Appendix D

Suds Policies and Case Studies

APPENDIX D

SuDS POLICIES AND CASE STUDIES

D1. INTRODUCTION

This Appendix is intended to supplement **Chapter 6** (Sustainable Drainage Systems) of the **Regional Policy on Environmental Management.** The policy introduced SuDS techniques and issues and SuDS experience from around the world. The relevant references for this appendix are provided in **Chapter 6**.

Best management practices (BMPs) have been used in many countries such as the United States, Sweden and Australia for a number of years. The comprehensive quantity and quality approach to stormwater management is relatively new. The following section outlines the experience of a number of countries in stormwater BMPs: Scotland, the US, Sweden, Australia, Ireland and Malaysia. Case studies are provided for illustration.

D2. SCOTLAND & REST OF UK

D2.1 Introduction

By the year 2010, it is estimated that another quarter of a million homes will have been built in Scotland (Surveyor Magazine, 1998). Unless a more sustainable approach to urban development is introduced, this, along with industrial and commercial development, will produce further degradation of watercourses which have already been affected by urban runoff.

The Forth River Purification Board (FRPB) was the first of the regulators in the UK to adopt a policy based on a best practice approach to urban drainage. The policy was implemented in response to a review carried out by the FRPB in 1996, which found that 41km of Class 3-4 rivers in the Forth Catchment were adversely affected by urban runoff. For freshwaters in the catchment this was equivalent to 25% of the Class 3-4 waters.

In 1996, the River Purification Boards were replaced by the Scottish Environment Protection Agency (SEPA), which decided to adopt urban best management practices as a national policy. The Environment Agency in England and Wales have only recently adopted such a policy.

A major statutory aim of SEPA is to '*provide an efficient and integrated environmental protection system for Scotland, which will both improve the environment and contribute to the government's goal of sustainable development'* (D'Arcy and Roesner, 1997).

D2.2 Regulation

Under the Control of Pollution Act 1974, the Scottish Environment Protection Agency (SEPA) has the power to consent discharges to controlled waters (coastal waters, relevant territorial waters, inland waters above freshwater limit, groundwaters).

The regulation of surface water is a discretionary power and SEPA seek to encourage the adoption of good practice (through conditional prohibition notices) so that smaller discharges need not be subject to a formal discharge consent.

Significant discharges into sensitive waters would require an absolute prohibition notice requiring a discharger to apply for consent. SEPA do not place numeric quality standards on consents or condition prohibition notices, provided the SuDS are designed in accordance with the Scottish SuDS Manual.

Formal approval for a drainage system is also needed from: the planning authority (planning permission), building control authority (building warrant), the water authority (drainage construction consent) and the roads authority (road construction consent).

D2.3 Implementation

SEPA require SuDS to be installed in most new developments to attenuate or treat surface water prior to discharge to watercourses. Although SuDS have been constructed in Scotland for the last 6 years, no UK based design guidance was available until 2000, which led to the construction of inappropriately designed structures and interested parties providing conflicting advice. In 1997, the Scottish authorities responsible for regulating urban development felt that a more co-operative and co-ordinated approach was required,

consequently the Sustainable Urban Drainage Scottish Working Party (SUDSWP) was formed. This working party comprises representatives from SEPA, the Scottish Executive, Local Authorities and developers. The working party's mission statement explains:

'..the aim of sustainable urban drainage will only be achieved through the co-operation of all of the organisations involved in urban development. To this end the Working Party will promote a partnership approach, through communication and education, to sharing the responsibility for protecting the aquatic environment'.

The SuDS WP aim to:

- provide a framework for the implementation of SuDS,
- co-ordinate SuDS research, (recognising that post project monitoring is required to determine performance and whole of life cost),
- produce a design manual for SuDS and
- promote better understanding and awareness of SuDS.

The design manual for SuDS in Scotland and Northern Ireland (CIRIA, 2000), was launched in March 2000 and promotes a holistic approach to urban drainage, whereby issues of water quality and water quantity are considered in designing systems, together with amenity considerations.

It is only by demonstrating that well designed structures work that poorly designed SuDS will cease to be built. The University of Abertay Dundee and a number of other partners are undertaking a major programme of research and monitoring, to address this knowledge gap.

Details of the stormwater management facilities in Scotland are included in a "SuDS" database that has been developed by the University of Abertay Dundee and the Scottish Environment Protection Agency, to provide a centralised record of information for Scotland. Since the database was initially compiled in January 1997, there has been a steady growth in numbers of sites and facilities. There were 65 in 1997 and by January 2001 the database contained details of 297 SuDS in Scotland.

Many of the earlier attempts at SuDS in Scotland were end of pipe systems. Developers planned the layout of developments and then planned SuDS as an afterthought, instead of integrating the systems into plans at an early stage. This led to a piecemeal approach to stormwater management and resulted in many SuDS being located in inappropriate places. There were many examples of systems where developers used conventional piped systems to convey water to end of pipe 'swales', which were fitted into any available space on the periphery of sites. Many of these were also poorly designed and have become clogged as a result of construction runoff being routed the facilities. Erosion has also been a problem, as the swales were unable to attenuate the runoff at source. Lessons were learnt from these mistakes and most of the later examples have been appropriately designed and appear to be functioning adequately.

The UK is still many years behind the states of Florida and Texas in the provision of SuDS stormwater treatment structures. A clear organisational framework, such as providing design criteria, which is accepted by all governmental entities, is required before the BMPs in the UK reach the high standards of systems in these areas of the United States.

D2.4 Maintenance

Originally, the responsibility for maintenance was a grey area and agreement on this issue was difficult to achieve. The Local Authorities and the Water Authorities drew up a framework agreement under section 7 of the Sewerage (Scotland) Act 1968. This agreement related only to the situation where it is proposed that the drainage of surface water from adopted roads and curtilage water from premises be directed through a shared system designed in accordance to the Scottish SuDS Manual. Under the agreement Water Authorities were responsible for below ground structures (such as infiltration trenches) and Local Authorities were responsible for above ground structures (such as ponds).

Recently (late February 2003), the framework agreement was replaced by the Water Environment and Water Services (Scotland) Bill. This new Bill amends the Sewerage Scotland Act 1968 and states that Scottish Water now have the responsibility to adopt SuDS if they comply with appropriate design standards. This does not include road drainage which is still the responsibility of the Roads Departments.

D2.5 Conclusion

One of main lessons learnt from the Scottish experience is that SuDS should be planned in at the start of a development. For example, SuDS features (such as ponds) are accepted by the community if they are incorporated into the development at the outset. Otherwise, ponds are perceived to be dangerous and there is resistance to their development. The provision of clearly defined design standards contributes to the successful functioning of SuDS.

A co-ordinated approach is required within which responsibilities are clearly defined and agreed upon at the outset. This requires new legislation.

D2.6 Case Studies

A number of Scottish case study examples are outlined below.

D2.6.1 Dunfermline Eastern Expansion Area (DEX)

The largest development in Scotland - and indeed in the UK - to date to incorporate SuDS is in Dunfermline. This is a town of some 56,000, drained by a number of streams including the Lyne Burn (catchment area approx. 48 km^2). A development of some 5,500 homes, 138 hectares of land set aside for light industry, commercial leisure park (15 hectares), public open space (85 hectares) and a district centre (9 hectares) on greenfield and brownfield land is underway to the east of town. This site, called the Dunfermline Eastern Expansion Area (DEX) has become a major UK demonstration site for the SuDS concept.

The use of stormwater management facilities was essential in the development of this greenfield site, due to existing flooding problems and lack of capacity in watercourses downstream from the proposed development area. Flooding was the responsibility of the Local Authority: Fife Council.

Although SuDS (or rather their precursors) were being installed in 1996, no UK design guidance was available. A general lack of design and construction experience in the UK, often resulted in inappropriate structures being built. There was also a general lack of UK based information on their effectiveness which meant that many barriers needed to be overcome before this new (for the UK) technology could be implemented.
In 1996, a partnership was formed to oversee the implementation of the stormwater facilities for this major urban development. Consultants were appointed to develop a surface water management policy for the proposed development on behalf of the partnership. The intention was to use Scottish/American engineering expertise to learn from US best management practices and apply them to local conditions at Dunfermline. A total of 4 workshops were held to reconcile interests and co-ordinate activity. Issues such as land take, design criteria, safety and maintenance were explored at the workshops, which provided an open forum to address the barriers to new technology as they became apparent. The parties involved (local councils and roads authorities) were reluctant to take responsibility for the maintenance of the SuDS. The developers are currently maintaining the regional treatment facilities, and discussions are ongoing over who should ultimately pay for this work to be carried out.

A stormwater masterplan was developed incorporating the treatment train concept. As new developments occur within the site, they are required to provide a facility which will attenuate flow, prior to connection to one of the regional facilities. SuDS from industrial and commercial sites were expected to provide some level of treatment.

The original economic driver for the DEX development, a new semi-conductor plant, has been constructed and the rest of the development of the site is now well underway. Much of the surface water drainage infrastructure and 331 houses, has been completed. So far, one extensive area of permeable block paved car park has been built, as well as 4 retention ponds, extended detention basins and detention basins. DEX is located on an area of predominantly low permeability clay soil so infiltration methods have limited application.

The retention ponds were designed to minimise safety risks by providing gently sloping margins with extensive barrier planting and it was also a requirement of the local planning authority to have houses overlooking the ponds. A safety audit required construction of a 1m high fence around each of the retention ponds, but not around the stormwater wetland which is situated within a public park area.

Monitoring the effectiveness of the system is being undertaken with the assistance of the Universities of Abertay and Edinburgh over a five year period. The cost of maintaining the systems will also be assessed, however, the use of conventional drainage systems would have resulted in prohibitive costs to the development as a 5km stormwater sewer to the Forth River would have been required.

Figure D1 Layout of SUDS at the DEX Site

INSERT Dunfermline East Case Study double-sided page

INSERT M74 Case Study double-sided page

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D3. USA

D3.1 Overview

In the United States, Environmental Protection Agency (USEPA) regulations govern stormwater pollution at federal level. At a state level, each develop their own rules which are compatible with the USEPA regulations.

Maryland was one of the first states in the US to require the control of smaller runoff events (using detention) and by the late 1970's it was also the first to require stormwater quality BMPs. In other areas of the US (such as Orlando, Florida and Austin, Texas), treatment of stormwater has been required since the early 1980's.

Florida developed its stormwater rules as far back as 1982 (which required all new developments to include BMPs) and therefore have a vast amount of experience implementing BMP technology for both water quantity and quality control.

The municipalities in other states such as Colorado have only just started to design BMPs for water quality purposes (although flood control structures have been in place for many years). While in Texas, the city of Austin believe in grass roots approach to stormwater management. A variety of initiatives have been developed to educate the general public about the importance of controlling stormwater. A variety of BMPs have been implemented ranging from large concrete structures to aesthetically pleasing landscaped ponds. Innovative ideas have also developed in the US, such as the use of bio-retention systems (vegetated depressions which attenuate and filter runoff, but do not require large amounts of land).

D3.2 Stormwater Management in the State of Massachusetts

Early efforts to improve water quality in Massachusetts focused on controlling direct wastewater discharges from municipal and industrial facilities. These point sources of pollution were regulated by a permit system and by setting limits for discharge concentrations of pollutants.

In 1987, the Clean Water Act was amended, launching a phased approach to address the impacts of stormwater. Phase I requirements related to runoff from certain industrial activities for which controls for stormwater discharges were set; construction sites greater than 5 hectares required a permit from the EPA and municipal storm drains in highly populated areas required gullypot cleaning, street sweeping and public education. Phase II tightened up on the Phase I requirements and required all industrial categories to produce no increase in runoff; construction sites greater than 1 acre required a permit from the EPA and all municipalities less than 100,000 population were to develop a stormwater management plan. Combined sewer overflows became a major focus to control pollution of watercourses. Due to the threat of enforcement orders, the public have assisted in the clamp down on illegal connections and for example took to their kayaks after dry periods to look for illegal discharges.

However, despite the early development of SuDS in some US states, in 1998 40% of assessed waters did not meet water quality standards. The USEPA identified stormwater as the leading cause. In the State of Massacheusetts almost 50% of Rivers & Coastal Waters are not in compliance with surface water quality standards due to stormwater pollution.

The Centre for Watershed Protection has conducted studies which relate land use to water quality. The studies found that waters were generally healthy where the impervious area was less than 10%. As a rule of thumb, if the impervious area were greater than 15% then water quality suffered. Impacts which focus public attention were those of bathing beach closure after rainstorms and shellfish area closure. Since the early 1980's there has been a development control requirement of an 80 m wide riparian zone.

In 1997, the Massachusetts Department of Environmental Protection issued a Stormwater Management Policy to address stormwater impacts though the implementation of performance standards. The standards are designed for use under multiple statutory and regulatory authorities of the Department of Environmental Protection. The Standards comprise a nine point list as follows:

1) No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters.

2) Stormwater management systems must be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.

3) Loss of annual recharge to groundwater should be minimised through the use of infiltration measures to the maximum extent practicable. The annual recharge from the post-development site should approximate the annual recharge from the pre-development or existing site conditions, based on soil types.

4) For new development, stormwater management systems must be designed to remove 80% of the average annual load (post-development conditions) of Total Suspended Solids (TSS). It is presumed that this standard is met when:

   (a) Suitable non-structural practices for source control and pollution prevention are implemented;

   (b) Stormwater management best management practices (BMPs) are sized to capture the prescribed runoff volume; and

   (c) Stormwater management BMPs are maintained as designed.

5) Stormwater discharges from areas with higher potential pollutant loads require the use of specific stormwater management BMPs (refer www.state.ma.us/dep). The use of infiltration practices without pretreatment is prohibited.

6) Stormwater discharges to critical areas must utilise certain stormwater management BMPs approved for critical areas[1]. Critical areas are Outstanding Resource Waters (ORWs), shellfish beds, swimming beaches, cold water fisheries and recharge areas for public water supplies.

7) Redevelopment of previously developed sites must meet the Stormwater Management Standards to the maximum extent practicable. However, if it is not practicable to meet all the Standards, new (retrofitted or expanded) stormwater management systems must be designed to improve existing conditions.

8) Erosion and sediment controls must be implemented to prevent impacts during construction or land disturbance activities.

9) All stormwater management systems must have an operation and maintenance plan to ensure that systems function as designed.

[1] Includes extended detention basins, retention ponds, constructed wetlands, water quality swales, sand filters, organic filters, infiltration basins, infiltration trenches.

Applicability: Industrial, commercial, institutional, residential subdivisions, roads projects. The standards do not apply to single-family houses projects; residential subdivisions of four or fewer lots; or emergency repairs to roads and their drainage systems.

The Stormwater Management Policy is enforced under the Wetlands Protection Act & other Department of Environmental Protection Acts.

The experience in the US suggests that funding is critical to the successful implementation of best management practices. In the State of Massachusetts a fund of $200 million per annum is available for planning, design and construction of SuDS.

D3.3 Stakeholder Participation

D3.3.1 The Groundwater Foundation

The Groundwater Foundation (GF) is a non-profit organisation that is dedicated to informing the public about the nature and value of groundwater. Since 1985, GF programs and publications present the benefits everyone receives from groundwater and the risks that threaten groundwater quality.

The Groundwater Guardian (GG) program is the centrepiece of the GFs work. It began in 1992 with a grant from the W.K. Kellogg Foundation. The purpose of the GG program is to create a network of local groundwater protection projects. The most important element of the GG program is the willingness of local

citizens to organise a team of local stakeholders. These stakeholders identify local groundwater problems, develop an education/action plan to address the issues and document their progress. The GF provides administrative assistance, information resources and official recognition. But it is community stakeholders who lead, implement and benefit from the program.

This high level of citizen involvement is vitally important as many small groundwater dependent communities lack the financial resources and/or professional expertise to ensure protection of the resource. The 'best practice' for many of these communities is an educated and empowered citizenry acting responsibly on behalf of their community. The experience of the GF is that when citizens understand the vital importance of groundwater to their environmental and economic future, they are able to develop innovative cost efficient strategies for its protection.

The GF rigorously requires that each GG team includes at least one representative from local government agencies, educational institutions, citizen interest organisations and local businesses and/or agricultural producers. The GF find that the most common approach to team building is to find an especially committed and enthusiastic individual (a 'spark plug') responsible for starting a new group.

Community action plans are comprised of 'Result Orientated Activities (ROA's). Once an action plan is drawn up, implementation involves activities such as Community groundwater festivals; newspaper articles; retrofitting homes and businesses with conservation devices; developing local ordinances that include best management practices and/or protective land uses. Specific examples of local issues addressed within the GG program include:

- ***Central Platte Natural Resources District, Grand Island, Nebraska.***
  Landowners have been participating in a groundwater education program since 1973. Since 1986 a nitrogen management program that includes voluntary groundwater protection practises have successfully stabilised the nitrate levels throughout the Central Platte Basin.

- ***Anaheim, California and El Paso, Texas.***
  Where there are unsealed, abandoned wells, there is the potential for groundwater contamination. Older citizens on GG teams led teams to locate and promote the sealing of abandoned wells such that thousands of wells have been protected from spills and thousands of people from potential harm.

- ***Cape Girardeau, Missouri and Desert Hot Springs California.***
  Community education campaigns were implemented to help citizens understand the importance of pollution prevention. Both communities have vulnerable groundwater because of local spring. The end results: sewer systems and on going pollution prevention activities.

- ***Upper Republican Natural Resources District near Imperial Nebraska.***
  A well metering and allocation program, in place since the early 1980's has maintained groundwater supplies and agricultural production in an area that saw serious depletion during previous decades. Farmers are given a 5 year water account and use best practises to conserve water to maintain a constant supply. The practical results is less water use from the account in wet years so more will be available in dry years.

- ***East Lansing, Michigan.***
  An innovative multi-jurisdictional approach to groundwater protection has helped the area protect groundwater quality and supply. Local leaders on the GG team have created partnerships and cost-effective initiatives that are making a difference in the long term. A common water supply has created the ability to share resources across jurisdictional boundaries in order to maintain a safe and ample water supply. This model will be increasingly common and will create an expanded sense of community in the future.

One of the GF's more high profile stakeholder groups has been the Nebraska youth through an annual water education event - the Children's Groundwater Festival. Lively entertainment and interactive displays are led by groundwater and natural resources professionals representing government agencies, environmental organisations, higher education, and private business. The activities are designed to teach children about groundwater while they have fun.

The festival is followed up with another youth event 'Groundwater University, a groundwater education camp for 12-15 year olds. The summer program teaches young people about groundwater in hands-on, practical ways by groundwater professionals. Students learn about groundwater, groundwater research, and

hydrologic studies. Students also have the opportunity to participate in field trips to monitoring wells, groundwater springs, streams, irrigation canals and lakes, and to collect water samples.

The GF also produces various products and publications such as: an Aquifer Education Kit for teachers; a Groundwater Catalogue – a collection of groundwater education products for adults and children; *The Aquifer* – a quarterly print newsletter for Groundwater Foundation members; and *The Recharge Report* – a free online newsletter published 8 times per year.

Further information about Groundwater Foundation can be found at www.groundwater.org.

D3.3.2 Watershed Agricultural Program, New York State

The Watershed Agricultural Council (WAC) is a non-profit organisation established in 1993 to promote voluntary participation of the landowners and farmers in the New York City (NYC) watershed area. The WAC is a partnership between farmers and NYC Department of Environmental Protection that balances pollution prevention, economic viability and public health concerns. The WAC has two main programs: Agriculture and Forestry.

The primary objectives of the Watershed Agricultural Program include:

- to enable the NYC water supply to continually meet water quality protection policies of New York State, City and Federal Law;
- to promote improved understanding of the impacts that best management practices in farming has on water quality;
- to encourage the balanced economic and environmental benefits of 'whole farm planning'.

Further details can be found at www.nycwatershed.org.

D3.3.3 American Ground Water Trust

The American Ground Water Trust is a national not-for-profit education organisation incorporated in 1986 and headquartered in Concord, New Hampshire, USA. The Trust, an independent authority on the hydrologic, economic and environmental significance of groundwater, combines technical expertise with networking and communication skills.

The Mission of the American Ground Water Trust is to:

- protect ground water and promotes resource sustainability,
- promote public awareness of the environmental and economic importance of ground water,
- provide accurate information to assist public participation in water resources decisions, and
- facilitates stakeholder participation.

Further details can be found at www.agwt.org.

D4. SWEDEN

D4.1 Overview

In Sweden in the 1970's, due to the limitations of dual pipe systems and the rising costs of construction and maintenance of traditional pipe systems, there was an increasing interest for alternative forms of stormwater treatment. The concept of LOD – ("Lokalt Omhändertagande av Dagvatten" - Local Deployment of Stormwater) was introduced and a number of examples were created. Most of these were either infiltration facilities, i.e. stormwater percolated to the groundwater table; or open trench facilities with grass as a top-layer that slowed down the transport of stormwater; in Swedish called "Tröga system". They often had a purely technical design.

Due to use in wrong situations, mismanagement, lack of understanding of the maintenance-demands, etc. the concept of LOD did not succeed. The conventional concept of treating and transporting stormwater in separate pipes was the overall dominating system in Sweden up until the 1990's.

In the 1980's, there was an increased focus on environmental protection in Sweden. Stormwater treatment was slowly integrated into the environmental protection process. The ideas from the 1970's (LOD) were brought back into the discussion and the environmental aspects were added. The environmental protection goal focuses on leakage of nutrients (nitrogen and phosphorus) and heavy metals as well as polyaromatic hydrocarbons (PAHs). Biologists, landscape architects and town planners were included in the process of developing new forms of sustainable stormwater treatment concepts. The concept of ED – ("Ekologisk Dagvattenhantering"- ecological stormwater treatment) was introduced.

The concept of ED has four defining criteria:

1) Purification
   By slowing down the transport process to the receiving waters, natural purification processes (sedimentation, de-nitrification, infiltration etc.) result in cleaner water reaching receiving waters.

2) Biodiversity/Landscaping
   By designing the stormwater treatment facilities according to the local demands and conditions, the facilities can be integrated into recreation areas and parks thus improving the landscape qualities for people as well as improving the biodiversity for plants and wildlife.

3) Cost reducing
   The costs for constructing and maintaining the stormwater facilities should be lower than for the conventional treatment concept.

4) Protection
   The ED concept as well as the traditional concept must by law guarantee that the built up areas are protected from damaging impact of stormwater.

In the beginning of the 1990's, some of these ED-facilities came to reality in the cities of Halmstad and Malmö in the southern part of Sweden. Since then a number of cities and communities have created their own ED-facilities. There are no statistics for the whole of Sweden but one estimation (Torsten Rosenqvist, Technical manager, City of Halmstad) is that there are some 100-200 ED-facilities in cities and communities throughout Sweden. In addition, the National Board of Roads has created some 200 ED-facilities along the national road system in Sweden.

Research is being conducted on wetlands/stormwater treatment by several universities throughout Sweden: in Lund, Alnarp, Halmstad, Gothenburg, Luleå and Stockholm, including the Agricultural University.

D4.2 Sustainable Drainage System in the City of Halmstad

D4.2.1 Introduction

In the 1970's, the City of Halmstad created some LOD-facilities. Ten of these are infiltration facilities which still operate. Another is Lake Vallåssjön which was constructed in 1969 as a pond with the purpose of storing stormwater. The alternative was to construct a large pipe, 1.8m diameter and 800m in length to the receiving water, the river Nissan. Instead the water (8000m^3), is stored in the lake which has a water area of 16,000m^2 and depth of approx. 1 m. The catchment area is 215 ha of urban area, most of it residential area with some 5,000 inhabitants. It was designed to also be a part of the park area in the residential area of Vallås. Lake Vallåsjön is still operating as a stormwater facility.

Lake Vallås is an artificial pond which saved 3 million Swedish Kroner for the city.

Today the lake and the surrounding areas are used as a park.

Every year some 0.5 million cubic metres of water pass through Lake Vallås.

The lake is rich in birdlife.

Figure D2 Lake Vallås, Sweden

In the late 1980's, the environmental aspects were focused in the Halmstad area as a result of the heavy load of nutrient, most of it nitrogen, in coastal areas at Laholm Bay. The coastal water quality suffered badly from the overload. This resulted in problems which manifested themselves in a growth of algae which threatened the tourism, fishery and coastal recreation. Research conducted by the county of Halland showed that Lake Vallåssjön also had a positive environmental effect such as reducing the nitrogen load and storing phosphorus and heavy metals.

Although the stormwater only had a very small part in the environmental impact at the Laholm bay, the city of Halmstad decided to improve the stormwater quality. Other measures that were undertaken included improving the sewage treatment plants, regulating the management of agriculture, livestock and manure etc. A plan for treating the stormwater; "Ekologisk Dagvattenhantering – våtmarker för havets skull" in built up areas was created by the Parks, Streets and Water-and-Sewage-facilities Departments. The technical board approved the plan in 1991 and decided that the concept of ED for treatment of stormwater should be the overall concept in Halmstad. Also the board of town planning adopted the concept of ED for new urban areas in Halmstad.

The 1991 plan showed some 50 sites suitable for creating ponds, wetlands and flooding areas. By 2003 some 40 of these had been constructed. These are ponds, wetlands, streams and flooded grass-areas. The size of the facilities differs from approx. 100 m^2 to 5-6 ha. The catchment areas range from approx. 1,000 m^2 to 215 ha. The original plan from 1991 will be completed in 2004 as a result of support from government subsidies. The concept of ED is always incorporated in the planning process for new urban areas in Halmstad.

Some examples of ED-facilities in Halmstad are presented below.

D4.2.2 Vallås Wetlands

A system of wetlands were constructed in 1990-93 down-stream of the Vallåssjön lake facility with the goal of improving water quality. The focus was on nitrogen removal but also on reducing phosphorus and heavy metals. Another goal was to improve the quality of the surrounding nature park and recreational area. By adding the water area to the nature park the expectation was to increase the diversity of plant and wildlife. A further goal was to extend the storing capacity of the system as the construction of new paved areas in the catchment area had made the pipe-system insufficient.

The wetlands act as a natural sewage treatment works by absorption of nitrogen by wetland plants.

Sediment particles containing nitrogen are also deposited in the bottom sediments.

Wetlands further eliminate nitrogen through a process of denitrification, a biological process whereby bacteria respire in environments with very little oxygen, breaking down nitrate and nitrite creating mainly (harmless) nitrogen gas.

Figure D3 Vallås Wetlands, Sweden

The additional wetland area is about 2 ha. The average depth of the wetland is about 0.5 m. The landscaping goal is to make the wetlands blend in to the surrounding natural park area. The slopes were designed with a flat angle of inclination, roughly 1:6. This contributed to minimise the risk for accidents with children. Small rapids were created in order to dam up the water. The material that was used for this purpose consisted of natural stone blocks and heavy clay. The surplus from the excavation was integrated into the surrounding park area. This contributed to keep the construction cost for the wetland area as low as £40,000 in 1990/93. Vegetation in the wetland and surrounding areas consisted mainly of the natural growth which established during the initial 2-3 year period.

The Vallås wetlands helps improve the water quality and boost wildlife

Figure D4 Vallås Wetlands, Sweden

Scientific evaluation of the lake Vallåssjön and the Vallås wetlands has been conducted by the county of Halland and the Wetland Centre at the Halmstad University. This evaluation shows that Vallåssjön has an environmental effect in nitrogen removal and reducing of phosphorus in the water as well as heavy metals. The bottom area is covered with a 20 cm mud layer built up after 30 years of existence. The contents of the layer has been analysed in the evaluation. According to existing regulations it can be used for landscaping purposes.
During some periods there was some leakage of phosphorus from one of the wetlands. This is explained by the shallow depth of 0.5 m that results in erosion during periods with heavy flooding. This experience has resulted in a change of design concept for ED-facilities in Halmstad. The depth in new wetlands is increased to 1-1.5m and if possible bypasses are created in order to avoid heavy flooding events having an impact at the wetland.

D4.2.3 The Stream of Knebildstorpsbäcken

In the western parts of Halmstad a smaller stream with a catchment area of about 500 ha. runs through an urban area before discharging into the Laholm Bay. Most of the urban area consists of small industries/enterprises and the regional airport. The stormwater from this area ran into the stream of Knebildstorpsbäcken at about ten locations, resulting in extermination of fish life.

During 1991-92 all points of outflow of stormwater were completed with a small pond, wetland, flooding of grass-slope or natural forest. Thus, all stormwater-flow into the stream was completed with an ED-facility. The ponds/wetlands vary in size from 100 to 500 m^2. The costs for these measures was £3000 (1991/92).

Evaluation of the county of Halland by trial fishing showed that there was no fish life during the period 1984-1992. After the measures were conducted, fish life, consisting of trout and salmon parr, returned to the stream.

During 1996 a hazardous outflow of stormwater from the airport ended up in the stream and resulting in a new extermination of all wildlife in and along the stream. In order to avoid new outflow of hazardous stormwater from the airport, ponds were constructed at the airport.

Those ponds were designed as three hearts, which is the coat of arms for the city of Halmstad. They are visible from the air when arriving and departing from the airport. For a second time the fish life returned to the stream at a even higher level than before.

D4.2.4 Söndrums Industrial Area

A new industrial area 50 ha in extent, was developed upstream of the urban areas along Knebildstorpsbäcken stream. All stormwater from this area discharges to Knebildstorpsbäcken stream.

This resulted in two new issues to deal with:

- An increased environmental impact on the stream.
- A heavier stormwater load during flood events than the stream could accommodate.

The start of the project involved town planners, landscape architects and water engineers. The initial goal was to design the master plan for the area in order to make space for creating ED-facilities (sustainable drainage systems). The facilities/systems have three main characteristics:

- Slowing stormwater-flow from the industrial sites.
- Slowing stormwater-flow along the roads by a system of trenches with flat grass slopes.
- Storing water in a system of ponds.

The ponds have a total area of 31000m^2 and a depth of 1m in average. The storing capacity is 8000m^3. At the time of writing, there has not yet been any evaluation of the impact on the Knebildstorpsbäcken stream.

D4.2.5 Slottsparken Pond

The city of Halmstad originates from the 14th century. It was earlier surrounded by a moat. Remnants of the moat could be seen in the park "Slottsparken". In the 1980's, the combined sewer system was changed into a dual system. Thus it was possible to create ED-facilities with the stormwater in the city. In 1997 a pond with an area of 3000 m^2 and a depth of 1m was created. The catchment area is about 17 ha. In the beginning the pond had a positive effect on the park and the environment. Later an odour was emitted from the pond. In the 2001 and 2002 the odour worsened. Efforts in research of the pipe-system were conducted on a large scale. There was a rising suspicion that there was a misconnection in the pipe-system.

The explanation emerged in 2002 when a misconnection was found on the site of the local brewery. Dishwater and surplus wastewater from the beer production was occasionally, but in substantial quantity, released into the stormwater system instead of the sewer system. This flow of sewage disposal into the pond resulted in a biological collapse of the pond due to overload of BOD.

The pond had to be emptied of water and its mud-layer dredged. Following the implementation of measures and correcting the mis-connections in pipe-system, the pond is now restored.

D4.3 Public Response

The focus on environmental protection and preserving the Laholm Bay is strong among the people in Halmstad. Partly because the ED-facilities have great public support. Another important reason for the support is the efforts to create ED-facilities that blend in to the surroundings and contributes to the biodiversity and peoples experience of the nature park-areas. Lake Vallåssjön is featured in real-estate advertising. Negative response has occurred as a result of the odour from the pond in "Slottsparken". There has also emerged some concerns about security for children. This concern has in some cases resulted in fencing of some of the ED-facilities. However, most of them are unfenced.

D4.4 Management of ED Facilities

Managing of ED-facilities is a coherent process which includes different competences in various phases of the process. It is also a complicated process to integrate biological, technical and humanistic aspects. The knowledge of this practice is at an early stage of development. Especially if facilities that are cost-effective are to be created. However at the current stage it is widely acknowledged that the practice gives positive environmental effects and that it is accepted by the public.

With regard to maintenance, experience from Halmstad shows that in the initial period of a wetland or pond development the flooding area needs attention. Problems that occur often relate to the outflow area, were there is often erosion. Focus of maintenance at these locations is important to stabilise them. Old agricultural drainage-systems can tend to re-activate and thereby drain out ponds and wetland. Heavy growth of plants can also create demands for maintenance. In Halmstad at Lake Vallåsjön, grass-eating carp have been introduced which solved this problem. As a result no harvesting of vegetation is undertaken or planned, in Halmstad. Mud-layers are often of concern in maintenance-discussion. However, no pond or wetland has so far been subject to mud-removal.

By optimisation of the process in planning-design-constructing-maintenance and focusing on design versus maintenance, cost can be minimised. In order to develop this knowledge it is important that practitioners from the relevant disciplines and scientists work together on those issues.

In Halmstad, the Halmstad University has started a centre for Wetland research together with the different practitioners in communities, agriculture, County-administration, local economic life etc. The goal is to develop the knowledge of ED together with scientists and practitioners in other parts of the world.

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D5. AUSTRALIA

D5.1 Introduction

In Australia, increasing attention has been given to the effect of stormwater discharges on the aquatic environment since 1990.

The Australians use the terminology Water Sensitive Urban Design or WSUD to describe a new approach to urban planning and design that offers sustainable solutions for integrating land development and the natural water cycle. SuDS forms one component of WSUD, with the aim of minimising the impact of development on receiving waters.

The vision for WSUD is to provide a holistic approach to the urban water cycle involving the integration of potable and non-potable supply systems and stormwater and wastewater management systems. There is growing support and enthusiasm for a fundamental change in the way urban water resources are managed.

Four major categories of issues have been identified (WSUD Conference, 2000) as being the most important to the advancement of WSUD practices in Australia:

- the regulatory framework;
- technology and design;
- assessment and costing; and
- marketing and acceptance.

The major challenge ahead is modifying institutional frameworks, amending urban planning regulations and assisting stakeholders with developing their skills to facilitate a widespread adoption of WSUD practices.

The key impediments to the widespread adoption of Water Sensitive Urban Design aligned with these issues were identified (WSUD conference, 2000) as:

- An effective regulatory and operating environment does not exist at the state or local government level.
- The current culture and technical skill of local governments and water authorities do not support the changes required for the assessment, approval, construction and maintenance of development schemes based on the principles of WSUD.
- Institutional fragmentation of responsibilities in the urban development and approval process creates difficulties in working across administrative boundaries and impedes collaboration between organisations.
- Poor construction site management practices lead to reduced effectiveness or failure of Best Management Practices.
- Insufficient information on the operation and maintenance of structural Best Management Practices in WSUD leads to local government concern about their long-term viability.
- There is limited quantitative data on the long-term performance of Best Planning Practices and Best Management Practices in WSUD.
- The assessment of project costs require an examination of externality costs and currently there is no established procedure to guide this aspect of a life cycle cost analyses.
- The market acceptance of WSUD needs defining.

Despite the impediments listed above, numerous WSUD projects have been completed. This demonstrates how the benefits associated with WSUD projects often significantly outweigh the current impediments. Some examples of the Australian experience of WSUD implementation are given below along with site specific case studies.

D5.2 General Experience

New South Wales
In Sydney, community concern over pollution in Sydney Harbour led to pressure which resulted in the NSW State Government committing $A60 million to a 3 year Urban Stormwater Programme. The programme was to encourage and support better urban stormwater quality management practices. The main components include:

1) A Stormwater Grants Programme (awarded to over 250 projects to improve stormwater quality);

2) An Urban Stormwater Education Programme (to educate the community, industry, Local Councils and other stakeholders); and

3) Development of a Stormwater Management Planning Process, i.e. funding all Local Councils to prepare catchment based plans outlining issues and implementation strategies.

Victoria
In Victoria, a Stormwater Committee was established which produced Best Practice Environmental Guidelines for Urban Stormwater in 1999, for use by:

1) Local government: in land use planning and land and stormwater management.

- Each Local Authority is responsible for the development of stormwater management plans which identify actions to improve the environmental management of urban stormwater and protect the environmental values and beneficial uses of receiving waters.

2) The urban development industry: in planning and design of new development.

- Construction impacts must be considered as well as post construction impacts as a result of increased impervious areas.

3) State government agencies such as:

- The EPA: in providing advice on stormwater environmental management and assessing performance of stormwater managers;
- Melbourne Water Corporation (the Regional Drainage Authority): as a basis for drainage infrastructure standards;
- Catchment Management Authorities: to assist in the development and implementation of water quality and nutrient management plans; and
- The Department of Natural Resources and Environment: to promote good environmental management of urban stormwater through its partnership approach to water quality management.
- Other infrastructure providers such as the Victorian Roads Authority (Vic Roads) as a basis for planning and design of measures to protect the environment from the impact of run-off from infrastructure.

In Greater Melbourne SuDS options are being readily adopted in new developments by local authorities, developers and property owners alike. Developments which incorporate constructed wetlands and ponds are proving popular with new home owners who appreciate their aesthetic and amenity value. Developers are able to recoup the cost incurred from resulting increased property values as illustrated by the Lynbrook case study below.

Further SuDS projects in Greater Melbourne include the re-development in a formerly industrial area for housing. In this area stormwater is to be treated in a constructed wetland system which is lined to separate groundwater from the stormwater. The project will bring a high amenity value for the area.

In highly urbanised areas, retrofitting generally involves the installation of litter and sediment traps as they do not have a large space requirement. Elsewhere detention basins are being upgraded to provide water quality improvements by the establishment of wetlands.

Within each municipality stormwater management plans are being developed for improving the quality of receiving waters.

Australiawide

Water Watch

In recognition of the growing concern for water quality the Government initiated Waterwatch in 1993. Waterwatch Australia is a national community water monitoring program that encourages all Australians to become involved and active in the protection and management of their waterways and catchments.

Since Waterwatch began, the number of monitoring groups has grown from 200 operating in 16 catchments, to nearly 3000 groups in 200 Catchments. Regular monitoring occurs at approximately 5,000 sites nationally. The Waterwatch network is made up of individuals, community groups and school groups who undertake a variety of biological & habitat assessments and physical & chemical tests to build up a picture of the health of their waterways and catchments. By monitoring their local waterways over time community members can determine if the health of the waterway and surrounds are improving, declining or being maintained.

Waterwatch groups have initiated many positive solutions to improve the quality of their waterways by fencing areas of riverbanks, eradicating weeds and invasive species and reducing the use of pesticides and other pollutants.

The Waterwatch network strives to achieve a shared responsibility and collective action for natural resource management through partnerships between community, government and industry.

A waterwatch group undertake water quality Assessments.

Funding for Waterwatch is provided by the Federal Government's Natural Heritage Trust and is administered by a team based in the Sustainable Water Section of Environment Australia.

Local communities also regularly get involved in clean up days for their local waterways.

Hardhitting advertising campaigns also help spread pubic awareness.

D5.3 Site Specific Case Studies

A number of development projects incorporating elements of WSUD have been completed in Australia. Five key projects are presented below to highlight the range and scale of WSUD application in Australia. The most widely recognised demonstration site is Homebush Bay, site of the Sydney 2000 Olympics. Smaller scale projects demonstrating unique applications of WSUD practices at the sub-catchment, streetscape and allotment scales include Lynbrook Estate, Figtree Place and the Healthy Home. On a larger scale, the Mawson Lakes residential development provides an example of integrated urban water management, and demonstrates the potential for WSUD in Australia. These projects provide valuable information on aspects of implementing WSUD and enable an assessment of their performance as a water management scheme. **Table D1** summarises the key features of the five demonstration sites described in more detail below.

WSUD Project	Development Type	Scale of Adoption	Developer
Homebush Bay, Sydney	Residential estate, state sporting facilities, business park and open space (760 ha)	Catchment and Allotment	Olympic Co-ordination Authority
Lynbrook Estate, Melbourne	300 lot residential estate and open space (55ha)	Sub-catchment and Streetscape	Urban Land Corporation
Figtree Place, Newcastle	27 unit community housing venture and open space (<1ha)	Streetscape and Allotment	Newcastle Council & Department of Urban Affairs and Planning
Healthy Home, Gold Coast	Single residential house	Allotment	Chris Prosser Owner/Builder
Mawson Lakes, Adelaide	3,400 lot residential estate, commercial precinct and open space (620 ha)	Catchment and Allotment	Delfin-Lend Lease Consortium

Table D1 Summary of Key Demonstration Sites in Australia

INSERT LYNBROOK ESTATE CASE STUDY PDF

Lynbrook page 2

INSERT FIGTREE PLACE CASE STUDY PDF

INSERT HOMEBUSH BAY CASE STUDY PDF

INSERT HEALTHY HOMES CASE STUDY PDF

INSERT MAWSON LAKES CASE STUDY PDF

D6. IRELAND

A stormwater management policy for developers was produced for Dublin in 1999 which follows international best practice and promotes the concept of sustainable development.

In general new developments, such as roads projects, throughout Ireland look to the UK for guidance on SuDS design, i.e. the CIRIA SuDS manuals. In general, these designs incorporate filter drains with sealed drainage where groundwater is vulnerable or kerb and gully systems which link to attenuation ponds at discharge points to local watercourses. Oil interceptor traps are located at the discharge point to the ponds. In the past the focus of this type of development has been on flood control, however it is recommended that water quality impacts are also addressed though implementation of appropriate SuDS controls.

The City West case study overleaf illustrates how Local Authority requirements for flood control were met through innovative design solutions.

Throughout Ireland there is a growing awareness of the importance of conserving the environment to provide habitats for wildlife as well as to allow its citizens some breathing space in an increasingly urbanised society. This is reflected in projects such as the 'Neighbourwood' scheme which provides grant assistance for the development of woodland amenities and is funded under the National Development Plan 2000-2006. The scheme is designed to complement existing Local Authority activities, funding structures and programmes and the growing involvement of community groups and environmental NGOs in the management of local amenities. The scheme assists local Authorities in demonstrating, on a practical level, their commitment to implementing Local Agenda 21. The 'Neighbourwood' at Terrylands, Galway City includes the development of riparian wildlife corridors and the planting of native species. (refer **www.dcmnr.gov.ie/files/neighbour.pdf**)

A number of successful public awareness initiatives have been undertaken by the Three Rivers Project including "The Happy Fish Campaign" aimed at primary school children, a project website (**www.threeriversproject.ie**), information leaflets, seminars, field trips and pilot studies to publicise Best Farm Management Practices and an information leaflet aimed at the owners of septic tanks. The Three Rivers Project was sponsored by the then DoEHLG and by the constituent Local Authorities, with 85% support from the European Cohesion fund.

North of the border, Invest Northern Ireland (**www.investni.com**) provides grants for SuDS schemes.

INSERT CITY WEST CASE STUDY (2 PAGES)

D7. MALAYSIA

In Malaysia, the potential impacts of urban development on stormwater have been discussed since the late 1980s due to the widespread occurrence of flash floods. Conventional storm drainage, based on rapid disposal has long been practised. During the early 1990's policy makers and professionals began to recognise the need for an innovative approach to stormwater management, in light of a rapid increase in urban development.

A new integrated Urban Stormwater Manual for Malaysia was compiled during 1999 and 2000 by the department of Irrigation and Drainage and it is now mandated for widespread use throughout the country. The manual provides guidance to all relevant regulators, planners, designers and recognises the need for effective partnership among all levels of government and industry to achieve the desired outcomes.