SuDS & Urban Drainage

Seminar & Workshop – March 2016

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Agenda

Time	Item	Comment
10:00	Welcome and Introduction	
10:10	1 - SuDS – The Basics • The SuDS Philosophy • The 4 Pillars of SuDS Design • SuDS Types & SuDS Controls	Starting at a fairly basic level for those less informed about SuDS
10:40	2 – Legislation & Responsibilities • CAR – Water Quality • FRM – Flooding • Scottish Water and Building Standards	Controlled Activities Regulations, Flood Risk Management Act, Technical Handbook
11:00	3 – SuDS Guidance • The SuDS Manual 2015 – CIRIA C753 • WADAG – Water & Drainage Assessment Guide • SEPA's RM-08	New and recent updates
11:30	Coffee	
11:40	5 - Some Details • Source Control • Options	The Importance of Source Control
12:00	6 – Case Studies & Participation • Case studies – J4M8; Nitshill • Quiz & competition • Discussion / Q&A	Open session to encourage discussion
12:45	Lunch	
13:15	7a - Introduction to workshop session	Workshop session (in groups) to provide solutions for various scenarios
13:25	7b - Break-out sessions • Local site plan • Given scenario	
14:05	7c - Feedback from Group sessions	
14:25	8 - The SuDS Life Cycle – from cradle to cradle • Maintenance • Section 7 Agreements & Scottish Water Responsibilities • The CAPEX, OPEX and whole life costs arguments	The importance of long-term management
14:45	Coffee	
15:00	9 – SuDS Tools • BeST Tool • SuDS4Rds Whole Life Cost Tool o Simple Index Approach - SEPA	Useful tools for downloading
15:30	Discussion	
16:00	Close	

What do you want from today?

Note it

The SUDS Philosophy

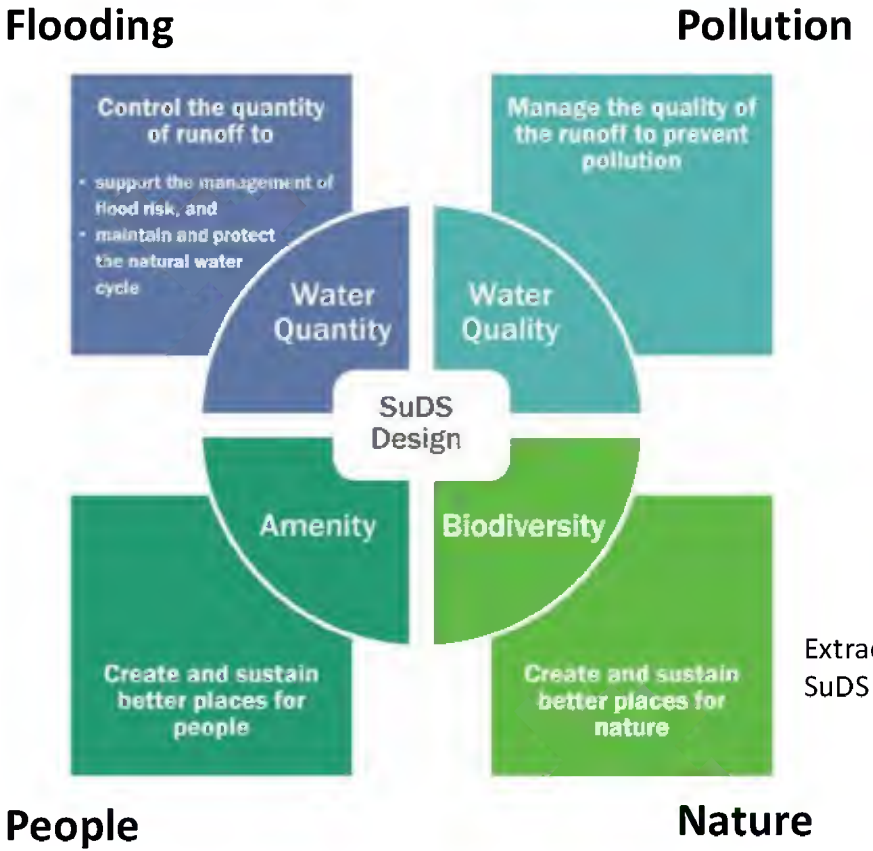
"MIMIC NATURAL DRAINAGE"

- Allow **infiltration**
  - Where possible;
    - permeable soils,
    - rock type,
    - proximity of groundwater
  - Where appropriate;
    - no groundwater risk
    - no contaminated land issues

- Encourage **attenuation**
  - Of Peak Flows;
    - Contain storm volume
    - Controlled release
  - Of Polluted Runoff;
    - Allow settlement of sediments
    - Encourage natural treatment processes

The 4 Pillars of SuDS Design

- Surface water should be managed for maximum benefit
- All 4 pillars should be considered in any design

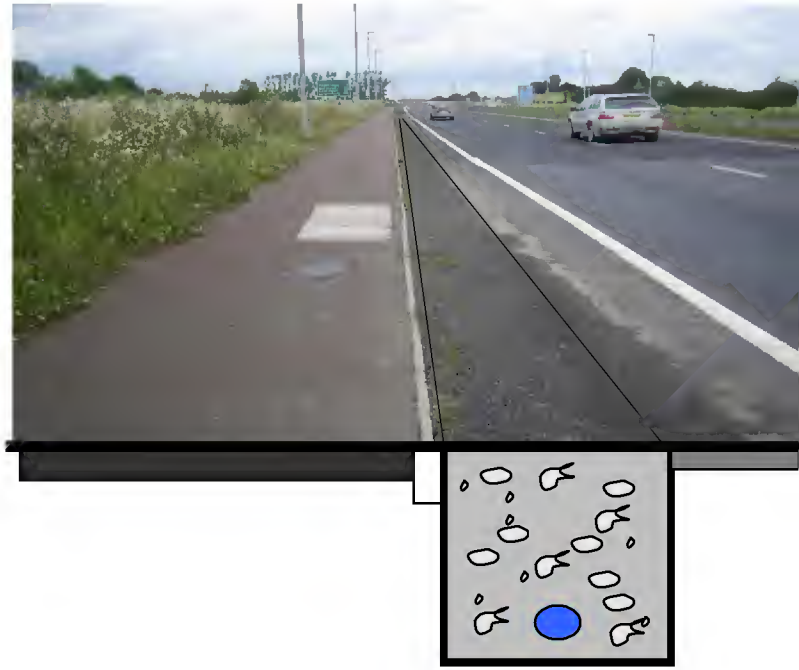


Extract from CIRIA SuDS Manual 2015

Types of SuDS

Filter Trench

- Narrow stone filled trench
- Usually road-side facilities
- Must be lower than paved surfaces
- May be lined with
  - Impermeable membrane
  - Geotextile*
- Usually has pipe above floor
  - Carrier pipe – whole length
  - End pipe – last few metres only
- May need maintenance in a few years
- Similar types;
  - **Infiltration Trench* (Liner is geotextile not impermeable membrane)
  - *French Drain*



Don’t forget about **Filter Strips**

- Grassed surface
- Gentle slope away from impermeable area; typically 2 – 5%
- Sheet-flow runoff drops onto filter strip
- Typically > 2.5m wide
- May allow infiltration depending on catchment and soils
- Motorway Service Station;
  - Monitoring showed good evidence of treatment

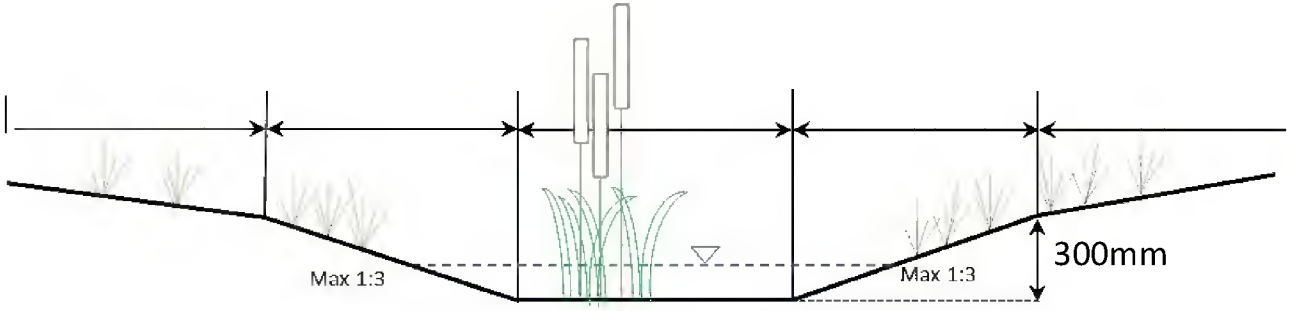
Swales

- Linear Depression
- Often roadside facility
- Also conveyance for
  Pipe-Free system
- Shallow sides
- Not deep

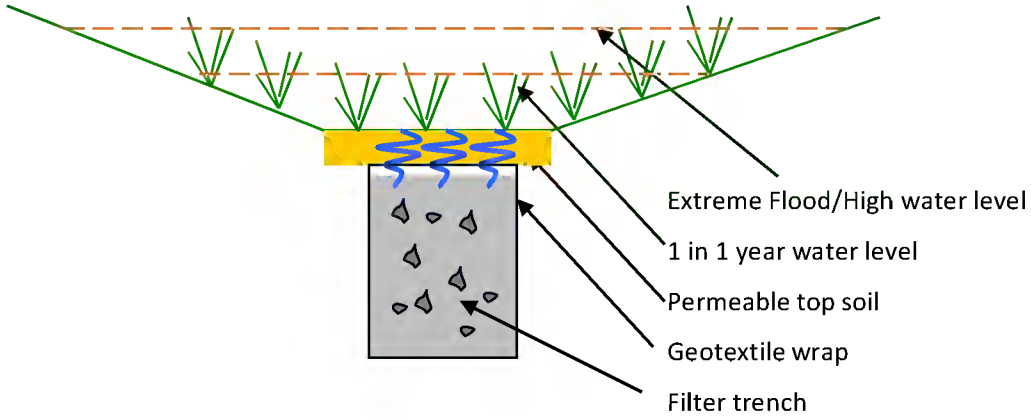
  – More later….

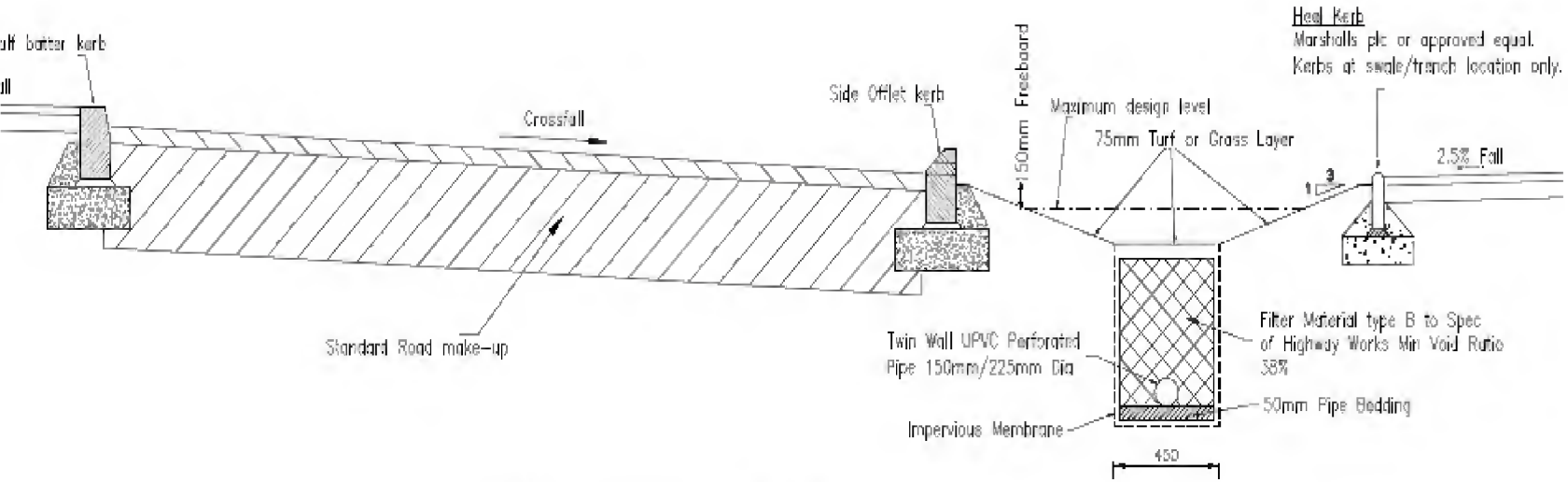
Swales

- **Standard swale**
  - Typically gentle side slopes with a flat base (floor)
  - Longitudinal section is flatter (1:200 – 1:50)
  - Not deep if not wide; typically 300mm, but can be deeper if much wider



Cross Section of an Underdrained (or Dry) Swale





SWALE/DRAINAGE DETAIL

Allow for New Growth

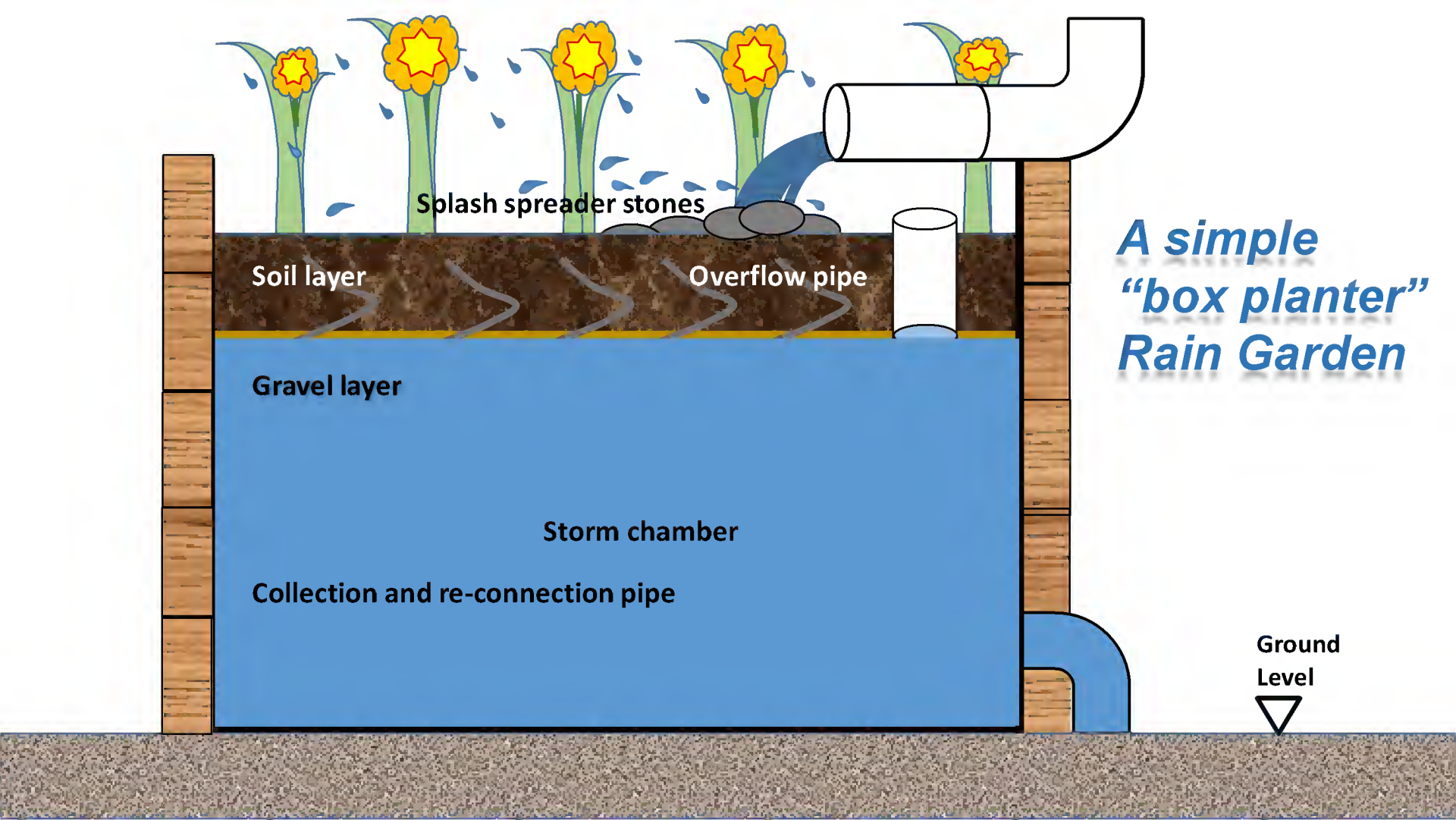
- To allow for lateral flow into the swale there must be a drop in level from the road.
- Newly established grass will “bulk-up” as it matures and fills the swale, so allow for this in the design.

Bioretention

- Bioretention systems or cells are shallow landscaped depressions capable of reducing runoff rates and volumes and can treat pollution

Rain Gardens

- Rain Garden is typically smaller bioretention module
- One definition "...vegetated area designed to attenuate rainfall"



A simple "box planter" Rain Garden

Steep Ground?

Introducing the
“Rain Ladder”
a Bioretention Hybrid

Artist’s impression

Permeable paving

SUDS Vs Conventional

Basins

- Normally dry but fills during rainfall
- Also known as Extended, Enhanced, Detention Basin!
- Contains runoff during storms
- Drains down after storm
- Wetland areas?
- Controlled outlet…

…to regulate discharge

Basin in Dunfermline

The same basin on a wet day

Green Roofs – getting SuDS off the ground

- Vegetated roofs of varying vegetation type and intensity
- Capable of attenuating runoff depending on substrate and roof slope
- Many benefits including thermal and sound insulation, habitat provision, amenity (on the roof)

Ponds

- Commonly used in residential developments
- Can provide good amenity
- Great landscaping potential

Wetlands

- A wetland is a shallow pond with vegetation surface cover of >70%
- Can offer different water quality benefits from a pond, e.g. hydrocarbons

The Treatment Train

- **Source controls**
  - Managing runoff at or adjacent to the surface that rain falls on
    - Filter strip
    - Filter trench
    - Swale
    - Bioretention/Rain Gardens
    - Green Roofs
    - Permeable paving
- **Conveyance Controls**
  - Pathway to route (convey) runoff
    - Swale
    - Filter trench
- **Receptor (end of line) Control**
  - Facility that will receive runoff from upstream areas
    - Pond
    - Basin
    - Wetland

The Importance of Source Control

- Manages runoff at source

Therefore,

- Small amounts of runoff (at source)
- Small amounts of pollution (at source)

SEPA Edinburgh Office Car Park

Around 10 years with no maintenance on paving

Could do better…

- SuDS introduced to UK 1996
- Principle adopted by SEPA & EA
- First SuDS Manuals from CIRIA in 2000
- So have we made progress?

- Yes, with some excellent examples across the land

- But, progress has been slow with reticence in many quarters

The Right SuDS in the Right Place

Topography is the driver

- Drainage infrastructure is lowest/deepest and therefore;
  - Constructed first on site
  - Includes SuDS as surface water infrastructure
- Pumping should be avoided
- Generally ponds/basins at the bottom
- Conveyance may follow footpaths and roads
- Innovation is good

The hole-in-the-ground-filled-with-water approach!

Is this pond OK?
Any thoughts to improve?

- Fulfilling environmental and flooding regulations is the easy bit
- We should go beyond the hole-in-the-ground-filled-with-water approach
- Improving the efficiencies of each system requires careful consideration
- This can even save money

…and provide “Better Places” – a Scottish Government agenda

Pond Safety

Barrier Vegetation

Retrofitted in a Dense Development

	Number of houses / car park spaces				
Receiving Water Type	**<25**	**25-50**	**>50-100**	**100-1000**	**>1000**
Normal sensitivity watercourse	1 level	1 level	2 levels	2 levels	2 levels
Low sensitivity watercourse	1 level	1 level	1 level	2 levels	2 levels
Transitional waters	Minimal	Minimal	Minimal	Minimal	Section 4.5
Coastal waters	None	None	None	None	Section 4.5
GBR applies	*Standing planning advice* Local Authority checks source control design				
GBR applies	*SEPA provides site-specific planning advice* LA checks source control design				
GBR applies	*SEPA provides site-specific planning advice* LA checks source control design, Scottish Water checks pond/basin design if Sewers for Scotland 2				
Licence required	*SEPA provides site-specific planning advice* LA, Scottish Water, SEPA may check design				

Still Applies but Changing Soon – See SEPA Guidance in Later Session

An Extract from SEPA's Guidance

- Regulatory Method

  (WAT-RM-08)

"Sustainable Urban Drainage Systems"

Levels of Treatment

- Levels of treatment
  - In series
    - 1 - Permeable paving, then
    - 2 - Basin, then
    - 3 - Swale
  - NOT in parallel
    - ~~1 or 2 or 3~~

SUDS Treatment Train

Taken from SEPA's Website

Surface Water Management Plans

- South Glasgow Flood Visualisation

We don’t want hazardous, muddy puddles with no habitat potential....

Any Questions?

The Flood Risk Management (Scotland) Act 2009

Duties of responsible authorities

The FRM Act places a duty on Scottish Ministers, SEPA and the responsible authorities to act to reduce 'overall flood risk'.

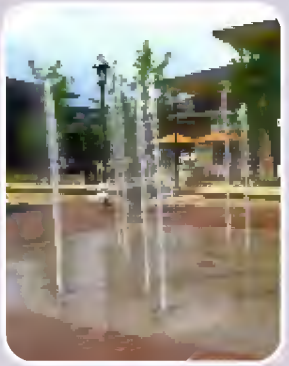
It is also places a duty on them to:

1. Act in the way best calculated to manage flood risk in a sustainable way;
2. Promote sustainable flood management;
3. Act with a view to raising public awareness;
4. Act in the way best calculated to contribute to the achievement of sustainable development.

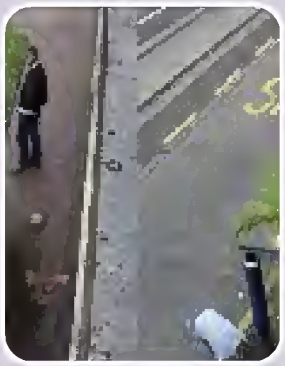
Aims of sustainable flood management

- The 5 main aims of SFM are:

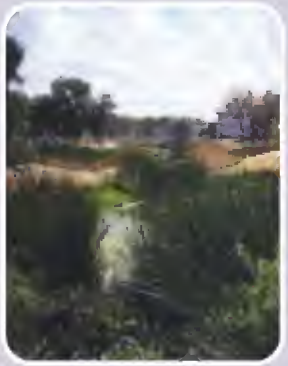
A reduction in the number of people, homes and property at risk of flooding



Integrated drainage that decreases burdens on our sewer systems



Rural and urban landscapes with space to store water and slow down the progress of floods



Flood management actions being undertaken that will stand the test of time and be adaptable to future changes in the climate.

A well informed public

Developing a catchment approach

'Actions that affect one part of a river or coastline can have consequences elsewhere. This means that flood management measures are most effective when they are coordinated across catchments and along coastlines in a way that is uninhibited by administrative boundaries'.

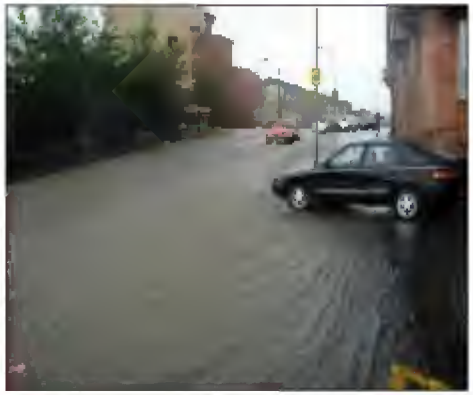
Scottish Government SFM Guidance

SEPA and the responsible authorities now have to coordinate their actions to tackle flood risk across catchments.

General Duties - 1

As a "Responsible Authority", Scottish local authorities have general duties as described in the Act that include:

1. A direct role in contributing to reducing flood risk;
2. A duty to consider the social, environmental and economic impacts of carrying out it's functions;
3. A duty to act in the best way to contribute to the achievement of sustainable development.



General Duties - 2

4. The council is required to work in partnership and collaborate with other responsible authorities, adopting an integrated 'joined up' approach to managing flood risk;
5. It is required to promote sustainable flood risk management;
6. There is a duty to prepare Local Flood Risk Management Plans.

What is a Local Flood Risk Management Plan (LFRMP)?

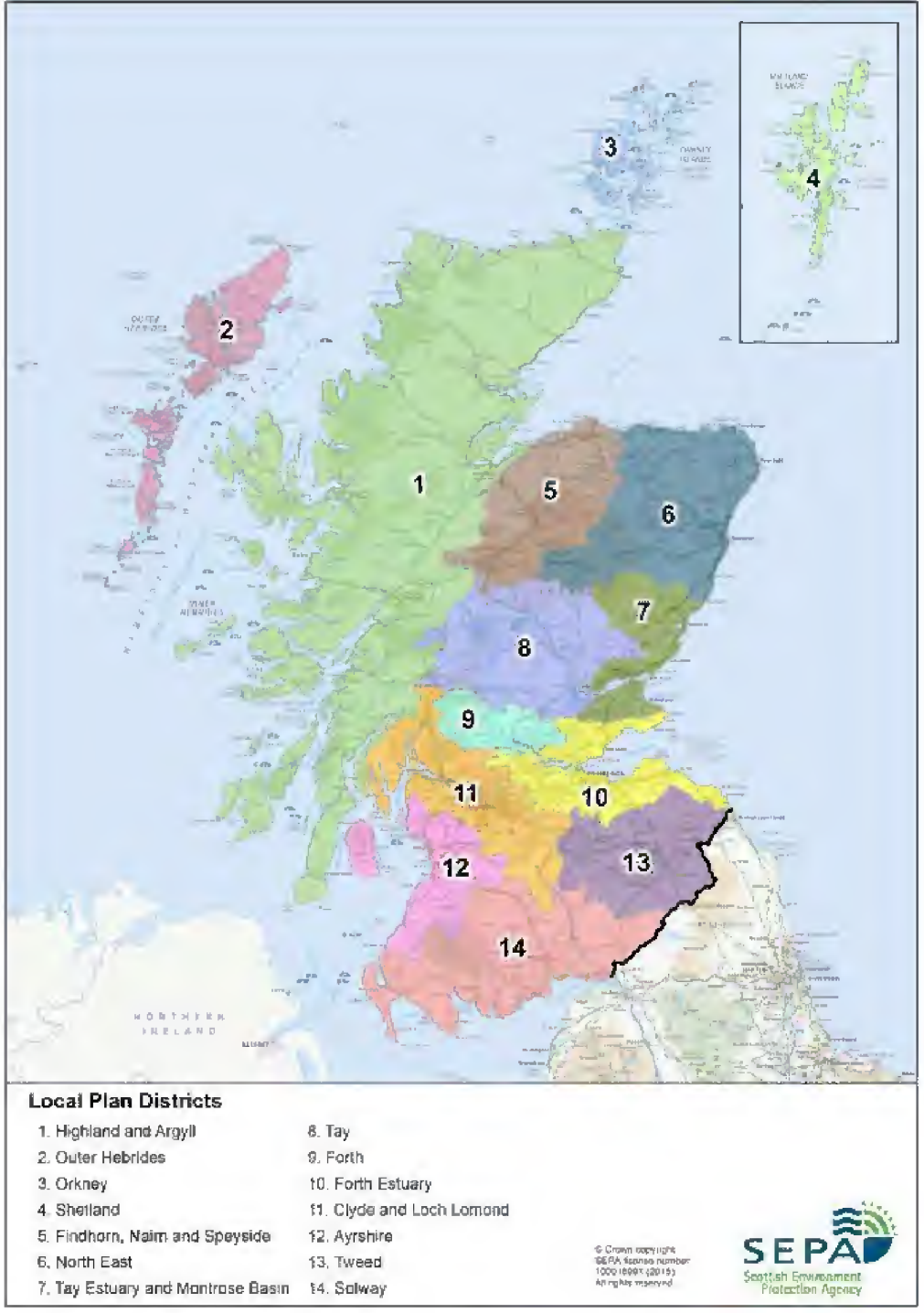
National Flood Risk Assessment

- Identifies area most vulnerable to flooding
- Identifies where flood management effort should be targeted

Local Flood Risk Management Plans (14 Districts)

- Deliver nationally based strategies which will be refined to meet local needs and priorities;
- Designed to identify and address flood risk within designated area;
- To be led and prepared by local authorities with support from local advisory groups;
- Will include a summary of how actions will be implemented.

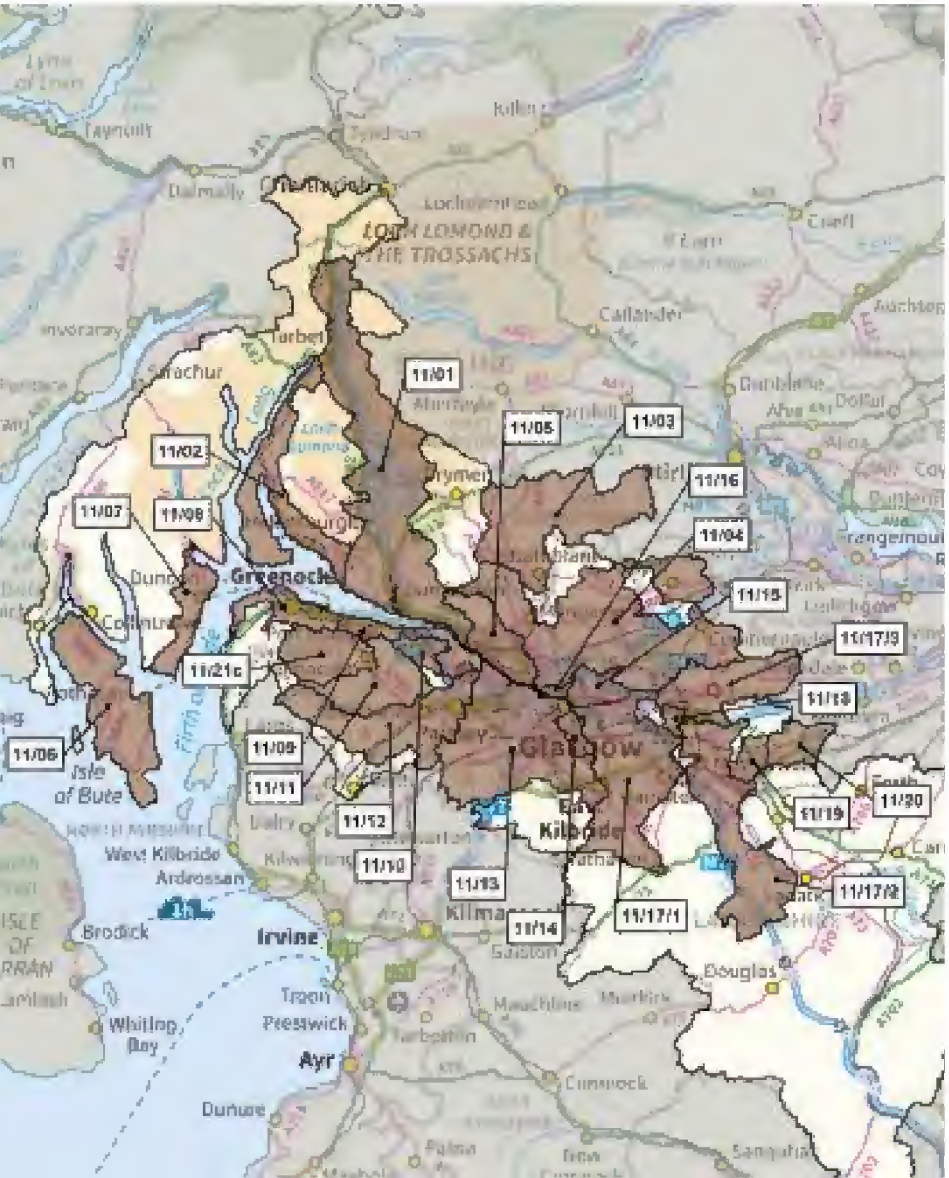
Local Plan Districts



Local Plan Districts

- The FRM Act requires the production **of Flood Risk Management Plans** covering each Local Plan District.
- For each Local Plan District a **lead local authority** will be identified and a wider partnership formed.
- New **Flood Risk Management Str**ategies formed
- Highlighting **Potentially Vulnerable Areas** (PVAs)

Flood Risk Management Strategy



Objectives to manage flooding in Potentially Vulnerable Area 11/02

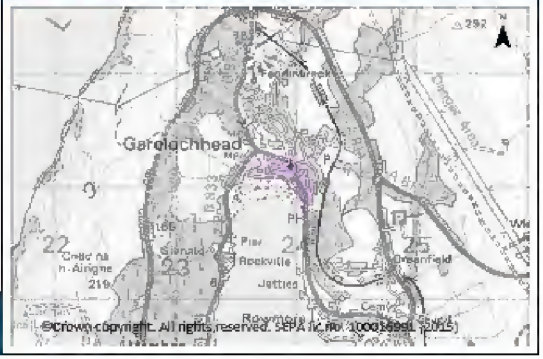
Objectives provide a common goal and shared ambition for managing floods. These objectives have been set by SEPA and agreed with flood risk management authorities following consultation. They were identified through an assessment of the underlying evidence of the causes and impacts of flooding. Target areas have been set to focus actions; they do not necessarily correspond to areas at risk in SEPA's flood map. The objectives below have been set for Helensburgh to Loch Long Potentially Vulnerable Area.

Reduce the risk of coastal flooding to residential properties and non-residential properties in Garelochhead

Indicators:

- 10 residential properties
- <10 non-residential properties
- £47,000 Annual Average Damages

Target area:



Objective ID: 11002

Reduce the risk of coastal flooding to residential properties and non-residential properties in Helensburgh

Indicators:

- 30 residential properties
- 10 non-residential properties
- £48,000 Annual Average Damages

Target area:

Objective ID: 11003

Controlled Activities Regulations

Water Environment (Controlled Activities) (Scotland) Regulations

- Europe – *Water Framework Directive*
  - Scotland – *Water Environment and Water Services (Scotland) Act*
    - Regulations – *Water Environment (Controlled Activities) (Scotland) Regulations*
      - *General Binding Rules – 10 & 11*

Water Environment (Controlled Activities) (Scotland) Regulations

General Binding Rule 10

10. Discharge …. from a surface water drainage system to the water environment …..

(a) All reasonable steps [illegible] to ensure that the discharge [illegible] pollution to the water [illegible]

(d) the [illegible] contain any water run-off [illegible] developments, the [illegible] which is completed after 1st [illegible], or from construction sites [illegible] after 1st April 2007, [illegible]

(ii) following construction those developments or construction sites are drained by a SUD system equipped to avoid pollution of the water environment;

SUDS are the law!

Nature Conservation (Scotland) Act

Part 1 - Biodiversity

Section 1 - Duty to further the conservation of biodiversity

- (1) It is the duty of every public body and office-holder, in exercising any functions, to further the conservation of biodiversity so far as is consistent with the proper exercise of those functions.
- (2) In complying with the duty imposed by subsection (1) a body or office-holder must have regard to;
  - (a) any strategy designated under section 2(1)*, and
  - (b) the United Nations Environmental Programme Convention on Biological Diversity of 5 June 1992 as amended from time to time (or any United Nations Convention replacing that Convention).

* Scottish biodiversity strategy

Technical Handbook

(Building Standards)

3 – Environment

3.6 - Surface Water Drainage

Mandatory Standard 3.6

Every building, and hard surface within the curtilage of a building, must be designed and constructed with a surface water drainage system that will:

a. ensure the disposal of surface water without threatening the building and the health and safety of the people in or around the building, and

b. have facilities for **the separation and removal of silt, grit and pollutants**.

Technical Handbook

(Building Standards)

3.6.4 Sustainable Urban Drainage Systems

Sustainable urban drainage (SUD) is a concept that focuses decisions about drainage on the environment and people. The concept takes account of the quantity and quality of surface water run-off and the amenity value of surface water in the urban environment.

The variety of design options available allows designers and planners to consider local land use, land take, future management and the needs of local people. SUD systems often stretch beyond the confines of the curtilage of individual buildings but need to be considered as a whole.

Fundamental to a successful SUD system is a management train that allows for a range of components to be incorporated for control or management of surface water, such as:

- **Source Control** – control of run-off at or very near its source by components including soakaways, other infiltration methods, green roofs or permeable surfaces.
- **Site Control** – management of surface water within a building site by components including large soakaways, infiltration systems or detention basins.
- **Regional Control** – management of surface water from building sites by components including balancing ponds are wetlands.

SUD systems range from the use of basic components such as permeable materials that allow surface water to infiltrate to ground in a way that can mimic natural drainage to more complex engineered components including filter strips, swales, or wet ponds that will convey or store surface water. The CIRIA document C697 'The SUDS Manual' 2007 provides comprehensive advice on initial drainage design assessments and best practice guidance on the planning, design, construction, operation and maintenance of SUD systems.

Careful consideration should be given to the design of surface water drainage from brownfield land, particularly where contamination might be expected. SEPA provides guidance in their SUDS Advice Note – 'Brownfield Sites' http://www.sepa.org.uk .

Generally SUD systems are designed to utilise natural processes and regular monitoring and maintenance will be needed to ensure the system as conceived is operating as intended.

Technical Handbook

(Building Standards)

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New fully revised manual released Nov 2015

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C753 **"The SuDS Manual" 2015** http://www.ciria.org/Memberships/The_SuDs_Manual_C753_Chapters.aspx

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Scottish Planning Policy

S.263

Surface Water Flooding

- Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years).
- Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas.

S.268

Proposed arrangements for SuDS should be adequate for the development and appropriate long-term maintenance arrangements should be put in place.

Questions?

SuDS Guidance

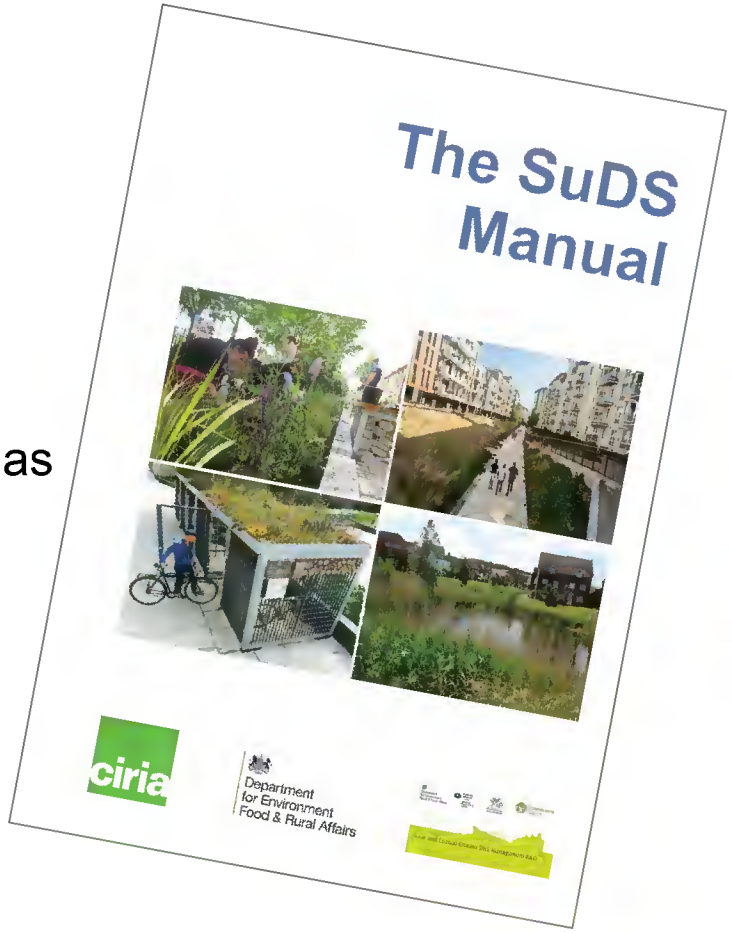
- There are many different pieces of guidance relating to SuDS
- Many from CIRIA alone with “The SuDS Manual” on its third version

Focus on 4 Recent & Forthcoming Documents

1. The SuDS Manual – C753
   - CIRIA, 2015
2. Water Assessment & Drainage Assessment Guide (WADAG)
   - SUDSWP (Sustainable Urban Drainage Scottish Working Party), 2016
3. Regulatory Method 08 (RM-08)
   - SEPA, to be updated before May 2016
4. Sewers for Scotland 3rd Ed'n
   - Scottish Water, 2015

The SuDS Manual 2015 - C753

- Recognised by most as the go-to guide
- SEPA have an expectation that all SuDS installations will be built to this guide
- Full revision and released November 2015
- Very comprehensive at 968 pages!
- “High level” guide
- Probably not a cover to cover read but excellent as reference
- Supersedes older “SuDS Manual” of 2007
- Covers Scottish legislation, policy and best practice, although more emphasis on E&W



SuDS Manual (2015) C753

- Part A
  - Introduction
- Part B
  - Philosophy & Approach
- Part C
  - Applying the Approach
- Part D
  - Technical Detail
  - Includes 13 chapters on different types of SuDS
- Part E
  - Supporting Guidance
  - Hydrology & hydraulics
  - Water Quality
  - Inlets & Outlets
  - Maintenance
  - Etc.

15 Filter strips

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300 Part D: Technical detail

Chapter 15

Filter strips

This chapter provides guidance on the design of filter strips – vegetated areas of gently sloping ground designed to drain runoff evenly from impermeable areas, filtering out silt and other particulates.

▸ *Appendix C, Section C 5.4 demonstrates how to design a filter strip for an industrial area*

15.1 GENERAL DESCRIPTION

Filter strips (Figure 15.1) are uniformly graded and gently sloping strips of grass or other dense vegetation that are designed to treat runoff from adjacent impermeable areas by promoting sedimentation, filtration and infiltration (where acceptable).

The runoff is designed to flow as a sheet across the filter strip at sufficiently low velocities that treatment processes can take place effectively. They are often used as either a pre-treatment component before swales, bioretention systems and trenches (to extend the life of these components by capturing sediment) or as a treatment component (where the flow path length across the strip is sufficient).

At low to moderate velocities, filter strips effectively reduce particulate pollutant levels by removing sediments, organic materials and heavy metals. Settling-out of sediment that contains clay particles also removes absorbed nutrients and other pollutants. Some removal of free soluble pollutants in filter strips is accomplished when pollutants infiltrate into the soil, where they are subsequently taken up by rooted vegetation

Where infiltration is possible and permitted, its extent tends to be limited during intense storms as only a small proportion of the runoff is lost (the "initial" loss), but where there is some subsoil permeability it will be the dominant mechanism for small rainfall events, and filter strips can therefore contribute effectively to the delivery of interception.

Figure 15.1 Filter strip at motorway service draining to filter drain, Hopwood (courtesy Ilman Young)

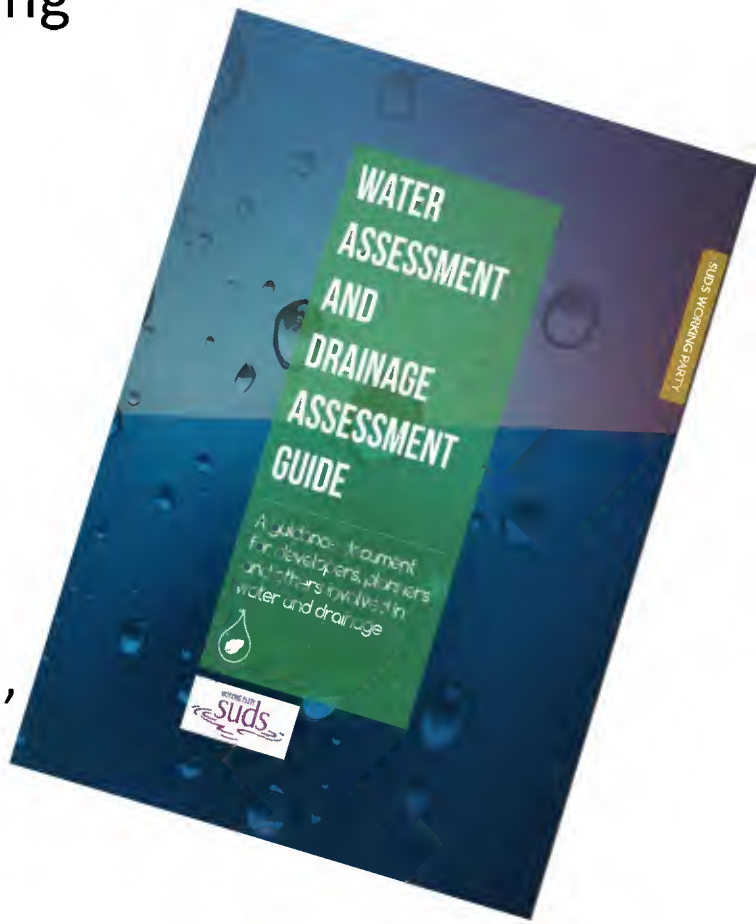
Chapter 15: Filter strips 291

The SuDS Manual (2015) - C753

- Can be downloaded from http://www.ciria.org/Memberships/The_SuDs_Manual_C753_Chapters.aspx
- Registration required, but otherwise free to access
- 2 versions – low resolution and high
- CIRIA operate the “SusDrain” programme

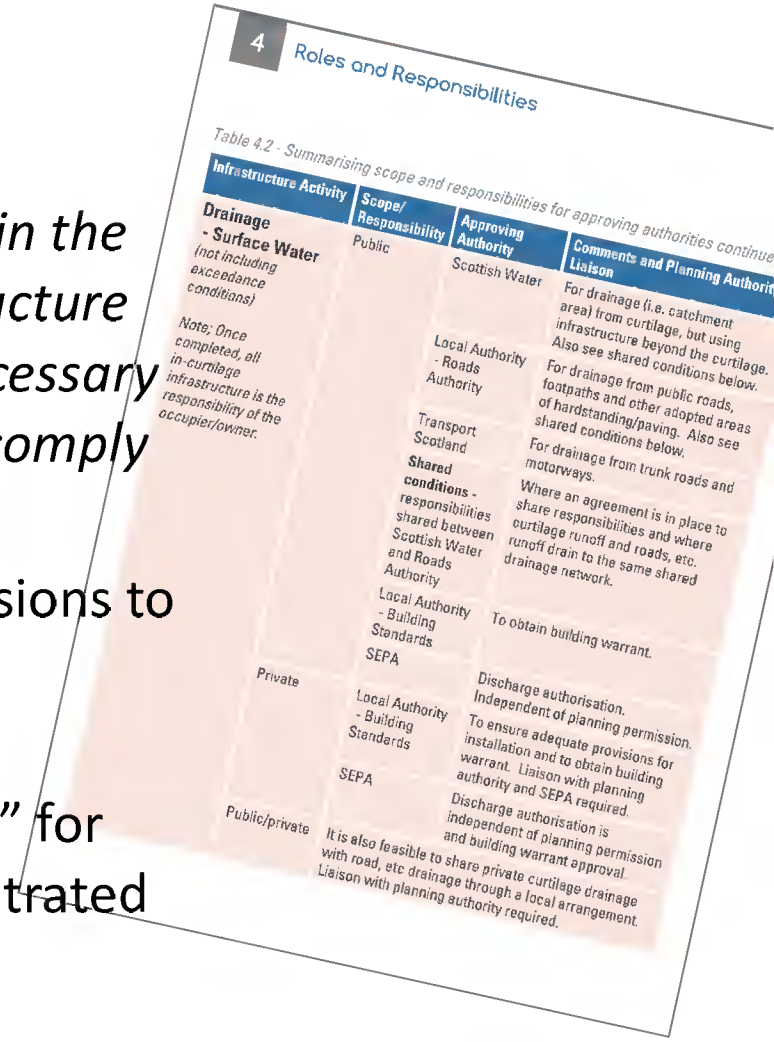
Water Assessment & Drainage Assessment Guide (WADAG)

- Produced by SUDS (Scottish) Working Party (SUDSWP)
- Multi-stakeholder partnership
  - SEPA
  - Scottish Water
  - Scottish Government
    - Planners
    - Transport Scotland
    - Flooding
    - Building Standards
  - Architects (RIAS, LIS), Planners (HoPS), Roads (SCOTS), Flooding (SCOTS), Developers (HfS, Scot Ent), Building Standards (LABSS)



WADAG

- Released Jan 2016
- Aimed at developers and planners
- *"…is intended to help guide those involved in the installation of water and drainage infrastructure (both new and retrofitting) through the necessary stages to obtain relevant permissions and comply with standards and policies."*
- Guidance for gaining the necessary permissions to install water and drainage assets and infrastructure.
- Introduces an expectation "where possible" for first 5mm of rainfall to be contained or infiltrated



4 Roles and Responsibilities

Table 4.2 - Summarising scope and responsibilities for approving authorities continue

Infrastructure Activity	Scope/ Responsibility	Approving Authority	Comments and Planning Authorit Liaison
Drainage - Surface Water (not including exceedance conditions)	Public	Scottish Water	For drainage (i.e. catchment areal from curtilage, but using infrastructure beyond the curtilage. Also see shared conditions below.
		Local Authority - Roads Authority	For drainage from public roads, footpaths and other adopted areas of hardstanding/paving. Also see shared conditions below.
Note; Once completed, all in-curtilage infrastructure is the responsibility of the occupier/owner.		Transport Scotland	For drainage from trunk roads and motorways.
		Shared conditions - responsibilities shared between Scottish Water and Roads Authority	Where an agreement is in place to share responsibilities and where curtilage runoff and roads, etc. runoff drain to the same shared drainage network.
		Local Authority - Building Standards	To obtain building warrant.
		SEPA	Discharge authorisation. Independent of planning permission.
	Private	Local Authority - Building Standards	To ensure adequate provisions for installation and to obtain building warrant. Liaison with planning authority and SEPA required.
		SEPA	Discharge authorisation is independent of planning permission and building warrant approval.
	Public/private	It is also feasible to share private curtilage drainage with road, etc drainage through a local arrangement. Liaison with planning authority required.	

WADAG

- Can be downloaded from https://www.sepa.org.uk/media/163472/water_assessment_and_drainage_assessment_guide.pdf
- Other information about SUDSWP at https://www.sepa.org.uk/regulations/water/diffuse-pollution/diffuse-pollution-in-the-urban-environment/#Information

FOREWORD

This document is produced by the Sustainable Urban Drainage Scottish Working Party (SUDSWP): a multi-stakeholder group established to promote the use of sustainable drainage in Scotland.

Members of the SUDSWP represent the following groups

- Scottish Environment Protection Agency (SEPA)
- Scottish Water
- The Scottish Government
  - Planning and Architecture Division
  - Building Standards Division
  - Transport Scotland
- Homes for Scotland
- Scottish Enterprise
- Society of Chief Officers for Transportation in Scotland (SCOTS)
- Royal Incorporation of Architects in Scotland (RIAS)
- Landscape Institute Scotland (LIS)
- Heads of Planning Scotland (HOPS)

Main Author: Neil McLean

Contributing authors: Kelvin Limbrick, Chris Digman

Steering group members

Brien Fotheringham	SEPA, Planning
Doug Buchan	Scottish Water
Clyde Ashby	Scottish Government, building standards
Bill Gladstone	Scottish Enterprise
John Thomson	SCOTS, Roads Group (Perth & Kinross Council)
James Travers	Homes for Scotland & Taylor Wimpey

In addition, the following stakeholders have been consulted and their input is gratefully acknowledged:

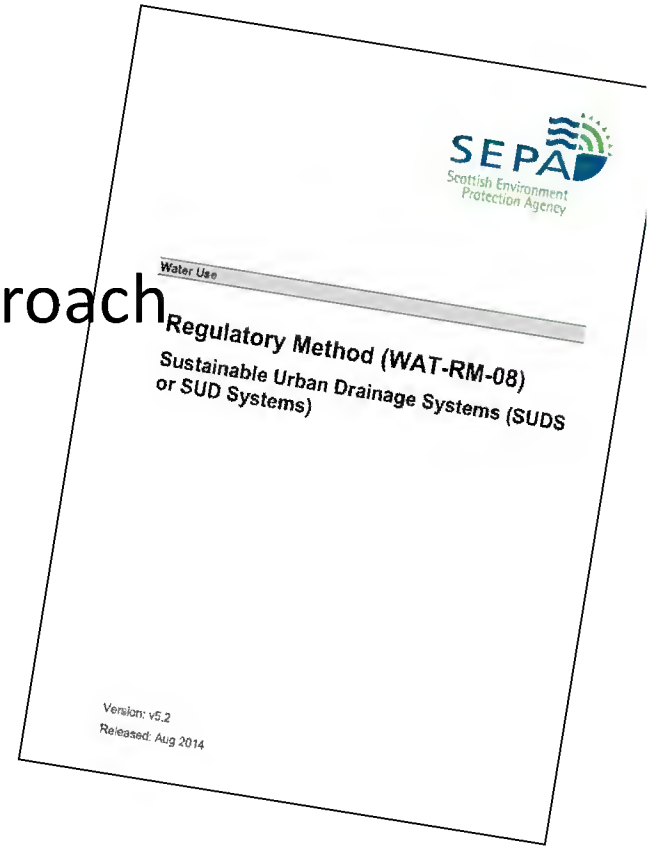
Willie Burns	Homes for Scotland &Taylor Wimpey
Simon Pellant	Scottish Government, Planning
Stephen Dunn	Perth and Kinross Council
Stuart Cullen	Clackmannanshire Council
Julie Waldron	Landscape Institute, Scotland
Neil Young	SCOTS Floods Group

Water Assessment and Drainage Assessment Guide

Regulatory Method - 08

Sustainable Urban Drainage Systems

- SEPA's guide to their own officers and external applicants
- Emphasis on water quality & pollution
- Current version (Aug 2014) will be updated to accommodate new approach to SuDS provisions
- Will use pollution indices of hazard and mitigation
- More details in final session – Tools



RM-08

- SEPA's standing Advice to local authorities;
  - Expectation from SEPA that CIRIA's SuDS manual will be used
  - Also important to *require* interception of first 5mm, i.e. source control

RM-08

- Can be downloaded from https://www.sepa.org.uk/media/152740/wat_rm_08.pdf
- Transition acceptable through to May '16

Existing Approach

	Number of houses / car park spaces				
Receiving Water Type	**<25**	**25-50**	**>50-100**	**100-1000**	**>1000**
Normal sensitivity watercourse	1 level	1 level	2 levels	2 levels	2 levels
Low sensitivity watercourse	1 level	1 level	1 level	2 levels	2 levels
Transitional waters	Minimal	Minimal	Minimal	Minimal	Section 4.5
Coastal waters	None	None	None	None	Section 4.5
GBR applies	*Standing planning advice* Local Authority checks source control design				
GBR applies	*SEPA provides site-specific planning advice* LA checks source control design				
GBR applies	*SEPA provides site-specific planning advice* LA checks source control design, Scottish Water checks pond/basin design if Sewers for Scotland 2				
Licence required	*SEPA provides site-specific planning advice* LA, Scottish Water, SEPA may check design				

New Approach

Table 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices [1]		
Type of SuDS component	**TSS**	**Metals**	**Hydro-carbons**
filter strip	0.4	0.4	0.5
filter trench	0.4 [2]	0.4	0.4
swale	0.5	0.6	0.6
bioretention system	0.8	0.8	0.8
permeable pavement	0.7	0.6	0.7
detention basin	0.5	0.5	0.6
pond [4]	0.7 [3]	0.7	0.5
wetland	0.8 [3]	0.8	0.8
proprietary treatment systems [5, 6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Sewers for Scotland (S4S) - 3rd Edition

- Scottish Water will vest (adopt) SuDS if built to their standards
- 3rd edition is now mandatory standards
- Standards are detailed in S4S
- Fairly strict about vesting new SuDS!

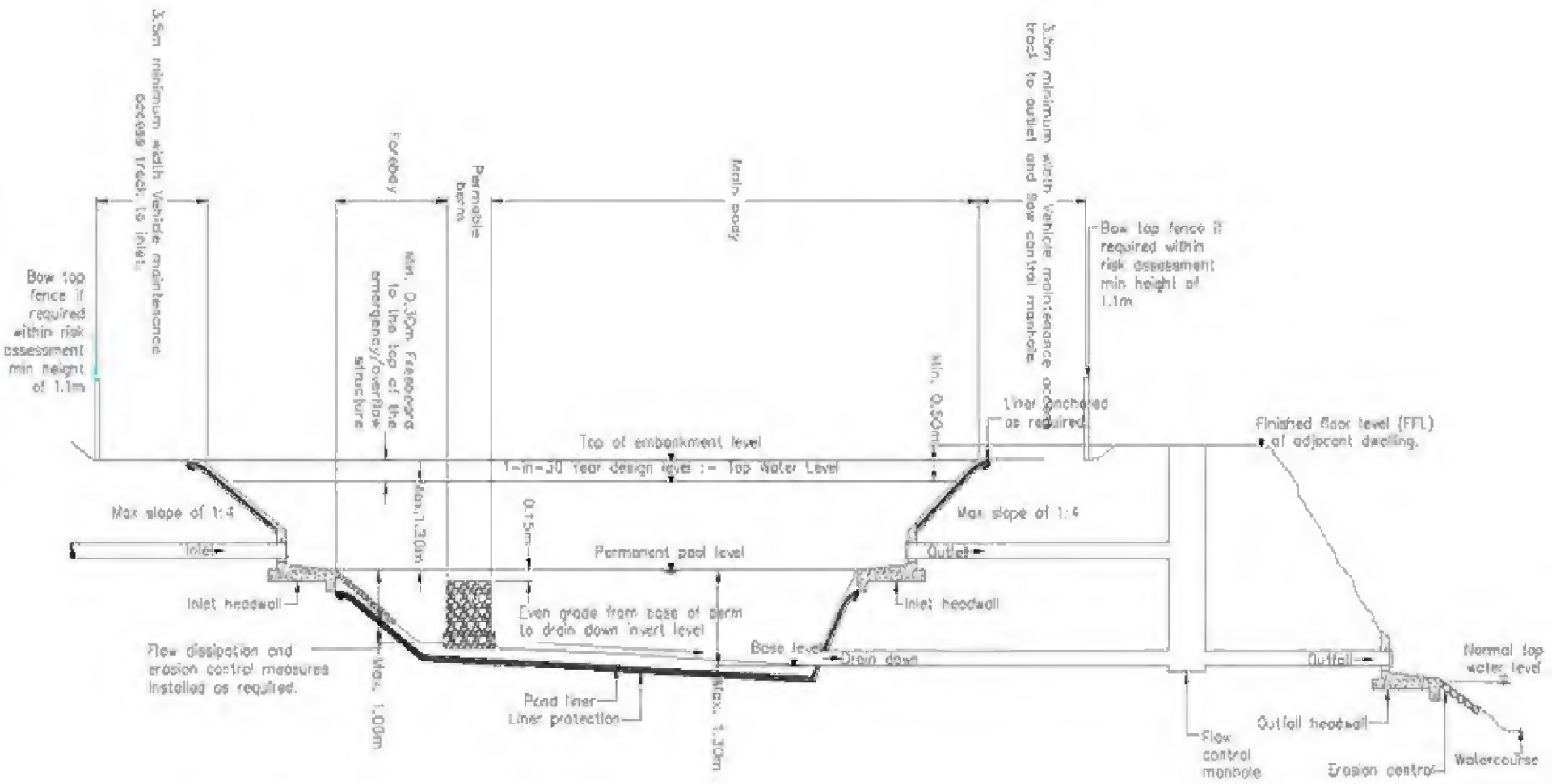
Sewers for Scotland 3

- Presently Scot Wat will only vest;
  - Ponds ☺
  - Basins ☺
  - Underground storage ☹
- "Waiver" required if alteration from standards

- Sewers for Scotland 4th (3a?) Ed'n is already drafted
  - Likely to be more flexible and may contain further end-of-pipe arrangements

S4S3

Example section through pond



Any questions?

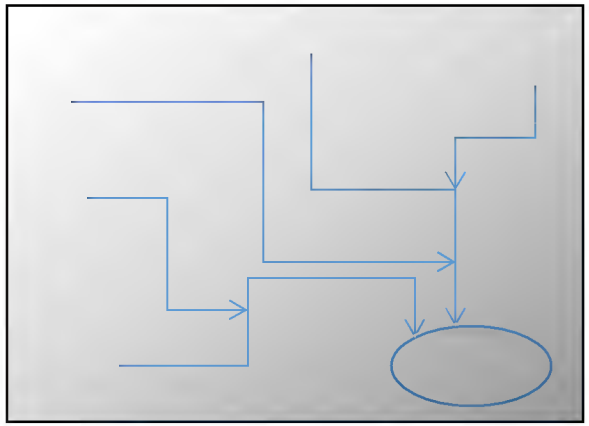
Some Details

- The Importance of Source Control
- Green roofs
- the “5m Rule”
- other options

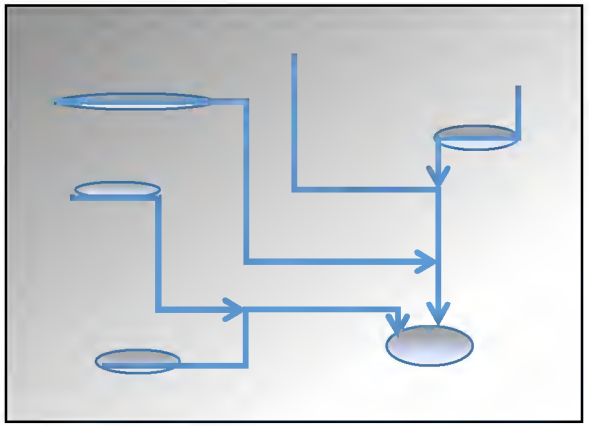
Source Control

- Better to manage runoff where it lands than to gather it at a downstream location where hydraulic loads and pollutants are more concentrated.

Collect over catchment (End of pipe)



Mange at Source



What is a Green Roof?

Green roofs, or vegetated roofs, or living roofs are systems that are essentially roofs with vegetation placed upon them in a way to provide benefits. The installation of a green roof may be for various reasons and will almost always provide a suite of additional benefits.

The 2 main categories of roof are;

- **Extensive** green roof – thin growing layer and low maintenance; most commonly sedum mat system
- **Intensive** green roof – deep growing layer and generally more managed and higher amenity with larger plants including trees; a park on the roof

Green Roof Types

Extensive;

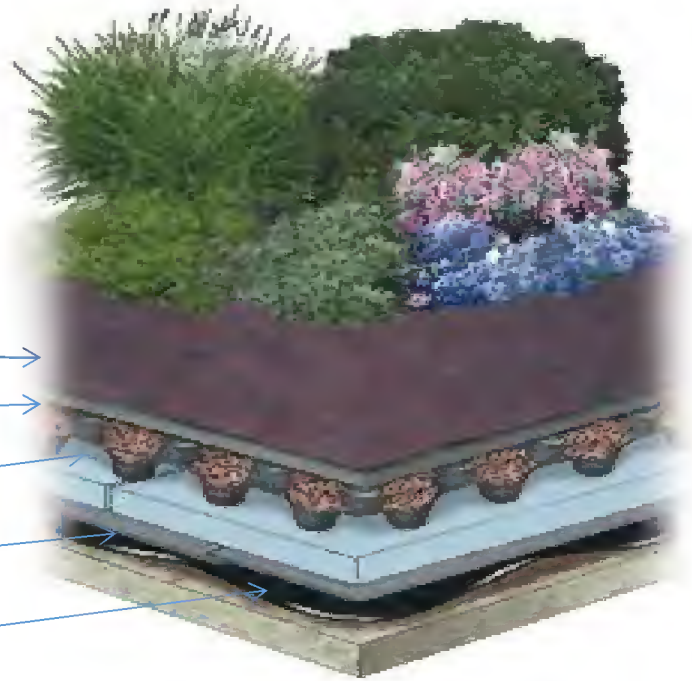
Glenco

Intensive;

Scottish Parliament

What you don't see…

- Typically a green roof will have discr
  layers between roofing surface and
  vegetation;
  - Substrate
  - Geotextile
  - Water Storage
  - Root Barrier
  - Waterproofing



Why provide Green Roofs?

Benefits include (in no particular order);

- Climate change & adaptation
- General environmental, economic & social benefits
- **Flood mitigation**
- Water quality improvements
- Health and well being
- Habitat & Biodiversity
- Air quality improvements
- Building thermal efficiency
- Reduced whole life cost
- Noise reduction
- Urban heat island effect reduction

A green "Barrel" roof, Duff Street, Edinburgh

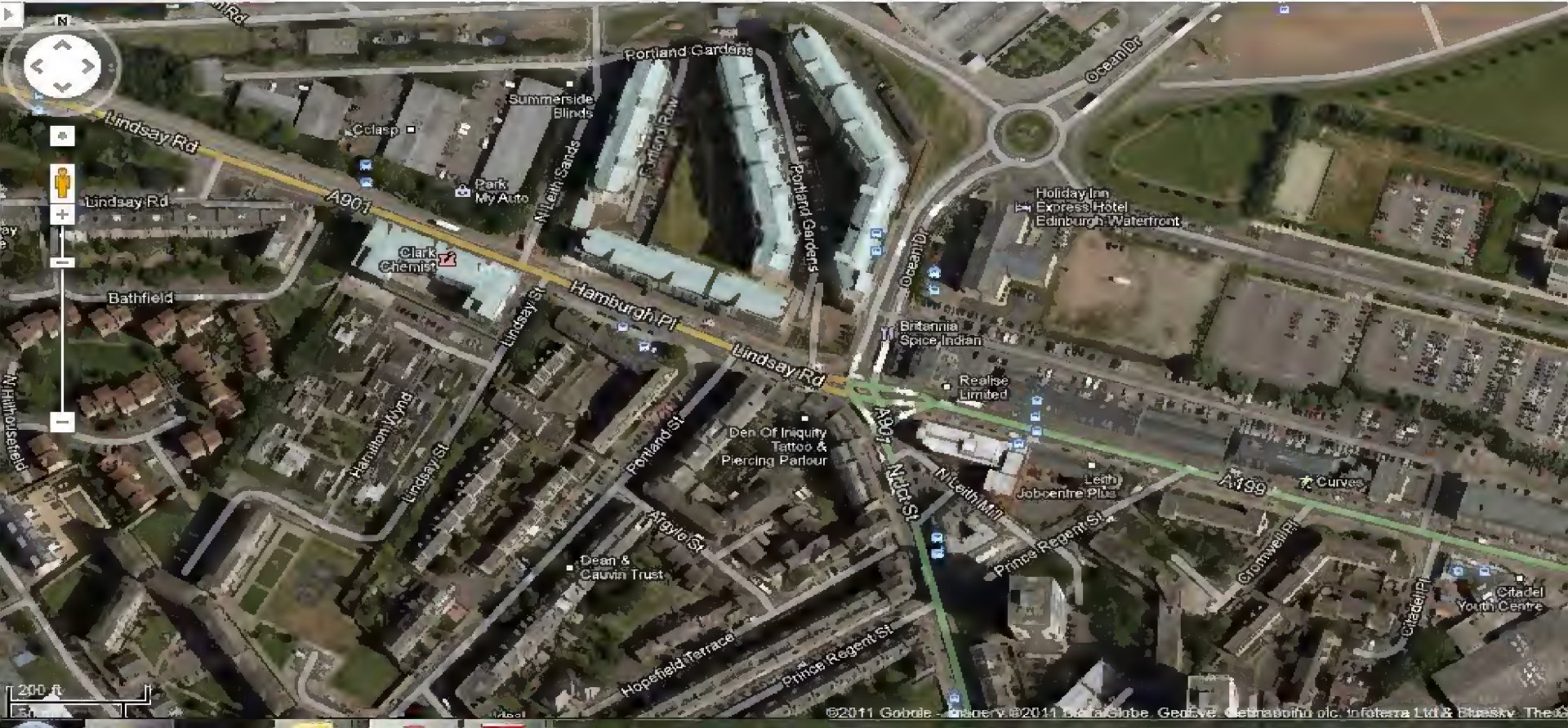
Habitat & Biodiversity

- Changing climate will see species become more threatened
- New buildings in green field sites will remove habitat – green roofs can be used to replace this loss
- Green roofs can provide important, undisturbed refuges for wildlife – Swiss and UK studies have shown rare invertebrate populations within green roofs.

North American Studies

- Toronto Study
  - If green roofs were installed on roofs greater than 350 m^2 in size
  - Would cover at least 75% of the roof area
  - Energy savings from air conditioning $21m
  - 4.15kWh/m2
- Chicago Study
  - City wide green roofing would save the equivalent of a small nuclear power station

Leith – Spot the Green Roof?




Portland Gardens
N Leith Sands
Leith Sands
Image Printers
Summerside Blinds
Colasp
Park My Auto
A901
Clark Chemist
Hamburgh Pl
Lindsay St
Ocean Drive Dental Care
Britannia Spice Indian
Ocean Dr
Portland Gardens
©2011 Google Imagery ©2011 DigitalGlobe, GeoEye, Getmapping plc, Infoterra Ltd & Bluesky, The GeoInformation Group, Map data ©2011 Tele

Portland Gardens, Leith

Discussion

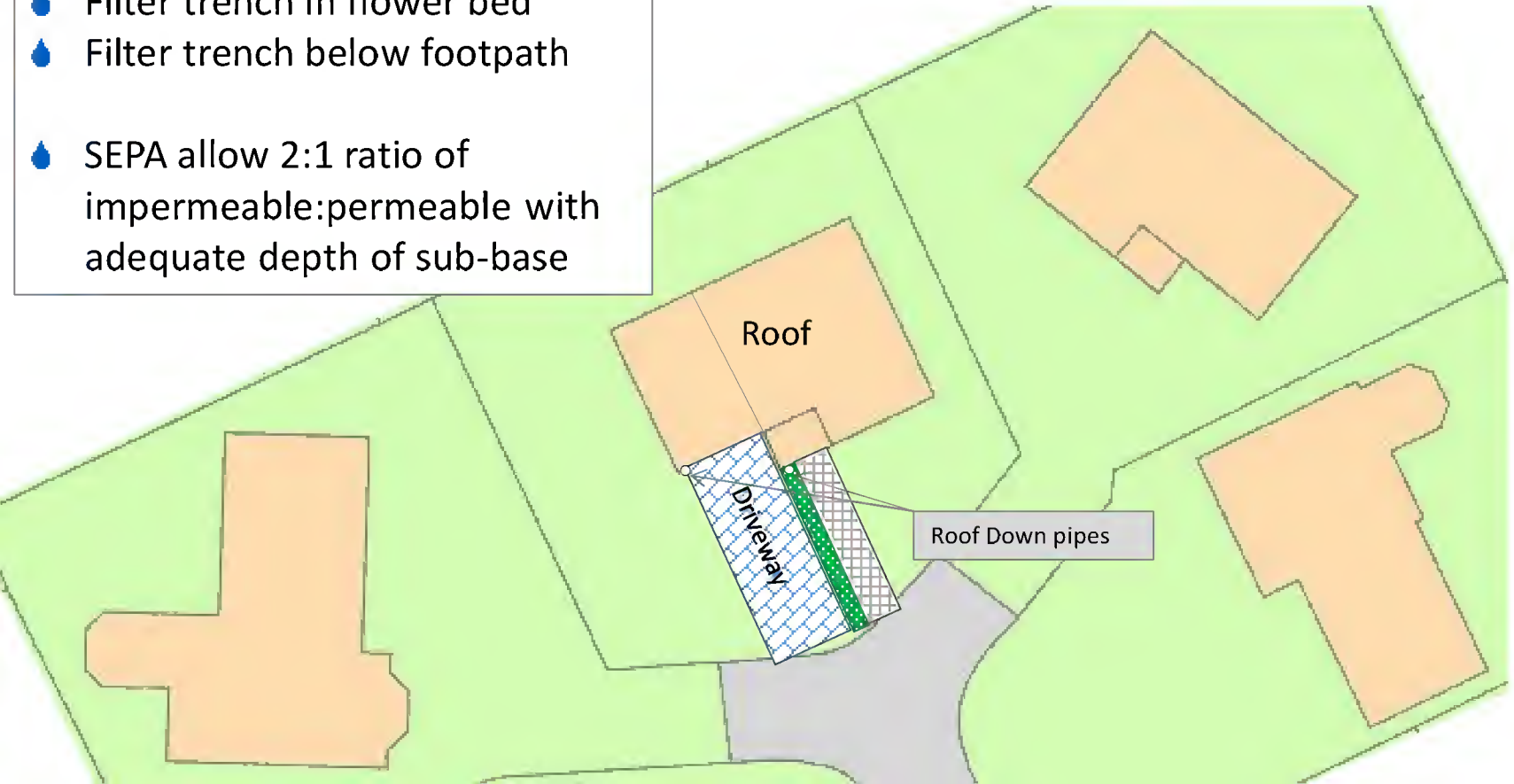
The 5 metre Rule - “Deem to Satisfy”

- Flatted housing development
- Permeable paving in shared surfaces
- Prepared sub-base is wrapped in impermeable membrane
- Sealed unit
- No infiltration

Roof drains to;

- Permeable paving in drive
- Filter trench in flower bed
- Filter trench below footpath

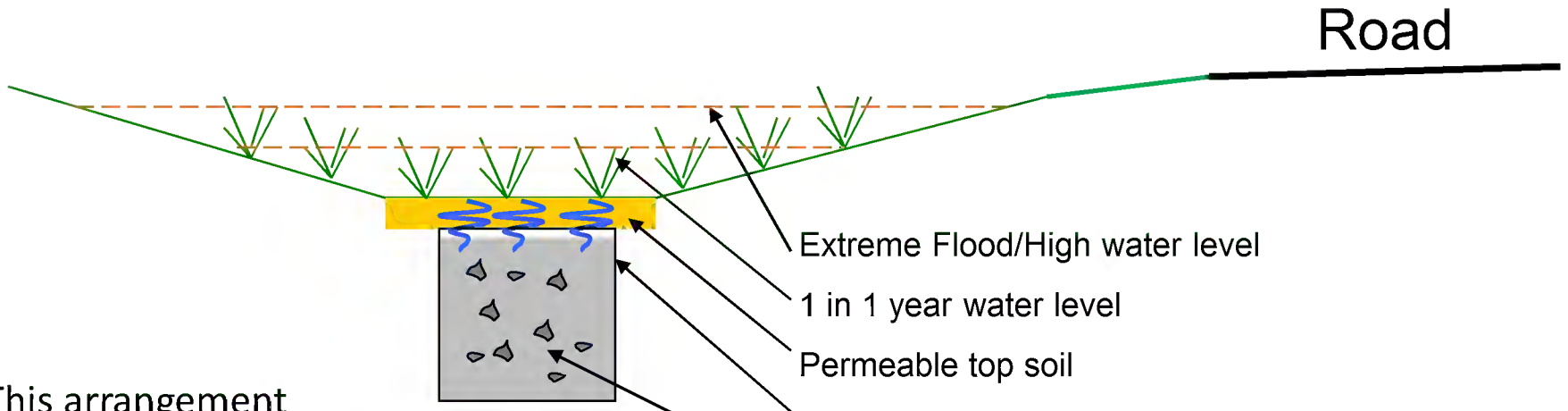
- SEPA allow 2:1 ratio of impermeable:permeable with adequate depth of sub-base



Soakaways & Perm Paving

- It is quite acceptable to have permeable paving adjacent to buildings – same as grassed area/garden next to building
- Not acceptable to take large area of surface drainage to a small location immediately adjacent to buildings
- Fact Sheet by geo-tech engineer; http://www.susdrain.org/files/resources/fact_sheets/09_12_fact_sheet_suds_close_to_buildings.pdf

Cross Section of an "Underdrained" or Dry Swale



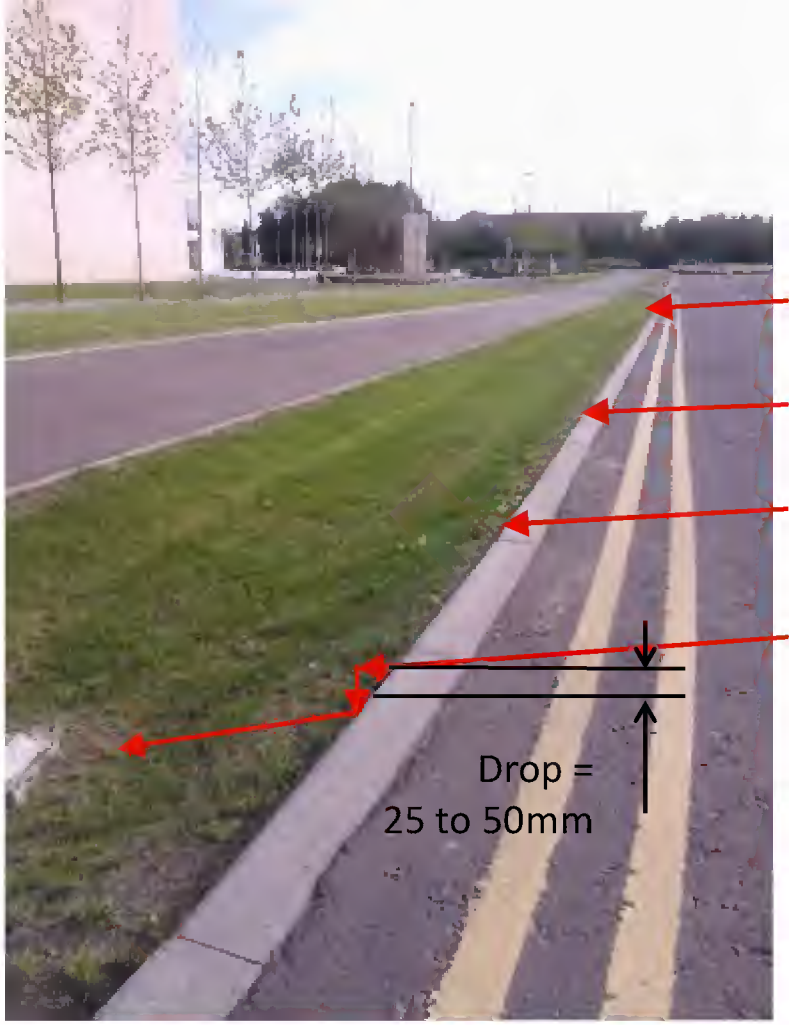
This arrangement constitutes 2 levels of treatment for SEPA


Swales don’t have to be straight or flat
Swale in flatted development

Allow for New Growth

- To allow for lateral flow into the swale there must be a drop or at least level from road.

- Newly established grass will “bulk-up” as it matures and fills the swale, so allow for this in the design.



Don’t put loose soils above permeable surfaces

SEPA Edinburgh Office Car Park

Around 10 years with no maintenance on paving

Occasional landscaping overspill – no impact on hydraulic function

Edge detail has limited signs of blinding but otherwise fine

SUDS Vs Conventional

Dingwall - Porous Tarmac

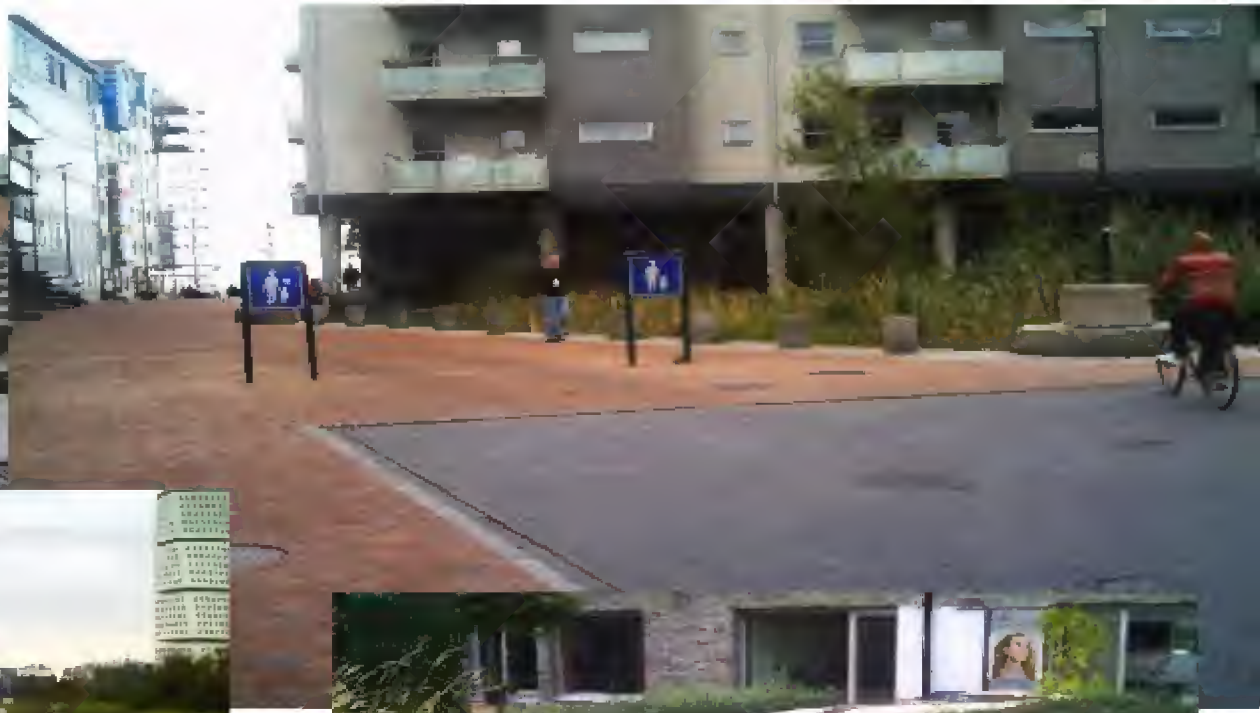
Headwalls – why?

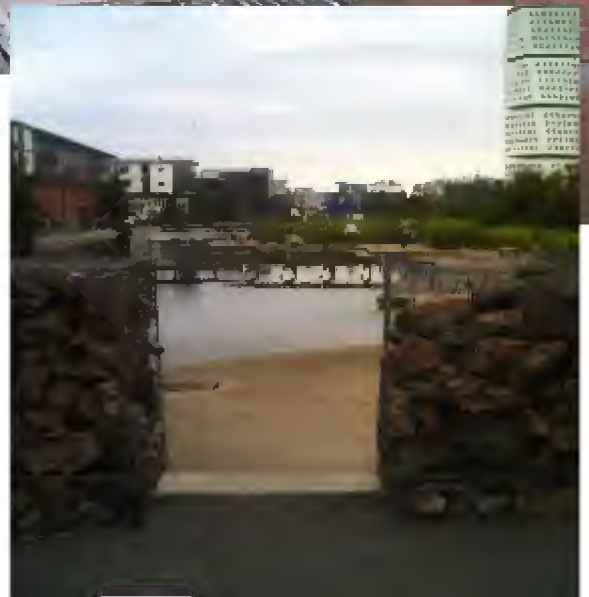
- Headwalls are constructed as standard in many cases
- Often there is no need
- Expensive
- Unsightly
- Unsafe..?

- Alternative is a mitred or chamfered pipe profiled to meet the bank slope

Mitred or chamfered inlets

Western Harbour, Malmo





Questions?

What We Don't Want, What to look out for & Use of Proprietary Products

Neil McLean

Some Examples of What Doesn't Work

Basins;

Early examples

"Bomb-craters"? ☹
Muddy floors

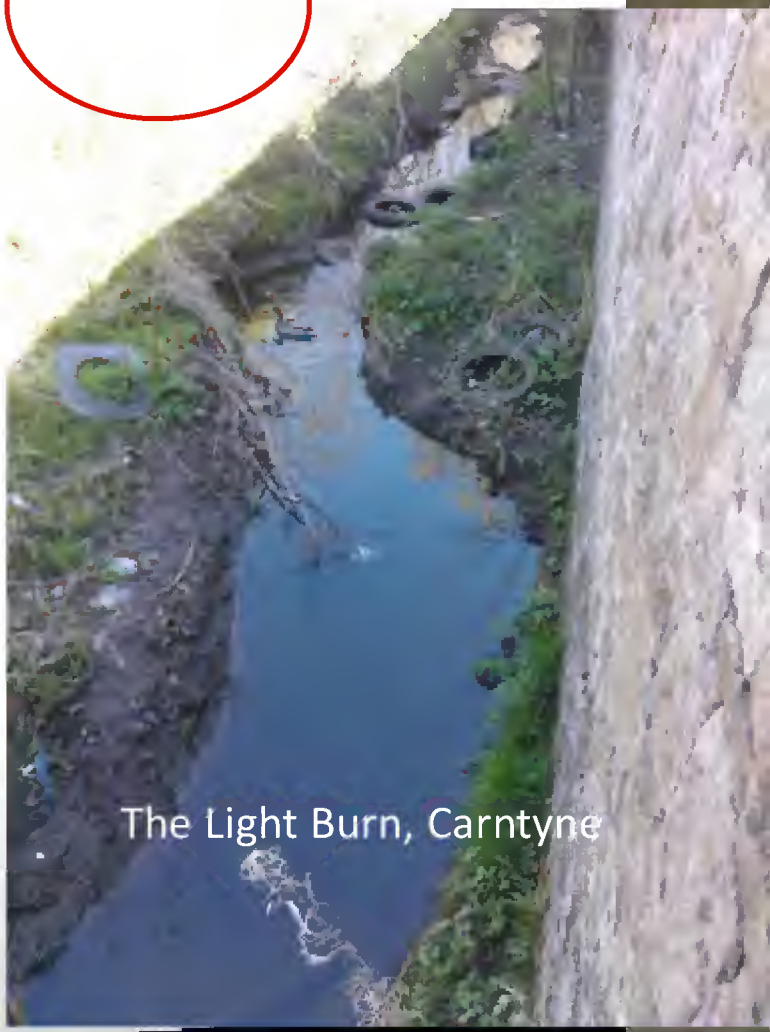
Bad example - Livingstone Swale

Construction runoff into swale.
Developer had to clear and re-instate

Details , Details.

Need to have a Firm Stance

New Garthamlock SUDS



The Light Burn, Carntyne

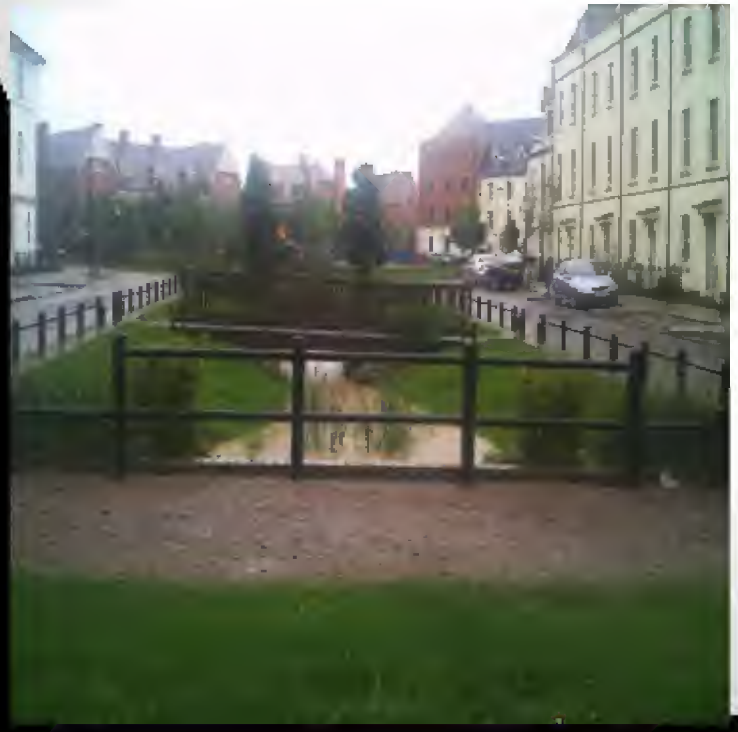
Upton, Northampton

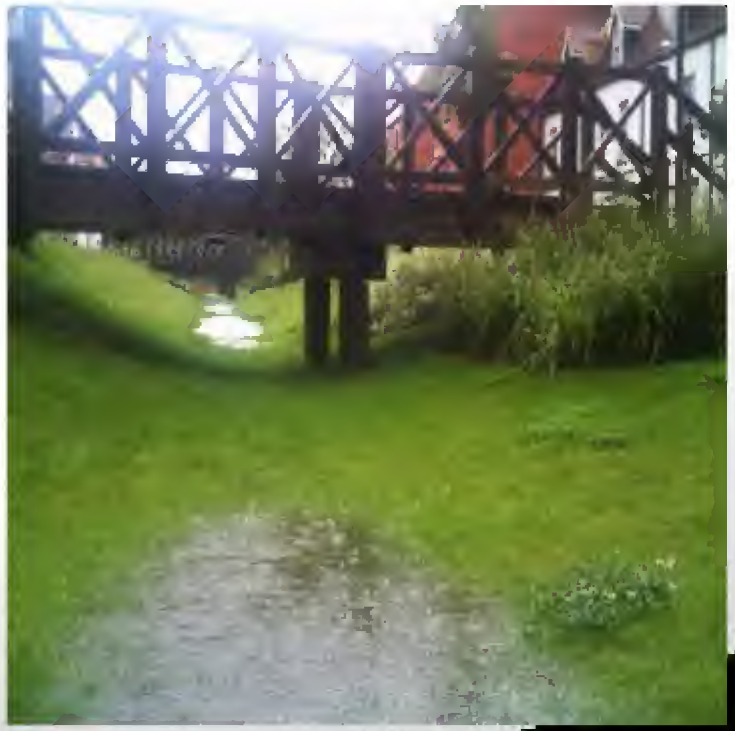
…on a sunny day!

Upton, Northampton

…in wetter weather

- Network of swales and green space, which look good …





Network of swales and green space but uses gullies before swales forcing a greater depth of swale

Blocked gulley

Proprietary Products

Extract from SEPA's **Regulatory Method - 08**;

S7.2.1

"Increasingly sophisticated proprietary systems are being developed for use to treat runoff from the completed phase of a development.

In recognition of this, SEPA has agreed that there may be specific situations where proprietary systems would constitute a level of SUDS, as explained in section 7.2.2 below.

It should be emphasised however that SEPA's general position is that conventional SUDS will be required for the majority of developments."

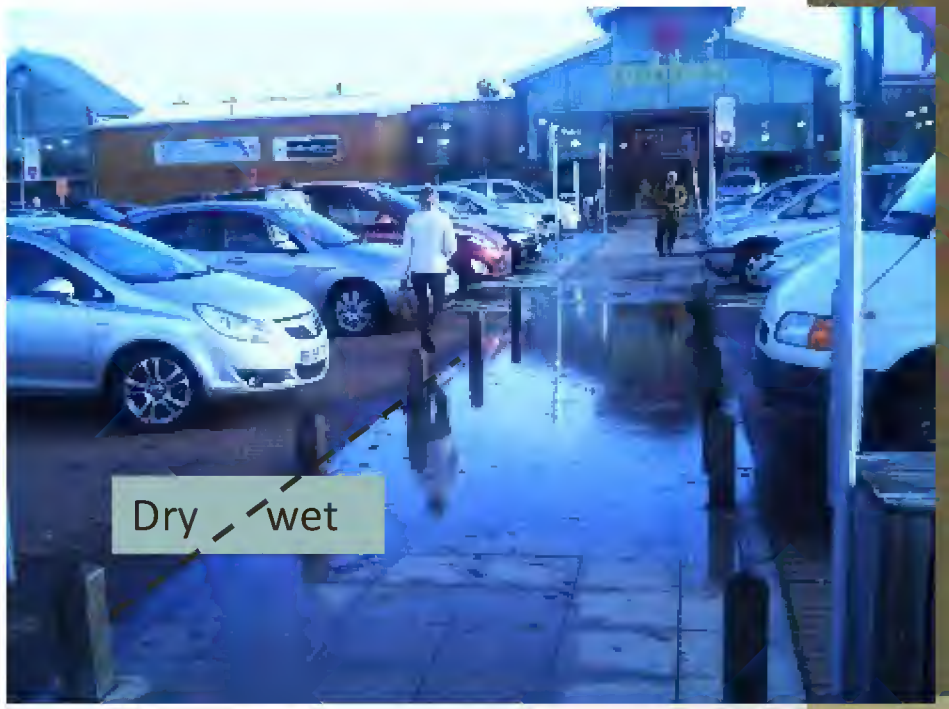
What are Proprietary Products?

Generic terms	Proprietary products
• Permeable paving	• Formpave
• Hydrodynamic vortex separators	• Downstream defender
• Vortex flow control	• Hydro-brake
• Geocellular modules	• Stormcell
• Oil separators	• Klargester?
• Offlet kerbs	• Beanie block
• Filtration systems	• Upflow filter
• Contraptions	• Contraptions
• Devices	• Devices

Permeable Block Paving

Various block paving manufacturers and related permeable block paving;

- Hanson Formpave – *Aqua flow*
- Marshalls - *Priora*
- Aggregate Industries - *Infilta*
- Tobermore - *Hydropave*

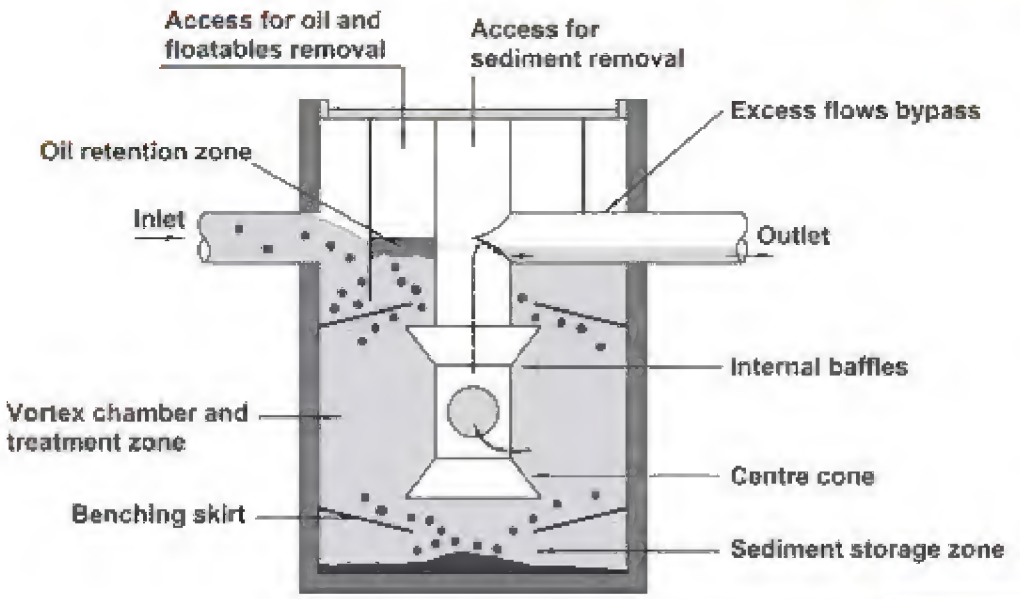


Hydrodynamic/Vortex Separators

Considered as pre-treatment

- Hydraulic device – no moving parts
- Water enters;
  - Floatables are retained
  - Some sediment is captured – sink floor
- Cleaner water is discharged
- Gulley sucker to remove sediments

- "Downstream Defender"© is a trade name and should not be used as this may show preference



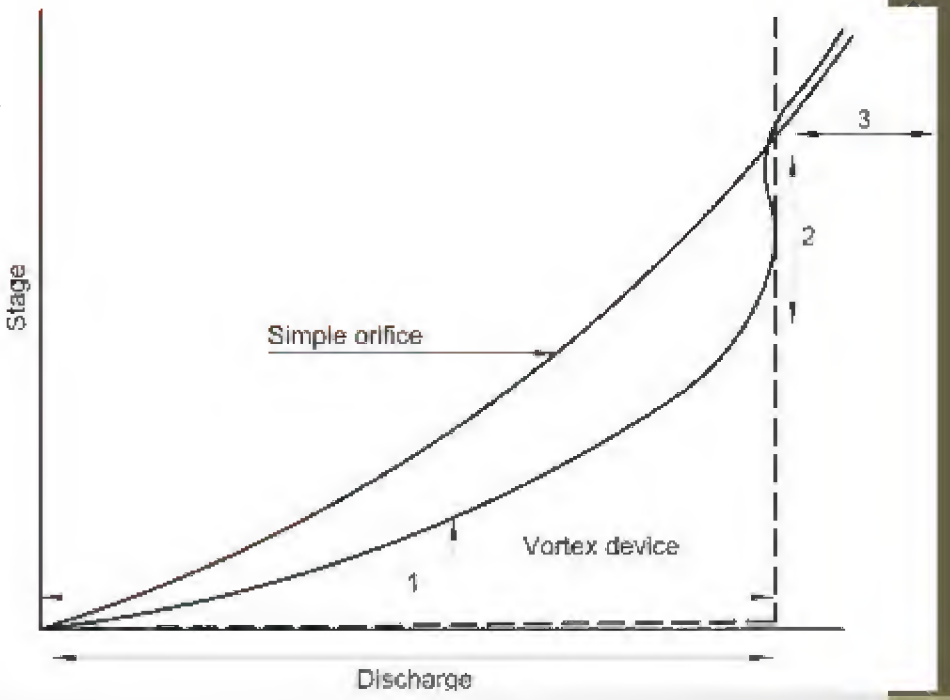
Extract from CIRIA C697 SUDS Manual

Vortex Flow Control

Hydraulic control only – not SUDS

- A hydraulic throttle to control flow discharge
- No moving parts
- Much better than orifice plate (hole in the wall)
- Good control of reasonably fixed flow over a range of depths

"HydroBrake©"

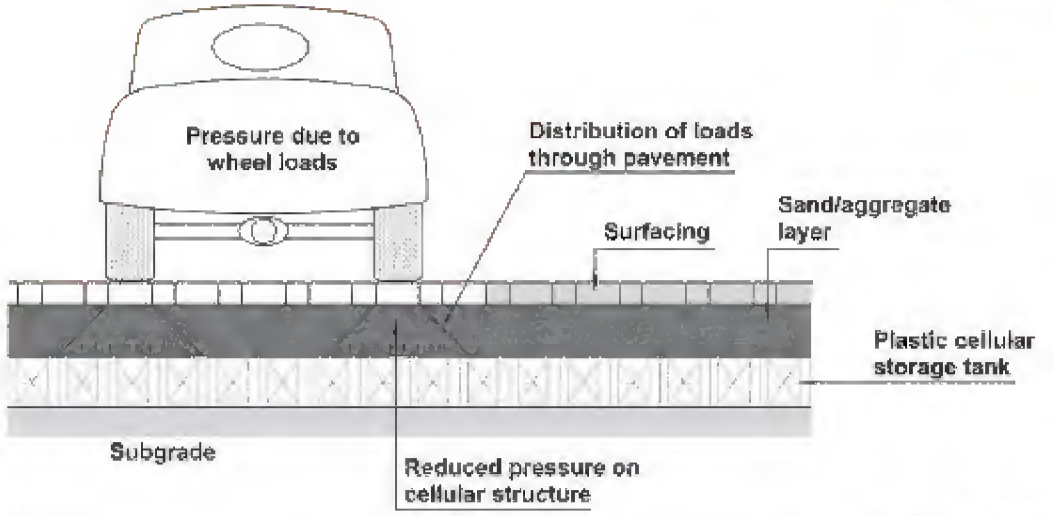


Extract from CIRIA C697 SUDS Manual

Geocellular Modules

Underground storage

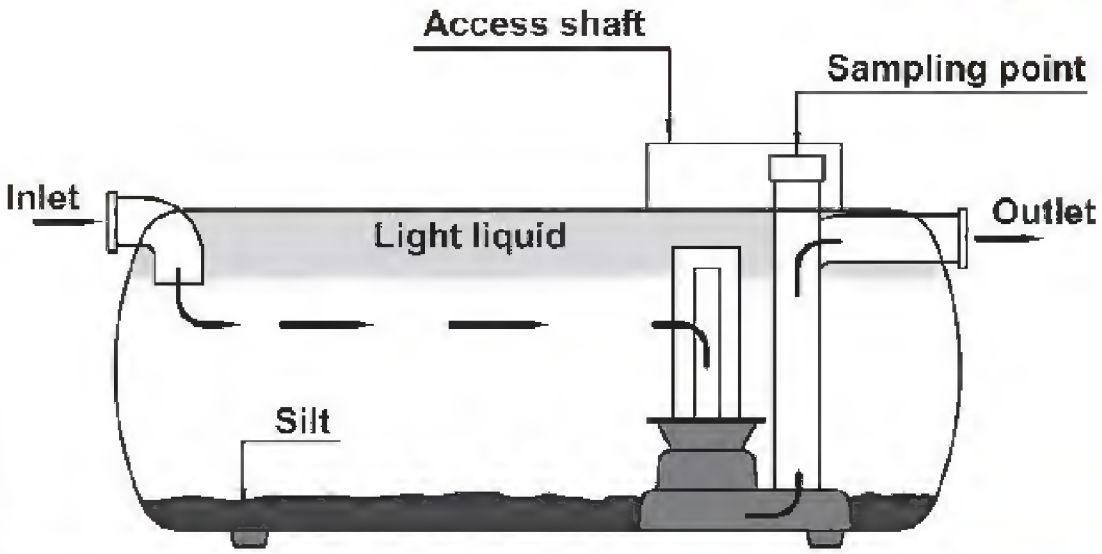
- Plastic crates placed underground
- High voids; 95 – 97% void
- Many manufacturers with varying strengths and load bearing capacity
- Past structural failures have caused caution
- No treatment, but excellent for flood storage where land is limited
  - Stormcell©
  - Hydrovoid ©
  - Skeletank ©



Oil Separators

Pre-Treatment

- Often wrongly suggested as SUDS
- May be used as pre-treatment for high risk sites to protect downstream assets; ponds, basins, etc.
- Needs regular maintenan
- No flow attenuation
- No amenity/biodiversity



Extract from CIRIA C697 SUDS Manual

Filtration Systems

- Many different types and configurations
- Some have a mixture of filterin media
  - Coconut husk
  - Volcanic ash – pumice
  - Hydrophobic
  - Oil binding characteristics
- Professional certification is a g indicator of "real" performanc

Offlet Kerbs

Hydraulic function – not SUDS

- A means of capturing road runoff and conveying within the kerb or occasionally through the kerb to a swale behind
- Offlet
- Inlet
- Beanie Block©
- Hydrokerb©

Others; “Contraptions & Devices”

CAUTION; Please be very careful when considering other devices and contraptions

- Manufacturers have jumped on the SUDS bandwagon
- Many claims that are not always completely true
- Not often adequately tested
- Testing should be performed by an independent credible and recognised party;
  - Professional lab
  - Researcher
  - Academic
- Innovation should be encouraged, but not at risk to the environment
- Certification is expensive and smaller groups may not afford

Beware of Gullies

- Especially if you have a young family….
  of ducklings

QUESTIONS?

Case Studies

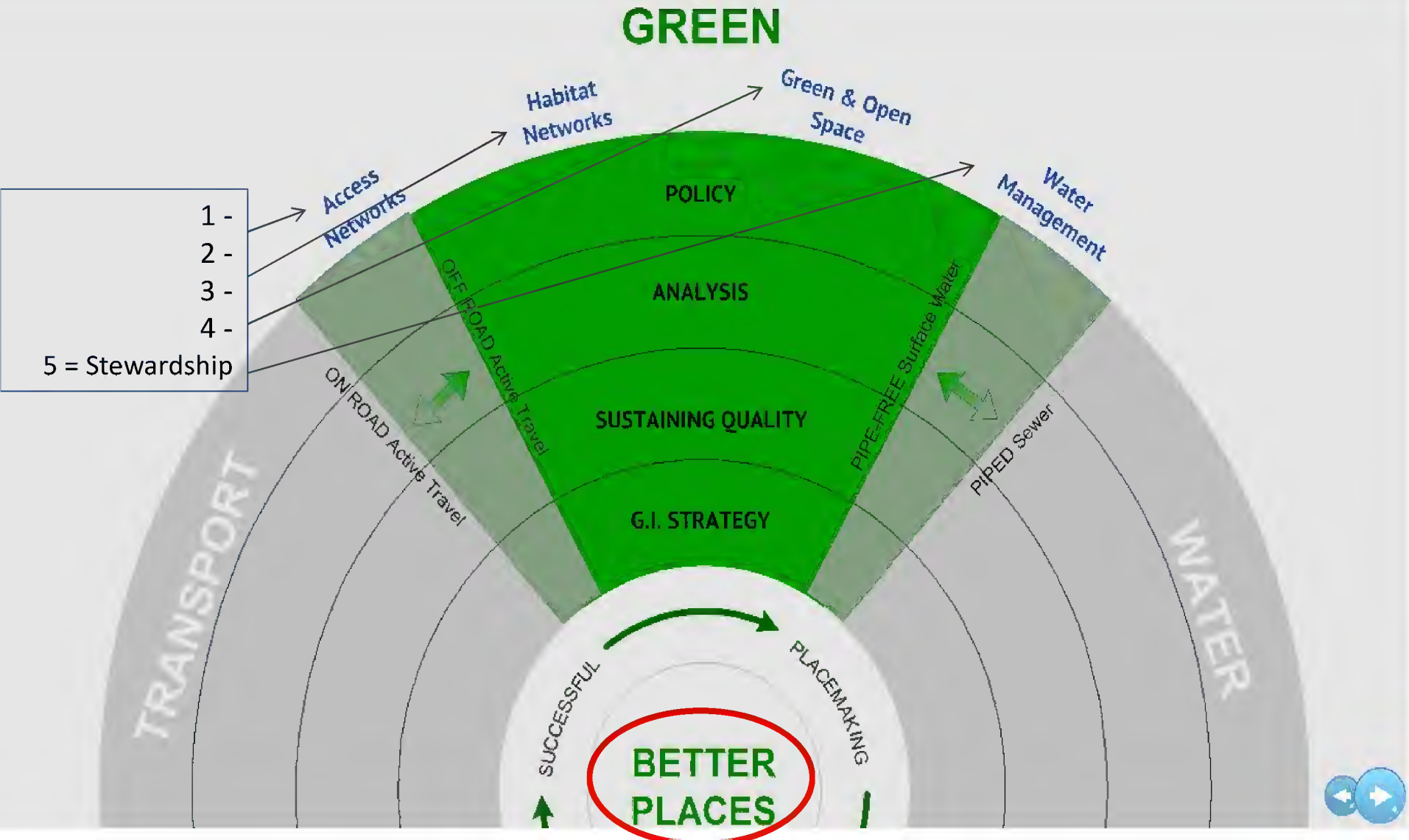
The “IGI Approach”
and
“Essential” Infrastructure

gcv green network

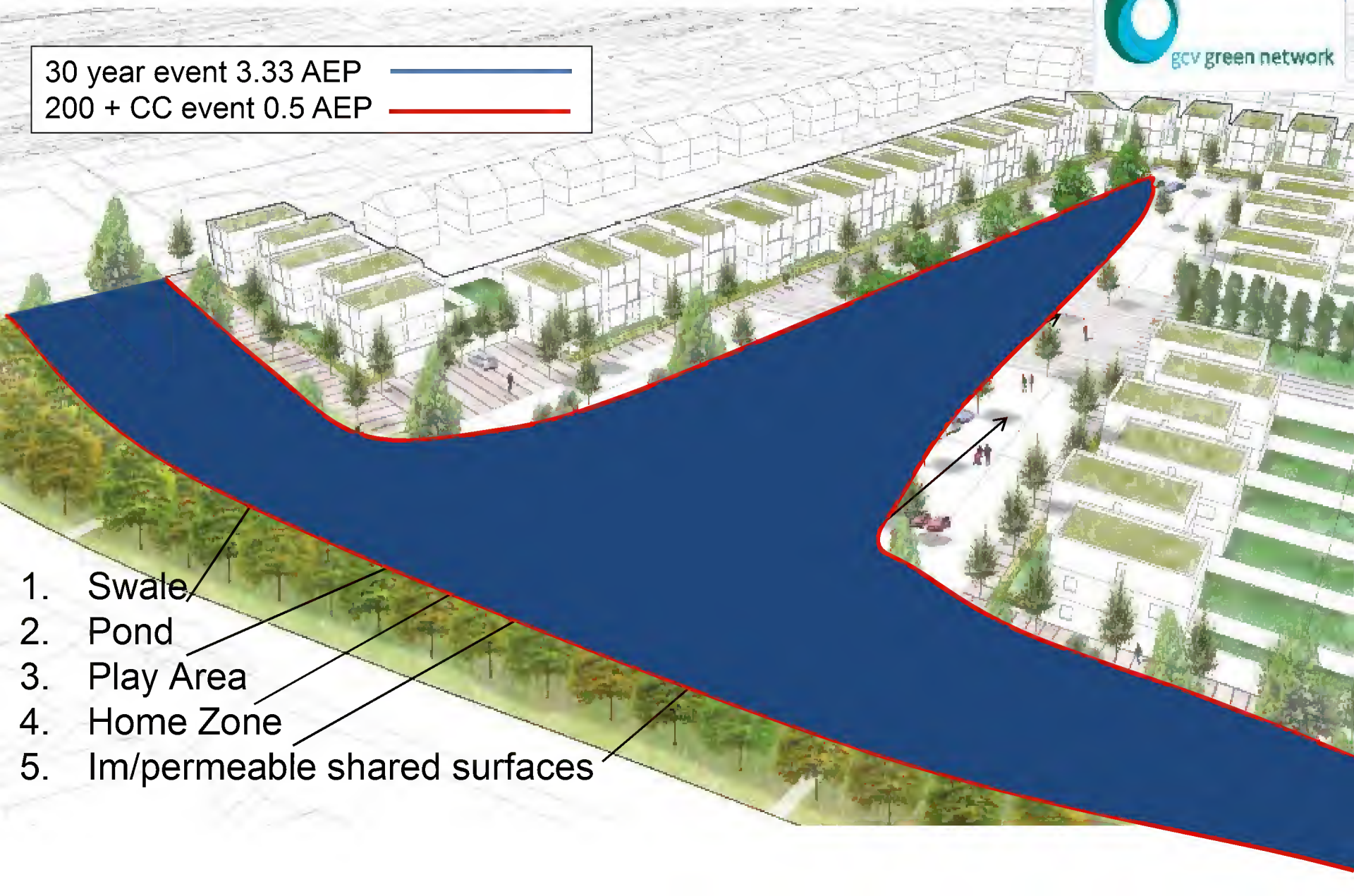
The "IGI Approach"

The "IGI Approach"
4 of the 5 Elements of IGI

www.GCVGreenNetwork.gov.uk



Newfield Square/Craigban



Upton, Northampton

…on a sunny day!

The “Pipe-Free” System – J4M8

A selling point?

- Capable of adding up to 20% to the value of your house?
- Requires good design
- Importantly good construction

The SuDS Life-Cycle

Building Control or Scottish Water

Question;

1. Will SuDS be vested (adopted) by Scottish Water?

If yes, *Building Standards Surveyors still* have a part to play – any in-curtilage drainage forming part of the overall design still needs to be checked by Building Standards.

If no, Building Standards will be the checking and approving body regardless of final adopting arrangement (local authority, Factor, developer)

Quote from SBSD

"Like all other aspects of building warrant approval and completion certificate acceptance, it is the Building Standards Surveyors, not some third party that ultimately has responsibility for the adequacy of the design and construction of the [SuDS] installation."

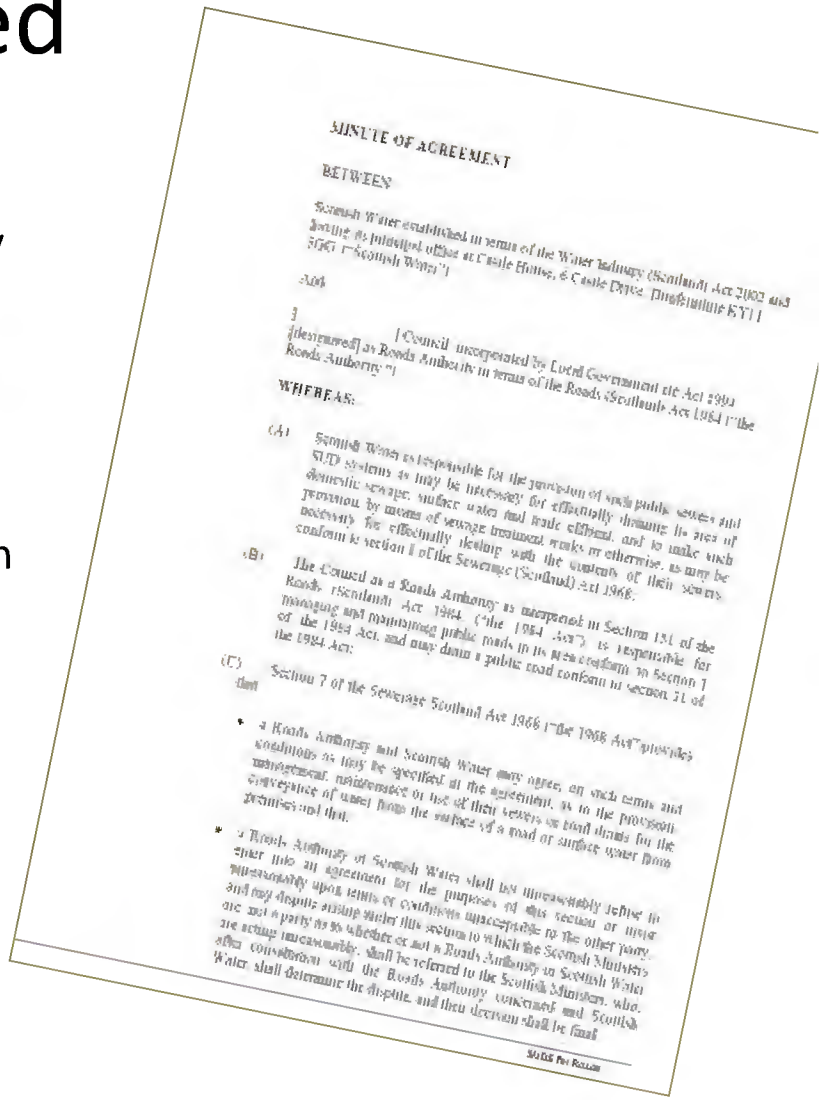
SBSD - “Legacy” SuDS

- Around 1500 un-adopted SuDS in Scotland
- Currently the *Building (Scotland) Act* 2003 excludes buildings where “any sewer or water main which is, **or is to be**, vested in Scottish Water”, but it is likely that this will change and that BS will become responsible.

- Need for robust understanding of SuDS design and construction, either directly or through an agent.

Sewerage (Scotland) Act 1968 – As Amended

- Section 7 of Sewerage (Scotland) Act
- Allows a roads authority and a drainage authority to share assets by agreement
- Initially no agreements were in place due to old County Councils sharing duties; roads and drainage in the same office
- 2007 “Minute of Agreement” attempted between Scottish Water and LAs (S4Rds Appendix)
- Discussions still “*In progress*”
- New MoU now drafted for SCOTS approval
  - Legals still to be sorted
  - Then 32 local authority agreements
  - Then “schedules” for all new developments



MINUTE OF AGREEMENT

BETWEEN

Scottish Water established in terms of the Water Industry (Scotland) Act 2002 and having its principal office at Castle House, 6 Castle Drive, Dunfermline KY11 [redacted] ("Scottish Water")

AND

[ ] Council incorporated by Local Government etc Act 1994 [designated] as Roads Authority in terms of the Roads (Scotland) Act 1984 ("the Roads Authority")

WHEREAS:

(A) Scottish Water is responsible for the provision of such public sewers and SUD Systems as may be necessary for effectually draining its area of domestic sewage, surface water and trade effluent, and to make such provision by means of sewage treatment works or otherwise, as may be necessary for effectually dealing with the contents of their sewers conform to section 1 of the Sewerage (Scotland) Act 1968;

(B) The Council as a Roads Authority is empowered in Section 151 of the Roads (Scotland) Act 1984 ("the 1984 Act") is responsible for managing and maintaining public roads in its area conform to Section 1 of the 1984 Act, and may drain a public road conform to section 71 of the 1984 Act;

(C) Section 7 of the Sewerage Scotland Act 1968 ("the 1968 Act") provides that

- a Roads Authority and Scottish Water may agree, on such terms and conditions as may be specified in the agreement, as to the provision, management, maintenance or use of their sewers or road drains for the conveyance of water from the surface of a road or surface water from premises and that

- a Roads Authority or Scottish Water shall not unreasonably refuse to enter into an agreement for the purposes of this section or impose unreasonably upon terms or conditions unacceptable to the other party, and any dispute arising under this section to which the Scottish Ministers are not a party as to whether or not a Roads Authority or Scottish Water are acting unreasonably, shall be referred to the Scottish Ministers, who, after consultation with the Roads Authority concerned and Scottish Water, shall determine the dispute, and their decision shall be final

Initialled for Identification

Sewers for Scotland – 3rd Edition

- Design guide for developers
- Build to these standards and Scottish Water will adopt – in theory…
- Contains a chapter on SuDS
- First in UK through S4S2 2007
- Only Ponds, Basins & Underground Storage
- Fairly strict details required
- Any guesses how many SuDS Scot Water have adopted since 2007?

Scottish Water Vested Pond
DEX – Dunfermline East Expansion

The Same Pond Today

Maintenance

Long-term Maintenance
Example of Maintenance Schedule and Considerations

See file;
Example Maint Schedule - Colquhoun Square Swale

Maintenance Schedule

The swale design is simple and will require basic and straightforward maintenance. It is intended that all maintenance will be performed by responsible authority personnel or appointed agent/s. The following is a schedule of necessary maintenance for the continuing efficient service of the swale.

Maintenance Schedule	Required Action	Frequency
Inspections & checks	• Inspect inlet and outlet for blockages and clear as required • Inspect inlet for signs of erosion and repair as necessary • Inspect hydraulic throttle for normal operation including bypass arrangement • Inspect swale for contamination and repair as required • Inspect swale floor for standing water and remediate as required	• Monthly/ as required • Monthly/ as required • Monthly/ as required • Monthly/ as required • Monthly/ as required

Regular maintenance	• Litter and debris removal
	• Grass cutting*;
	  ○ Mowing banks
	  ○ Strimming swale floor to maintain grass height to 100 – 150 mm
	• Manage other vegetation and remove nuisance plants
	*All grass cuttings must be removed from the swale to eliminate blockages
		• Monthly
		• Monthly during growing season
		• Monthly for first year, then as required

Occasional maintenance	• Re-seed areas of sparse vegetation or where nuisance vegetation has been removed • Remove build-up of sediment	• Annually for first three years at the beginning of the growing season, then as required • As required
Remedial actions	• Replace or repair damaged turf • Repair erosion on side slopes	• As required • As required

Maintenance Schedule	Required Action	Date J F M A M J J A S O N D
Inspections & checks	• Inspect inlet and outlet for blockages and clear as required • Inspect inlet for signs of erosion and repair as necessary • Inspect Hydro-Brake for normal operation including bypass arrangement • Inspect swale for contamination and repair as required • Inspect swale floor for standing water and remediate as required	

Regular maintenance	• Litter and debris removal
	• Grass cutting*;
	  ○ Mowing banks
	  ○ Strimming swale floor to maintain grass height to 100 – 150 mm
	• Manage other vegetation and remove nuisance plants
	*All grass cuttings must be removed from the swale to eliminate blockages	

Occasional maintenance	• Re-seed areas of sparse vegetation or where nuisance vegetation has been removed • Remove build-up of sediment	• Annually for first three years at the beginning of the growing season, then as required • As required
Remedial actions	• Replace or repair damaged turf • Repair erosion on side slopes	• As required • As required

Return Periods

- Return period relates event to time using statistics

  e.g. 50YRP= 50 Year Return Period

  = 2% AEP

  = 2% Annual Exceedence Percentage

  = 50:1 chance of that event occurring in any year

- Rainfall & river return periods are different

  50 rainfall YRP ≠ 50 river YRP

- Unlike river flow return period, rainfall includes duration e.g. M5-60 Storm;

  60 minute rainfall storm with 5 year return period

- Varies according to location;

  typically 12mm to 18mm for Scotland

Rainfall – Critical Storm

- Run various durations 15 min, 1 hour, 2 hour, etc.
- Significant short storms are heavier/more intense;

  5mm in 15 mins → 20mm/hour intensity
- Longer storms are less intense;

  30 mm in 2 hours → 15mm/hour intensity
- Determine critical storm

Rainfall – Critical Storm (2)

Duration (mins)	M5-(mm)	M100 (mm)	Intensity (mm/hr)	Flow (l/sec/Ha)	Outlet control (l/sec)	Volume Req'd (m^3)
30	12.6	24.8	49.6	77.0	5.25	129.2
60	16.6	32.7	32.7	50.6	5.25	163.3
120	21.2	41.7	20.8	32.3	5.25	194.6
240	27.6	51.8	12.9	20.1	5.25	213.4
360	32.4	59.2	9.9	15.3	5.25	217.1
600	38.5	69.3	6.9	10.7	5.25	197.8

Capex & Opex Tool

- SuDS for Roads Whole Life Cost Tool
- See next presentation

SuDS Tools

Roads, BeST and Simple

- Basic
  - SuDS for Roads Whole Life (and Carbon) Cost Tool
  - Over-run from S4Rds Project
  - 2010'ish
- BeST – Benefits from SuDS Tool
  - CIRIA
  - 2015
- SIA – Simple Index Assessment
  - SEPA
  - 2016

SuDS4ds - Whole Life Cost Tool

- Provides good indicative costs for SuDS
- Easy to learn and apply
- Useful carbon module as integrated benefit
- Not all SuDS – it's for roads, so no green roofs for example!

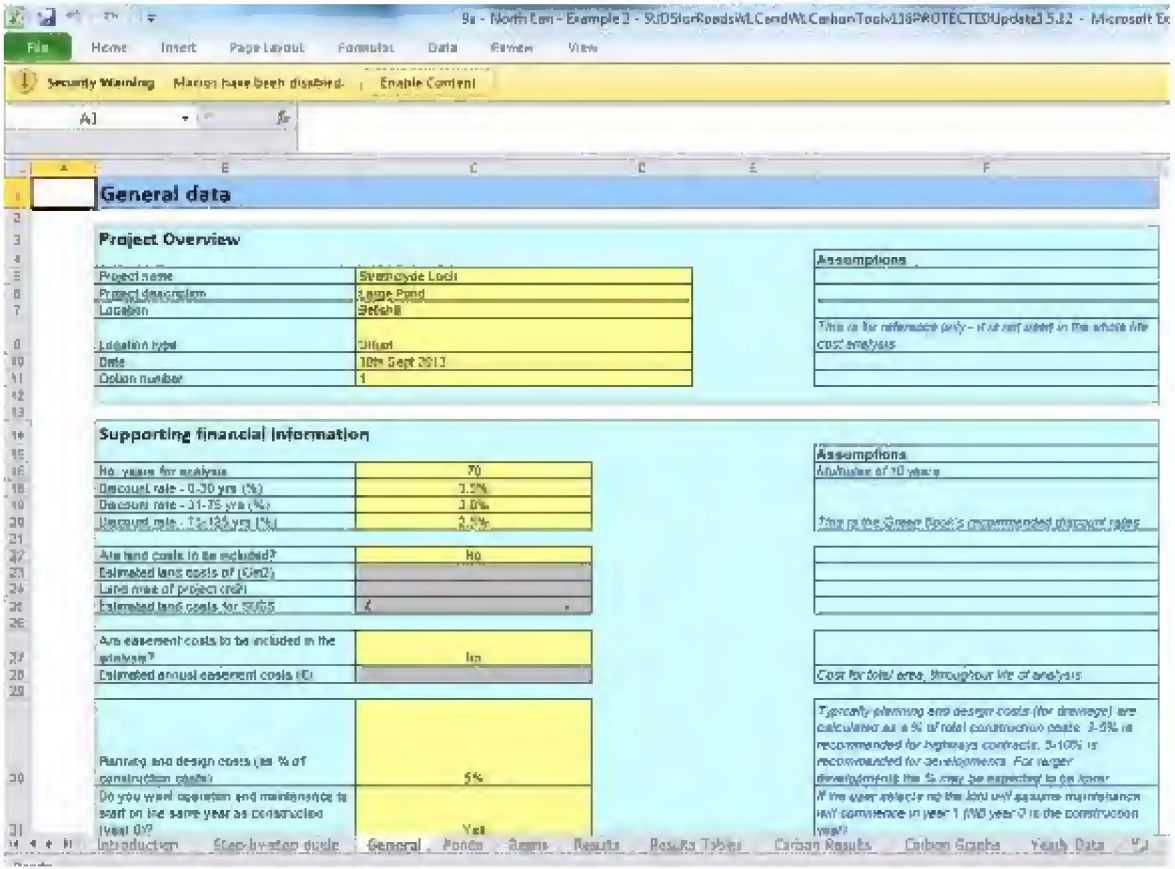
- Available at;

http://www.scotsnet.org.uk/best-practice.php

SUDS4Rds – WLC

Provides Indicative Costs for Various SuDS throughout life cycle

SuDS4RDs WLC Tool



Simple Index Assessment Tool

For Water Environment Quality & Protection

- SEPA Tool to assess adequate SuDS measures for water quality
- Basic scoring approach for hazard
- Countered by SuDS provisions

- Can be downloaded at;

http://www.susdrain.org/resources/SuDS_Manual.html

Designing for Water Quality - Simple Index Approach

- Land use defines **Pollution Hazard Index**
- Different SUDS have differing potentials to reduce different pollutants
- SuDS provide **Mitigation index**
- CIRIA/HRWallingford has developed an Excel tool to assist with the assessment

Table 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	very low	0.2	0.2	0.05
Other roofs (typically commercial/industrial roofs)	low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie <300 traffic movements/day	low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	high	0.8[2]	0.8[2]	0.9[2]

(1) Motorways and trunk roads should follow the guidance and risk assessment process set out in HD45/09 (Highways Agency, 2009)

(2) These should only be used if considered appropriate as part of a detailed risk assessment – required for all these land use types (Table 4.3). When dealing with high hazard sites, the environmental regulator should first be consulted for pre-permitting advice. This will help determine the most appropriate approach to the development of a design solution.

Table 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices [1]		
Type of SuDS component	**TSS**	**Metals**	**Hydro-carbons**
filter strip	0.4	0.4	0.5
filter trench	0.4 [2]	0.4	0.4
swale	0.5	0.6	0.6
bioretention system	0.8	0.8	0.8
permeable pavement	0.7	0.6	0.7
detention basin	0.5	0.5	0.6
pond [4]	0.7 [3]	0.7	0.5
wetland	0.8 [3]	0.8	0.8
proprietary treatment systems [5, 6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Total SuDS Mitigation Index (for each contaminant type) ≥ **Pollution Hazard Index** (for each contaminant type)

Total SuDS Mitigation Index = Mitigation Index $_1$ + 0.5 (Mitigation Index $_2$)

Where:

Mitigation Index $_n$ = Mitigation Index for Component 'n'

A factor of 0.5 is used to account for the reduced performance of secondary or tertiary components associated with already reduced inflow concentrations

- Expect source control in addition

Simple Index Approach Tool

Timescales

- RM08 to be changed
- Launched 12 November
- After 31 May – only SIA acceptable

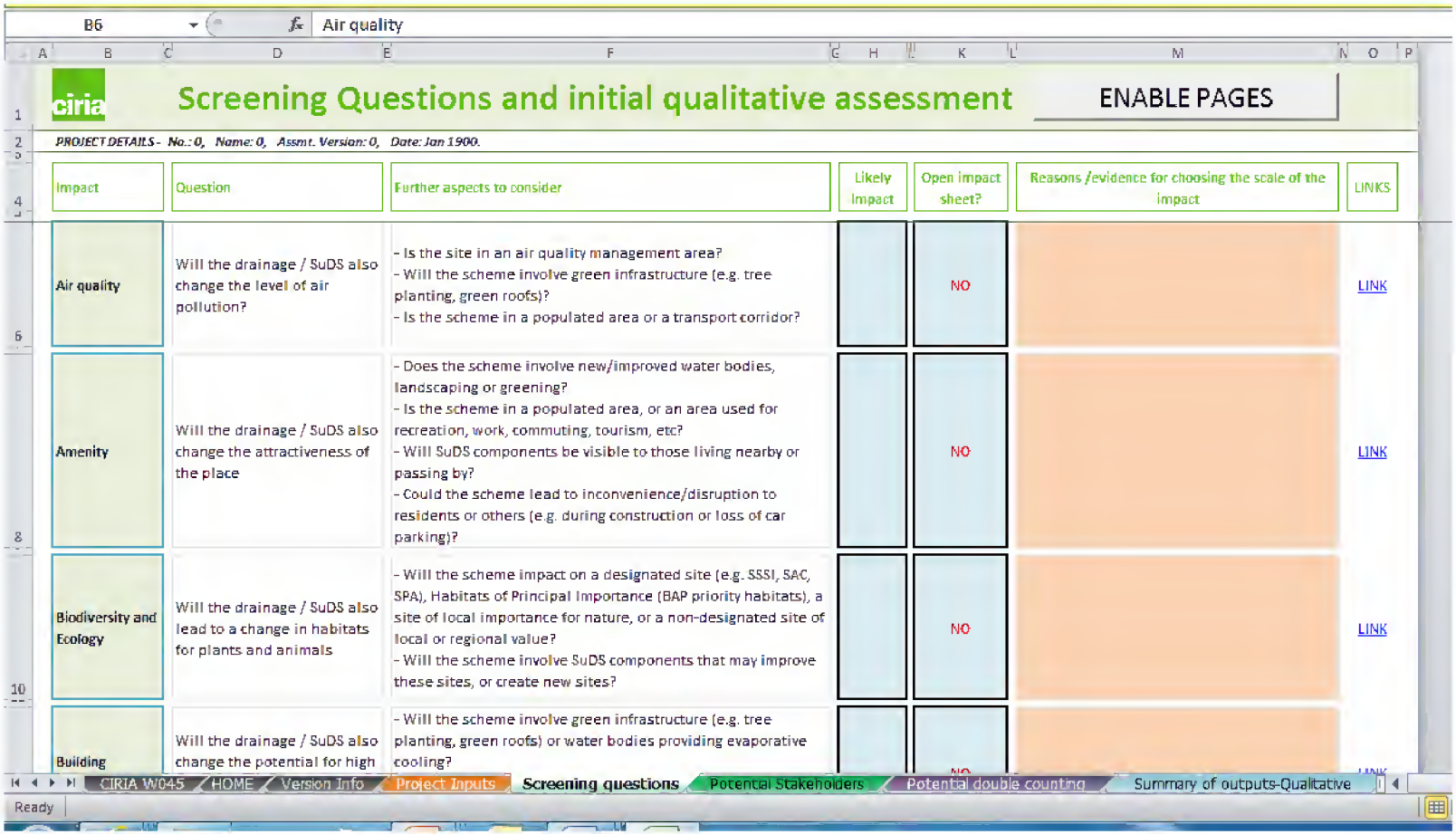
Benefits of SuDS (BeST) Tool

- Very useful tool but takes time to grasp
- Comprehensive spreadsheet
- Better for real developments, i.e. serious proposals
- CIRIA development

BeST Tool

- Available free (but need to register) from;

http://www.susdrain.org/resources/best.html



B6 Air quality

ciria **Screening Questions and initial qualitative assessment** ENABLE PAGES

PROJECT DETAILS - No.: 0, Name: 0, Assmt. Version: 0, Date: Jan 1900.

Impact	Question	Further aspects to consider	Likely impact	Open impact sheet?	Reasons /evidence for choosing the scale of the impact	LINKS
Air quality	Will the drainage / SuDS also change the level of air pollution?	- Is the site in an air quality management area? - Will the scheme involve green infrastructure (e.g. tree planting, green roofs)? - Is the scheme in a populated area or a transport corridor?		NO		LINK
Amenity	Will the drainage / SuDS also change the attractiveness of the place	- Does the scheme involve new/improved water bodies, landscaping or greening? - Is the scheme in a populated area, or an area used for recreation, work, commuting, tourism, etc? - Will SuDS components be visible to those living nearby or passing by? - Could the scheme lead to inconvenience/disruption to residents or others (e.g. during construction or loss of car parking)?		NO		LINK
Biodiversity and Ecology	Will the drainage / SuDS also lead to a change in habitats for plants and animals	- Will the scheme impact on a designated site (e.g. SSSI, SAC, SPA), Habitats of Principal Importance (BAP priority habitats), a site of local importance for nature, or a non-designated site of local or regional value? - Will the scheme involve SuDS components that may improve these sites, or create new sites?		NO		LINK
Building	Will the drainage / SuDS also change the potential for high	- Will the scheme involve green infrastructure (e.g. tree planting, green roofs) or water bodies providing evaporative cooling?		NO		LINK

CIRIA W045 | HOME | Version Info | Project Inputs | Screening questions | Potential Stakeholders | Potential double counting | Summary of outputs-Qualitative

Ready

- Considers 19 possible “Impacts” that SuDS can provide benefits to

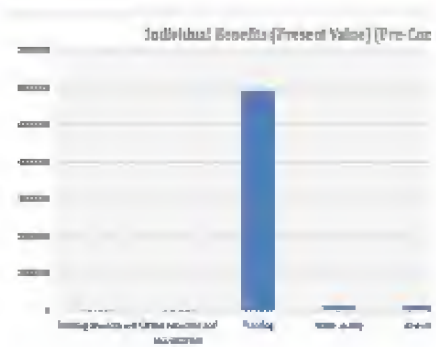
Glasgow SWMP Case Study
Available from website at
http://www.susdrain.org/files/resources/BeST/best_case_study_glasgow_swmp.pdf

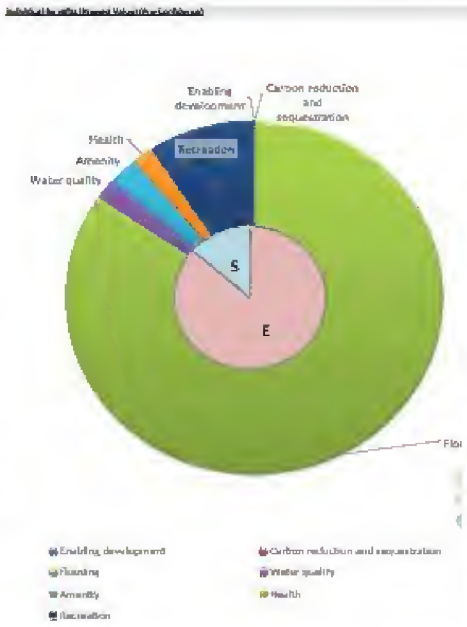
Air quality
Amenity
Biodiversity (habitats)
Carbon sequestration / reduction
Crime
Economic growth
Education
Enabling development
Flexible infrastructure / CCA
Flood risk
Groundwater recharge
Health
Pumping wastewater
Recreation
Building Temperature
Tourism
Traffic calming
Treating wastewater
Water quality of receiving water

Table 1: Summary of results

Present Value Assessment Stage	Total PV Benefits	Total PV Costs	Net Present Value	Benefit Cost Ratio
Present Value before confidence applied	£69,858,591	£26,833,659	£43,024,932	2.6
Present Value after confidence applied	£62,707,500	£26,833,659	£35,873,841	2.3
Present Value sensitivity - low				
Present Value sensitivity - high				

BeST Case Study - Glasgow





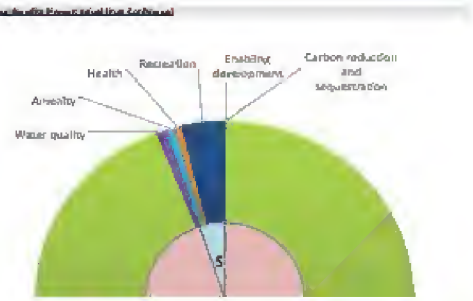


Figure 1: Breakdown of benefits per cate

Figure 2: Distribution of benefits pre (left) and post (right)

BeST Case Study - Glasgow

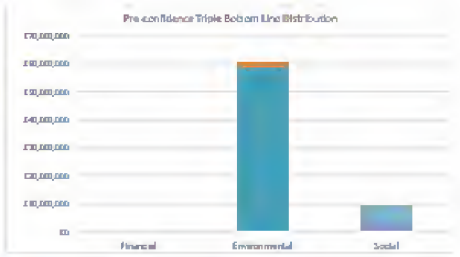
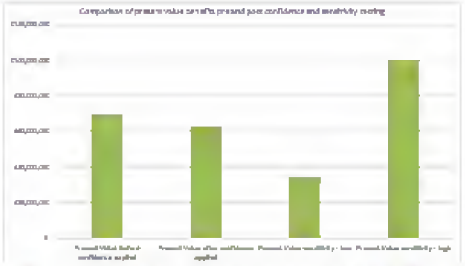


Figure 3: Breakdown of benefits under triple bottom line categories pre (left) and post (right) confidence



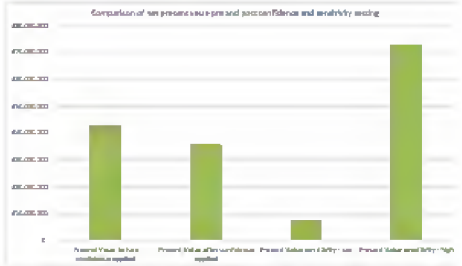


Figure 4: Comparison of benefits present value (left) and net present value (right) for pre and post confidence and sensitivity testing.

Visualisation Tools

Good for Community Engagement and Elected Member Sessions

Questions?

Discussion?

Notes?