities, upgraded CSO treatment facilities and storage facilities at a total cost of $747 million (£400 miilion).

The city of Boston has mixed areas of separated and combined sewerage systems. MWRA is not responsible for stormwater drainage; this is the responsibility of the specific communities (60 of which make up the Massachusetts area). At present there is a stormwater disconnection programme in four communities (Boston, Somerville, Cambridge and Chelsea). The success of the Charles River clean up has lead to calls for clean up activity in other areas such as the Mystic River. It has been recognised that the level of CSO improvements made in this area will have little impact if the stormwater is not better managed as it is causing deterioration.

As a result, municipalities (such as Cambridge) have been issued with stormwater permits to ensure that at least BMP techniques are being implemented to reduce stormwater impact.

All communities barring one are metered to enable easy identification of system I/I and exfiltration. As such, flow instrumentation in sewer networks is considered essential to:

- understand performance and I/I
- target and improve maintenance efficiency
- optimise performance (d) allows calibration of models (quality modelling is not done, except for the harbour FCs/EC).

I/I control programme works right across the catchment. Metering of connected communities was universal and not only encouraged the control of I/I by communities themselves, but reductions in charges were not necessarily forthcoming as capital needed to be repaid over 25 years. I/I represents typically 50-60% of flows even in notionally sanitary sewers.

### Summary: Cambridge City of Public Works

Cambridge city is the sixth most densely populated city in the US. The sewer system dates to the early nineteenth century and is home to 15 CSOs, the majority of which sit on the north side of the city. The sewer system is predominantly combined and as such there is a federal court requirement to address sewer separation. Surface water management is also being implemented to resolve the growing number of flooding problems. This is a result of householders using/inhabiting basements due to the rising costs of land and house prices. Currently, sewer systems manage up to two year storm events, 10 year storm events can cause highway flooding.

An MWH consultant provided a presentation on flow controls used to prevent/reduce flooding, sediment controls and LIDs.

## Site visits

Numerous sites were visited focusing mainly on the MWRA's current programme of detention tank, discharge pre-treatment and CSO construction to achieve federal requirements of Boston Harbor clean up.

Site visits included Prison Point and Cottage Farm – new disinfection and dechlorination facilities, and Union Park Detention Treatment Facility, a project to eliminate 20 out of 26 discharges by increasing detention capacity and treating flows via screening, disinfection and dechlorination.

***Exhibit C.10*** *Union Park Detention Treatment Facility*

## Conclusions

- Direct citizen involvement in managing boards improves engagement and commitment. Linking lifestyle improvements and recreational benefits to costs and investments associated with projects assisted public approval. Public choice about expenditures is part of decision making. Use of local professionals (eg architects) in design details can help keep the local community on board.
- High property and land values have forced people to convert basements to habitation and has highlighted the problems of flooding risk and increased buy-in.
- Local communities decide individually if tariffs should be rising, declining or fixed.
- Limited investment targeted well can produce big benefits. There was a retreat from a large scale storage solution ($1.3 billion (£700 million) in 1993) to a larger number of smaller disbursed projects (100) locally targeted, at a much lower cost of $835 million (£450 million) at today's prices. These are seen to be more flexible and involve new storage, disconnections and other approaches (didn't mention non-structural).
- The use of instrumentation and meters (such as water meters and hand-held scanning devices for maintenance personnel) has greatly improved efficiency. Metering has led to water usage reduction of 120 million gallons per day. Water usage is now the same as in 1911. All but one community has water metering.
- Flow instrumentation in sewer networks is considered essential to: (a) understand performance and I/I; (b) target and improve maintenance efficiency; (c) optimise performance; and (d) allow calibration of models (quality modelling is not done, except for the harbour FCs/EC).
- Daily in-sewer flushes can control FOGS.
- 'External' factors are important – such as the maintenance of high groundwater levels to keep the wooden piles submerged – the knock on effect is backing up of drainage systems and more sediments.
- Other utilities have to pay for their own re-routing when storm sewer facilities are built.
- Stormwater was the responsibility of the local communities, but MWRA could design, maintain, construct and operate these – some communities do not take their stormwater management duties seriously
- For new developments in the MWRA area, developers that wish to add new flows

have to provide compensatory reductions elsewhere of between three-15 times the proposed new foul inputs.
- There is no public warning system for flooding risk. Flood risk to control 25 year event, but also some 100 year events.

## C8 John Sansalone: work on surface drainage in Florida and elsewhere

**Visited:** John Sansalone, University of Florida (UoF)

**Location:** Boston

**Date:** 18 March 2006

**Purpose:** To understand the work being undertaken at UoF on stormwater and where it is focusing its research activities.

### Outline of information provided

- overview of rainfall runoff and historical controls
- coupled quantity and quality issues
- aqueous and particulate chemistry
- treatment and controls concepts
- source control to central control
- data and behaviour required at range of scales
- examples and required analysis of control/treatment
- laboratory scale – controlled pilot – uncontrolled full scale.

### Summary

The science and understanding of stormwater is still very much in its infancy and so are the systems/processes that treat it. There is also very little real knowledge or understanding of the maintenance and operation of all these types of systems, whichever option is chosen: LID, BMP and proprietary etc. There needs to be proper management systems in place, which is generally not the case in US, if units are to perform over their working life as originally designed.

Hydrology, chemistry and particulate transport are coupled and complex phenomena. Simple rules of thumb such as 'first-flush' are fraught with uncertainty. If fact there is probably no such event as a first-flush and regulations based on it are not going to deliver the desired effect of cleaning up diffuse pollution.
There are significant challenges in properly sampling any stormwater system. The methods used are critical and auto-sampling does not work. A mass balance is required and the error should be within 10% otherwise the data is suspect. The make up of stormwater is complex and full analysis is expensive and complex. It is important to look at the dissolved and particulate bound pollutants, particularly at a full range of particle sizes from colloidal to gross solids. All these issues then make the widespread characterisation of sites and catchment areas impractical, thus the TMDLs are really not appropriate and the 80% reduction required naïve (and unachievable).

### Conclusions

- Stormwater is not wastewater. The current methods of sampling and analysis, plus the concepts we retain from our biological waste treatment backgrounds, are very problematic for effectively understanding stormwater and all the possible solutions.
- BMPs and LIDs can only really handle small storm events, but these smaller storms are the highest in number and generally transport the predominance of annual pollutant load.
- The key to success is integrated design and unit operations/processes as well as a fundamental knowledge of the loadings. Not all engineered solutions are the same. Properly engineered media and maintenance of media systems are needed to resolve quality issues. Perlite and sand are of no real use.

- Many tools and solutions are needed to solve the stormwater problem. Reuse must be considered and planned for, especially in areas where water is scarce. We must deal with residuals differently than we deal with biosolids. This combination of tools should include both classical treatment systems (so-called structural controls) and development of non-structural controls that have viable verification schemes. How we build our infrastructure and the selection of infrastructure materials we utilise can be of potential benefit in load reduction of specific contaminants.
- More development is urgently required. There should be an open design where the operation and maintenance are transparent with the systems well documented, tested and verified. The systems should be thought of as unit operations and processes that we can build in treatment modules or 'trains' similar to the package treatment concepts and systems.
- There are severe limitations on what we know about stormwater control and treatment, which needs to be recognised and the complexities relating to rainfall run-off acknowledged. These uncertainties need to be explicitly reflected in the regulations so that there is a flexible approach to delivering the solutions.
- Reuse and reclamation of stormwater as an integrated part of the urban water system is urgently needed.

## C9 City of Portland, Oregon – Bureau of Environmental Services

**Organisation visited:** Bureau of Environmental Services (BES) *http://www.portlandonline.com/bes*

**Location:** City of Portland, Oregon

**Date:** 20 March 2006

**Purpose:** Presentation including video and discussion with Tom Liptan regarding the City of Portland's stormwater management. Question and answers session with Tom Liptan and Dean Marriott.

**Details of persons met:** Tom Liptan – Landscape architect, working as a stormwater specialist within the bureau, Dean Marriott – Director of Environmental Services

**Information provided:** Tom Liptan presentation of green-roofs, various examples of promotional and educational material

The BES is a government department responsible for protecting the quality of surface and ground waters with specific areas of responsibility in wastewater treatment and collection, storm-water management, watershed management, CSO programme and pollution prevention.

They are located in the City of Portland, which is located in the state of Oregon and is perhaps the closest we came to finding an equivalent in terms of the weather conditions in the UK. Average annual rainfall is approximately 37 inches (939.8 mm) a year. This compares favourably to the north of England, which has an approximate annual rainfall of 37 inches (ref. Met Office-climate averages – 1971 to 200 and 1961 to 1990)

The City of Portland has approximately half a million people stretched over an area of 85,000 acres, it has approximately 110,000 homes and has a main river running through it called the Willamette River. The city has a whole range of BMP types including eco-roofs, indigenous street trees, porous pavements, bio-swales/ bio-filters, rain gardens, infiltration devices and downpipe disconnections.

### Summary of meeting

- Within Portland it is the responsibility of the residents to maintain the sidewalk in front of their property unless it has been adopted by the city.

- Very strong public information programmes are run to communicate the work of the ES and the stormwater management programmes that are being initiated. Public information is distributed through mailings and advertising media along with educational schemes run with schools in conjunction with Ameri-corps.
- Currently the drainage and CSOs empty in to the Willamette River causing pollution and damage to the eco system. This has caused destruction of salmon habitat along with damage to the wildlife causing great public concern; this concern has been exploited and used as a driver for change.
- The City of Portland has a separate 'stormwater charge' based on the impervious area of the site/property/house. This has been in force since-the 1970s and has recently been updated (April 2006) to include a restructured discount scheme limited to a maximum discount of 35% of the basic stormwater charge and calculated on a sliding scale. Large sites could reasonably expect to save in the order of $10,000 (£5,500) per annum (in the region of one third of their total bill) on their stormwater charge by implementing the full range discountable actions.
- Stormwater management is the cheapest of water charges in Portland with the split between water services for an average family being:

| Water bill breakdown | ($) Cost per month |
|---|---|
| Stormwater charge | 13 |
| Sewer charge | 33 |
| Potable water charge | 15 |

- The stormwater management charge for commercial properties is approximately $8.5 (£4.60) per 100 square feet (9.3 square metres) per month.
- It is recognised that transportation plays a big part in stormwater management problems and is claimed to provide the source of 70% of the demands on the stormwater systems and proportionally high loads of pollutants. It is currently recognised that transportation should be charged accordingly for their stormwater management, but at present no charge is collected due to a historical agreement.
- The City of Portland has a 'stormwater design manual' based on the 'City Code and Charter' and ultimately the CWA (1972).
- A legal agreement was signed to clean up the river by reducing CSO discharge in to the river by six million gallons a year.
- The City of Portland has developed and promoted a 'downpipe disconnection' programme. This enables participants to receive a fee of $53 (£29) per disconnected downpipe, dependant on the participant carrying out the work. Alternatively, a licensed contractor can be paid by the city to carry out the disconnections.
- 44,000 homes out of a possible 110,000 houses have participated in the program, which has removed over a billion gallons of roof water per annum from combined sewer systems.
- Signs advertising a homeowner's participation in the downpipe disconnection scheme was provided by the bureau of environmental services in an attempt to promote community pride in their efforts.
- The downspout disconnection scheme has a deadline for completing its objective of disconnecting all eligible downspouts from the combined sewer system by 1 December 2011.
- City zoning code 33.510 'Planning and Zoning' FAR Bonus: eco-roofs are a bonus option within the code, which can mean for every square foot of rooftop garden, a bonus of one square foot of additional floor area is earned, which could equal an extra floor. The building owner must also execute a covenant with the city to maintain and continue the facility.
- A resolution was passed in 2005 that requires all city buildings to install eco-roofs when re-roofing, where practical.
- As a demonstration project a street has been fitted with what can be termed as a street garden. The road has been necked in

at a selected point to provide a drainage feature (bio-swale) that combines with a traffic calming measure.

- Stormwater reuse is not widely used within Portland, but is just starting to be explored as an option, although they are unsure how to charge for services if the take up is high. Annual water use in Portland is approximately 23 billion gallons and the annual yearly rainfall is approximately 91 billion gallons.
- As part of the LEED programme, which is equivalent in the UK to the 'Code for sustainable homes', rainwater harvesting plays a part in achieving the accreditation levels. *http://www.usgbc.org/Display Page.aspx?CategoryID=19*
- The use of green-roofs in Portland has raised concerns about ground water recharge.
- Two large pipes are being constructed to carry all the CSO to a sewerage treatment plant. The pipes are 22 feet (6.7 metres) in diameter and six miles long, and 14 feet (4.3 metres) in diameter and three-and-a-half miles long.
- The cost of the whole CSO abatement programme will be met by the rate payer without any federal assistance at a cost in the region of $1.4 billion (latest estimate).The whole programme will take in the region of 20 years to be completed.
- An expressed opinion in hindsight was that if the work carried out to date in reducing the inflow of stormwater in to the sewerage facility, then the large pipes might not have been necessary.
- Four events during the winter period will overflow from the tunnel with stored/intercepted water being pumped from the pumping station at Swan Island to treatment at a maximum of 10 miles away. This has produced concerns regarding the operating and maintenance (O&M) costs of the pipe.

## Conclusions

- Demonstration sites with full dissemination of the results promote learning amongst the community, as well as developers, and help to alleviate worries surrounding new or unconventional techniques.
- In Portland, maintenance arrangements are inconsistent and tackled on a case-by-case basis.
- Change is a time consuming occupation. Public agencies have a duty to retain support through the telling of proper stories to ensure continuation of support during lengthy periods of change.
- Disconnection incentives need to be worthwhile, communicated effectively, and pitched at a level that is coherent to householders.
- Problems can arise where the enforcers of development regulations are not involved in making the specification for stormwater management.
- UK planning documents do not account sufficiently for the importance of stormwater. Perhaps it is looked at more as a waste product then a resource.
- Charges based on the inpermeability of a property footprint may be the best bases from which to create a stormwater revenue stream separate from other water streams and start to solve infill development issues.
- Design manuals should be easily translated with the use of examples and case studies, but should not be done in such a way as to stifle innovation.
- It is important to identify the public drivers and motives and use them as a basis to implement a staged programme of changes that will achieve quick wins that demonstrates effectiveness and a clear route to goal.
- Bio filters incorporated in the streets serve a dual purpose of stormwater treatment and infiltration as well as acting as a traffic calming measure. However, they would be impractical where there is a requirement for on street car parking.
- The big pipe project is smaller then first envisaged due to the effectiveness of programmes such as the downspout disconnection programme.

Visits

During the second part of the visit the team was given a guided tour of some of the projects that the BES had undertaken or been involved with:

Rainwater harvesting – University of Portland: this building was built to comply with the LEED programme. Part of the drainage system is used to divert stormwater through bio filters in to storage tanks where the water is used to flush toilets on the first floor. The scheme was restricted to supplying water to the toilets on the first floor due to objections/reservations from plumbing control.

Green-roof – University of Portland accommodation: roof dedicated to an eco-roof and the rooftop installed services.

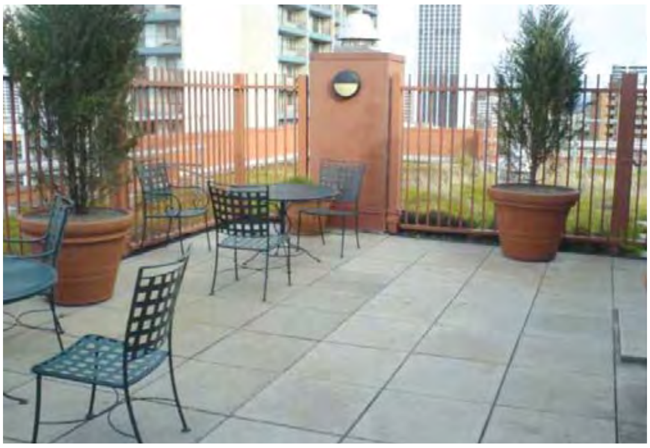


*Exhibit C.11 Green-roof used to provide an amenity for the residents of a flat*


*Exhibit C.12 Surburban drainage in an integrated urban environment*

## C10 Eric Strecker, GeoSyntec Consultants and Wayne Huber, University of Oregon

**Organisation visited:** GeoSyntec Consultants.

**Location:** 55 SW Yamhill Street, Suite 200, Portland, Oregon 97204

**Date:** 21 March 2006

**Purpose:** Workshop and discussion regarding the design and implementation of BMPs and LID.

**Details of persons met:** Eric Strecker – Principal at GeoSyntec Consultants, Wayne Huber – Professor at Oregon State University

**Information provided:** Design storm meeting, design standards presentation – E Strecker, Hydrologic regionalisation impacts presentation – W Huber, SWMM5 presentation – W Huber.

Presentation by Eric Strecker and discussion

- *www.geosyntec.com*
- The California Project estimated that some 35% of precipitation will evaporate. Greater consideration for UK design of wet BMPs.
- Always use a filter medium or filtration medium before infiltration.
- Green-roofs are an excellent medium for evapotranspiration.
- 'Managing the sponge'; infiltration.
- Avoid accidentally introducing diffuse pollutants (such as zinc) when establishing natural BMPs (eg preservatives in timber).
- Eric Strecker comments on smart sponge and other such sorbent techniques; *'Good for hydrocarbon removal, especially for a spill or an illegal dump. Not convinced regarding the capture of bacteria or other pollutants. These types of products are expected to 'do-all' in terms of their performance, which isn't really fair.'*

- Important to consider long term durability and whole life costing for BMPs.
- If there is a well manicured landscape strip available, the additional whole life operational maintenance costs are only marginally increased if that soft area is actually implemented as a BMP.
- Treatment design should focus on the 'size of storm' and less on the pollutants.
- Eric Strecker comments on good BMP practice for design; 'consider how much surface water runoff is prevented and how much runoff is treated.'
- Pollutant parameters to consider; physical, biological, chemical and hydraulic.
- Good design and implementation practice to have a treatment train.
- Do not overlook downstream erosion control.
- Wetland BMPs should always be protected from siltation; install specific BMP/ structure upstream to trap silt.
- The outlet structure from a BMP is very important (especially structures such as detention basins).
- For effective sustainable water quality; Eric Strecker's suggested management train:
  1 Hydrological source control
  2 Pollutant source control
  3 On-site treatment
  4 Regional treatment
  5 Watercourse restoration/stabilisation.
- *www.bmpdatabase.org* – National BMP database.
- Consider using multiple outlets at different invert levels for increasing severity storm return periods; this will enhance the performance of the flow control.
- Key American eco-drivers for water quality improvements: the northwest and salmon, California and its beaches, Florida and the Everglades. This replicates what was seen and heard in Maryland (Chesapeake Bay) and Boston (harbour).
- The effect of vegetation in BMPs is significant; improving water quality and providing some attenuation of flows.
- It is important to implement waterproofing preventative measures when locating water boxes close to buildings.
- *www.naturaltreatmentsystem.org*

## Conclusions

- Evapotranspiration is an under-rated means of surface water management – manage the 'sponge' first before anything else.
- Percentage removal is not a sensible design standard – EIA or equivalent based approach is much more sensible.
- Treatment training BMPs and assuming similar performance at each step will over-predict the performance.
- Water quality modelling should be a long-term continuous simulation in order to account properly for the storage elements.
- General diffuse pollution from agriculture is poorly understood but known to be a significant problem.
- The approach should be to manage the problem, not simply meet regulations.
- Flow duration control is important for downstream watercourse erosion.
- Partnering is needed to properly understand the issues and solve the problems.
- It is worth considering investment in the downstream watercourse rather than refinements to BMPs.
- The whole catchment/watershed should be managed (eg regionally)
- Standards seem to vary significantly from state to state. This has led to criticism.
- Bacterial pathogenic indicators are unrealistically onerous in the US.
- Regulatory standards are confusing in the US because they are so variable.
- Building materials should be inert to water solubility.
- Proprietary products have a place where they are targeted in terms of their process and cannot be expected to do too many things; in the US manufacturers can be almost forced into misrepresenting their products. The market should not force this misrepresentation.
- Assessment of pre- and post-conditions using flood criteria will not show as big differences as when looking at quality performance differences.

- There may be a need for a little 'less religion and more science' in LIDs.
- Below ground solutions are 'out-of-sight, out-of-mind'; when above ground it is (usually) apparent when maintenance is needed (if inspected).
- BMP solutions can be cheaper in terms of capital investment than below ground solutions – one example in the US (Davis, California) quoted where this was true and the system has continued to perform well for 30 years. Whole life costing data is required for the UK industry.
- It is now essential for landscape architects to be part of the design team and ideally others such as ecologists and social scientists.
- Environmental requirements should be both prescriptive AND performance based.
- There is no 'silver bullet' and engineers should be educated to realise how complex this area is.
- A runoff coefficient of 0.1 is likely from a green-roof compared with 0.9 from a conventional roof.
- Post-project monitoring is essential to show compliance for/to/from litigation.
- Maintenance for BMPs is not that much more onerous than for a landscape feature anyway (local authority departments in the UK could become responsible for the quality control BMPs, but flood control may be too important to leave to these groups).
- The City of Portland is not too worried about maintenance and is keen to 'get systems in' in the expectation that it will work out – on the principle that it will work out as communities seem to be more committed to engaging in this.
- Plants and trees are essential for BMPs; for example, evapotranspiration and nitrogen removal.
- In the US climate change factors have not been accounted for.
- Property owners and users may be irresponsible in regard to the use of pesticides.
- Maintenance by property owners is more likely where this influences property values. However, where BMPs are considered to be aesthetically or otherwise unappealing these may be ignored.
- Hydraulic models should use long term observed rainfall records if available.

## C11 Seattle City Council/SEA streets

**Visit Report:** Seattle Public Works, Seattle, Washington

**Visited:** Tracy Tackett, PE, Senior Civil Engineer, Seattle Public Utilities

**Date:** 22 March 2006

**Purpose:** To examine the use of natural drainage systems in new developments.
To learn processes for retrofitting natural drainage systems in existing neighbourhoods.
To understand funding issues and public engagement examples.

### Seattle

Seattle is considered one of the most beautiful and prestigious places to live and work in the whole of the US. The city is bounded by the Rocky Mountains to the east, which drop down to Washington Lake, and the city is sandwiched between the lake and Puget Sound with the impressive Olympia Mountains in focus to the west. Its climatology is temperate, with similar seasons and rainfall to the UK.

### Outline of information provided

- Wide ranging discussion on the implementation, adoption, maintenance and funding of natural drainage systems.
- Site visits
  - High Point, development of new housing
  - SEA streets, retrofitting of natural drainage systems in existing neighbourhoods.

## Summary

At the initial meeting the mission team was met by Tracy Tackett who is a key player in the introduction of (SUDS) in the Seattle area.

It is rather incongruous that a city so focused towards the use of sustainable systems and source control elements in their stormwater systems should be engaged in such a large amount of high-rise building.

Over 17 years ago the planning authorities of Seattle confined the construction of high-rise buildings in downtown Seattle to a limit. It is now recognised that the high-rise offices allow urbanisation to be confined to a small area and, with careful planning and architectural control, has produced a wonderfully exciting and enhanced view of the city – almost Manhattan-esque.

Tracy is an avid believer in the use of natural drainage systems. She was able to provide the group with a range of important information and was also able to talk of the final detail of the drainage systems. It is clear that the city is very proud of their environmentally friendly projects.

As with the other local authorities that the group met in the US, discussion and engagement with the public was considered an extremely important issue. The public works department does not try to work against the public view. They seek to do the opposite. They encourage local participation in the projects, but should any resident not wish to take part in any project then they are not forced to do so.

## Conclusions

Some of the key information is summarised in the following:

- A development disturbing more than 5,000 square feet (465 square metres) must use and provide stormwater treatment.
- The Western Washington State Standards stipulate that any development greater than 10,000 square feet (930 square metres) must replicate the pre-development condition for both water quality and quantity.
- The municipality has the power to close sites if the contractor fails to meet the required standards in terms of stormwater runoff.
- It was recognised in certain situations that permitting can be slow, but this tended to be a function of the lack of experience of the contractor and the dialogue that necessitated between the council and the contractor.
- The budget for stormwater control is $20 million (£11 million) a year. SUDS are not called BMPs or LIDs in Seattle, they are known as natural drainage systems. This seems a much more appropriate terminology.
- Each of the natural drainage systems seeks to trap any storm of six months or less in magnitude. Using this method, they manage to retain 91% of the annual average storm and this is always stored for 48 hours to allow for sedimentation or settlement to take place.
- Washington state has acquired over 50 years of rain data. This data has been used to develop the Western Washington Hydrologic Model which is provided freely on the internet. This hydrologic model allows continuous simulation which it claims brings an accurate understanding of the way in which natural drainage systems are going to work. The system is not without its drawbacks as it was clear in discussion that climate change had not been allowed for.
- The green roads that have been constructed give up to 91% infiltration and attenuate the stormflows to the pre-developed condition. The green roads include runoff from both the roads and roofs.

- Unfortunately the situation is not all rosy. It was reported that the transportation department has not been entirely supportive to this way of thinking. It is estimated that the green roads strategy costs around $300,000 (£160,000) per 660 feet (200 metres) long block.
- Design costs are high in this type of construction but the municipality feels that the design and highly engineered solution produces the best solutions and overall optimum results.

### Maintenance

In the majority of cases infiltration is expected to take place within 24 hours of the storm. If after three days the system has not drained down, a maintenance response is triggered from the city. The city has a 'no ditch filling' law, which means that should a resident decide to fill in his ditch the city authorities will return to re-excavate and replace it at the residents' expense.

It was noticeable that Seattle in general is an affluent area and the demographics of the population seemed to be high. This seems to help with public engagement with an appreciative environmental concern.

### Funding of the projects

The city used to have a flat rate on private properties for the funding of stormwater. However, this has now been changed to a method which employs actual roof areas. This seems a fairer way of analysing the costs of stormwater systems since it relates to the actual impervious area of the property, ie properties with larger roofs and surface area contribute a greater amount than those that have less. The city encourages an incentive to disconnect their stormwater systems and the three main methods of natural drainage system being employed are bio-retention, porous pavement and 'compost mended lawns'[17] (spongified).

*Note: The annual average rainfall for Seattle is around 39 inches, which is similar to many areas of the UK.*

### Site Visits

#### *High Point development*

The High Point development is a new development that consists of some 300 acres of land. It is an interesting development because natural drainage systems have been planned in from the development's earliest conception. The development uses a wide range of natural drainage systems from bio-retention swales and porous car parks to a large retention pond.

The developers and contractors work hard to keep sediments out of the swales. This is very important as sediment would quickly clog up the swales and render them redundant. The swales are carefully constructed of specially made soils and planted with appropriate species that will enable the maximum amount of evapotranspiration to take place.

The project team has worked around mature trees whenever possible. Each tree has been valued and has been closed off to avoid damage. If any damage to the tree should occur within 18 months of construction, this cost will be served on the contractor. Many trees are planted as part of the project and the project will see a net increase in the number of trees. The City of Seattle is aware of the damage that stormwater run-off can have on creeks, lakes and ocean waters and the natural drainage systems meet multiple goals and have a number of things in common:

17 Compost mended lawns – A method of changing soil type to create a surface more conducive to absorption of rain water (sometimes referred to as 'managing the sponge')

*Exhibit C.13 High Point development*


*Exhibit C.14 Protecting established trees*

- they meet the public's expectations for managing flooding in their neighbourhoods
- they provide an asset to communities by improving the appearance and function of the street right of way
- they provide responsible stewardship of the environment
- they meet city, local and state environmental regulations.

How well the bio systems are maintained around properties is ultimately up to the resident. The city provides basic maintenance and the plants used require low service. However 'low maintenance' does not mean 'no maintenance'.

### *SEA streets (green streets)*

SEA streets was the city's first integrated natural drainage system project combining neighbourhood enhancements with a new stormwater system that reduces run off volumes from a one block residential area.

These streets direct stormwater through wide step pools to improve water quality for the large volumes of runoff for a wide area (serving nearly 50 acres) before it gets to Piper's Creek.

The Broadview Green Grid project, involving 15 city blocks, is almost an entire sub-basin of the Piper's Creek watershed. The city combines both cascade and SEA streets prototypes to reduce stormwater pollution and impact while providing other neighbourhood improvements like tree cover and traffic calming sidewalks.

Americans love their cars and changing the look and use of the street right of way will alter the way in which the street is used. After construction, parking will be reduced but will still exceed the neighbourhood's current use. Street use and parking studies are conducted for the neighbourhood. The new street designs provide adequate parking along each block.

*Exhibit C.15 Typical Layout prior to SEA streets*

***Exhibit C.16*** *Post construction of SEA street*

***Exhibit C.17*** *SEA street bio systems*

The road looks quite different from the original. The wide gravel shoulder that existed has been eliminated. Parking on the new paved portion of the street is legal as long as a 10 foot wide lane is maintained for traffic. This means parking is available only on one side of the street. It will be up to residents to inform visitors and guests of this requirement. Vehicles that need to be parked for long periods will simply be parked in the driveway.

City law allows parking on the street for up to 72 hours; however, the law is only enforced in response to citizen complaints. Parking of detached trailers on the street is never legal. Vehicles wider than 80 inches are prohibited from parking on the street between midnight and 6 am. Residents park trailers and larger vehicles on private property.

In summary, it would appear obvious from the photographs that this style of management of runoff represents not only an effective, but also an aesthetically pleasing way of managing runoff. Although at an early stage, it would seem that residents are very happy with the new arrangements. An interesting anecdote was that some of the neighbourhoods that were offered this style of management refused it. On seeing the results of the changes made, they have made representation to the city to have their streets upgraded in this way. They have even offered to part fund it!

***Exhibit C.18*** *SEA street bio systems*

The overall effect on this work has been to clean up the creeks into which the stormwater ultimately flows. There is a programme ongoing in conjunction with these works that is trying to bring salmon back to the rivers and creeks. They have found that they need to use a Chub salmon, which seem more able to respond to the waters in the best way.

*http://www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/index.asp*

## C12 CDS City of Los Angeles

**Visit report:** CDS Los Angeles

**Date:** 23 March 2006

**Visited:** Host: Mark Cuneo, LA General Manager, CDS. CDS is one of the leading companies in US for providing proprietary hydrodynamic separators and filter systems. Its system is unique in that is has an in build screen (patented). *www.cdstech.com*

**Los Angeles (LA):** Population of 10 million, high-density, high-land costs, average rain 14 inches (356 mm), which is highly variable and seasonal. It has an area of 4,447 square miles, plus 120 miles of coast.

**Purpose:** To look at some proprietary systems being maintained, to visit the SMURRF facility and to discuss regulations and the stormwater market in LA.

### Outline of information provided

- Site visits – beach-front storm separator outlets and SMURRF
- Presentations on CDS products

### Site visits

1 The clean out of a large hydrodynamic separator, a PSW70, which is a 7 feet (2.1 metres) diameter by 7 feet tall screen cylinder with a lift-out basket on Redondo Beach. This was rated at 26 cubic feet per second (cfs) (736 litres/second) screening capacity.
2 The Pico Kenter Drain diversion was a PSW30 device, 3 feet (0.9 metres) in diameter by 3 feet deep, diverting nuisance flow of up to 3 cfs (85 litres/second) from a storm drain to the SMURRF on Santa Monica beach. It acted as a pre-treatment screen.
3 Viewed the SMURRF complex at Santa Monica.
4 Looked at 25 acres (10 hectares) of wetlands (freshwater marsh) created at the playa Vista project (1,000 acres (405 hectares) of new development).

### Summary

Maintenance seems to be an issue not addressed by the regulators, and there is no planned servicing by any of the city departments (townships). New developments (disturbing an acre or more) are where the surface water regulations are being applied, thereby slowly improving the stormwater infrastructure. In many cases, these developments are private and even more 'disconnected' from the maintenance process. However, the county does specify where BMPs should be used, and if they were put on public property then they would adopt them, with an associated commuted sum. The cost of emptying a hydrodynamic device ranges from \$850 to \$1,700 (£460-£920), depending upon their size plus the number of rainfall events. Emptying is usually annual.

There were devices for creating dry weather diversions from stormwater sewers to the foul sewers which seem to be an effective method of treating infiltration and ingress. The figure being quoted (for I/I) was a 50-150 US gallons/day/house. A number of proprietary systems were being used to catch trash and solids: nets, gravity settlement, vortex systems, bar screens in manholes and pumping chambers. A significant problem is that watersheds cross municipal boundaries.

The City of LA has very little money allocated for the control and quality issues associated with stormwater. However, a \$500 million (£270 million) bond was raised to be paid for by the LA residents. It was successful as it was not seen as a tax. \$12 million (£6.5 million) will be spent per annum for the next 10 years on reducing trash, 10% of which is maintenance. This is considered a fraction of what is really required to meet the trash TMDL.

There are concerns that the bond is still under-funding the stormwater needs of LA and the funds raised may not be spent effectively.

The Santa Monica urban runoff recycling facility (SMURRF) is a state-of-the-art treatment facility for stormwater, *http://sannica.org/epwm/smurrf/smurrf.html*. The system treats 500,000 US gallons per day and comprises: a coarse and fine screen to remove trash and debris; a DAF unit to remove oil and grease with a degritting product to remove sand and grit; a micro-filtration unit and finally a UV component. The system cost about $10-12 million (£5.4-6.5 million) and was commissioned in 2001. One of its main purposes was to educate and improve awareness of stormwater treatment/recycling.

Conclusions

- The main driver for quality seems to be related to the cleanliness of the beaches and associated tourism income.
- It seems the environmentalists force action on stormwater issues by successful litigation. This is not always the most effective way to resolve the problem and is very confrontational.
- Charging for stormwater is based on property values and is included in the sewage charge. Bringing in new taxes requires a 70% approval of the voters.
- Diverting nuisance flows from storm sewers to treatment works in dry weather so that they can receive full treatment seems to make good sense.
- Maintenance is an unresolved issue. CDS has installed approximately 1,000 units in Southern California and it is estimated that only 30% are being maintained.
- SMURRF is very useful for promoting pubic awareness of stormwater issues and its educational value meets some of the obligations of the CWA.
- The target of zero litter in stormwater discharges by 2013 is totally unobtainable because of the multiple inputs and lack of funding required to achieve it.
- The $500 million (£270 million) bond was not seen as tax and was agreed by the ratepayers. A possible reason for this is that it 'ring fenced' the money, meaning it would only be spent on stormwater improvements.
- There is a need for the right champions, with good knowledge, to select the best options and to make sure the water quality and other performance aspects, such as flooding, are appropriately 'joined up', especially when they cross functional and municipal boundaries.

## C.13 AbTech Industries City of Los Angeles

**Organisation visited:** AbTech Industries (Scottsdale, Arizona). Department of Public Works Watershed Protection, City of Los Angeles (California).

**Location:** 'The City of Los Angeles field study on smart sponge,' Santa Monica, Los Angeles, California.

**Date:** 24 March 2006

**Purpose:** Evaluate US advanced polymer technique (smart sponge) for cleaning surface water runoff with manufacturer (AbTech) and project promoter (City of LA). This technique may be significant for future use by the UK water industry for improving surface water runoff quality, in accordance with the requirements of the WFD.

**Details of persons met:** Rodolfo Manzone – Executive Vice President, AbTech Industries.
Duanne Cook – AbTech Industries.
Elvin Yeck – Borough of Sanitation, Department of Public Works Watershed Protection, City of Los Angeles

Information provided: The Norwalk storm drain filter project – presentation and accompanying handout by AbTech Industries. Smart sponge news clips DVD – AbTech Industries.

## Site visit to the Santa Monica Bay area

The field study is being funded by AbTech Industries in collaboration with the City of Los Angeles. The City of Los Angeles has an estimated population of 3.9 million, while Los Angeles County has 10 million. The surface water discharges into Santa Monica Bay have gradually been cleaned up since the early 1980s through the implementation of the CWA and strong environmental groups including the Santa Monica Baykeeper and Heal the Bay. Trash (a big problem for LA) and pollution still threatens the beach with damaging closures, so there is still strong support for continued improvements. This proved to be a good test site for AbTech to demonstrate its smart sponge advanced polymer technique.

The mission team was shown examples of the AbTech trash baskets and smart sponge 'ultra-urban' filter inserts installed into 80 storm drain catchpits (gullies) in the watershed around Thornton Avenue and draining out to Santa Monica Bay. It was noted that all of the other catchpits in the vicinity also contained the AbTech dual filter system. It is a dual filter system because the proprietary collar and basket collects all trash entering the catchpit, while the smart sponge insert filters the surface water runoff, permanently taking out harmful pollutants.

The project timescale is 12 months.

## Presentation and discussion

- *www.abtechindustries.com*
- *www.sourcecontrol.co.uk*
- The visit is to an AbTech funded field study to retrofit 80 catch basins with trash baskets and smart sponge. The trash problem in Santa Monica is medium to low, dependent upon street sweeping.
- The City of LA is carrying out independent testing to verify the field work; this will be complete in 12 months, but will probably not be published and only used internally.
- AbTech's advanced polymer smart sponge has elastic behaviour and differs from other similar products in that water passes through smart sponge to capture pollutants and not over the surface area. In this way, the smart sponge advanced polymer is unique in its porous design.
- Income for the Bay clean-up will be by bond funds paid for by property taxes, with an average estimated tax increase on a $350,000 (£190,000) home of $35 (£19) a year for 24 years. Project funds can be used for project planning, design, advertisement, bid and award, construction, construction management and inspection.
- The position of the screen in the catchpit (usually on top) is critical and fixed screens are not permitted.
- AbTech offered the field study to the City of LA and is meeting all the costs.
- Only commercial areas are required to have trash bins; this explains the lack of them on the sidewalks and why trash is such a problem. The first line of source control could be trash bins. Additional social education would also be good.
- BID (Business Improvement District; companies get a tax relief to assist in the clean up).
- LA has a high percentage of homeless, which contributes greatly to the trash problem.
- Street cleaning should be carried out weekly; but is probably not achieved in reality.
- The LA River has a trash TMDL for the clean up; there are no plans to soften its concrete lining structure with natural surfaces.
- The City of LA has no plans for a surface water impermeable area charge.

- No single proprietary technology can be expected to solve all the problems. There has to be an integrated surface water management train.

### Conclusions

- Ownership of stormwater systems and maintenance is confused and seems to be primarily based on which municipal organisation owns the most land in an area on which the BMPs sit.
- The best approach is to ensure that BMPs are used progressively as areas are redeveloped. No plans for big retrofits other than screening for litter.
- Water quality samples are taken during each rain event (inlet and outlet). The city is also involved and does bacterial analysis. AbTech Industries is funding the field study.
- The ocean is sampled either side of outfalls and 20 yards offshore (some environmental groups also do sampling).
- The involvement of environmentalists and litigation has been both a nuisance and a benefit in driving improvements.
- Adjacent (inland) municipalities in the same watershed can change their minds about stormwater management and do nothing, potentially compromising LA city successes and approaches. Recent change in leadership has led to great difficulties for the City of LA.
- There are various types of advanced polymer technologies that ostensibly claim to do the same, but differ. AbTech's smart sponge has unique characteristics and is probably the market leader in this developing technology field.
- Proprietary products are sometimes unfairly expected to do almost everything, although in reality there is no 'silver bullet' and there has to be an integrated surface water management train.
- Certified equipment can be replaced with similar but inferior products that do not perform adequately.
- The city sends out questionnaires to the public to help decide what solutions are applied in particular areas.
- The huge LA homeless community creates a lot of trash in particular areas and trash bins will not solve this problem.
- Cross-municipality rivers lead to downstream impacts from others upstream that don't behave responsibly.
- As yet, little evidence of advanced technology performance research that is academically peer-reviewed; the view is that this field study will be internal only for LA city, although some other states' work has USEPA collaboration.
- Trash movement may well be related to a first flush.


***Exhibit C.19*** *The mission visiting the AbTech Los Angeles field study*

***Exhibit C.20*** *A line of ultra-urban filter inserts in an LA catchpit*

# Appendix D

## LIST OF EXHIBITS

# Appendix E

## GLOSSARY

| | |
|---|---|
| AWWA | American Water Works Association |
| AWWARF | AWWA Research Foundation |
| BMP | best management practice |
| BOD | biochemical oxygen demand |
| CC | county council |
| CCW | Consumer Council for Water |
| CFD | computational fluid dynamics |
| COD | chemical oxygen demand |
| CPP | cementitious permeable pavement |
| CSO | combined sewer overflow |
| CWA | Clean Water Act |
| CWP | Center for Watershed Protection |
| DPD | Department of Planning and Development |
| ECA | Enhanced Capital Allowance Scheme |
| EA | Environment Agency |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Agency |
| ETV | Environmental Technology Verification Program |
| EU | European Union |
| HIG | holes in the ground |
| GIS | Geographic Information System |
| GCP | good construction practice |
| I&I or I/I | inflow and infiltration |
| IMP | integrated management practices |
| LDF | Local Development Framework |
| LID | Low Impact Development |
| MWRA | Massachusetts Water Resource Authority |
| MCTT | multi-chambered treatment train |
| MDP | Master Drainage Plan |
| NPDES | National Pollutant Discharge Elimination System |
| O&M | operation and maintenance |
| PPS | Planning Policy Statement |
| R&D | research and development |
| RSS | Regional Spatial Strategies |
| SEA | Strategic Environmental Assessment |
| SEA street | street edge alternative street |
| SMURFF | Santa Monica Urban Runoff Recycling Facility |
| SPEP | stormwater public education programme |
| SUDS | sustainable drainage system |
| SWMM | stormwater management model |
| TMDL | total maximum daily load |
| TSS | total suspended solids |

| | |
|---|---|
| UOP | unit operation and process |
| UPD | urban planned development |
| USEPA | Unites States EPA |
| UWWTD | Urban Wastwater Treatment Directive |
| WEFTEC | Water Environment Federation Technical Exhibition and Conference |
| WERF | Water Environment Research Foundation |
| WFD | Water Framework Directive |
| WSUD | water sensitive urban design |
| widget | water integrated device giving effective treatment |

# Other DTI products that help UK businesses acquire and exploit new technologies

**Grant for Research and Development** – is available through the nine English Regional Development Agencies. The Grant for Research and Development provides funds for individuals and SMEs to research and develop technologically innovative products and processes. The grant is only available in England (the Devolved Administrations have their own initiatives).
*www.dti.gov.uk/r-d/*

**The Small Firms Loan Guarantee** – is a UK-wide, Government-backed scheme that provides guarantees on loans for start-ups and young businesses with viable business propositions.
*www.dti.gov.uk/sflg/pdfs/sflg_booklet.pdf*

**Knowledge Transfer Partnerships** – enable private and public sector research organisations to apply their research knowledge to important business problems. Specific technology transfer projects are managed, over a period of one to three years, in partnership with a university, college or research organisation that has expertise relevant to your business.
*www.ktponline.org.uk/*

**Knowledge Transfer Networks** – aim to improve the UK's innovation performance through a single national over-arching network in a specific field of technology or business application. A KTN aims to encourage active participation of all networks currently operating in the field and to establish connections with networks in other fields that have common interest.
*www.dti.gov.uk/ktn/*

**Collaborative Research and Development** – helps industry and research communities work together on R&D projects in strategically important areas of science, engineering and technology, from which successful new products, processes and services can emerge.
*www.dti.gov.uk/crd/*

**Access to Best Business Practice** – is available through the Business Link network. This initiative aims to ensure UK business has access to best business practice information for improved performance.
*www.dti.gov.uk/bestpractice/*

**Support to Implement Best Business Practice** – offers practical, tailored support for small and medium-sized businesses to implement best practice business improvements.
*www.dti.gov.uk/implementbestpractice/*

**Finance to Encourage Investment in Selected Areas of England** – is designed to support businesses looking at the possibility of investing in a designated Assisted Area but needing financial help to realise their plans, normally in the form of a grant or occasionally a loan.
*www.dti.gov.uk/regionalinvestment/*

# The DTI Global Watch Service provides support dedicated to helping UK businesses improve their competitiveness by identifying and accessing innovative technologies and practices from overseas.

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*Contact: itp@globalwatchservice.com*

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