Lissenhall East

Local Area Plan

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Appendix 4: Sustainable Drainage System Strategy

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Fingal County Council

Comhairle Contae Fhine Gall

SuDS Strategy for the Lissenhall East Local Area Plan

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SuDS Strategy for the Lissenhall Local Area Plan

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1.0 INTRODUCTION

1.1 Scope

The scope of this report is as follows:

- Review of existing surface water and foul drainage network in respect of SuDS for current situation, future scenario with all live planning permissions built and with all proposed development and infrastructure in place as set out in both Fingal Development Plan 2011- 2017 and the proposals in the Lissenhall East LAP.
- Prepare a SuDS Strategy with recommendations regarding appropriate SuDS systems and devices for the implementation of the SuDS strategy for all proposed development and Planning Permission applications and development as determined by the Lissenhall East LAP, currently being developed, including maps showing possible layout, locations and sizing of proposed recommended SuDS devices and/or systems
- Incorporate the effects of Climate Change, groundwater and the existing surface water drainage system into the SuDS Strategy
- Determine the effects on and of flooding, groundwater and surface water drainage system in the LAP area due to the incorporation of the SuDS Strategy
- Provide an assessment of the attenuation requirements needed and identify the regional attenuation structures necessary for the LAP area
- Provide information gathered or generated from the Flood Risk Identifications and Assessments, by liaising and attending meetings with Consultants completing the Strategic Environmental Assessment (SEA) and Flood Risk Assessment (FRA) for the Lissenhall LAP.

1.2 Study Area

1.2.1 Overview

Lissenhall is located in North County Dublin approximately 8.1km north of the M50/M1 motorway connection and 5km from the Irish sea.The study area primarily consists of the rural outskirts of Lissenhall with farmland surrounding. The existing R132 regional road and the M1 motorway run along the boundary of the study area with the Broad Meadow river and urban townland of Swords to the South of the study area.

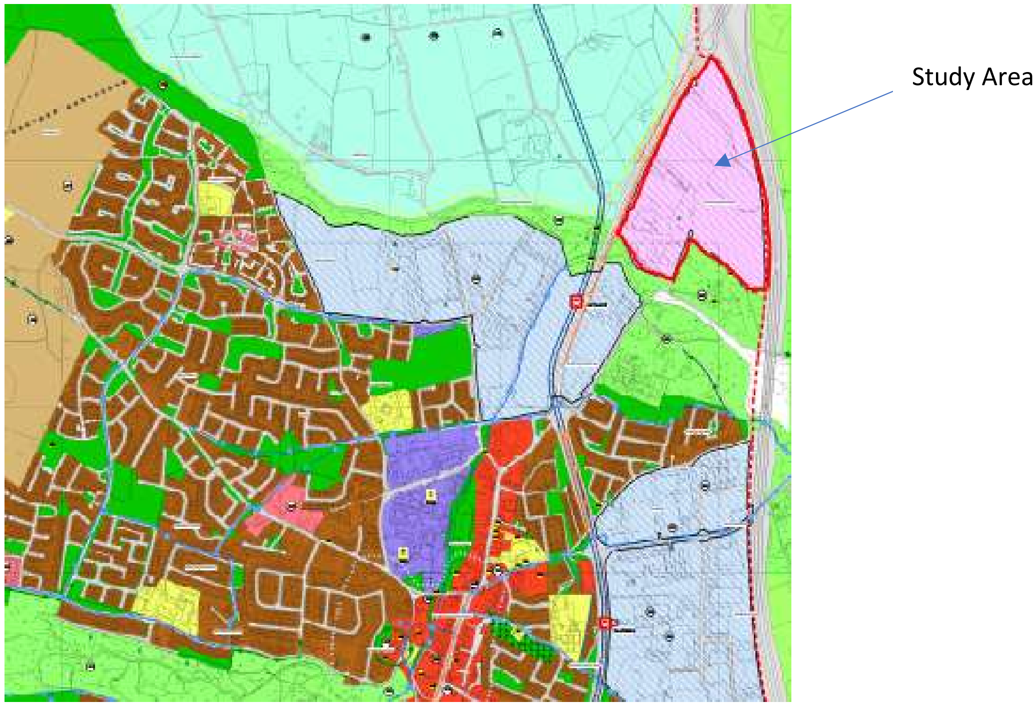


Image 1.1- Study Area at Lissenhall along M1 and R132 National and Primary Routes

The topography of the study area has been examined from the topographical survey provided by Precision Surveys. The topography of the zoned area is moderately sloped in both the north-eastern and south-eastern site areas creating a small valley to the Lissenhall stream.

1.2.2 Catchment Description

The LAP study area lies north west of the Malahide Estuary with the Broad Meadow Estuary located to the south of the study area. The study area is drained by a combination of watercourses and a surface water drainage network which runs to the Broad Meadow Estuary.

The primary watercourse in the study area is the Lissenhall stream which flows in a south-easterly direction through the northern half of the study area and running to the Broad Meadow estuary. The catchment area of this stream is approximately 3.6km^2 with a main channel length of approximately 3.4km. The majority of the surface water drainage network serving Lissenhall outfalls to this stream. Due to the low-lying topography of the study area no pumping of this watercourse is required to gravity feed the surface water to the Broad Meadow estuary.

The secondary watercourse in the study area is The Broad Meadow river. The Broad Meadow river flows in an easterly direction along the southern boundary of the study area before discharging to the Broad Meadow Estuary. The catchment area of the river is approximately 114.4km^2 with a main channel length of approximately 26km. The agricultural lands in the north-western section of the LAP study area drain to this river.

1.2.3 Environment

There are no Natura 2000 sites located within the study area; however, the Natura 2000 sites adjacent to the study area are listed below:

- Broad Meadow River Special Protection Area (SPA)
- Broad Meadow Special Area of Conservation (SAC)

Under Article 6(3) of the EU Habitats Directive, an "appropriate assessment" (AA) is required where any plan or project, either alone or 'in combination' with other plans or projects, could have an adverse effect on the integrity of a Natura 2000 site. Therefore, the management of flood risk within the LAP study area must have regard to potential negative impacts to this environment.

1.3 Proposed Development

The LAP study area is zoned HT "provide for office research and development and high technology manufacturing type employment in a high quality built landscaped environment" in the Fingal Development Plan 2017– 2023.

2.0 SUDS OVERVIEW

2.1 Introduction

Sustainable Drainage Systems (SuDS) are surface water drainage systems designed with a focus on sustainable development. The purpose of SuDS is to, as best as possible, replicate the natural drainage system prior to the development taking place. The three main objectives of SuDS are to:

- minimise the impacts of the development on quantity of run off;
- minimise the impacts of the development on quality of run off;
- maximise the amenity and biodiversity opportunities.

2.2 SuDS Objectives

2.2.1 Quantity Control Processes

Several techniques can be implemented to control the quantity of runoff from a development. Each technique presents different opportunities for stormwater control, flood risk management, water conservation and groundwater recharge.

a) Infiltration
- Soaking of water into the ground
- Most desirable solution to runoff management as it restores the natural hydrologic process
- Impacted by groundwater vulnerability and infiltration ability of subsoil

b) Detention / Attenuation
- Slows down surface water flows before their transfer downstream
- Usually achieved through use of a storage volume and constrained outlet
- Can be above/below ground
- Reduces peak flow rate but total volume of runoff remains the same

c) Conveyance
- Transfer of surface runoff from one place to another
- Through open channels/pipes/trenches
- Transfer essential for managing flows and linking SuDS components
- Uncontrolled conveyance to a point of discharge in the environment not considered sustainable

d) Water Harvesting
- Direct capture and use of runoff on site for domestic or irrigation
- Contribution to Flood Risk Management depends on scale of system

2.2.2 Quality Control Processes

A number of natural water quality treatment processes can be exploited within SuDS design. Different processes will predominate for each SuDS technique and will be present at different stages in the treatment train (*Refer to Section 2.3*).

a) Sedimentation – reducing flow velocities to a level at which the sediment particles fall out of suspension;

b) Filtration & Biofiltration – trapping pollutants within the soil or aggregate matrix, on plants or on geotextile layers;

c) Adsorption – pollutants attach or bind to the surface of soil or aggregate particles;

d) Biodegradation – Microbial communities in the ground degrade organic pollutants such as oils and grease;

e) Volatilisation – transfer of a compound from solution in water to the soil atmosphere and then to the general atmosphere;

f) Precipitation – transform dissolved constituents to form a suspension of particles of insoluble precipitates;

g) Plant Uptake – removal of nutrients from water by plants in ponds and wetland;

h) Nitrification – Ammonia and ammonium ions can be oxidised by bacteria in the ground to form nitrate which readily used as a nutrient by plants;

i) Photolysis – The breakdown of organic pollutants by exposure to ultraviolet light.

2.2.3 Amenity & Biodiversity Processes

SuDS provides opportunities to create attractive landscaping features which offer a variety of amenity, biodiversity and recreational benefits. The following are the main SuDS components offering aesthetic, amenity and ecological benefits *(Refer to Chapter 5 for details on each technique)*

Primary Processes:

a) Ponds

b) Wetlands

c) Green Roofs

d) Bioretention Areas

Benefits subject to design:

a) Filter Strips

b) Swales

c) Detention Basins

d) Infiltration Basins

2.3 SuDS Techniques

In addition to the objectives above, in order to replicate the natural drainage system, a 'Management Train' is required. The Management Train sets a hierarchy of SuDS techniques which should be implemented in series as follows:

(i) Prevention – prevent runoff and pollution

(ii) Source Control – control runoff at or close to the source

(iii) Site Control – management of surface water in the site/local area

(iv) Regional Control – management of surface water from a number of sites together

Various SuDS components have different capabilities regarding the objectives outlined above and are more suited to certain stages of the Management Train. The principle of the Management Train is that wherever possible, surface water should be managed locally in small, sub-catchments rather than being conveyed to and managed in large systems further down the catchment. Table 2.1 below contains examples of SuDS techniques for Source, Site and Regional controls. (Refer to Chapter 5 for details on each technique).

Table 2.1 SuDS Techniques for Source, Site & Regional Control

Source Control	Site Control	Regional Control
Rainwater Harvesting	Permeable Paving	Detention Ponds
Green Roofs	Bioretention Strips	Retention Ponds
Permeable Paving	Infiltration Trenches	Wetlands
Bioretention Strips	Filter Drains	Infiltration Basins
Filter Drains	Filter Strips	Detention Basins
Infiltration Trenches	Swales	Petrol Interceptors*
Filter Strips	Sand Filters	
	Infiltration Basins	
	Detention Basins	
	Petrol Interceptors*	

*Use of Petrol Interceptors should be avoided except where the potential for hydrocarbons entering the surface water drainage network is particularly high. Treatment of surface water runoff should be provided through the use other SuDS techniques.

3.0 REVIEW OF EXISTING DRAINAGE NETWORK IN RESPECT OF SUDS

This section outlines the various SuDS techniques, existing and proposed in either live planning applications or development proposals, within the Lissenhall East LAP area. Information has been gathered from a review of planning applications in Lissenhall, Fingal Development Plan 2011- 2017 and preparatory work for the Lissenhall East LAP. Development in Lissenhall is predominantly rural/ urban with the majority of construction occurring before the turn of the millennium during the mid to late 1990s. Implementation of SuDS techniques by Local Authorities typically only began following the publication of the Greater Dublin Strategic Drainage Strategy (GDSDS) in 2005. Since that time, development in Lissenhall has been low with limited construction taking place.

3.1 Current Scenario

Due to the limited amount of development that has occurred since the introduction of SuDS no substantial SuDS techniques have been adopted to date . The majority of the lands are greenfield . The HSE lands drain through the Sword Food Park site in a surface water pipe which in turn discharges to the Broad Meadow River.

3.2 Future Scenario – Proposed Development and Infrastructure as per Fingal Development Plan 2017-2023 if Built

Proposals for the Lissenhall area in the Fingal Development Plan 2017-2023 include the following:

- Facilitate the development of Swords Western Ring Road (SWRR) linking the R132 east of M1 and north of the Lissenhall interchange.
- Facilitate and actively promote the provision of a Lissenhall Metro North Stop to include significant Park and Ride capabilities and bus service facilities

The primary impact on the existing surface water and foul drainage networks will be as a result of new industrial development around the perimeter of Lissenhall. Integration of SuDS techniques with these new developments will be required to ensure that the capacity of the existing network is not exceeded and the quality of surface water runoff is not negatively impacted by the development.

Based on the existing surface water drainage network and the ground levels obtained from the topographical survey, it is likely that the majority of the LAP lands will outfall to the Lissenhall Stream and the Broadmeadow River . The quality of any runoff from any new development will need to be such that the environmentally sensitive areas of Swords the Lissenhall Stream and the Broad Meadow Estuary are not negatively affected.

4.0 SUDS SELECTION

4.1 Land Use

26.83 Ha of land within the LAP area are Zoned Objective HT – 'provide for office, research and development/high technology manufacturing'. The majority of this land is currently used for agricultural purposes, namely grass and tillage farms.

4.2 Site Characteristics

Table 4.1 'Site Characteristics Outcomes Matrix; in the SuDS Manual (2015) outlines various site characteristics which influence SuDS techniques. The site characteristics have been obtained from a desktop study of topographical survey, Ordnance Survey maps and Geological Survey of Ireland (GSI) maps. Refer to Appendix A for relevant maps.

***Table* 4.1 Site Characteristics Outcomes Matrix (SuDS Manual, 2015)**

Site Characterisation Outcomes		
1	Site Topography	The area in general slopes towards the North East towards the Lissenhall Stream
2	Existing flow routes and discharge points	The existing HSE lands drain to the Sword Food Park which then discharges to the Broad Meadow River at the Southwest of the area.
3	Potential for infiltration	There are no records of trial pits or boreholes in the area. Experience of foundations for the recently constructed Ambulance Centre and new entrance from the Swords Food Park revealed brown glacial till. This soil typically has low permeability values in the range of 1 x 10^{-8} - 10^{-9} m/sec. Therefore, the potential for infiltration is likely to be low.
4	Potential for surface water discharge	The main surface water drainage outlet will be the Lissenhall stream. Generally, the topography shows the ground contours following towards this outlet. There may be some discharge to the Broad Meadow River on the South of the area although this is likely to be of minor significance.
5	Site flood risks	The area has not flooded. However, a flood risk assessment indicates potential fluvial and tidal flooding for the 0.1% event. This mainly occurs in the vicinity of the Lissenhall Stream and the outfall at the culvert under the M1. Flood defence measures including berms and retention ponds will be required subject to detailed design.
6	Existing site land ruse	Generally, the area is in agricultural use. The Swords Food Park has a Cold Store complex, the HSE have a Sheltered Workshop and Ambulance Centre. There is a centre for kennels midway up the site on the Western boundary.
7	Existing site infrastructure	The only known surface water drainage is through the HSE and the Sword Food Park to the Broad Meadow River. There are no foul sewers. The existing uses are served by treatment plant and septic tanks. There is a public water supply, broadband and overhead electrical lines.
8	Existing soils	The existing soils are likely to be top soil overlying glacial till.
9	Local habitats and biodiversity	Refer to the Ecology Report in Appendix 7
11	Local landscape and townscape	The area is generally agricultural with the exception of the kennels , food park and HSE complex at the Southern end of the area.

4.2.1 Soils

The soil in Lissenhall generally consists of made up ground, limestone till derived and with aluvium present in the flood plain of the Broad Meadow River. Results from trial pits in the neighboring townland of Lissenhall Little obtained from GSI records show that the depth to bedrock is greater than 13.0m. Localised ground investigation will need to be undertaken to determine the depth to bedrock at the development area. The aquifer vulnerability is typically classed as low to the east and south of the area while a vulnerability of moderate is noted to the west and north in the area.

4.2.2 Area Draining to SuDS Component

The 26.83 ha of LAP land is located in the one area (Lissenhall). The SuDS Manual (2015) states that areas >2ha should rarely drain to a single SuDS component. As such, a Management Train with various SuDS components will be required to effectively manage surface water runoff.

4.2.3 Minimum Depth to Water Table

Infiltration SuDS techniques require a minimum 1m depth of soil between the maximum water table level and the base of the device. Localised ground investigation will need to be undertaken to determine the depth to groundwater at each development area.

4.2.4 Site Slope

The slope of the land within the LAP Area is moderate in nature which runs into Lissenhall stream and flows in a south-easterly direction. See image 4.1 for site contours and groundwater directional flow.

Image 4.1 Groundwater Directional Flow

4.2.5 Available Head

Based on existing levels in the proposed development areas, available head is unlikely to be an issue for any SuDS solutions.

4.2.6 Available Space

Due to the large area of the lands and the proposed density of the development, there will be significant available space for SuDS features such as ponds, detention basins, swales and wetlands .

4.3 Catchment Characteristics

4.3.1 Freshwater Fisheries, Sites with an Ecological Designation e.g. SPAs, SACs

The Broad Meadows Estuary is designated as a Special Area of Conservation. In order to protect these environmentally sensitive areas, it will be necessary to provide a combination of source controls, site controls and regional controls as part of the surface water drainage system to ensure high water quality from runoff into these areas.

4.3.2 Aquifers used for Public Water Supply

The study area is underlain by Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones. This suggests a reasonable depth to groundwater. There are no GSI or EPA Source Protection Zones in the vicinity of the LAP area. GSI records show three wells are located to the south west of Sword with a further small well located the northern corner of the LAP. There are no details on the use or depth of the well. Refer to Appendix A.

4.3.3 Coastal / Estuarial Waters

According to the SuDS Manual (2015) and GDSDS, discharge to coastal waters do not typically require attenuation as there will be no deterioration in flood risk as a result of an increase in runoff. However, as Broad Meadows Estuary is a designated Special Area of Conservation, in order to protect this environmentally sensitive area, it will be necessary to provide a combination of source controls, site controls and regional controls as part of the surface water drainage system to ensure high water quality from runoff into these areas.

4.3.4 Requirement for Sustainable Water Management / Water Conservation Measures

The provision of rainwater harvesting for landscaping purposes will be encouraged throughout the LAP area. Any commercial, educational or institutional buildings should provide rainwater harvesting for non-consumption purposes.

4.3.5 Habitat – Dependent Flow Regime

There are no habitat-dependent flow regimes required in the existing environment. Depending on any proposed ecological use, it may be necessary to ensure a permanent water level in ponds.

4.3.6 Flood Risk

Proposed surface water drainage networks should be designed such that greenfield runoff rates are not exceeded.

4.3.7 Discharges to the Sewerage Network

Areas proposing to discharge to the existing surface water sewage network must agree discharge rates with the water authority.

4.4 Quantity and Quality Performance

Table 4.2 below taken from The SuDS Manual (2007) shows a selection matrix for quantity and quality performance of various SuDS techniques. This table indicates the following:

- Source Control techniques are most effective in reducing run off volume.
- Open Channels and Retention Ponds/Subsurface Storage provide the best hydraulic control for large flows (1% AEP).
- Permeable paving, Infiltration and Filtration techniques are most effective for water quality treatment.
- Subsurface storage, detention basins and rainwater harvesting have the lowest potential for water treatment.

Table 4.2 Quantity and Quality Performance Selection Matrix (SuDS Manual, 2007)

SuDS group	Technique	Maintenance	Community acceptability	Cost	Habitat creation potential
Retention	Retention pond	M	H*	M	H
	Subsurface storage	L	H	M	L
Wetland	Shallow wetland	H	H*	H	H
	Extended detention wetland	H	H*	H	H
	Pond/wetland	H	H*	H	H
	Pocket wetland	H	M*	H	H
	Submerged gravel wetland	M	L	H	M
	Wetland channel	H	H*	H	H
Infiltration	Infiltration trench	L	M	L	L
	Infiltration basin	M	H*	L	M
	Soakaway	L	M	M	L
Filtration	Surface sand filter	M	L	H	M
	Sub-surface sand filter	M	L	H	L
	Perimeter sand filter	M	L	H	L
	Bioretention/filter strips	H	H	M	H
	Filter trench	M	M	M	L
Detention	Detention basin	L	H*	L	M
Open channels	Conveyance swale	L	M*	L	M
	Enhanced dry swale	L	M*	M	M
	Enhanced wet swale	M	M*	M	H
Source control	Green roof	H	H	H	H
	Rainwater harvesting	H	M*	H	L
	Permeable pavement	M	M	M	L

H = High
M = Medium
L = Low
* there may be some public safety concerns associated with open water that require addressing at design stage

4.5 Community, Environmental and Amenity Performance

Table 4.3 below taken from The SuDS Manual (2007) shows a selection matrix for community and environmental factors for various SuDS techniques. These factors are Maintenance Regime, Community Acceptability, Construction and Maintenance Costs and Habitat Creation Potential. This table indicates the following:

- Detention Basins and Swales (particularly Conveyance Swales) provide the most cost-effective solutions while also incorporating the potential for habitat creation.
- Wetlands score highly in terms of habitat creation and community acceptability however capital and maintenance costs are relatively high.
- Filtration techniques typically score poorly overall.

- There may be some public safety concerns associated with SuDS techniques involving open water, however good design and education can help minimise these concerns.

Table 4.3 Community and Environmental Factors Selection Matrix (SuDS Manual, 2007)

SuDS group	Technique	Water quality treatment potential					Hydraulic control			
		Total suspended solids removal	Heavy metals removal	Nutrient (phosphorous, nitrogen) removal	Bacteria removal (*)	Capacity to treat fine suspended sediments and dissolved pollutants	Runoff volume reduction	Suitability for flow rate control (probability)		
								0.5 (1/2 yr)	0.1 - 0.3 (10/30 yr)	0.01 (100 yr)
Retention	Retention pond	H	M	M	M	H	L	H	H	H
	Subsurface storage	L	L	L	L	L	L	H	H	H
Wetland	Shallow wetland	H	M	H	M	H	L	H	M	L
	Extended detention wetland	H	M	H	M	H	L	H	M	L
	Pond/wetland	H	M	H	M	H	L	H	M	L
	Pocket wetland	H	M	H	M	H	L	H	M	L
	Submerged gravel wetland	H	M	H	M	H	L	H	M	L
	Wetland channel	H	M	H	M	H	L	H	M	L
Infiltration	Infiltration trench	H	H	H	M	H	H	H	H	L
	Infiltration basin	H	H	H	M	H	H	H	H	H
	Soakaway	H	H	H	M	H	H	H	H	L
Filtration	Surface sand filter	H	H	H	M	H	L	H	M	L
	Sub-surface sand filter	H	H	H	M	H	L	H	M	L
	Perimeter sand filter	H	H	H	M	H	L	H	M	L
	Bioretention/filter strips	H	H	H	M	H	L	H	M	L
	Filter trench	H	H	H	M	H	L	H	H	L
Detention	Detention basin	M	M	L	L	L	L	H	H	H
Open channels	Conveyance swale	H	M	M	M	H	M	H	H	H
	Enhanced dry swale	H	H	H	M	H	M	H	H	H
	Enhanced wet swale	H	H	M	H	H	L	H	H	H
Source control	Green roof	n/a	n/a	n/a	n/a	H	H	H	H	L
	Rain water harvesting	M	L	L	L	n/a	M	M	H	L
	Permeable pavement	H	H	H	H	H	H	H	H	L

* limited data available
n/a = non applicable
H = high potential
M = medium potential
L = low potential

5.0 SUDS STRATEGY

5.1 Management Train

A Management Train is usually required when developing a SuDS strategy. A Management train sets a hierarchy of SuDS techniques which are subsequently linked together. Each technique employed contributes in different ways and degrees to the overall drainage network. The scale and number of components required will depend on the respective catchment characteristics and likely concentration of pollutants in the inflow. It is recommended that no area greater than 2 hectares should drain to a single SuDS component. Considering the scale of proposed development and in order to protect the environmentally sensitive areas of the Lissenhall, Broad Meadow and Malahide Estuaries, a combination of source controls, site controls and regional controls is required as part of the surface water drainage system to ensure high water quality from runoff into these areas.

Following a review of all the information presented in previous chapters, a range of SuDS techniques suitable for inclusion in the Lissenhall LAP have been selected and are presented below.

5.2 Source Controls

5.2.1 Water Butts

Water Butts are small, offline storage devices designed to collect runoff from roofs. They are the most common means of harvesting rainwater for garden use and have a typical capacity of less than 0.5m3. Two-stage devices can provide some storage volume for attenuation using a throttled overflow, however poor maintenance can lead to blockages.

Table 5.1 Advantages / Disadvantages of Water Butts (CIRIA C697)

ADVANTAGES / DISADVANTAGES	PERFORMANCE	
ADVANTAGES	**PERFORMANCE**	
• easy to construct, install and operate	Peak flow reduction:	Low
• easy to retrofit	Volume reduction:	Low
• inexpensive	Water quality treatment:	Low
• marginal stormwater management benefits	Amenity potential:	Poor
• provides water for non potable water uses, eg garden watering	Ecology potential:	Poor
	TREATMENT TRAIN SUITABILITY	
DISADVANTAGES	Source control:	Yes
• high risk of blockage of small throttles	Conveyance:	No
• very limited water quality treatment benefits	Site system:	No
• property owner responsible for operation and maintenance, so cannot be guaranteed	Regional system:	No
	SITE SUITABILITY	
	Residential:	Yes
	Commercial/industrial:	Yes
	High density:	Yes
	Retrofit:	Yes
	Contaminated sites/sites above vulnerable ground water	Yes
	COST IMPLICATIONS	
	Land-take:	None
	Capital cost:	Low
	Maintenance burden:	Low
	POLLUTANT REMOVAL	
	Total suspended solids:	Low
	Nutrients:	Low
	Heavy metals:	Low

KEY MAINTENANCE REQUIREMENTS:

- inspection of inlet and outlet for blockages
- silt and debris removal.

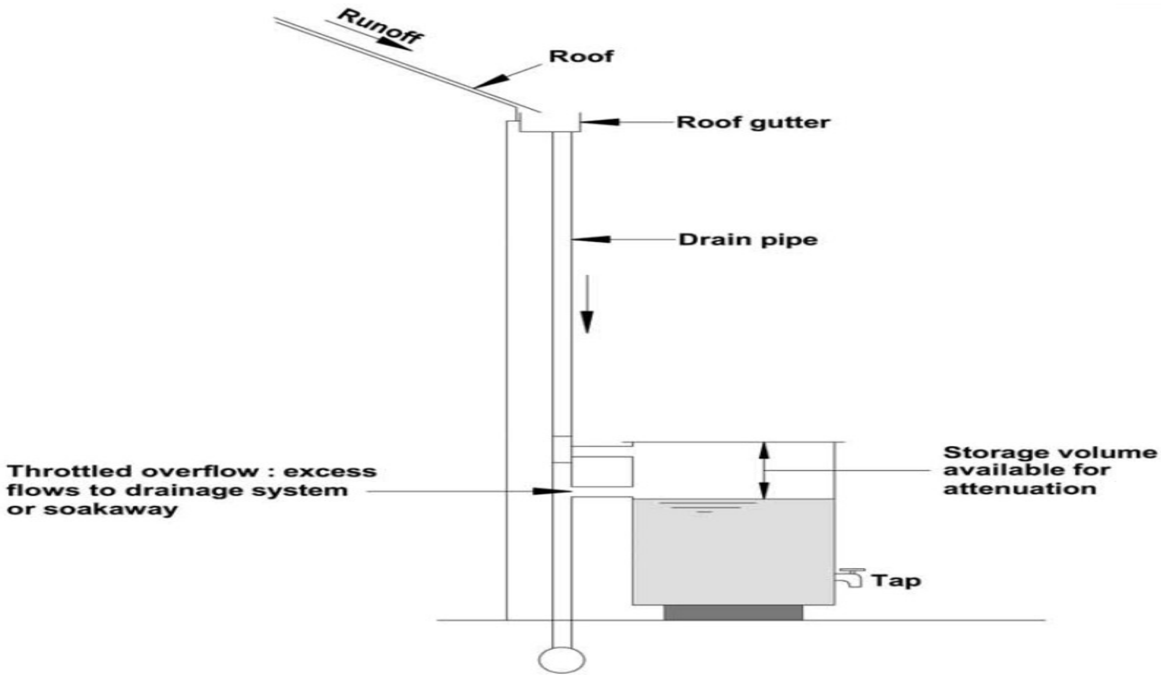


Image 5.1 - Water Butts Schematic (CIRIA C697)

5.2.2 Rainwater Harvesting

Rainwater harvesting involves collection of rainwater from roofs and hard surfaces, similar in principle to Water Butts but generally on a much larger scale. Collected water is typically used for non-potable purposes such as irrigation, flushing toilets and washing machines. The size of the harvesting tank depends on catchment area, seasonal rainfall pattern, demand pattern and retention time. Stormwater attenuation can also be provided by additional storage capacity in the tank.

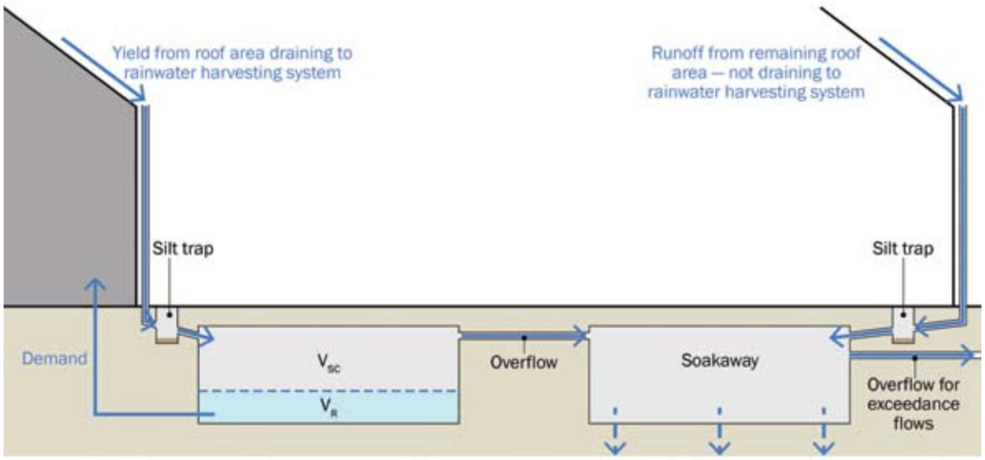


Image 5.2 - Rainwater Harvesting Schematic (CIRIA C753)

Rainwater Harvesting is recommended for use in commercial, industrial and educational buildings.

Table 5.2 Advantages and Disadvantages of Rainwater Harvesting (CIRIA C697)

ADVANTAGES	PERFORMANCE	
• with careful design, can provide source control of stormwater runoff	Peak flow reduction:	High
• reduces demand on mains water.	Volume reduction:	High
	Water quality treatment:	Poor
DISADVANTAGES	Amenity potential:	Poor
	Ecology potential:	Poor
• potential risks to public health		
• systems can be complex and costly to install	**TREATMENT TRAIN SUITABILITY**	
• above ground tanks can be unsightly.	Source control:	Yes
	Conveyance:	No
	Site system:	No
	Regional system:	No
	SITE SUITABILITY	
	Residential:	Yes
	Commercial/Industrial:	Yes
	High density:	Yes
	Retrofit:	Yes
	Contaminated sites/sites above vulnerable ground water	Yes
	COST IMPLICATIONS	
	Land-take:	None
	Capital cost:	High
	Maintenance burden:	Medium
	POLLUTANT REMOVAL	
	Total suspended solids:	High
	Nutrients:	Low
	Heavy metals:	Medium
KEY MAINTENANCE REQUIREMENTS:		
• inspection and cleaning of collection systems, filters, throttle and valves, pumps.		

5.2.3 Permeable Pavements

Permeable pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater infiltrate through the surface and into the underlying layers where it is subsequently infiltrates to the ground and/or is collected and conveyed to the drainage network. Permeable pavements are most suitable for areas with light traffic loads and volume. The pavement generally caters for rainwater which lands directly on its surface but in certain cases, can accept runoff from other impermeable areas.

Table 5.3 Advantages / Disadvantages of Permeable Paving (CIRIA C697)

ADVANTAGES

- effective in removing urban runoff pollutants
- lined systems can be used where infiltration is not desirable, or where soil integrity would be compromised
- significant reduction in volume and rate of surface runoff
- suitable for installation in high density development
- good retrofit capability
- no additional land take, allows dual use of space
- low maintenance
- removes need for gully pots and manholes
- eliminates surface ponding and surface ice.
- good community acceptability.

DISADVANTAGES

- cannot be used where large sediment loads may be washed/carried onto the surface
- in the UK, current practice is to use on highways with low traffic volumes, low axle loads and speeds of less than 30 mph
- risk of long-term clogging and weed growth if poorly maintained.

PERFORMANCE:	
Peak flow reduction:	Good
Volume reduction:	Good
Water quality treatment:	Good
Amenity potential:	Poor
Ecology potential:	Poor
TREATMENT TRAIN SUITABILITY:	
Source control:	Yes
Conveyance:	No
Site system:	Yes
Regional system:	No
SITE SUITABILITY:	
Residential:	Yes
Commercial/industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater (with liner)	Yes
COST IMPLICATIONS:	
Net Land-take:	Low
Capital cost:	Medium
(Net capital cost:	Low)
Maintenance cost:	Low
POLLUTANT REMOVAL:	
Total suspended solids:	High
Nutrients:	High
Heavy metals:	High

KEY MAINTENANCE REQUIREMENTS

- sweeping
- regular brushing and vacuuming.

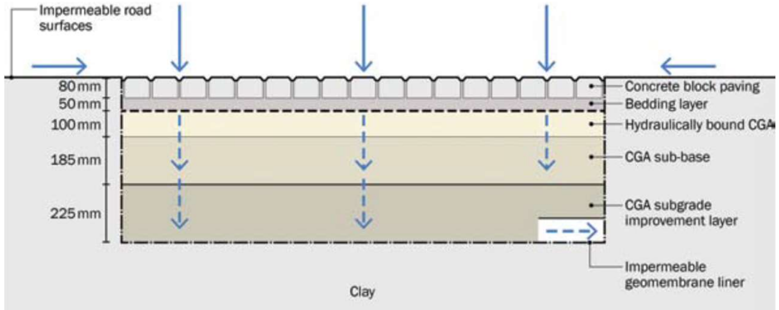


Image 5.3 - Permeable Paving Schematic (CIRIA C753)

5.2.3 Green Roofs

Green Roofs comprise of a multi-layered system which covers the roof of a building with vegetation and landscaping over a drainage layer. They are designed to intercept and retain precipitation which reduces the volume and rate of surface water runoff. Green roofs can provide noise absorbent barrier and surfaces. Green roofs can be used on a variety of roof types and sizes, although larger roof areas are typically more cost effective. They are particularly suited to flat / gently sloping roofs on commercial buildings, sports centres, schools, apartment blocks and other similar buildings.

Table 5.4 Advantages / Disadvantages of Green Roofs (CIRIA C697)

ADVANTAGES

- mimic predevelopment state of building footprint
- good removal capability of atmospherically deposited urban pollutants
- can be applied in high density developments
- can sometimes be retrofitted
- ecological, aesthetic and amenity benefits
- no additional land take
- improve air quality
- help retain higher humidity levels in city areas
- insulates buildings against temperature extremes
- reduces the expansion and contraction of roof membranes
- sound absorption.

DISADVANTAGES

- cost (compared to conventional runoff
- not appropriate for steep roofs
- opportunities for retrofitting may be limited by roof structure (strength, pitch etc)
- maintenance of roof vegetation
- any damage to waterproof membrane likely to be more critical since water is encouraged to remain on the roof.

PERFORMANCE

Peak flow reduction:	Medium
Volume reduction:	Medium
Water quality treatment:	Good
Amenity potential:	Good
Ecology potential:	Good

TREATMENT TRAIN SUITABILITY

Source control:	Yes
Conveyance:	No
Site system:	No
Regional system:	No

SITE SUITABILITY

Residential:	Yes
Commercial/industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater	Yes

COST IMPLICATIONS

Land-take:	None
Capital cost: (depending on roof type and capacity)	Low–High
Maintenance burden:	Medium

POLLUTANT REMOVAL

Total suspended solids:	High
Nutrients:	Low
Heavy metals:	Medium

KEY MAINTENANCE REQUIREMENTS:

- irrigation during establishment of vegetation
- inspection for bare patches and replacement of plants
- litter removal (depending on setting and use).

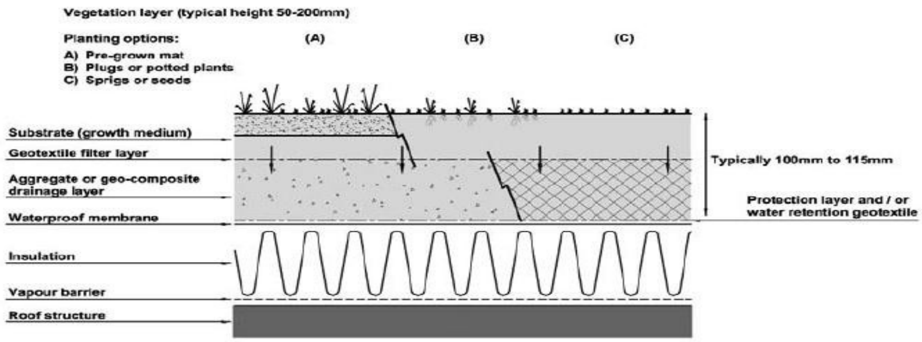


Image 5.4 - Green Roof Schematic (CIRIA C753)

Image 5.5 - Green Roof (CIRIA C753)

5.2.4 Green Walls

Green Walls are walls that have plants growing on, or integrated within them, providing a living and self-regenerating cladding system. Green walls can comprise climbing plants supported by the wall, hanging plants which hang from suspended planters or plants growing within them.

Table 5.5 Advantages / Disadvantages of Green Walls

Advantages	Disadvantages
Can occupy much greater surface area than green roofs	Maintenance of vegetation required
High amenity & biodiversity benefits	Can take a long period of time for vegetation to cover entire wall
Improves thermal efficiency of building	Some climbers can impact structural integrity of the wall if roots penetrate small cracks
Good removal of atmospherically deposited pollutants	

Image 5.6 - Green Wall (CIRIA C753)

5.2.5 Filter Drains

Filter drains are shallow excavations backfilled with granular material that create temporary subsurface storage for either filtration or infiltration of stormwater runoff. Filter drains can contain a perforated pipe at the base to convey runoff to further SuDS components in the Management Train.

Table 5.6 Advantages / Disadvantages of Filter Drains (CIRIA C697)

ADVANTAGES / DISADVANTAGES	PERFORMANCE	
ADVANTAGES		
• well-suited to implementation adjacent to large impervious areas	Peak flow reduction:	Poor
• encourages evaporation and can promote infiltration	Volume reduction:	Poor
• easy to construct and low construction cost	Water quality treatment:	Medium
• effective pre-treatment option	Amenity potential:	Medium
• easily integrated into landscaping and can be designed to provide aesthetic benefits.	Ecology potential:	Medium
	TREATMENT TRAIN SUITABILITY	
	Source control:	Yes
	Conveyance:	No
	Site system:	Yes
	Regional system:	No
DISADVANTAGES	**SITE SUITABILITY**	
• large land requirement	Residential:	Yes
• not suitable for steep sites	Commercial/industrial:	Yes
• not suitable for draining hotspot runoff or for locations where risk of groundwater contamination, unless infiltration is prevented	High density:	Yes
• no significant attenuation or reduction of extreme event flows.	Retrofit:	Yes
	Contaminated sites/sites above vulnerable groundwater (unless infiltration prevented)	No
	COST IMPLICATIONS	
	Land-take:	High
	Capital cost:	Low
	Maintenance burden:	Low
	POLLUTANT REMOVAL	
	Total suspended solids:	Medium
	Nutrients:	Low
	Heavy metals:	Medium

KEY MAINTENANCE REQUIREMENTS:

- litter/debris removal
- mowing
- repair of eroded or damaged areas.

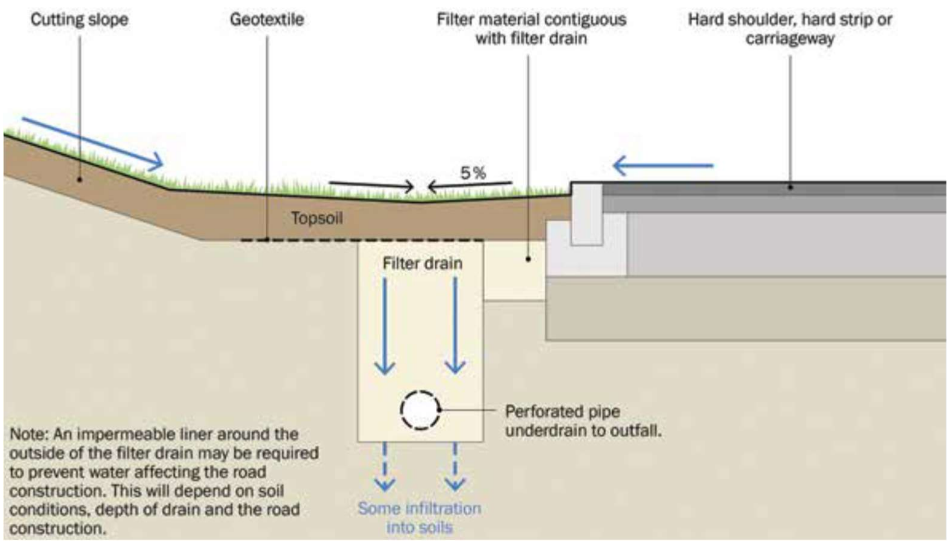


Image 5.7 - Filter Drain Schematic (CIRIA C753)

Image 5.8 - Example Filter Drain (CIRIA C753)

Subject to appropriate ground conditions, filter drains are recommended for draining residential back gardens and other small grassed areas where subsoil permeability is low. Filter drains can also be used to drain carriageways. The base of the filter drain should be a minimum 500mm above highest expected groundwater table level.

5.3 Site Controls

5.3.1 Swales

Swales are broad, shallow, vegetated drainage channels which can be used to convey or store surface water. Swales are generally suited for small catchments with impermeable areas. They are typically provided along roads in grass verges. Swales can be designed for infiltration to subsoil or detention and conveyance to another stage in the management train. Conveyance can be in the open channel or in a perforated pipe within a filter bed below the base of the channel.

Table 5.7 Advantages / Disadvantages of Swales (CIRIA C697)

ADVANTAGES / DISADVANTAGES	PERFORMANCE / SUITABILITY / COST / REMOVAL
ADVANTAGES • easy to incorporate into landscaping • good removal of urban pollutants • reduces runoff rates and volumes • low capital cost • maintenance can be incorporated into general landscape management • pollution and blockages are visible and easily dealt with. **DISADVANTAGES** • not suitable for steep areas • significant • not suitable in areas with roadside parking • limits opportunities to use trees for landscaping • risks of blockages in connecting pipework.	**PERFORMANCE:** Peak flow reduction: Medium Volume reduction: Medium Water quality treatment: Good Amenity potential: Medium Ecology potential: Medium **TREATMENT TRAIN SUITABILITY:** Source control: Yes Conveyance: Yes Site system: Yes Regional system: No **SITE SUITABILITY:** Residential: Yes Commercial/industrial: Yes High density: Limited Retrofit: Limited Contaminated sites(s) above vulnerable groundwater (with liner): Yes **COST IMPLICATIONS:** Land-take: High Capital cost: Low Maintenance cost: Medium **POLLUTANT REMOVAL:** Total suspended solids: High Nutrients: Low Heavy metals: Medium
KEY MAINTENANCE REQUIREMENTS • litter/debris removal • grass cutting and removal of cuttings • clearing of inlets, culverts and outlets from debris and sediment • repair of eroded or damaged areas.	

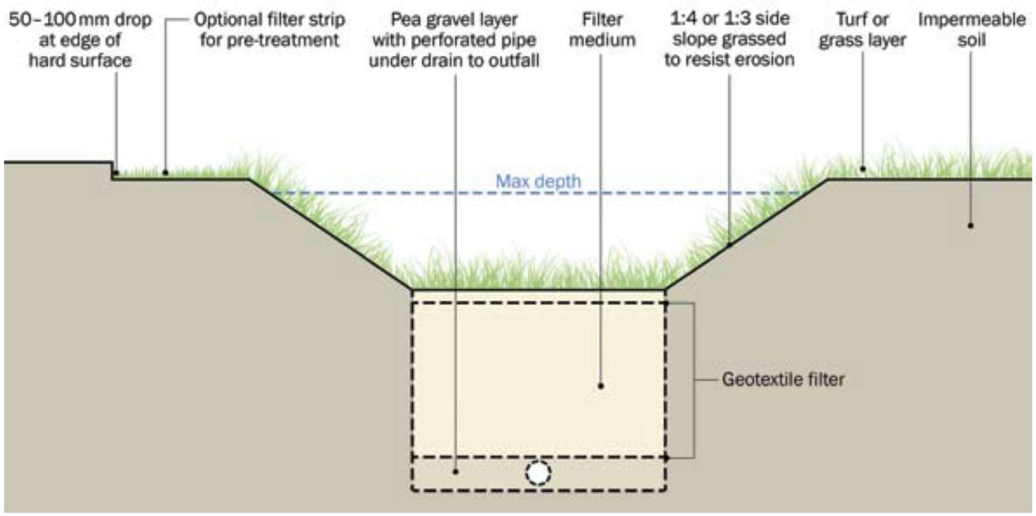


Image 5.9 - Swale Schematic (CIRIA C753)

Image 5.10 - Example Roadside Swale (CIRIA C753)

Swales are recommended to cater for runoff from access and distributor roads, providing water treatment and reduction in peak flow. Depending on local subsoil conditions, dry swales are recommended which provide infiltration and further reduce runoff volume.

5.3.2 Bioretention Areas / Modified Planters

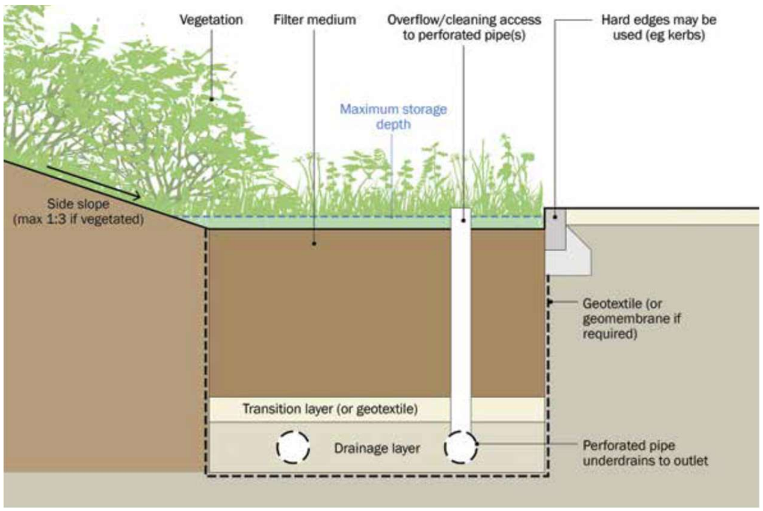


Image 5.11 - Bioretention Area Schematic (CIRIA C753)

Image 5.12 - Example Roadside Bioretention Area (CIRIA C753)

Table 5.8 Advantages and Disadvantages of Bioretention Areas (CIRIA C697)

ADVANTAGES	PERFORMANCE:
• can be planned as landscaping features • very effective in removing urban pollutants • can reduce volume and rate of runoff • flexible layout to fit into landscape • well-suited for installation in highly impervious areas, provided the system is well-engineered and adequate space is made available • good retrofit capability. **DISADVANTAGES** • requires landscaping and management • susceptible to clogging if surrounding landscape is poorly managed • not suitable for areas with steep slopes.	Peak flow reduction: Medium Volume reduction: Medium (High with infiltration) Water quality treatment: Good Amenity potential: Good Ecology potential: Medium **TREATMENT TRAIN SUITABILITY:** Source control: Yes Conveyance: No Site system: Yes Regional system: No **SITE SUITABILITY:** Residential: Yes Commercial/Industrial: Yes High density: No Retrofit: Yes Contaminated sites/sites above vulnerable groundwater (with liner) Yes **COST IMPLICATIONS:** Land-take: High Capital cost: Low Maintenance cost: Medium **POLLUTANT REMOVAL:** Total suspended solids: High Nutrients: Low Heavy metals: High
KEY MAINTENANCE REQUIREMENTS • regular inspection • litter/debris removal • replacement of mulch layer • vegetation management • soil spiking and scarifiying.	

Bioretention areas are recommended to cater for runoff from residential neighbourhoods and car parks.

5.3.3 Detention Basins

Detention Basins are dry basins that attenuate stormwater runoff by providing temporary storage with flow control of the attenuated runoff. Detention basins are generally applicable to most types of developments. In residential areas, they are normally dry and often function as a recreational facility, e.g. sports fields or play grounds. They may be constructed such that surface runoff is routed through them during storm events with an outflow restriction (online), or such that runoff typically bypasses the detention basin until a design storm event occurs when runoff is received by a flow diverter or overflow and temporarily stored until the inflow recedes below a design level (offline). Small permanent pools at the outlet can enhance water treatment quality.

Table 5.9 Advantages / Disadvantages of Detention Basins (CIRIA C697)

ADVANTAGES	PERFORMANCE	
• can cater for a wide range of rainfall events	Peak flow reduction:	Good
• can be used where groundwater is vulnerable, if lined	Volume reduction:	Poor
• simple to design and construct	Water quality treatment:	Medium
• potential for dual land use	Amenity potential:	Good
• easy to maintain	Ecology potential:	Medium
• safe and visible capture of accidental spillages.	**TREATMENT TRAIN SUITABILITY**	
DISADVANTAGES	Source control:	No
• little reduction in runoff volume	Conveyance:	No
• detention depths may be constrained by system inlet and outlet levels.	Site system:	Yes
	Regional system:	Yes
	SITE SUITABILITY	
	Residential:	Yes
	Commercial/industrial:	Yes
	High density:	Yes
	Retrofit:	Yes
	Contaminated sites/sites above vulnerable groundwater (with liner)	Yes
	COST IMPLICATIONS	
	Land-take:	Medium
	Capital cost:	Low
	Maintenance burden:	Low
	POLLUTANT REMOVAL	
	Total suspended solids:	Medium
	Nutrients:	Low
	Heavy metals:	Medium
KEY MAINTENANCE REQUIREMENTS: • litter/trash removal • inlet/outlet cleaning • vegetation management • sediment monitoring and removal when required.		

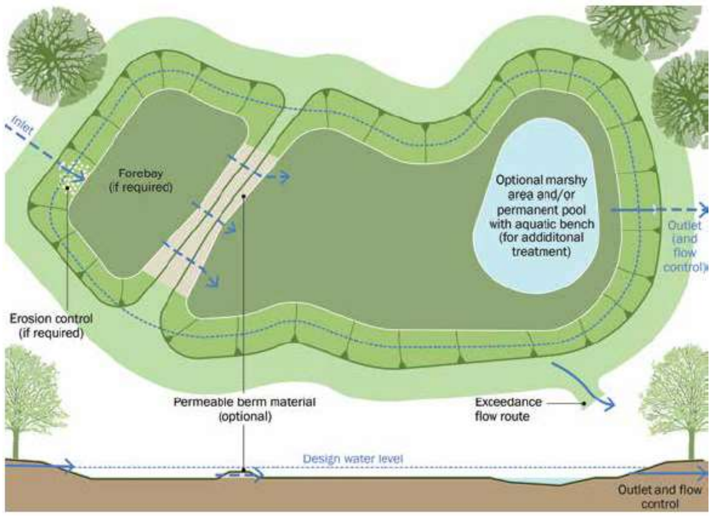


Image 5.12 - Detention Basin Schematic (CIRIA C753)

Image 5.13 - Example Detention Basin (CIRIA C753)

5.4 Regional Controls

5.4.1 Ponds

Ponds are basins which have a permanent depth of water. They can be constructed in an existing depression, by excavating a new depression or by constructing embankments. Runoff which enters the pond is detained and treated by settlement and often biological uptake before out falling. Ponds should contain the following features:

- Sediment Forebay – This may not be required if previous SuDS techniques are implemented upstream
- Permanent pool – This minimum volume of water (excluding losses due to infiltration and evaporation) will remain throughout the year. The main treatment associated with the pond occurs in this pool.
- Temporary Storage Volume – An additional storage volume within the pond to provide flood attenuation for design events.
- Aquatic Bench – A shallow zone around the perimeter of the pool to support wetland planting which provides biological treatment, ecology, amenity and safety benefits.

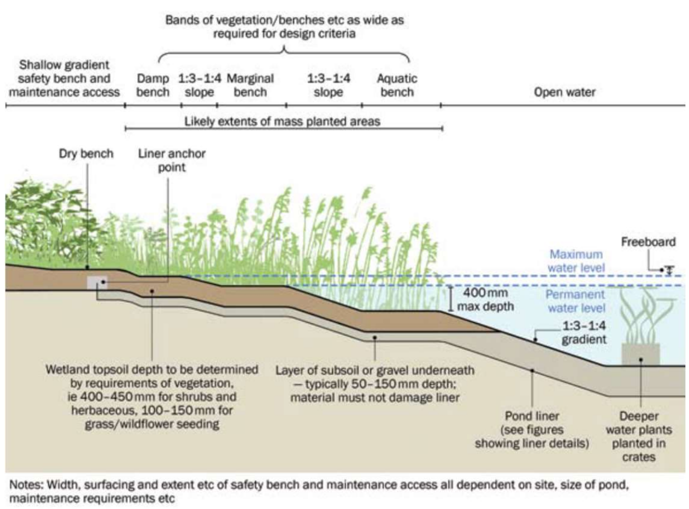


Image 5.14 - Pond Schematic (CIRIA C753)

Table 5.10 Advantages / Disadvantages of Ponds (CIRIA C697)

ADVANTAGES • can cater for all storms • good removal capability of urban pollutants • can be used where groundwater is vulnerable, if lined • good community acceptability • high potential ecological, aesthetic and amenity benefits • may add value to local properties. **DISADVANTAGES** • no reduction in runoff volume • anaerobic conditions can occur without regular inflow • land take may limit use in high density sites • may not be suitable for steep sites, due to requirement for high embankments • colonisation by invasive species could increase maintenance • perceived health and safety risks may result in fencing and isolation of the pond.	**PERFORMANCE** Peak flow reduction: Good Volume reduction: Poor Water quality treatment: Good Amenity potential: Good Ecology potential: Good **TREATMENT TRAIN SUITABILITY** Source control: No Conveyance: No Site system: Yes Regional system: Yes **SITE SUITABILITY** Residential: Yes Commercial/industrial: Yes High density: Unlikely Retrofit: Unlikely Contaminated sites/sites above vulnerable groundwater (with liner) Yes **COST IMPLICATIONS** Land-take: High Capital cost: Medium (High with liner) Maintenance cost: Medium **POLLUTANT REMOVAL** Total suspended solids: High Nutrients: Medium Heavy metals: High
KEY MAINTENANCE REQUIREMENTS: • litter/debris removal • inlet/outlet cleaning • vegetation management • sediment monitoring and removal when required.	

Image 5.15 - Example Landscaped Pond (CIRIA C753)

Ponds are recommended at the end of proposed surface water drainage networks following previous SuDS techniques in the Management Train. Outflow from any proposed ponds may be restricted at times due to high tide levels and as such may require additional attenuation volume. Inclusion of several independent cells is encouraged which will enhance biodiversity, improve water quality levels and provide a more environmentally effective management programme.

5.4.2 Constructed Wetlands

Constructed Wetlands comprise of shallow ponds and marshy areas which are designed primarily for stormwater treatment but can also provide some attenuation above the permanent water level. Well designed and maintained wetlands can offer significant aesthetic, amenity and biodiversity opportunities. Constructed wetlands require a continuous baseflow to support a plant-rich community. Wetlands should contain the following features:

- Shallow, vegetated areas of varying depths
- Permanent pools or micropools
- Small depth range overlying permanent pool in which runoff control volumes are stored
- Sediment forebay
- Emergency spillway
- Maintenance access
- Safety bench

Table 5.11 Advantages / Disadvantages of Wetlands (CIRIA C697)

ADVANTAGES • good removal capability of urban pollutants • if lined, can be used where groundwater is vulnerable • good community acceptability • high potential ecological, aesthetic and amenity benefits • may add value to local property. **DISADVANTAGES** • land take is high • requires baseflow • limited depth range for flow attenuation • may release nutrients during non-growing season • little reduction in runoff volume • not suitable for steep sites • colonisation by invasive species would increase maintenance • performance vulnerable to high sediment inflows • perceived health and safety risks may result in fencing and isolation of wetland.	**PERFORMANCE:** Peak flow reduction: Low frequency events — Good Extreme events — Good (if large wetland area available) Volume reduction: — Poor Water quality treatment: — Good Amenity potential: — Good Ecology potential: — Good **TREATMENT TRAIN SUITABILITY:** Source control: — No Conveyance: — Yes Site system: — Yes Regional system: — Yes **SITE SUITABILITY:** Residential: — Yes Commercial/industrial: — Yes High density: — Unlikely Retrofit: — Unlikely Contaminated sites/sites above vulnerable groundwater (with liner) — Yes **COST IMPLICATIONS:** Land-take: — High Capital cost: — High Maintenance cost: — Medium/Low (once established) **POLLUTANT REMOVAL:** Total suspended solids: — High Nutrients: — Medium Heavy metals: — High
KEY MAINTENANCE REQUIREMENTS: • litter/trash/debris removal • inlet/outlet cleaning • vegetation management to retain high vegetation coverage, possibly requiring specialist equipment • sediment monitoring and removal when required.	

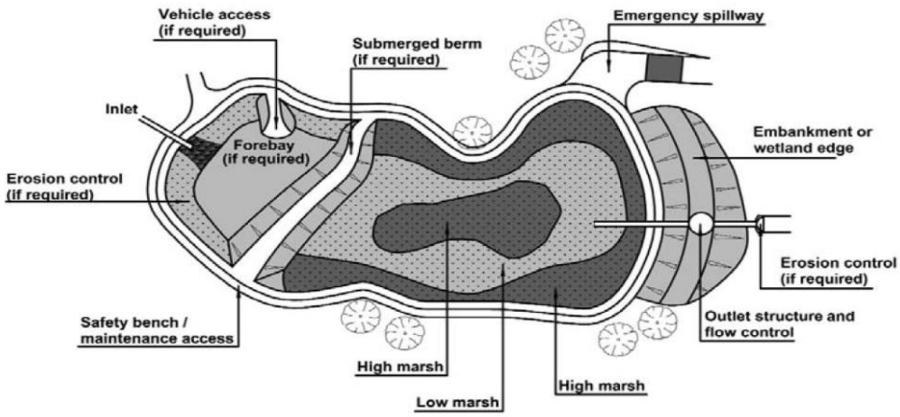


Image 5.16 - Constructed Wetland Schematic (SuDS Manual 2007)

Image 5.17 - Example Constructed Wetland

Constructed Wetlands are recommended at the end of proposed surface water drainage networks following previous SuDS techniques in the Management Train. Their primary objective should be treatment, not attenuation. Outflow from any proposed ponds may be restricted at times due to high tide levels and as such may require additional attenuation volume. Inclusion of several independent cells is encouraged which will enhance biodiversity, improve water quality levels and provide a more environmentally effective management programme. Permanent pond volume should be provided in accordance with Ciria C753 ‘The SuDS Manual’.

5.5 Recommended Management Train for Lissenhall East Lap Lands

Table 5.12 below provides recommended Management Trains for the proposed site location based on the information collated above

Site	Sub-Catchment Type	Source Control	Site Control	Regional Control
Lissenhall East	Roofs	Water Butts Rainwater Harvesting Green Roof	Existing Ditches Swales	Ponds Wetlands
	Green Areas	Filler Drains	Swales Detention Basins	Ponds Wetlands
	Roads		Filler Drains Swales Detention Basin	Ponds Wetlands
	Parking Areas	Permeable Paving	Swales Detention Basins	Ponds Wetlands

5.6 SuDS Layout

A sample layout for the proposed SuDS Strategy in presented in Drawing 1289-1-C03 'SuDS Strategy Overview in Apendix B This drawing shows the proposed locations of SuDS devices, primarily focusing on ponds, detention basins and swales

It is not possible to provide sizing and layouts of Source and Site Controls until proposed layouts of each development are provided. In lieu of this, it is recommended that the Management Train outlined in Section 5.5 should be incorporated where possible within the design of each development.

Regional Controls (ponds / wetlands) have been initially sized based on treatment requirements. Regional controls should not be used primarily for attenuation purposes. Attenuation of surface water runoff should be provided for by Source and Site Controls. Sizing is based on treatment for an inflow of existing greenfield runoff rates with an inclusion for tidal attenuation.

6.0 IMPACT OF SUDS STRATEGY

6.1 Runoff Quantity

Increase in the area of hard standing within the development areas will result in an increase in the total runoff quantity due to reduced infiltration of surface water to ground. This increase will be minimised thorough the use of rainwater harvesting and evaporation and transpiration from open channels / ponds and vegetation respectively. Attenuation will be required to store run off before discharge to the Lissenhall Stream.

6.1.1 Runoff Quality

The Broad Meadow Estuary is a designated SAC. In order to protect this environmentally sensitive area, runoff quality is of upmost importance. The proposed SuDS Strategy implements a Management Train whereby runoff will pass through a series of SuDS techniques prior to outfall. Each technique will provide different treatment processes – settlement, filtration, removal of nutrients, removal of heavy metals and biological treatment through vegetation.

6.1.2 Amenity and Biodiversity

The lands in Lissenhall zoned for new office, research and development and high technology/high technology manufacturing type development currently consist primarily of farmland with a mix of grass and tillage farms. The proposed SuDS Strategy will introduce a variety of features to promote and enhance amenity and biodiversity in the area. Tree plantings will be incorporated within Bioretention Areas. Ponds should be designed with an emphasis on ecology. Ponds should contain multiple pools fed by cleaner surface water runoff from surrounding grassland or scrub. This will allow a wider range of plants and animals to exploit the overall pond development. A variety of local (c.30km) pond plants should be included to maximise habitat structural diversity. A mix of open, lightly shaded and densely shaded areas will also add to the diversity of habitats available.

6.1.3 Flooding

Implementation of the SuDS Strategy will reduce peak flow runoff of the proposed development and minimise the risk of flooding. A Pond located in low lying area of the study area will need to be designed to provide additional attenuation volume as it may not be possible to outfall during periods of high tide. Refer to Lissenhall LAP Flood Risk Assessment.

6.1.4 Groundwater

It is expected that the infiltration capacity of the soil within the LAP will be low and as such infiltration SuDS techniques are not widely proposed in this SuDS Strategy. As a result of the proposed development, there will be a significant increase in the area of hard standing within the LAP, resulting in a loss of surface water infiltration to the underlying subsoil. Where possible, infiltration SuDS techniques will be implemented to minimise the effect of the development and replicate the natural hydrological process.

6.1.5 Surface Water Drainage Network

The land zoned for new development will require construction of new surface water drainage networks. These networks should discharge at the proposed pond areas.

7.0 CONCLUSIONS

- As part of new development in the LAP land, a new surface water drainage network will be required at Lissenhall.
- SuDS measures will be required as part of these new developments to ensure quantity and quality of surface water runoff does not negatively impact the surrounding environment. The required infrastructure includes wetlands / ponds for Lissenhall.
- A variety of SuDS techniques have been assessed which are suitable for inclusion as part of the development of the LAP area.

8.0 RECOMMENDATIONS

- New surface water drainage networks will be required as part of developments within lands zoned for new office, research and development and high technology/high technology manufacturing type development. These networks should be designed in accordance with this SuDS Strategy, Ciria C753 'The SuDS Manual' and the Greater Dublin Strategic Drainage Systems (GDSDS).

- Pond(s) should be constructed in the central eastern area close to the location of the culvert which drains under the M1. Attenuation volumes should be incorporated in the design of the pond(s).

- Permeable Paving is recommended for use in all parking areas and landscaped areas.

- Any commercial and educational facilities should incorporate rainwater harvesting for use within the facility. These facilities should also examine the feasibility of green roofs and green walls.

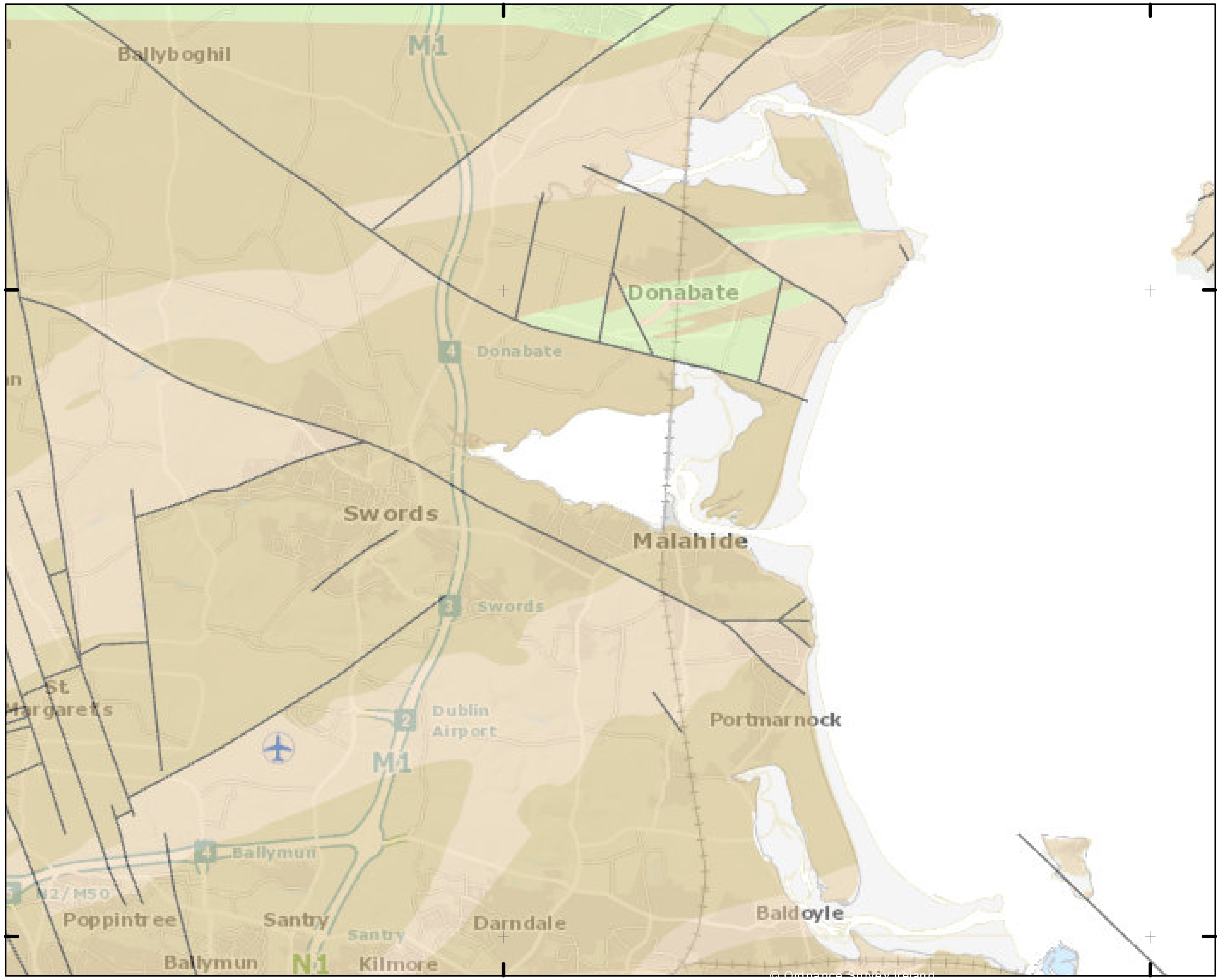
- Subject to subsoil permeability, filter drains may be required to drain landscaped areas and other small green areas within the development. Runoff from green areas should, where possible, infiltrate directly to groundwater.

- It is recommended that swales are constructed adjacent to the proposed drainage route to provide conveyance and treatment of runoff from the carriageway. These swales can also be used to provide separation between footpaths / cycle tracks and the carriageway.

- Runoff from each development upstream of ponds should be limited to existing greenfield runoff rates. Attenuation should be provided for the 1% AEP rainfall event + 20% allowance for Climate Change.

APPENDIX A – GSI MAPS

Geological Survey Ireland Public Data



Legend

Gravel Aquifer

- Locally important gravel aquifer
- Regionally important gravel aquifer
- Bedrock Aquifer Faults

Bedrock Aquifer

- Rkc - Regionally Important Aquifer - Karstified (conduit)
- Rkd - Regionally Important Aquifer - Karstified (diffuse)
- RK - Regionally Important Aquifer - Karstified
- Rf - Regionally Important Aquifer - Fissured bedrock
- Lm - Locally Important Aquifer - Bedrock which is Generally Moderately Productive
- Lk - Locally Important Aquifer - Karstified
- Ll - Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Pl - Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones
- Pu - Poor Aquifer - Bedrock which is Generally Unproductive
- Lake

Scale: 1:100,000

Geological Survey Ireland

0 0.5 1 2 mi
0 1 2 4 km

Map Centre Coordinates (ITM) 721,635 746,906

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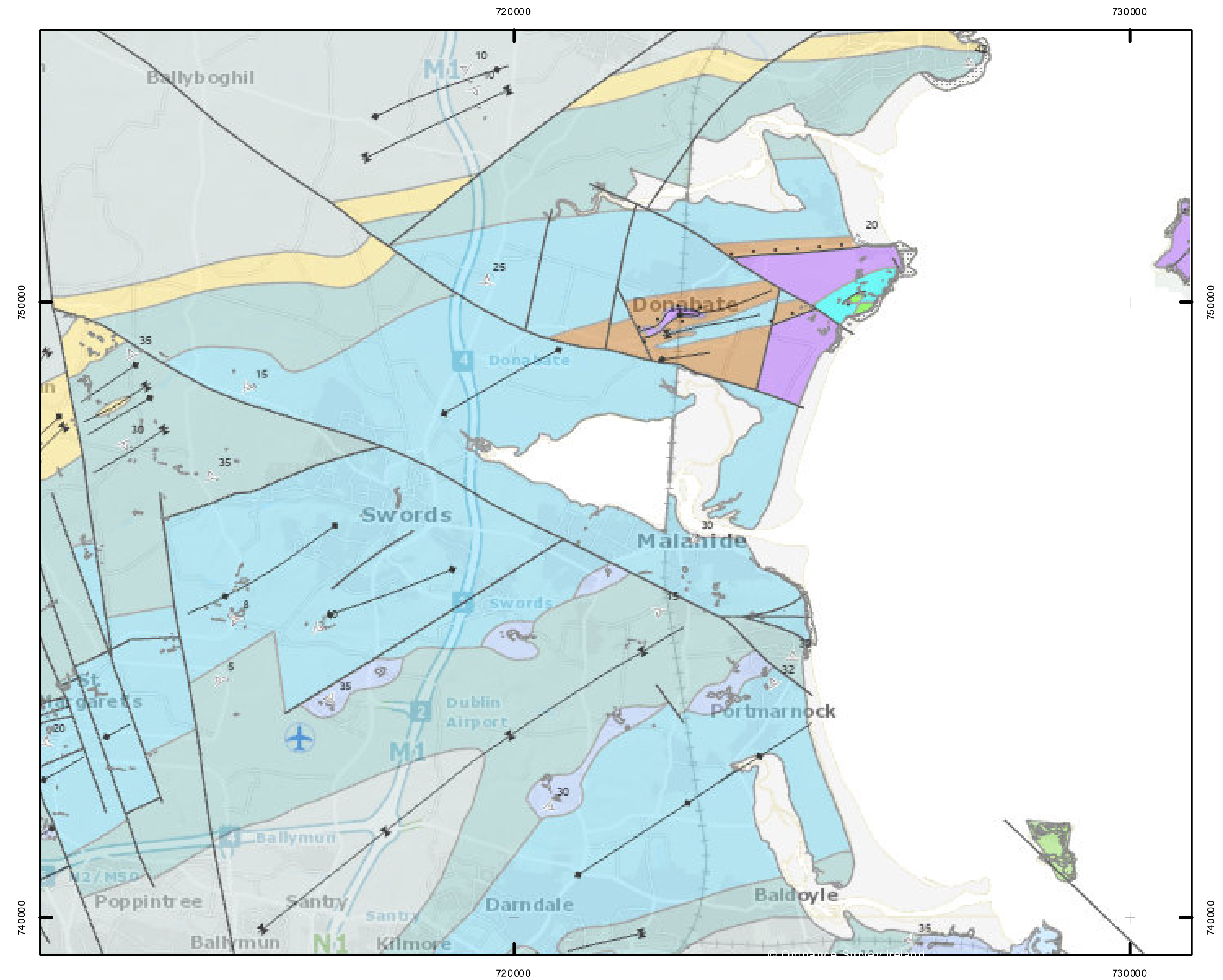

Legend

Structural Symbols 100K ITM 2018

- Dip of bedding or main foliation, old GSI data
- First foliation parallel to bedding
- Foliation trend, Thorr and Rosses Granites
- Horizontal Bedding
- Strike and dip of bedding, right way up
- Strike and dip of bedding, way up unknown
- Strike and dip of first foliation
- Strike and dip of overturned bedding
- Strike and dip of second foliation
- Strike and dip of third foliation
- Strike and plunge of first generation fold axis
- Strike and plunge of second generation fold axis
- Strike and plunge of third generation fold axis
- Strike of vertical bedding/foliation
- Strike of vertical first foliation
- <all other values>

- Bedrock Outcrops 100 ITM 2018

Bedrock Linework 100k ITM 2018

- Anticlinal Axis
- Antiformal axis
- Aquifer Boundary
- Area
- Coal seam
- Dyke
- Fault
- Ghost Line
- Goniatite marine band (R1-R4)
- Lithological boundary offshore
- Metadolerite sheet, mainly sills
- Paleogene/ Tertiary Dyke
- Synclinal Axis
- Synformal axis
- Tectonic Slide, barbs on hanging-wall
- Thin stratigraphical unit, diagrammatic
- Thrust, barbs on hanging-wall side
- Tuff band
- Unconformity, dots on younger side
- X-Section

Scale: 1:100,000

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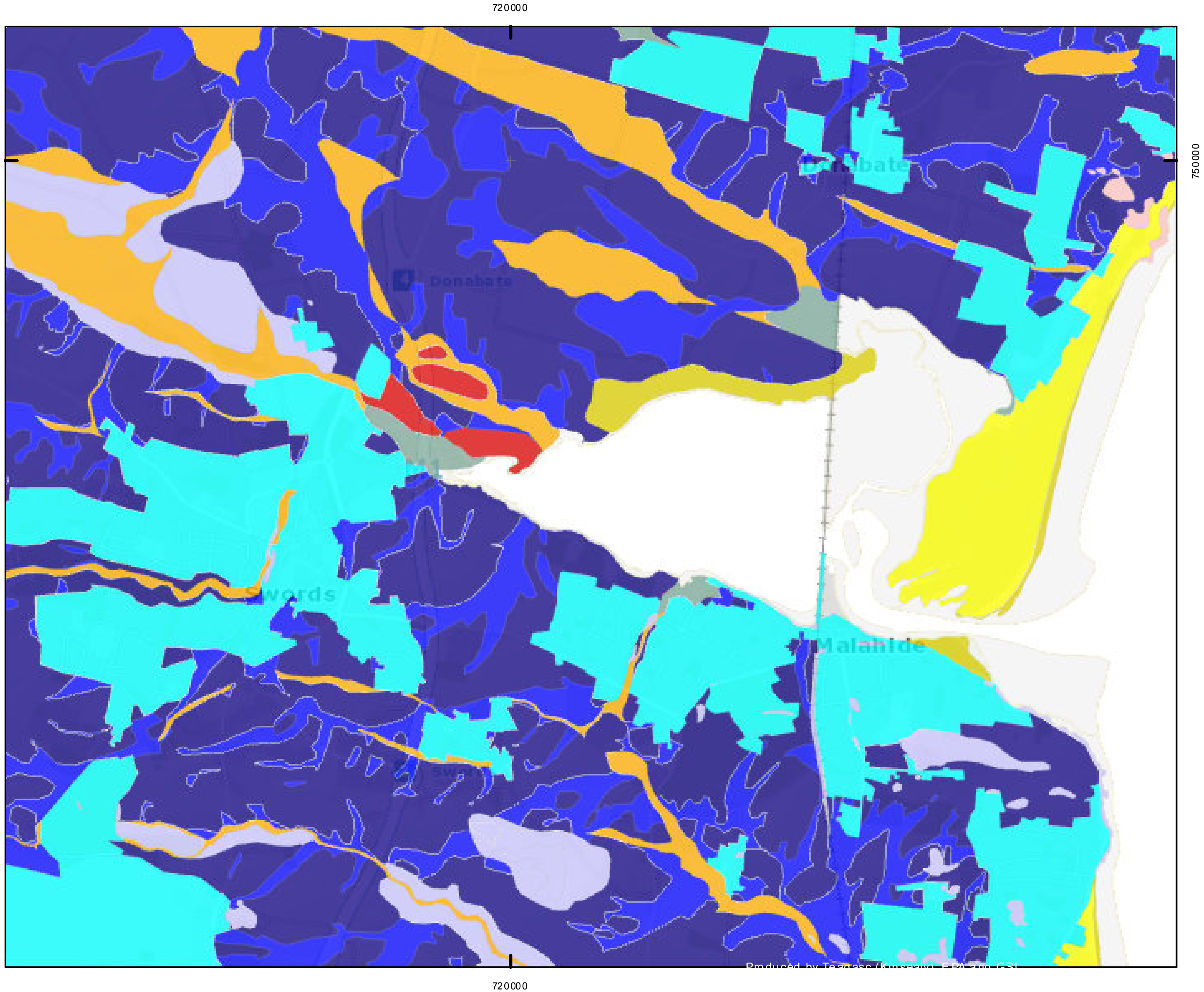


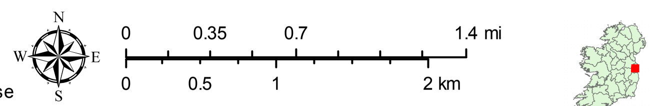
Legend

TEAGASC_Soils_50K...

- AminDW - Deep well drained mineral (Mainly acidic)
- AminPD - Mineral poorly drained (Mainly acidic)
- AminPDPT - Peaty poorly drained mineral (Mainly acidic)
- AminSW - Shallow well drained mineral (Mainly acidic)
- AminSP - Shallow poorly drained mineral (Mainly acidic)
- AminSPPT - Shallow peaty poorly drained mineral (Mainly acidic)
- AminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly acidic)
- BminDW - Deep well drained mineral (Mainly basic)
- BminPD - Mineral poorly drained (Mainly basic)
- BminPDPT - Peaty poorly drained mineral (Mainly basic)
- BminSW - Shallow well drained mineral (Mainly basic)
- BminSP - Shallow poorly drained mineral (Mainly basic)
- BminSPPT - Shallow peaty poorly drained mineral (Mainly basic)
- BminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly basic)
- BktPt - Blanket peat
- FenPt - Fen peat
- RsPt - Raised Peat
- Cut - Cutover/cutaway peat
- AlluvMIN - Alluvial (mineral)
- AlluvMRL - Alluvial (marl)
- Lac - Lacustrine type soils
- Scree - Scree
- AeoUND - Aeolian undifferentiated
- MarSands - Marine sand and gravel
- MarSed - Marine/estuarine sediments
- Made - Made ground
- Water - Water
- Unclass

Scale: 1:50,000

Geological Survey Ireland



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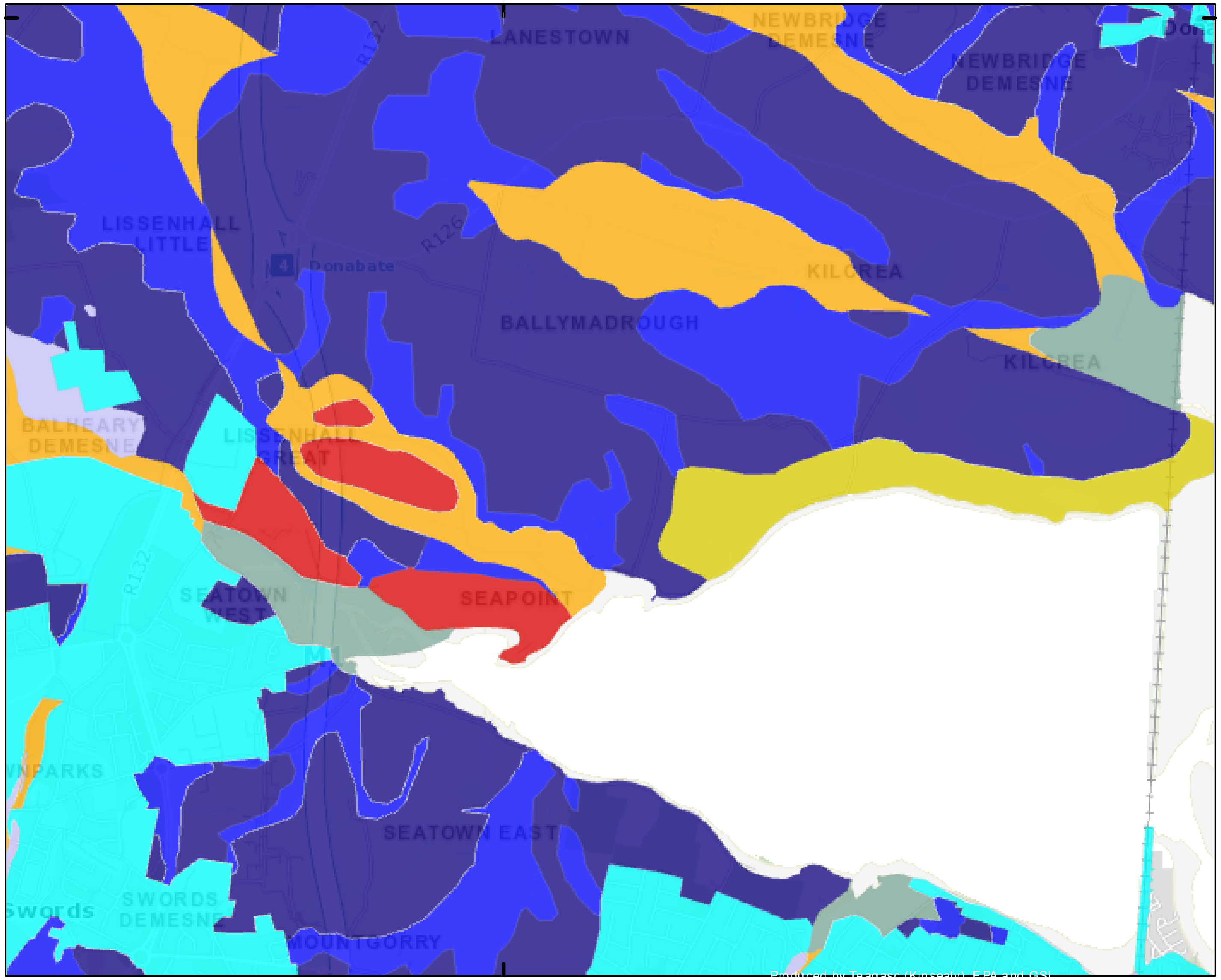
Geological Survey Ireland Public Data



Legend

TEAGASC_Soils_50K...

- AminDW - Deep well drained mineral (Mainly acidic)
- AminPD - Mineral poorly drained (Mainly acidic)
- AminPDPT - Peaty poorly drained mineral (Mainly acidic)
- AminSW - Shallow well drained mineral (Mainly acidic)
- AminSP - Shallow poorly drained mineral (Mainly acidic)
- AminSPPT - Shallow peaty poorly drained mineral (Mainly acidic)
- AminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly acidic)
- BminDW - Deep well drained mineral (Mainly basic)
- BminPD - Mineral poorly drained (Mainly basic)
- BminPDPT - Peaty poorly drained mineral (Mainly basic)
- BminSW - Shallow well drained mineral (Mainly basic)
- BminSP - Shallow poorly drained mineral (Mainly basic)
- BminSPPT - Shallow peaty poorly drained mineral (Mainly basic)
- BminSRPT - Shallow, rocky, peaty/non-peatymi... complexes (Mainly basic)
- BktPt - Blanket peat
- FenPt - Fen peat
- RsPt - Raised Peat
- Cut - Cutover/cutaway peat
- AlluvMIN - Alluvial (mineral)
- AlluvMRL - Alluvial (marl)
- Lac - Lacustrine type soils
- Scree - Scree
- AeoUND - Aeolian undifferentiated
- MarSands - Marine sand and gravel
- MarSed - Marine/estuarine sediments
- Made - Made ground
- Water - Water
- Unclass

Scale: 1:25,000

0 0.175 0.35 0.7 mi

0 0.275 0.55 1.1 km

Geological Survey Ireland

Map Centre Coordinates (ITM) 720,411 748,173

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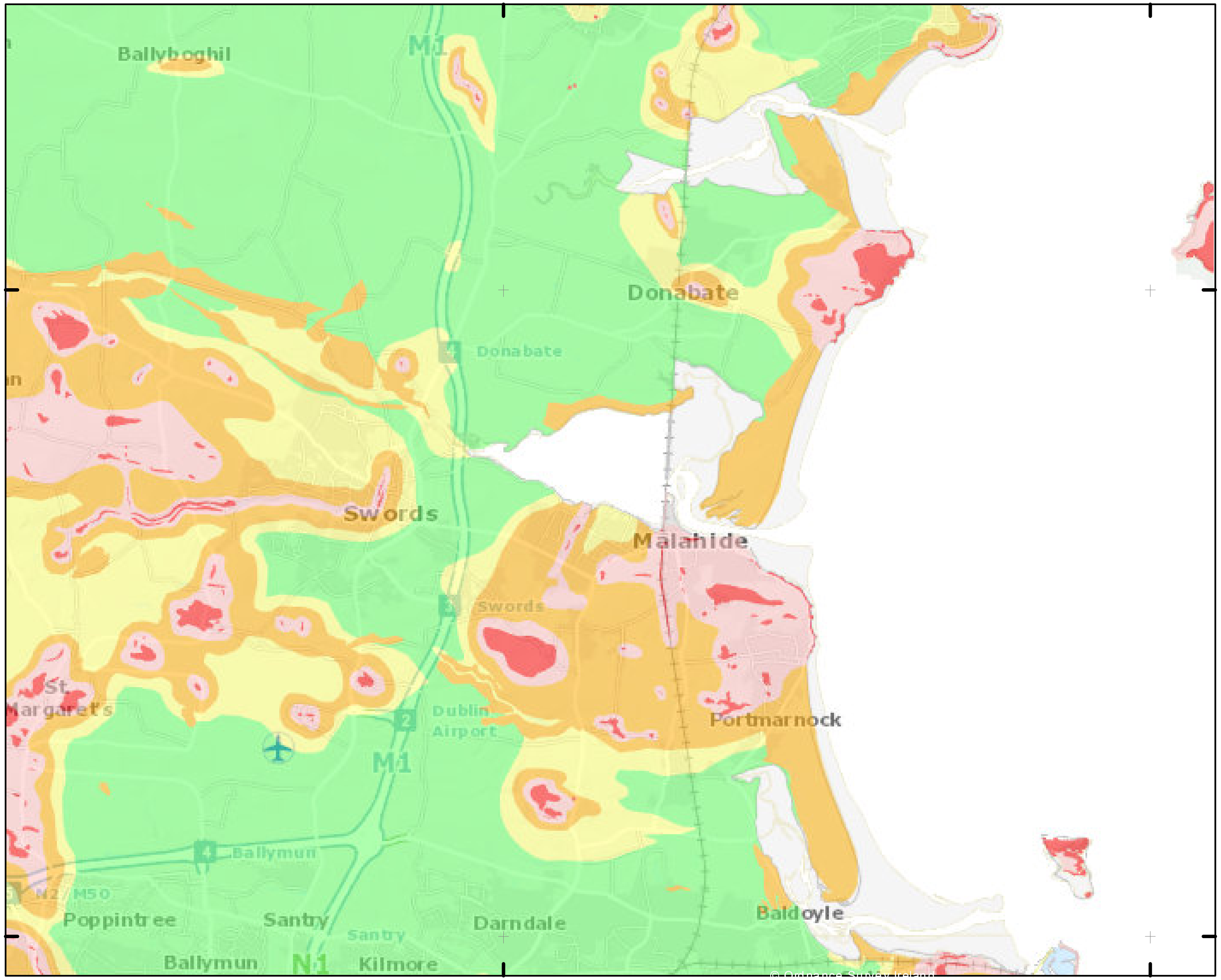
Geological Survey Ireland Public Data



Legend
Groundwater Vulnerability
- Rock at or near Surface or Karst
- Extreme
- High
- Moderate
- Low
- Water

Scale: 1:100,000

Geological Survey Ireland

Map Centre Coordinates (ITM) 721,635 746,906

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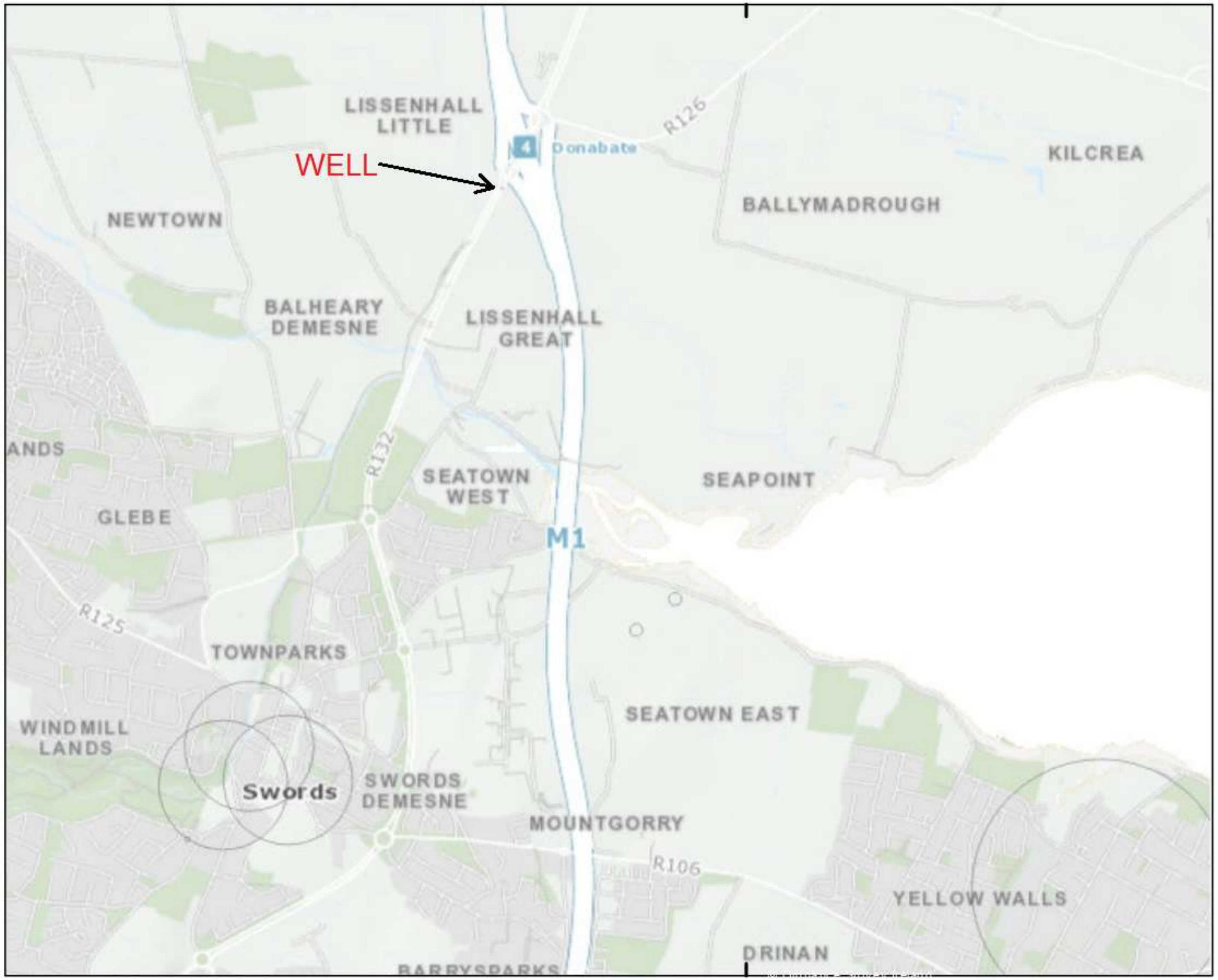
Geological Survey Ireland Public Data

Legend

Groundwater Wells and Springs



Scale: 1:25,000

Geological Survey Ireland

0 0.175 0.35 0.7 mi

0 0.275 0.55 1.1 km

Map Centre Coordinates (ITM) 719,465 747,718

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APPENDIX B – Suds Strategy Overview Drawing

SITE LAYOUT PLAN SHOWING PONDS
(Filter Drains, Permeable Paving and Wetlands Omitted for Clarity)
Scale: 1:2000

FIGURED DIMENSIONS ONLY TO BE TAKEN FROM THIS DRAWING.
ALL DIMENSIONS TO BE CHECKED ON SITE.

CONSULTANTS TO BE INFORMED OF ANY DISCREPANCIES BEFORE WORK PROCEEDS.

Rev	Date	Description	By	Chkd

Client
THE SWORDS PARTNERSHIP

Project Title
LISSENHALL EAST
LOCAL AREA PLAN

Drawing Title
SuDS STRATEGY OVERVIEW

Architect

Scale 1:2000 @ A1	Date JAN. 2017
Drawn WOJCIECH PRUS	Chkd RAY GOGGIN
Cad File: S:\1289\1289-1	

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Drawing Status	Job Number	Drawing Number	Revision
PLANNING	1289-1	C03	

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