GREATER DUBLIN STRATEGIC DRAINAGE STUDY

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Overall Policy Document

Volume Two
New Development

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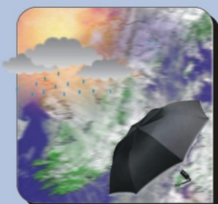

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REGIONAL DRAINAGE POLICIES
Technical Document

VOLUME TWO
New Development

March 2005

NDP
NATIONAL DEVELOPMENT PLAN

Dublin Drainage
A Strategic Study for Greater Dublin

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EXECUTIVE REPORT

Background

The brief for the Greater Dublin Strategic Drainage Study requires the development of policies appropriate to the provision of future drainage services in the region. These policies would assist Local Authorities to comply with their legal responsibilities, their planning and development objectives and would, in so far as practicable, conform to good international practice. A particular requirement from the study is that policies adopted across the region should facilitate a uniform and consistent approach to urban drainage infrastructure planning, design, construction and operation.

Policy Objectives

This volume of the policies is entitled “New Development” and is concerned with identification of similar approaches for the Local Authorities to adopt as to how drainage infrastructure for new development is managed. This requires an approach based on Best Management Practices (BMPs) from international experience, so that the following objectives are achieved:

- Emphasis on the role of drainage management in addressing environmental legislation, such as the Water Framework Directive, and systems set up to promote that role;
- Emphasis to developers and the public at large that sustainable drainage systems is mandatory, as a corner-stone on achieving environmental improvement for the region’s watercourses;
- New design approaches will be implemented to support SuDS and stormwater control in general;
- Liaison between Council Planning and Drainage Departments ensuring that drainage infrastructure for new developments will be co-ordinated;
- Management of planning applications, and drainage involvement will be co-ordinated;
- Ensuring that planning approvals will only be given to sustainable developments, avoiding floodplains, overloaded drainage systems and the like;
- Taking in charge procedures and requirements will be consistent;
- Taking in charge requirements for sustainable urban drainage systems will be consistent;
- Specifications and practices for design, materials and construction will be consistent;
- Drainage construction quality will be improved, thus reducing the current high occurrence of illegitimate flows in the drainage system;
- Drainage standards and practices will be periodically reviewed to take account of changes in technology, industry practices and local requirements;
- Promoting electronic management of drainage matters, such as planning applications and taking-in-charge, to improve efficiency within the Council departments and provide better service to the public;
- Promoting drainage systems as assets to be understood, protected and preserved for the environment and future generations.

Policy Details

Basic Definitions

Basic system definitions, for example the meanings of the terms “sewers” and “drains” are contained in current guideline documents, such as the Building Regulations. These documents contain basic policy principles, such as for separation of foul and storm drainage, which are proposed to remain.

Planning Implications

The principle of sustainable development required in the Planning and Development Act, 2000 is proposed to remain. The Regional Policies seek to fully support this principle, and the Act’s requirement that drainage considerations be included in the planning process.

The Act also seeks to systemise the planning application process, which these Policies support. The objectives of the policy are thus to:

- Ensure that the Planning Department maintains control of the planning process, and manages developments through use of a planning database;
- Ensure that proposed development is compatible with existing and proposed drainage infrastructure;
- Ensure that the Drainage Department agrees the requirements for the new development;
- Ensure that the Planning Department understands any constraints imposed by the Drainage Department on new development;
- Ensure that the Planning Department imposes any requirements specified by the Drainage Department related to new development;
- Ensure that the Developer understands any requirements for the design, construction and taking-in-charge of new development;
- Ensure that all drainage construction complies with satisfactory design and construction standards;
- Ensure that all records of new development are satisfactorily managed.

The Policy includes four procedures, corresponding to the phases in the life of a typical development.

The first procedure for **Development Plan Liaison** deals with the involvement of the Drainage Department (and other utility departments) in the production of the Council’s Development Plan.

The second procedure for **Planning Application Procedures and Approvals** covers the selection and review of planning applications, and approval by the Local Authority of the Developer’s Planning Application. The third procedure for **Drainage Construction and Connection** is concerned with the monitoring of site work, connections to the public system and associated certification.

The fourth procedure for **Taking in Charge** deals with the taking over of drainage from the developer, the final inspections and completion of agreements.

The purpose of the procedures, and their linkage to the Regional Drainage GIS, is to systemise the flow of information relating to planning decisions. The proposed management of information will allow drainage engineers to reach decisions in the shortest period, and with the greatest confidence in the correctness of their advice.

Design

The Policy is to maintain current guidelines for design of small residential developments, with the recommendation that daily flow allowances per dwelling be reduced in recognition of reduced occupancy trends.

All new development will incorporate Sustainable Drainage Systems (SuDS) unless it can be demonstrated that such facilities are not feasible. Where SuDS cannot be provided, the developer must provide alternative means of dealing with pollutants.

The Policy for stormwater systems will incorporate the principles of SuDS, and amend the existing DCC publications “Stormwater Management Policy for Developers” and “Stormwater Management Policy Technical Guidelines”.

Specifications

In view of the current lack of an Irish water industry specification, the Policy is that a Specification Committee be set up to produce such documents, and periodically update to reflect developments in technology and working practices.

Policy Acceptance and Implementation

Acceptance of new policies for urban drainage across the region will require implementation at various levels, as follows:

- **Drainage Departments:** Council Departments to raise its profile in planning and management of drainage infrastructure, including flood risk assessment and stormwater management;
- **Drainage Involvement in Planning**: Council Departments should adopt the policies and procedures to co-ordinate drainage infrastructure with new development;
- **Development Plans:** Should make allowance for drainage aspects, including provision of drainage infrastructure, risk of flooding and isolation of basements;
- **Council Liaison:** liaison committee to be maintained to implement Study recommendations with the ongoing role of agreeing future drainage matters for the region;
- **Public Liaison:** Sustainable Drainage Systems (SuDS) to be included in all new development and promoted by the setting up of a Regional Working Party of all stakeholders;
- **Design:** Design standards and emerging Codes of Practice will be required to ensure co-ordinated and consistent implementation of drainage systems;
- **Construction:** Requires that appropriate specifications are developed for the construction of drainage systems to satisfactory quality standards, including testing/acceptance procedures and standards of completion;
- **Drainage Department Management:** Most critical of all will be the effect on the Local Authority Drainage Departments of the policies on monitoring of construction, requiring additional staff resources or use of agencies. The setting up of a Drainage Inspectorate on a Regional basis should be considered.

1 INTRODUCTION

This document comprises Volume 2 of the Regional Policies being developed as part of the Greater Dublin Strategic Drainage Study (GDSDS) and is entitled “New Development”.

The objectives of the New Development Policies are to identify similar approaches for the Local Authorities to adopt as to how drainage infrastructure for new development is managed. Among the issues considered are:

- Legal requirements regarding new development, in particular the Planning and Development Act, 2000;
- Existing drainage regulations, in particular the Local Government (Sanitary Services) Acts 1878 to 1964 and the Building Regulations, 1997;
- Liaison between Council Departments to promote similar approaches;
- Procedures for drainage aspects of new development, involving Council Departments and developers;
- Design, materials and construction specifications to promote similar standards.

The departments principally involved in the new development process are the Planning Department, Drainage Department, Building Control and Roads Department. The Parks Department will be involved in stormwater management, using Sustainable Drainage Systems (SuDS). The level of co-ordination needed depends on the size of the Authority, and will vary from the largest, Dublin City Council, to the smallest, Bray Urban District Council. However the principles and procedures constituting the policy should be uniform across the region, and independent of size of Council.

The policies must be practical, capable of support, and compatible with the objectives of the other Regional Policies, in particular the policy for Environmental Management.

1.1 Background Investigations

During May 2002 the Consultant met with the drainage engineers for all constituent Local Authorities, to discuss their current practices and policies for dealing with new development. Some meetings also involved representatives from operations, planning and design departments. All meetings were held on an informal basis, and provided an invaluable insight into the working practices, difficulties and aspirations of the Councils’ technical staff.

The meetings also allowed the Consultant to explain to the Councils’ front-line staff the overall principles behind the Regional Policies for New Development, which are to systemise the procedures, and provide common principles and parameters, with the overall intention of streamlining the drainage management process. The meetings also discussed how other areas of the Study, such as the Regional Drainage GIS, could support the new development process.

Common areas of policy and practice between the Councils, with respect to drainage of new developments, include:

- The Planning Department controls the management of planning applications;
- The Planning Department manages the Taking in Charge process;
- Stormwater management principles, such as SuDS, are being promoted;
- Foul/combined sewerage is managed by of the Drainage Department;
- Stormwater drainage is managed by both the Drainage and Roads Departments.

1.2 External Investigations

We have also investigated the practices of some of the Water Companies in UK, who have been faced with the similar needs to systemise their operations. Approaches within the Water Companies have been different and have changed with time and experience.

The UK Water Companies generally started with Local Councils being responsible for sewerage and drainage through agency agreements. Some companies maintained that arrangement, while others took the design function “in-house” and left maintenance with the Councils. Other Companies, such as Welsh Water, have split the sewerage and drainage function and sub-contracted to specialist firms.

Case Study – Management of Sewerage Operations in Welsh Water UK

This Water Company provides water supply, drainage and sewerage services to some 3 million consumers. Their customers’ requirements vary hugely, from the major industrialised cities of Cardiff and Swansea to hill farmers in Central and North Wales.

In 1999 Welsh Water envisaged that efficiency and conformity of service could be improved by standardising their main operating procedures. A Pilot Study was run for one year, involving three Councils and local Consultants, during which sewerage management was analysed. Detailed procedures, job responsibilities and work specifications were produced for every aspect of the operation and maintenance of the business, for the use of developers, planners, consultants, operators and contractors.

The Pilot Study concluded that three major functions were needed, being Network Development, Sewerage Operations and Pumping Station Operations. These functions were set up in 2000 as a partnering arrangement, to cover the whole of Wales in three geographic areas.

These arrangements successfully completed their third year of operation in April 2004.

While we are not suggesting that such arrangements are suitable for the Dublin Region, the procedures and specifications created to manage the design and operation of the drainage function are very relevant.

1.3 Report Format

After the Executive Report and Introduction, Chapter 2 provides an appreciation of the legal background and the interface between Planning and drainage infrastructure. This chapter introduces the concept of procedures for managing the planning process.

Chapter 3 introduces the concept of procedures for managing the drainage aspects of the planning process, involving Council Planning and Drainage Departments and developers.

Chapter 4 covers the application of sustainable drainage systems to new development, in particular the practical requirements for taking in charge of sewerage, drainage and SuDS facilities.

Design matters relating to foul sewerage are contained in Chapter 5, with stormwater drainage design contained in Chapter 6. The recommendation is that information in Chapter 6 will update that contained in DCC Stormwater Policy documents.

Chapter 7 reviews the current situation on water industry specifications, and proposes that new specifications be prepared.

Chapter 8 summarises the Policies for New Development, and deals with their implementation.

The suggested requirements for Planning Applications and for taking-in-charge of drainage are contained in Appendices A and B.

Appendices C, D and E contain detailed information and examples to support the stormwater design processes contained in Chapter 6.

Appendix F contains particular specifications relating to common drainage matters.

Appendix G contains standard drawing information.

2 GENERAL

2.1 Legal Requirements to Support Policies

Current legislation relating to drainage involvement in new development includes:

- Local Government (Sanitary Services) Acts 1878 to 1964;
- Building Regulations, 1997;
- Planning and Development Act, 2000.

The Drainage Department of the Local Council represents the Sanitary Authority under current legislation.

2.1.1 Definitions

Basic system definitions, in accordance with the legislation are contained in the "Recommendations for Site Development Works for Housing Areas". "Drains" are defined as underground pipework or conduits for the conveyance of foul or surface water, not intended to be taken over and maintained ("taken in charge") by the Local Authority. This definition is extended to include "Shared Drains" which are defined as single private drain used for the drainage of two or more separate premises.

"Sewers" are defined as underground pipework or conduits for the conveyance of foul or surface water, which are intended to be taken in charge.

The Building Regulations state "No part of a drainage system conveying foul water shall be connected to a sewer reserved for surface water and no part of a drainage system conveying surface water shall be connected to a sewer reserved for foul water". This statement thus confirms that the drainage of all developments must be separate, and by implication that the sewerage systems serving those developments must also be separate.

Sustainable drainage systems (SuDS) require that surface water runoff be separated from foul flows and controlled on site, with the view of minimising discharge of stormwater from the site. Such systems also dictate separate foul and storm drainage systems. SuDS are being recommended for adoption in the Dublin Region, as expanded upon in later Chapters.

Separation of Foul and Storm Drainage

Existing Policy to be maintained: Drainage systems for foul water shall be connected to foul sewers, and drainage systems for surface water shall be connected to surface water sewers

New development shall incorporate SuDS for stormwater control and environmental improvement

2.1.2 Drainage Objectives in the Development Plan

The First Schedule of Section 10 of the Planning and Development Act, 2000 states that Development Plans should have the following objectives, with respect to drainage:

- Regulating, restricting or controlling development in areas at risk of flooding (whether inland or coastal), erosion and other natural hazards;

- Regulating, restricting or controlling development in order to reduce the risk of serious danger to human health or the environment;
- Regulating and controlling, in accordance with the principles of proper planning and sustainable development, the following: the provision of water, waste water, waste and public lighting facilities;
- Ensuring the provision and siting of sanitary services;
- Protecting and preserving the quality of the environment, including the prevention, limitation, elimination, abatement or reduction of environmental pollution and the protection of waters, groundwater, the seashore and the atmosphere;
- Prohibiting, regulating or controlling the deposit or disposal of waste materials, refuse and litter, the disposal of sewage and the pollution of waters.

From the drainage perspective, these objectives should be encapsulated in the general policy statements on the Council Development Plans:

Objectives for Drainage Planning of New Development

New development shall be controlled in areas at risk of flooding, erosion and other natural hazards

New development shall be controlled in order to reduce the risk of serious danger to human health or the environment

New development shall be controlled in accordance with the principles of proper planning and sustainable development

New development shall include the provision and siting of sanitary services

New development shall protect and preserve the quality of the environment

New development shall control the deposit or disposal of foul sewage and surface run-off, the disposal of sewage and the pollution of waters

Existing and new development lands shall be categorised in terms of risk of flooding with appropriate planning controls

2.1.3 Refusal of Planning Permission

The Fourth Schedule of the Planning and Development Act, 2000 states drainage related reasons for refusal of permission:

1. Development of the kind proposed on the land would be premature by reference to any one or combination of the following constraints and the period within which the constraints involved may reasonably be expected to cease-
    - An existing deficiency in the provision of water supplies or sewerage facilities;
    - The capacity of existing or prospective water supplies or sewerage facilities being required for other developments;
2. The proposed development is in an area which is at risk of flooding;

3. The proposed development would cause serious air pollution, water pollution, noise pollution or vibration or pollution connected with the disposal of water.

2.1.4 Granting of Planning Permission

The Fifth Schedule of the Planning and Development Act, 2000 states drainage related conditions, which may be imposed on the granting of permission:

1. A condition under *paragraphs (g) and (j) of section 34(4),* requiring the giving of security for satisfactory completion of the proposed development (including maintenance until taken-in-charge by the local authority concerned of roads, open spaces, car parks, sewers, water mains or drains);

2. A condition, included in a grant of permission pursuant to *sections 48 or 49*, requiring the payment of a contribution for public infrastructure benefiting the development;

3. Any condition relating to the regulation, restriction and control of development of coastal areas or development in the vicinity of inland waterways;

4. Any condition regulating, restricting or controlling development in areas at risk of flooding;

5. Any condition relating to the provision and siting of sanitary services and waste facilities, recreational facilities and open spaces;

6. Any condition relating to the protection and conservation of the environment including the prevention of environmental pollution and the protection of waters, groundwater, the seashore and the atmosphere;

7. Any condition prohibiting, regulating or controlling the deposit or disposal of waste materials and refuse, the disposal of sewage and the pollution of rivers, lakes, ponds, gullies and the seashore.

The Planning and Development Act requires that the period from receipt of planning applications to decision be no longer than 8 weeks.

2.2 Drainage Involvement in New Development

This Policy Document deals with the relationship between Drainage and Planning Departments and Developers, with particular respect to new development and its effect on the existing and future drainage infrastructure.

The objectives of the policy are to:

- Ensure that the Planning Department maintains control of the planning process, and manages developments through use of a planning database;

- Ensure that proposed development is compatible with existing and proposed drainage infrastructure;

- Ensure that the Drainage Department specifies the requirements for the new development. The conditions should be standardised as far as possible, with purpose-made requirements to suit the Council and particular development;

- Ensure that the Planning Department understands any constraints imposed by the Drainage Department on the new development;

- Ensure that the Planning Department imposes any requirements specified by the Drainage Department related to new development;

- Ensure that the Developer understands any requirements for the design, construction and taking-in-charge of the new development;
- Ensure that all drainage construction complies with satisfactory design and construction standards;
- Ensure that all records of new development are satisfactorily managed.

The Policy comprises four procedures, corresponding to the phases in the life of a typical development.

The first procedure for **Development Plan Liaison** deals with the involvement of the Drainage Department (and other utility departments) in the production of the Council's Development Plan.

The second procedure for **Planning Application Procedures & Approvals** covers the selection and review of planning applications, and the approval of the Planning Application from the Developer.

The third procedure for **Drainage Construction and Connection** is concerned with the monitoring of site work, the making of connections to the public system and associated certification.

The fourth procedure for **Taking in Charge** deals with the taking over of drainage from the developer, the final inspections and completion of agreements.

The procedures are demonstrated by coloured flow diagrams with accompanying text in Chapter 3.

<u>Drainage Involvement in New Development</u>

The following procedures will be adopted by Planning and Drainage Departments:

Development Plan Liaison

Planning Application Procedures and Approvals

Drainage Construction and Connection

Taking in Charge

2.3 Inter-Local Authority Discharges

All Local Authorities will be applying a charge for cross-border sewage flows contributing to their collection and treatment systems.

For example, Dublin City Council will be charged, by the plant operators, for all sewage flowing into the upgraded Ringsend WwTW. In addition to Dublin City, the Councils that contribute foul flows are Dun Laoghaire Rathdown, Fingal, Meath and South Dublin.

The cost of treating the sewage is based on a combination of the flow and organic load as it enters the treatment plant. Dublin City Council will in turn charge the adjacent Councils based on their flow and load.

Dublin City Council is installing permanent flow monitors on trunk sewers as they enter and cross their boundary from the adjacent Council areas. Readings taken from these monitors will be used to establish the actual flows being discharged from the adjacent Council areas into the Ringsend

WwTW catchment. The organic load will be established by taking regular samples at the cross border locations.

Similar arrangements will be needed for Meath sewage contributions to the new WwTW at Balbriggan, and for Wicklow discharges from Bray to Shanganagh.

Inter-Local Authority Discharges

All Local Authorities will charge neighbouring Councils for all sewage flow contributions to their collection and treatment systems

Treatment costs will be based on measurements of flow and organic load in the trunk sewers as they enter and cross the boundary between Local Authorities

2.4 Liaison Between Councils

The Steering Committee for the GDSDS has set up a Liaison Committee to co-ordinate the work of the Councils involved in the Study. This committee proved to be a useful forum for the Councils' drainage engineers.

The results and recommendations of the GDSDS will require Council involvement long after the completion of the Study, in such topics as:

- Roll out and implementation of the Regional Policies;
- Agreement and implementation of the Regional Drainage GIS;
- Updating of the Drainage Strategy resulting from the GDSDS;
- Resolving staffing arrangements resulting from recommendations.

It is therefore recommended that liaison be continued after the completion of the GDSDS.

Liaison Between Councils

The GDSDS Liaison Committee should be continued to implement the recommendations of the Study, and to agree on drainage matters as affecting the Councils of the Region

2.5 Liaison with the GDSDS

Relative to the life of drainage assets, the duration of the GDSDS represents a snapshot of the drainage of the Region. Planning scenarios, asset databases and hydraulic models are being produced as part of the Study, which should be updated to maintain their value to the Client Authorities.

Although the Study will produce paper-based reports of strategy etc, the electronic format of much of the base data means that maintenance and updating is readily achievable. Transfer of the Study GIS into the Regional Drainage GIS will provide much of the impetus.

Liaison with the GDSDS

The GDSDS Liaison Committee should promote maintenance of drainage data to support future drainage strategy in the Region

2.6 Development on Floodplains

Section 5.7 of the Regional Policy for Environmental Management recommends the following:

- Local authorities to actively participate in the National Flood Policy Review, being facilitated by the Office of Public Works (OPW);
- Local authorities to control development in the natural flood plain of rivers and develop guidelines, in co-operation with the adjoining local authorities, for permitted development in different flood risk category areas;
- Local authorities to require all significant developments impacting on flood risk areas to provide a Flood Impact Assessment, to identify potential loss of flood plain storage and how it would be offset in order to minimise impact on the river flood regime;
- Local authorities to require all developments to submit, prior to commencement, details of a Sediment and Water Pollution Control Plan, for the agreement of the Drainage and Environmental Departments.

In supporting these policies, the overall objectives of the New Development policy should be that:

- Local authority Drainage and Planning Departments understand the extent of flood plains, and the likelihood of such areas being flooded, by the production of flood risk maps;
- Development should not take place which has an unacceptable risk of flooding, leading to danger to life, damage to property and wasteful expenditure on remedial works;
- Development should not create or exacerbate flooding elsewhere;
- Development should not take place that prejudices possible works to reduce flood risk.

The Planning and Drainage Departments should generally steer inappropriate development away from flood plains. However a developer may wish to develop within the flood plain, in which case the onus should be on the developer to prove that his development will not be at risk of flooding or increase risk of flooding elsewhere.

Councils should promote these principles at two levels:

County Development Plan

Local authority Drainage Departments should produce flood risk maps of watercourses within the Dublin region. Many watercourses will cross Council boundaries, and such mapping will require liaison between the affected Councils. These flood risk maps should be integrated into the various County Development Plans, with the Planning and Drainage Departments categorising land for development.

In practical terms there will be pressures to develop land in areas under flood risk, where the more pragmatic approach is to manage flood risks rather than ban development.

The risk categories for future development should be:

1. Low risk from flooding, **no restrictions to development**;

2. Medium risk from flooding, **development allowed only with approval of flood impact assessment**;

3. High risk from flooding, **only certain types of development allowed subject to flood impact assessment, flood defence and warning facilities**;

4. Known areas of flooding, corresponding to the 1 in 100 year flood boundary (preferable) or 1 in 50 year flood boundary (minimum), **no development allowed**.

Where houses or other developments are located close to watercourses the finished floor level shall be a minimum of 500mm above the highest recorded flood level, or the boundary of the 1 in 100 year flood event, whichever is the higher.

The flood risk maps will also identify existing development within the risk categories. The Councils should seek to remove existing inappropriate development, particularly during redevelopment, and such lands should be marked accordingly in the Development Plan.

Subject to access and operational requirements, medium and high flood risk areas would generally not be suitable for essential civil infrastructure, such as hospitals, fire stations and emergency depots.

For high-risk areas, residential, commercial and industrial development would be subject to provision of flood defence and warning facilities, with preference against creation of new areas. Development in sparsely populated areas should not be permitted. Development of sports and amenity areas would be possible, with minimum infrastructure to service its use. No caravan or camping sites would be allowed.

Where flood risk maps are not available, the developer will be required to assess the flood risk for his site, in accordance with the above requirements.

Planning Approval

To obtain planning approval within medium and high risk areas, the developer should demonstrate that his site will be provided with appropriate flood defence, that it will not impede flood flows, that it will not result in a net loss of floodplain storage, and that it will not increase flood risk elsewhere.

The developer will therefore carry out a Flood Impact Assessment for his site, including the following minimum requirements:

- Liaison with the Council Drainage Department on available information on the site and its environs;

- Location plan of geographical features, watercourses and other bodies of water, cross-referenced to the existing drainage system;

- Site plans showing development and supporting infrastructure with both existing and proposed levels and contours;

- Location plan of flooding sources with existing information on extent and depth of flood events, flood risk boundaries and climate change effects;

- Assessment of flooding events, their effect on drainage, runoff, and impact on water courses and local areas;
- Design of any flood defences, storage compensation and watercourse modifications proposed, together with their effect under storm events;
- Site plans of routes of any overland flows resulting from flooding or blockage of drainage facilities, demonstrating that such flood routing will not cause detriment within or outside the site.

Failure to meet approval should result in the planning application being delayed or refused. Where the planning application is granted the developer should, prior to commencement, agree with the Drainage and Environmental Departments of the Council, the Sediment and Water Pollution Control Plan for the site.

Development on Floodplains

Flood risk mapping for the Dublin Region to be produced. Where such flood risk mapping is not available the developer will assess the flood risk for his site

Planning and Drainage Departments to categorise existing and future development areas in terms of low, medium, high and unacceptable flood risk, and state on Development Plans

Planning permission to be granted in accordance with flood risk categories

Planning permission for development in areas of flood risk to be subject to satisfactory Flood Impact Assessment

All development sites to operate under an agreed Sediment and Water Pollution Control Plan

2.7 Development Near Riparian Corridors

Section 5.3 of the Environmental Management Policy recommends the following for watercourses:

- Planning authorities to clarify riparian rights and responsibilities in urban areas and codify with planning instruments;
- Planning authorities to maintain or create where possible, a 10m to 15m wide riparian buffer strip either side of all watercourses measured from top of bank;
- DoEHLG, OPW and local authorities to establish a working group to oversee preparation of a guide on Irish river rehabilitation and a public education programme;
- Local authorities to evaluate all watercourses for rehabilitation potential, particularly in conjunction with sustainable drainage measures;
- Local authorities to undertake pilot studies for rehabilitation/enhancement of watercourses.

The main recommendation affecting new development policy relates to the maintenance or creation of buffer strips.

<u>Riparian Corridors</u>

New development will not be permitted within a 10m to 15m wide riparian buffer strip, either side of all watercourses measured from top of bank

Redevelopment shall seek to create riparian buffer strips in conjunction with other rehabilitation/enhancement measures for watercourses

2.8 Basements in New Development

The Regional Policy on Basements recommends that a register of basements be prepared containing information on location, use, floor level, drainage infrastructure and flooding history. The intention is to produce a register of at-risk properties, and to use hydraulic models to understand where basements are currently at risk, and would be at future risk from new development and climate change effects. The Regional Policy also recommends that basements in all new developments be hydraulically isolated from the Councils' drainage systems.

Planning applications for premises with basements should satisfy the Drainage Department on the following:

- Details of proposed basements, use, and drainage facilities;
- Level of risk to basements presented by the local drainage;
- Means of isolation of basement drainage from the Councils' systems.

The preference would be that all new basements install pumping stations to lift basement drainage to ground level, as it can discharge by gravity. Basement drainage installations would be subject to inspection by the Drainage Department but not be taken-in-charge. Capital, on-going costs and overall maintenance responsibility would remain with the owner.

The regional policy document on Basements (Ref: GDSDS/NE02057/28-06) should be consulted for more information.

2.9 Ransom Strips

Ransom Strips are corridors of land (usually narrow) left by developers through their developments to facilitate (and charge for) access for services for adjacent developments. Such charges are often excessive, and the practice should be curtailed.

Drainage layouts and plot boundaries should be reviewed to identify any obvious strips of land being left between the development and adjacent land and any oversizing of pipes without explanation. It is recognised that it is difficult to identify such instances where the developer is determined to obscure his intentions. Site inspectors should also be vigilant for unexplained revisions to boundaries or additional connections.

<u>Ransom Strips</u>

The use of Ransom Strips is to be curtailed, by review of drainage layouts at Planning Application stage to identify any obvious opportunity being created by the applicant. Site inspectors should be aware of the practice, and be vigilant for such opportunities being created on site

3 PROCEDURES

3.1 Development Plan Liaison

3.1.1 Current Arrangements

Development Plans are the responsibility of the Council's Planning department, who every 6 years prepare the maps of existing and future development for the County. The Planning and Development Act, 2000 requires that Development Plans should be compliant with Regional and Strategic Planning Guidelines. The Planning Department also prepares Local Plans for specific major development areas, and future development for each Local Authority. The Development Plans can be amended during their life by Planning Variations, authorised by the Council Members.

Section 11 of the Act requires the Planning Authority "to consult with….other services to ascertain any long term plans for the provision of the infrastructure and services in the area of the planning authority and the providers shall furnish the necessary information to the planning authority."

The processes for preparation, review and agreement of Development and Local Plans and their Variations are described in Sections 12, 13 and 19 of the Planning and Development Act, 2000. Each process involves public notification of the planning proposals and periods for comments and review. These reviews are the formal opportunity for the Drainage Departments to be involved in the preparation of County Development Plans, providing advice on the availability of sewerage and sewage treatment facilities to service the future developments.

3.1.2 Proposed Arrangements

It is proposed that the involvement of the Drainage Department, in the preparation of Development Plans, be formalised. The intention is for the Planners and Council Members to appreciate how development lands are serviced, rather than for the Drainage Department to dictate where development will take place. Planners also need to understand the flood risk attaching to all development lands, which could influence the type of development or indeed whether any development should be undertaken.

Where drainage and/or treatment are not available, then developments can be deemed to be "premature". In such circumstances, timescales for the development can be stipulated to suit the provision of supporting infrastructure.

The flowchart entitled "Development Plan Liaison" shows the sequence of actions involving the Planning and Drainage Departments.

Details of the Procedure

The enquiry stage involves the initial comparison of the draft Development Plan with the development assumptions within the Drainage Department's Strategy Plans for the affected foul/combined and stormwater catchments. These Strategy Plans will initially be those produced under the GDSDS, comprising upgrading works at both strategic and catchment levels. These Plans will thereafter be updated by the Councils as implementation of the Strategy Plans (and their subsequent amendments) takes place. The Drainage Department may require further clarification of development proposals, such as housing density, occupancy ratios, etc.

The consultation stage requires the Drainage Department to compare foul flows and surface run-offs generated by the proposed developments with those allowed for in the Drainage Strategy Plans. This will be done by quantifying the flows from the different types of development proposed and comparing with those from the assumed developments. Where there are appreciable differences, the hydraulic models should be modified and re-run to confirm the effects on system performance. Similarly the treatment loads should be compared with the assumptions in the Drainage Strategy Plan, and significant anomalies identified. Proposals for development lands should be compared with the Drainage Department's flood risk maps to confirm that proposed types of development are compatible with the flood risk categories, or indeed if lands should be developed at all.

The consultation stage ends with the Drainage Department comparing the proposed extent of development with the provision of infrastructure under the Drainage Strategy Plan. Any incompatibility identified will need to be scoped, costed and programmed and the Drainage Strategy Plan amended accordingly.

In the response stage the Drainage Department provides comments to the Planning Department on the ability of the existing and proposed infrastructure to service the intended development. These comments may well veto development, restrict its scope and timescale until the supporting infrastructure is in place, or suggest where excess drainage capacity is, or will be available. The flood risk categories and corresponding drainage requirements should be agreed. The Planning Department will then include all such comments in the final Development Plan.

The scope of construction of drainage infrastructure and implementation programmes will inevitably change, due to external constraints and opportunities, such as provision or lack of funds. The Drainage Department should therefore periodically update the Planning Department on such changes and their effect on the provision of drainage infrastructure serving future development in their area. Such information will ensure that the Planning Department understands the availability of drainage installations to service future development and allow them to manage planning issues accordingly.

All plans should be digitally mapped using Council approved software. Land Use categories, symbols and colours should be standardised across the Region. This will allow straightforward understanding and combination of Development Plans between Councils, and minimise confusion for the public.

The term “Development Plan” refers to the plans periodically produced for countywide development, as well as more localised planning documents, such as Action Plans and Local Area Plans. The intention is that all such planning proposals, which include drainage aspects, will have involvement of the Council’s Drainage Department.

3.2 Planning Application Procedures and Approvals

3.2.1 Current Arrangements

Local Authorities encourage developers to discuss drainage requirements for major sites prior to submission of planning applications. Any such discussions are regarded as informal and non-contractual, as they represent the forum for all parties to gain an initial understanding of the issues affecting the development. This approach obviates the need to try and resolve complex drainage issues in a very short time period, and should be continued.

The current procedure for planning applications is governed by the Planning and Development Act, 2000 and managed by the Council’s Planning Department. The sequence of events is:

1. The developer consults the Council’s Drainage Department regarding the availability of foul and storm drainage. The Drainage Department will provide drainage plans for viewing, and discuss the options for connection;

2. The developer submits his application for the site to the Planning Department, accompanied by layout plans and calculations for the foul and surface systems;

3. Section 34 of the Act requires the Planning Authority to make its decision on the application within 8 weeks, so the Planning Department therefore distributes paper copies of the application to the relevant Council departments (drainage, roads, building control, lighting) for comment;

4. Drainage comments often include requests for revised proposals and more information. Such comments are collected by the Planning Department, and requested of the applicant, in which case a further 4 week period is allowed for decision, from the date of receipt of the additional information;

5. The Planning Department collates all departmental comments and conditions into a single reply to the developer;

6. Where no decision is given within the 8-week period, the planning application is deemed to have been granted. Extension of the decision period is allowed with the agreement of the applicant. Applicants for complex or contentious developments often agree to extensions to avoid receiving refusal decisions;

7. Section 48 of the Act allows the Planning Authority to make agreements with applicants restricting the development of lands. This process can be valuable in regulating developments which are premature for the local drainage infrastructure.

The Planning Departments favour standard drainage conditions for simplicity with developers. This system is already being implemented in some Councils, with each Department having its own standard conditions, modified as necessary to suit particular developments.

Section 248 of the Act permits documents or other information to be transmitted in electronic format. The documents or other information include:

- A development plan or any draft or variation of it;
- A planning application and related documents and reports;
- Maps, plans and other drawings;
- Written submissions and observations.

Section 248 also allows the Minister to specify the technology and procedures for producing and managing documents in electronic format.

3.2.2 Proposed Arrangements

The overall principle being proposed is that the events required to carry out development be arranged as a seamless sequence, with each step being recorded in a shared database. This database will follow the life of the development from initial planning application through to processing of as-built records, and hence allow all involved bodies access to information about the status of the sequence, and to make their required contributions. The database would be held and managed by the Planning Department with data exchange to the Drainage Departments through the Regional Drainage GIS.

The same file on the database would then be used to track progress of the planning application through review, construction on site, taking in charge and customer information. Based on the application dates, the database could provide reminders on deadlines for processing, as well as highlight delays in taking in charge, etc.

The new Planning Act aspires to planning applications being managed electronically, and Regional Policy should promote such principles. Fingal County Council has such a system using an electronic, GIS linked, planning register (called PACES) that records applications and decisions. Dun Laoghaire and South Dublin County Councils are using the APAS system, from GIS supplier Swift.

The proposal is that planning applications be categorised, depending on parameters such as number of premises, population, type and plan area. This information would be entered into the planning register database with GIS co-ordinates. Applications should be encouraged to be in electronic format, with digital maps and plans compatible with OSI, to allow ready inclusion in the County development maps. It is recognised that small developers may be unable to provide digital maps and plans, but most other documentation should be possible in digital format, given the widespread use of word-processing and spreadsheet systems on computer.

The ultimate intention would be for planning applications to be made electronically, with developers entering their proposals directly to the database.

The proposed Procedure is demonstrated on the enclosed flow diagram, showing that the Planning Database is the central source of information, sourced by the interested parties.

Details of the Procedure

The Database will contain all applications, but each department providing comments will be interested in particular types of development. The Drainage Department should be made aware of all developments, so that they can assess the impact on the drainage system and the flood risk to the development. All development should be compatible with the flood risk maps and associated categories.

Small developments can present great risk to the drainage system in terms of damage and inflow/infiltration since workmanship may be of a poorer standard than with a large development. For small developments the builder may well be tempted to illegally connect surface water drains to the foul sewers to avoid the inconvenience and expense of installing stormwater drainage. In such circumstances local SuDS measures, such as soakaways could present an effective solution.

Each Council department would have access to the database, being able to select the developments of most relevance, and thus manage their inputs in providing comments. The degree of filtering of planning applications will depend on available resources, and would be the decision of the individual Council.

Comments would be made directly to the database, under the relevant file. Comments would include both standardised and purpose-made conditions. Standardised conditions would be common across the Region. Purpose-made conditions would be those required by the Council and those required for the individual development. The developer should be required to provide the information listed in Appendix A, in support of his application.

Vetting of Planning Applications

All Planning Applications are to be vetted by the Drainage Department, irrespective of size of development or whether the drainage will be taken-in-charge or not

Having the applications mapped and GIS linked will enable direct comparison of the development proposals with the County Development Plans, the availability of services to serve the site, and the flood risk to the development.

Comments from all Departments involved in approval of the development are co-ordinated and issued to the developer by the Planning Department under the Notice of Approval. The developer's subsequent detailed proposals would be vetted by the Drainage Department to ensure that all requirements in the Notice of Approval have been taken on board by the developer and the necessary designs, modifications and other measures have been carried out by him. The results of this vetting are issued through a Compliance Report, ideally prepared by the engineer responsible for the original Notice of Approval. It should be mandatory that a satisfactory Compliance Report is prepared before a Commencement Notice is submitted to the Council.

This procedure details the actions and responsibilities of the main parties to the planning approval process, being the planners, drainage engineers and the developer. As well as technical vetting and approval of Planning Applications, the procedure covers completion of planning agreements and processing of fees and deposits.

3.3 Construction and Connection

3.3.1 Current Arrangements

All Councils acknowledge that quality of construction of drainage works is of utmost importance to the performance of the asset over its lifetime, which can be up to 100 years. Among the results of poor quality materials and workmanship are:

- Premature failure of the pipeline, through cracking or collapse;
- Infiltration of groundwater through poorly jointed pipes and connections;
- Inflow of stormwater into foul systems through improper connections;
- Outflow of sewage resulting in groundwater contamination;
- Increased maintenance through poor quality jointing.

The effects of these problems are already evident in the existing substantial amounts of inflow and infiltration, which are compromising the capacity of collection systems, pumping installations and treatment facilities of the Dublin region. This situation will lead to restrictions on future development and increased maintenance costs. Further information on the adverse effects of defects in the drainage fabric is contained in the Regional Policy on Inflow, Infiltration and Exfiltration.

Monitoring of drainage construction varies, depending on availability of suitably skilled staff. The perception is that the hugely increased pace of development seen in recent years has put much strain on the situation, in that more sites are under construction, using less experienced, and probably less conscientious contractors. Evidence can be seen from the recent modelling results for the Grand Canal catchment, revealing substantial inflow and infiltration from areas of separate drainage and relatively recent construction.

Connection of the site to the main drainage is seen as the best opportunity that the Council has to enforce standards on the developer. This principle should continue.

Councils currently either carry out connections themselves, or allow suitably qualified developers to make the connections, under their monitoring. This practice should continue.

A large number of connections to the system are made as development proceeds and is occupied. These are generally to the newly laid sewers within the development before being taken in charge. There is generally only one connection to the public sewer. However the developer may well connect further phases of development, in which case all phases need to be monitored to ensure that drainage construction for the overall site is satisfactory.

3.3.2 Proposed Arrangements

The proposed procedures are intended to formalise and strengthen the monitoring of construction, with the benefit of much reduced future maintenance and improved performance of the systems. It is proposed that monitoring be carried out by the Local Authority Drainage Department. This arrangement would require increased technical staff in the Drainage Departments or out-sourcing if resources are not available.

The management of construction monitoring and agreements should remain with the Planning Department, with drainage matters being the responsibility of the Drainage Department. The Planning Department would remain responsible for upkeep of the Planning Database, and for collecting monitoring results from the various departments involved in the development.

3.3.3 Details of the Procedure

Together with specific drainage requirements for planning approval, the Council Drainage Department will have supplied the developer with their requirements for drainage construction, in terms of construction details and specifications, and the monitoring and approvals procedure. The Drainage Department will also have approved any Flood Impact Assessment and agreed the Sediment and Water Pollution Control Plan.

The concern with the monitoring process is that although there is overall certification for all phased developments, the connection approval for an early stage should not be extended to subsequent stages without further monitoring of construction. Certification should not be allowed until all drainage construction is satisfactory.

The procedure shown on the Flow Diagram is therefore reiterative, with monitoring at three stages:

- Initial connection of development (of first phase);
- Checking of connection to subsequent phases, or individual premises;
- Latent defect check of drainage for the whole development.

The procedure starts with notification from the developer of site work starting and his intended programme, thus allowing the involved departments to alert their inspectors of their forthcoming involvement in the development. This is done by the developer submitting a Commencement Notice to the Planning Department, which is lodged on the database. The Planning Department can then advise the developer of any particular Council requirements for the construction. These requirements would include the points during and after construction when inspections are required, as well as any testing and survey work required.

The Drainage Department's inspectors then monitor the works for each phase of the development throughout the construction period, concluding with the issue of a snag list on substantial completion. Substantial completion would be when all foul and storm systems are installed and tested and house connections completed. The inspectors will require powers of access to private lands and back gardens.

Having carried out any remedial works, the developer applies for final inspection and connection through the Drainage Department. Further inspection, and snagging as necessary, is carried out until the Drainage Department is satisfied that the systems are of satisfactory quality and then agrees to the connection being made, by issue of the Certification of Rectification of Defects. The connection is then made, and recorded on the Planning Database, thus providing evidence of the existence of new customers and their discharges to the drainage systems.

For subsequent phases of development the same procedure would be followed, with Certification of rectification of Defects issued for each Phase, or individual premises. When the development is completed the Drainage Department carries out a latent defect check on the whole development. The overall Completion Certificate is issued through the Planning Department, and the maintenance period started.

3.3.4 Recommendations for Drainage Inspectorate

Increasing the level of inspection will inevitably result in additional costs to the Councils for more inspectors. These costs can be offset by:

- Increasing charges to developers for processing of their development;
- Charging developers on a time and expenses basis for additional services, such as repeated visits to site;

- Reduction in sewerage infrastructure, pumping and treatment costs as a result of reducing illegitimate flows;

- Increased revenue from new developments able to connect as a result of reducing illegitimate flows.

It is worthwhile to assess the cost of the presence of inflow and infiltration to drainage and treatment systems, using the Ringsend WwTW catchment as an example.

Sewerage modelling under the GDSDS has confirmed that infiltration flows exist in the following major catchments contributing to flows to the Ringsend WwTW:

Catchment	Approximate Infiltration Flow
Grand Canal System	200 l/s
City Centre/Docklands	600 l/s
Dun Laoghaire Rathdown	500 l/s
Rathmines & Pembroke High Level	500 l/s
Total	1800 l/s

Table 3.1 Approximate Infiltration Flows to Ringsend WwTW

The Study also found substantial amounts of infiltration to predominantly separate systems, shown by rapid increases in flow rates in response to rainfall. Figures for inflow are more difficult to quantify, since they require flow monitor information for long periods. Nevertheless the presence of substantial amounts of inflow and infiltration in separate and fairly recent systems indicates that the drainage fabric is in unsatisfactory condition.

Inflow and infiltration can be reduced but it is a difficult and expensive process, and subject to “diminishing returns.” It is much more cost-effective to minimise its occurrence in the first place, and hence there is a pressing need to improve the quality of drainage construction and maintain its condition for as long as possible.

Significant savings in the costs of conveyance and treatment could be achieved by minimising inflow and infiltration, which would in itself pay for the drainage inspectorate. Further information is available in the Inflow/Infiltration/Exfiltration Policy document (Ref: GDSDS/NE02057/028-04).

Cost-effective methods of achieving more widespread and intensive drainage inspection for the Dublin Region would include:

- Sharing inspection work across the Region and Council boundaries, so that staff requirements could be flexibly matched to demands;

- Setting up a small team of dedicated, expert staff of inspectors;

- Providing inspectors with the authority to enter private lands and back gardens to investigate and inspect drainage systems;

- Supporting the team with laptop computers containing maps, sewers records, GIS information, so they can operate independently from Council offices;

- Provide electronic data links for the team to transfer records and information without having to return frequently to Council offices and depots.

The overall objective would be that the Drainage Inspectorate be a well-equipped and knowledgeable team, supported by electronic communications, so that they can maximise their time on site.

3.4 Taking-in-Charge Procedures

Taking in charge is the process whereby ownership and future maintenance of drainage assets passes from the developer to the Council Drainage Department. The Drainage Department therefore needs to be satisfied that the assets have been designed and constructed properly, are functioning satisfactorily and have accompanying record drawings, manuals, etc. to enable them to be maintained in the future.

Taking in charge is undertaken at the developer's request, since the developer does not normally want to retain responsibility for the drainage assets after he has sold the development properties. Some drainage systems, such as those within apartment complexes and industrial estates, remain in private ownership, with maintenance being carried out by the owners or a separate maintenance firm.

There are instances where such systems have had to be taken in charge due to default, and have caused considerable expense to the Councils in refurbishment to achieve satisfactory performance. Since private systems are subject to little or no monitoring of construction, there is the likelihood that many of the defects are located in private drains.

There is therefore a strong case for insisting that all drainage systems shall be designed and constructed to the same standards as those to be taken in charge.

Quality of Drainage Construction

All drainage shall be designed, constructed and monitored to a standard equivalent to that required for systems being taken-in-charge

3.4.1 Current Arrangements

The taking in charge process is managed by the Council's Planning Department, with drainage often being taken in charge in conjunction with the roads. As-built records are held by the Planning Department, and there is often no formal system for transferring such information to the Drainage Department.

Taking in charge agreements and associated bonds are generally managed by the Planning Department. There have been instances where the bond has been insufficient to finance remedial works. In such cases funds have had to be raised from the residents or financed by the Council.

3.4.2 Proposed Arrangements

Management of the taking in charge process should remain with the Planning Department. When the drainage systems have been connected the maintenance period starts, with the Planning Department publishing dates on the Planning Database. The Planning Department issues all Council requirements for meeting Taking-in-Charge requirements, which would include:

- Update of all information supplied in the Taking in Charge Submission to reflect actual construction;
- Up to date Health & Safety file;
- CCTV records of all pipelines;
- Data records in accordance with Local Authority requirements;
- Hydraulic models for medium to large developments, using Council approved software;
- Design calculations, checked and reflecting the final systems installed;
- Records of all tests of materials, installations and equipment;
- Operation and Maintenance manuals for all equipment;
- Maintenance plans for all SuDS installations;
- Flow surveys to be carried out as required by Local Authority;
- As-built record drawings of all pipelines, installations, buildings and compounds.

The arrangements are shown on the Flow Diagram entitled “Taking in Charge of Drainage.”

The maintenance period would be a minimum of one year, with final inspections being arranged for month 10, to allow time for remedial works. The Planning Department would continue to manage the agreement and financial arrangements, and the Drainage Department would have the option of undertaking remedial works at the developer’s expense, should he be in default.

Further details of taking in charge requirements, based on “Sewers for Adoption, 5th Edition” are contained in Appendix B.

3.5 Taking in Charge Requirements for Sewerage and Drainage

3.5.1 Current Arrangements

Sewerage, sewage pumping and sewage treatment facilities are currently taken in charge by the Council Drainage Department. Taking in charge of drainage is shared between the Council Drainage and Roads Departments. Responsibility for the drainage of motorways and trunk roads rests with the Roads Department.

Road drainage for developments is taken in charge by the Roads Department in conjunction with the road itself, but the responsibility for the drainage systems remains with either with the Drainage Department or the Roads Department. Maintenance of highway gullies in such taken-in-charge roads rests with either the Roads or Drainage Departments.

3.5.2 Proposed Arrangements

The taking in charge arrangements for the various elements of sewerage and drainage should be in accordance with Table 3.2.

All pipelines of 150mm diameter and above which are to be taken-in-charge shall be surveyed by CCTV, and the results supplied to the Drainage Department.

The developer shall provide a SUS25 survey of all manholes, etc, within 6 months of completion, with quality monitoring by the Drainage Inspector.

Sewerage and Drainage Element	TiC Responsibility	Comments
Foul Gravity Sewers and Drains	Drainage Dept.	Excepting private drains which are not TiC
Surface Water Gravity Sewers	Drainage or Roads Dept.	Excepting private drains which are not TiC
Road Drains in urban areas	Roads Dept.	Connecting road gullies to storm sewers
Road Drains in non-urban areas	Roads Dept.	Motorways, trunk and rural roads
Outfalls	Drainage Dept.	From WwTW, PS, CSO, etc, including headwall and flap valve
Pumping Mains	Drainage Dept.	Including discharge chamber
Manholes and Chambers	Drainage or Roads Dept.	Excepting on private drains which are not TiC
Ancillary Chambers	Drainage Dept.	CSO chambers, air valve and washout chambers, etc
Ancillary Equipment	Drainage Dept.	Valves, penstocks, CSO screens, etc
Road Gullies in urban areas	Drainage or Roads Dept.	
Road gullies in non-urban areas	Roads Dept.	Motorways, trunk and rural roads
Sewage Pumping Stations	Drainage Dept.	Including compounds and access roads
Stormwater Pumping Stations		Not recommended for TiC
Wastewater Treatment Works	Drainage Dept.	Major Works only. Residential Works and septic tanks are not TiC

Table 3.2 Taking in Charge Arrangements

4 SUSTAINABLE DRAINAGE SYSTEMS

The use of sustainable drainage systems is, quite correctly, being strongly promoted in the Dublin Region. This section briefly explains the applicability of such systems to new development, to provide the background information for setting policy on related issues, in particular taking-in-charge.

Information on volume control for flooding and water quality, related to SuDS is contained in Chapter 6 herein.

Full information on the justification, principles and application of sustainable drainage systems is contained in the Regional Drainage Policy on Environmental Management.

4.1 The Need for Sustainable Drainage Systems

Regional Drainage Policy on Environmental Management has confirmed that water quality is deteriorating due to historic and existing drainage practices, combined with rapidly increasing urbanisation. The inevitable result is that the requirements of environmental legislation, encapsulated by the Water Framework Directive (WFD) will not be met.

To date, drainage practices have promoted the rapid collection and conveyance of surface runoff through gullies and pipes away from the site and into watercourses, thus bypassing the natural buffering effect of the natural environment. Consequently both volumes and rates of runoff increase significantly after development incorporating such drainage systems. The resulting problems include flooding, scouring of watercourses and reduced infiltration to recharge aquifers and other sub-soil water bodies.

Runoff from impermeable surfaces associated with urban development is often contaminated by pollutants, such as oils, detergents, trace metals, pesticides and herbicides. Any such pollutants will also bypass any available natural treatment processes, such as percolation through the soil, adversely affecting the water quality in receiving waters.

4.2 Principles of Sustainable Drainage Systems

The principle of Sustainable Urban Drainage is to move away from the traditional approach of managing the volume and rate of runoff from larger storm events, towards integrating flood control and runoff treatment. Wherever practicable runoff flows and pollutants are managed on the site, rather than being directed to the nearest receiving waters.

Sustainable Drainage Systems (SuDS) thus involve a shift in our way of managing run-off from solely looking at volume control, to an integrated approach which considers land use planning, water quality, water quantity, amenity and habitat enhancements.

SuDS thus provide an excellent mechanism through which we can change the way of managing urban drainage, and help achieve the objectives of the WFD.

- **SuDS is therefore mandatory for all new developments**, except where the developer can demonstrate that its inclusion is impractical due to site circumstances. Where SuDS cannot be provided, the developer must provide alternative means of dealing with pollutants.

The assumption must be that SuDS will be used, with the onus of responsibility with the developer to provide SuDS measures to the Councils' satisfaction, or to demonstrate that SuDS cannot be provided or is not applicable.

4.3 SuDS Techniques

The overall objective is to minimise stormwater runoff. Therefore the area of impermeable surfaces, such as pavement and tarmac should be minimised by careful attention to site layouts and the specification of pervious surfacing where practicable.

The objective of SuDS drainage designs is to collect and treat this minimised amount of runoff as close to source as possible. SuDS techniques comprise a flexible series of options, which allow the drainage designer to select those systems that best suit the circumstances of the site. Drainage designers can combine various techniques through a stormwater management or treatment train approach for best effectiveness.

The treatment train approach assures that both runoff quantity and quality are addressed, through the overall techniques of:

- **Pollution prevention**: spill prevention, recycling, public awareness and participation;
- **Source control**: conveyance and infiltration of runoff;
- **Site control**: reduction in volume and rate of surface runoff, with some treatment provided;
- **Regional control**: interception of runoff downstream from all source and site controls, to provide follow-up flow management and water quality treatment.

The elements of the treatment train approach are shown in Figure 4.1, abstracted from the Environmental Management Policy.

The first element of treatment is **pollution prevention**, essentially good housekeeping, since minimising or preventing pollution in the first place is more practical and cost effective that having to treat it afterwards. Thus the best approach to urban runoff pollution is to prevent chemicals, and other pollutants from coming into contact with rainfall runoff through appropriate storage and management, and through public education.

The second element is to detain or infiltrate runoff as close as possible to the point of origin, including the use of water butts, roof collectors, filter strips, infiltration devices and swales. The use of such **source control** devices reduces the peak runoff rate and attenuates flows, thus reducing stress on downstream facilities, allowing them to be smaller in capacity. Infiltration of flows will ensure that unavoidable pollutants are treated where practicable.

Site control comprises runoff and treatment installations to serve individual developments (or combinations of developments on adjacent sites), using elements such as swales and detention basins. Such sites could be shopping centres, industrial sites or medium sized residential developments of 10 to 50 dwellings.

The final element is **regional control**, comprising treatment facilities to reduce pollutants from contaminated runoff, with the potential to provide biological treatment. These installations deal with runoff on a catchment scale rather than at source level, typically controlling areas of 2 hectares or larger. They are often end-of-pipe facilities.

Localised pollution prevention and source control measures are summarised in Table 4.1, and more drainage design orientated SuDS measures for source, site and regional control are summarised in Table 4.2.

Type of System	Device	Primary Function	Primary Characteristics	Example
Pollution Prevention	Council Maintenance	Minimises presence of pollutants to enter runoff, especially “first flush”	Regular sweeping and collection of rubbish	Maintenance regimes for Council staff and estate O&M.
Pollution Prevention	Public Involvement	Minimises presence of pollutants to enter runoff, especially “first flush”	Education in management of rubbish and domestic pollutants	Information leaflets, local estate management committees
Pollution Prevention	Management of Pollution Sources	Prevention of polluted runoff	Prevention of rainfall on polluted surfaces	Canopies over bin and rubbish storage areas
Pollution Prevention	Management of Pollution Sources	Prevention of polluted runoff	Prevention of runoff from polluted areas	Bunding of oil and chemical product tanks with isolated drainage arrangements
Pollution Prevention	Management of Pollution Sources	Prevention of polluted runoff	Interception of pollutants in runoff	Silt traps, petrol, oil and grease interceptors
Source Control	Water Butt	Minimise runoff, flow attenuation, water re-use	Rainwater collector with overflow to soakaway area	
Source Control	Minimising impermeable areas	Minimise runoff and washoff of pollutants	Gravelled surfaces on parking areas and driveways	
Source Control	Minimising Connected Areas	Minimise and attenuate runoff	Runoff from impermeable areas absorbed	Paved and roofed areas drained to unpaved areas and soakaways
Source Control	Avoiding foul connections to storm systems	Avoid direct pollution of storm systems	Maintaining principle of separate drainage systems	Public education and Building Control

Table 4.1 Local SuDS Measures

Type of System	Device	Primary Function	Primary Characteristics
Infiltration systems	Infiltration Trenches, Infiltration Basins, Permeable Paving	Encourage stormwater to soak into the ground while filtering pollutants	Permeable features allowing infiltration
Filtration systems	Swales, Bioretention Systems, Filter Strips	Capture heavy metals, grease, oil, nutrients and sediment	Grassed or planted features such as channels
Constructed wetlands	Stormwater wetlands	Filter stormwater and reduce runoff rate while providing a wildlife habitat	Heavily vegetated hydrologically charged area
Retention systems	Retention ponds	Primarily designed to retain pollutants	Artificial lake with fringing vegetation
Detention systems	Detention basins, filter drains	Primarily designed to reduce runoff rate	Vegetated depressions

Table 4.2 Site and Regional SuDS Measures

The treatment train approach involves the division of the drainage elements of the development into sub-catchments with different drainage characteristics and land uses, each with its own drainage strategy. A sub-catchment could be as small as a single building, with its own water butt, pervious paving, etc.

Dealing with runoff locally reduces the quantity of flow that has to be managed at any one point. Taking advantage of any treatment processes available at sub-catchment level can also successively reduce the pollutants in the runoff flows passing through the treatment train.

4.4 Implementation of SuDS Measures

Since SuDS are central to Environmental Management Policy, it is vital that its measures are implemented successfully. The Policies herein will apply to new development. However the intention would be that SuDS measures also be implemented on existing developments where suitable, i.e. retrofitting.

The issues relating to successful implementation include:

- Co-operation between stakeholders in promoting SuDS, including developers, designers, the Department of the Environment, Council Drainage, Planning, Parks and Roads Departments and the general public;
- Mandatory use of SuDS except where found to be impracticable;
- Agreement on design principles and parameters for SuDS facilities;

- Ensuring SuDS are designed to operate within current planning and regulatory guidelines;
- Ensuring effective whole-life solutions are implemented;
- Agreement on maintenance responsibilities;
- Agreement on taking-in-charge requirements and procedures;
- Maintenance of register of SuDS installations;
- Inclusion of facilities to monitor performance and maintenance.

It must be said that UK experience is that implementation of SuDS has been, and continues to be, a long process, due to the often conflicting interests of the stakeholders. The issues regarding taking-in-charge and maintenance of SuDS facilities are particularly difficult to resolve. Nevertheless the Policy for the Dublin Region must take advantage of others' experience, and set the road map for implementation of SuDS.

4.4.1 Co-operation Between Stakeholders

The best way to achieve co-operation is for all stakeholders to understand the reasons for SuDS and that its implementation is a corner-stone to environmental improvement, in which they all have their part to play.

Inclusion of SuDS in all new development is thus mandatory, with the onus on the developer to demonstrate that he cannot incorporate SuDS facilities. Nevertheless, general acceptance and appreciation of SuDS is best achieved through education and publicity, such as:

- Publishing and widespread distribution of posters, such as that produced for the Environmental Management Policy, explaining in a straightforward and graphically intensive format, the objectives involved and their role in helping to achieve them;
- Publishing and widespread distribution of case histories of local developments incorporating SuDS, recorded through the SuDS register;
- Site visits to local developments incorporating SuDS facilities;
- Invitations to developers, designers and institutions to seminars on SuDS, to explain the principles, and the Councils' intentions to implement them;
- Setting up of a SuDS Regional Working Party, involving all stakeholders (DoE, Council Drainage, Planning, Parks and Roads Departments, major developers) to promote implementation and resolve any issues arising.

The principle must be that implementation of SuDS will be an evolving process, and that there will be adoption of its successes and changes to its failures. SuDS implementation in the Dublin region is in its infancy, and the Policy therefore recommends that databases be kept of SuDS installations, and their performance, in order that knowledge can be built up and shared between the stakeholders.

The above measures will ensure that all stakeholders understand that SuDS is required by the Councils, and that their best position is to be involved and contributing positively to its implementation.

4.4.2 Use of SuDS Measures

The use of SuDS is encapsulated in the Regional Policies, and therefore is to be incorporated into drainage designs where possible. However it must be recognised that SuDS measures will need to be selected to suit the particular circumstances of each development. Examples where SuDS selection would be affected by site constraints include:

- Areas where groundwater is vulnerable to pollution, hence limiting filtration techniques;
- Areas where ground has low permeability, hence limiting filtration techniques;
- Areas of unstable soils, where infiltration devices may affect nearby structures;
- High-density development without adequate space for basins and ponds.

Developers and their designers must recognise that their SuDS installations are to achieve the best stormwater and environmental control for the site, not merely be the cheapest or most compact arrangement.

Drainage departments must recognise site constraints, and also suggest opportunities, such as combining facilities for adjacent sites, when approving designs.

Planners should stipulate in Development Plans that all developments must incorporate SuDS principles in the drainage systems, and must make allowance in their land use and density projections for inclusion of SuDS, particularly on the larger development sites.

Further information on the selection and requirements for SuDS installations is contained in the Regional Drainage Policy on Environmental Management.

4.4.3 Agreement on Design Principles and Parameters

The SuDS information sheets contained in the Environmental Policy contain much general design information for SuDS installations, and should be adopted as part of the New Development Policy. The design and best practice manuals for SuDS, as produced by CIRIA, should be agreed for use by drainage designers.

The Regional Working Party should have responsibility for reviewing and updating the design principles and parameters in the light of international improvements in knowledge and local experience.

4.4.4 Implementing Effective Whole-life Solutions

To be effective, whole-life drainage solutions should demonstrate that:

- The installations operate efficiently for long periods (say 20 to 50 years) before replacement is needed;
- The installations operate efficiently for long periods (say 1 to 5 years) before maintenance is needed;
- Where needed, the maintenance regime (period and type of work) is understood, and known to be effective in keeping the facility operating efficiently;
- Facilities and finances are available to carry out the required maintenance throughout the life of the installation.

We are used to drainage systems requiring little or no maintenance. Provided gravity pipelines are designed with adequate flows and gradients, they should operate for the life of the material, often 100 years and beyond. Screens and flow controls that could block with detritus are discouraged.

Pumping stations are recognised as needing regular maintenance, minimised by such measures as the installation of "unchokeable" pumps. To the traditional drainage engineer, often working with constrained maintenance budgets, such systems represent the most cost-effective whole-life solution.

However the Environmental Management Policy has demonstrated that such traditional systems are environmentally very inefficient, and therefore can no longer be considered as effective whole-life solutions.

To achieve their purpose, SuDS installations must incorporate containment, treatment or attenuation functions and are therefore to some extent correspond to an "active" system, rather than a "passive" system such as a gravity pipeline network. As such it must be recognised that SuDS installations do require maintenance, as we would expect any other "active" installation, such as a pumping station or a road gully, to require periodic maintenance.

Operations and maintenance information for various SuDS installations is provided on a qualitative basis in the Environmental Management Policy. Experience with SuDS installations and manufacturers' systems is increasing, and should also be periodically reviewed by the Regional Working Party.

Taking-in-charge of SuDS installations would involve future maintenance and replacements responsibilities for the Council, on a similar basis as for a pumping station. In the UK commuted sums have been charged to the developer to finance such future commitments.

4.4.5 Regulatory Requirements for SuDS

In common with the UK, Irish drainage law was drawn up before the existence and use of SuDS, and hence the responsibility for provision, operation and maintenance of SuDS is not clearly set out.

The ownership and maintenance of conventional drainage systems is clearly understood, and outlined earlier. However, by their nature, many SuDS can be considered as either drainage or landscape features, or a combination of both, and there is no clear guidance on who is responsible for the operation and maintenance of such facilities.

For England and Wales a Framework for SuDS is being prepared for endorsement by Government, the Local Government Association, Water UK, the Association of Highway Authorities, the House Builders Federation, the Association of British Insurers, etc. The Framework is to include the aims of SuDS, SuDS devices, design standards, conservation and habitat enhancement, decision framework to match SuDS to conditions, consents, and maintenance responsibilities and ownership. Unfortunately the Framework is very much in draft with most of the technical and legal content not yet written.

However the Framework does rule that only SuDS corresponding to "sewers", i.e. having a discharge to a watercourse, other sewer or highway drain, may be adopted (taken-in-charge). Thus swales, infiltration trenches and soakaways can be taken-in-charge provided they have "proper outfalls." Infiltration basins, permeable surfaces, water butts, ponds and wetlands are not to be taken-in-charge.

In Scotland, the Water Environment and Water Services (Scotland) Bill, passed in 2003, addresses SuDS for the first time. The Bill defines SuDS as " a drainage system which – (a) facilitates attenuation, settlement or treatment of surface water from 2 or more premises (whether or not together with road water) and (b) includes one or more of the following: inlet structures, outlet structures, swales, constructed wetlands, ponds, filter trenches, attenuation tanks and detention basins (together with any associated pipes and equipment)" In order to be connected and vested (taken-in-charge) the SuDS system must comply with specified construction standards, and its owner has entered into a connection agreement and provided any required security for performance of obligations.

The restriction to 2 or more premises rules out taking in charge of household-based SuDS facilities, such as water butts, but is more flexible on taking in charge of SuDS units without "proper outfalls".

4.5 Taking in Charge Situation for SuDS

The Councils in the Greater Dublin Area are facing similar problems to international Water Companies in deciding which type of SuDS installation (or part of the installation) will be taken in charge, and which will remain the responsibility of the developer, and thereafter normally the owner of the development. There has been much discussion through articles in the engineering press, such as the New Civil Engineer.

The UK Water Companies are concerned that SuDS installations fall outside the definition of Public Sewerage contained in the UK 1980 Water Act, its successors and predecessors, and hence are not recognised by the Water Regulator as an asset. They have therefore been reluctant to adopt SuDS as pubic sewerage, or only accept SuDS where legal definitions allow.

Natural Step/Environment Agency in their September 2002 Report, entitled “Putting SuDS into practice” proposes that the Water Companies own and maintain all SuDS which discharge into public sewers. Landowners should maintain all assets not draining into sewers, such as above-ground retention ponds. This principle is attractive for its simplicity, but will require new legislation to allow the Water Companies to include such SuDS assets within their asset base, with consequent justification for price increases due to extra maintenance.

CIRIA RP664: Model Agreements for sustainable water management systems has been reviewing the question of eventual ownership of SuDS, and in particular, who will maintain and repair them. This consultation involved representatives of UK Local Authorities, Regulators, Water Companies, practitioners, consultants and end users. The review has not as yet produced firm conclusions, but the consensus was:

- SuDS are in most cases an improvement over conventional and traditional drainage solutions as they generally consider a wider range of social, economic and environmental factors;
- Clarification of the design and construction requirements and definition of responsibilities will help encourage the incorporation of SuDS within developments;
- Arrangements should provide increased security about planning, designing and constructing sustainable water management systems in the knowledge that they will be adopted and maintained in the long term by a competent organisation;
- The most straightforward solution would be for taking-in-charge for SuDS by a statutory organisation, possibly a Local Authority or Water Company.

SuDS on private lands would not be taken-in-charge.

4.5.1 Current Arrangements

The Dublin Councils have the authority to define their taking in charge requirements for SuDS installations. Design and construction of SuDS in Ireland is in its early days, with some use of ponds and attenuation systems. The main emphasis so far has been on providing flow attenuation, with water quality issues not extensively considered. So far there has been little co-operation between developers of large sites for large ponds and wetlands.

However the Councils did generally recognise that their current attitudes are somewhat conservative, due to unfamiliarity with SuDS installations, and in particular their performance, and public reaction. The Councils also recognised that the stormwater management problems facing the Region are so significant that local drainage preferences can no longer be followed. Hence taking in charge of SuDS installations would have to encompass many systems with which they are currently unfamiliar. This will be a developing process, which is allowed for in the following proposals.

Following discussions with the Councils, current views and proposed attitudes (in italics) can be summarised as:

4.5.1.1 Infiltration Systems (stormwater soaking into ground, filtering pollutants)

Pervious Paving

Although being proposed by developers, there are concerns about the long-term blockage of the underlying layers.

It was recognised that pervious paving represented a straightforward SuDS method, and present a solution to high-density development with little open area for swales, etc. They therefore should be encouraged, with suitable outfall. Paving must be properly constructed to suitable specification, but for the most part would be the responsibility of the householder or private property management company.

Infiltration Trenches

Not favoured, with doubts about long-term performance due to blockage, clay ground conditions and high water table;

Not to be encouraged or Taken in Charge, unless further evidence of success is demonstrated. Solid separation needed before entry into the trench.

Filter Drains

Favoured, since essentially similar to existing road drainage systems.

To be taken in charge provided there are dedicated inlet and outlet pipes.

Soakaways

Concerns that unsuitable ground conditions would lead to problems for householders.

Not to be Taken in Charge, but encouraged subject to suitable ground conditions.

Roof Drainage to Gardens

Concerns at potential flow damage and standing water in gardens;

Recognised as possible for large gardens, but not suitable for most urban developments.

4.5.1.2 Filtration Systems (filtering pollutants)

Swales

Maintenance and safety problems are seen with swales adjacent to houses, but swales in open areas and along main roads would be favoured, with maintenance by the Parks Departments;

Swales in open areas and along main roads (and possibly local roads) to be Taken in Charge, subject to agreement of maintenance by the Parks Departments. Further investigation needed into public attitudes for swales in local roads, by trialing developments with supportive residents.

4.5.1.3 Constructed Wetlands (filter, reduce run-off rate, wildlife habitat)

Large Ponds and Stormwater Wetlands

Favoured subject to satisfactory and site-sympathetic design, little experience so far;

Encourage developers to install these systems, especially sharing facilities between sites. Maintenance needs to involve Parks Department, and be feasible. Otherwise maintenance would be *in private hands, subject to satisfactory maintenance plans. Involve the Planning Department in land zoning for such facilities.*

4.5.1.4 Retention Systems (primarily to retain pollutants)

Little experience, since SuDS installations have concentrated on flow attenuation rather than pollution reduction;

Further investigation needed, driven by water quality and treatment, rather than the current emphasis on run-off attenuation.

4.5.1.5 Detention Systems (primarily to reduce run-off rate)

Detention Basins

Generally in favour subject to resolution of maintenance and safety aspects; it was recognised that open space in urban development is very limited, and therefore should be designed to maximise public use and aesthetic value when considering its use for stormwater as well. Detention systems for average storm events should not take much space, and extreme events, by their nature, are very rare.

Encourage suitable designs to meet maintenance and safety aspects. Will also be subject to public acceptance. Policy of ownership of land will need to accompany Taking in Charge arrangements.

Underground Tanks

Some tanks have been taken-in-charge. Tanks are normally located on private property and hence not TiC; any underground tanks, whether taken-in charge or privately owned, need to be designed for safe operation and maintenance. The design approach should be to minimise the need for entry by inclusion of self-cleansing arrangements. The tanks would be regarded as confined spaces, with attendant health and safety requirements. Structures would thus need to be appropriately vented and have minimum height for safe man entry.

Designs will need to address access and safety concerns, but generally not in favour of taking in charge. However any decision on Taking in Charge will require further investigation into long-term maintenance requirements.

Underground Attenuation

Oversized pipes for on-line storage are favoured, and some examples of proprietary cellular structures have been installed;

Continue current policy to Take in Charge oversize pipes. Cellular storage structures are normally installed on private property, and hence not Taken in Charge.

Petrol/Oil/Grit Interceptors

Retention tanks used for specific treatment rather than flow and environmental attenuation.

Usually on private lands serving specific premises. Not to be taken in charge.

4.5.1.6 General Principles

System Operation

Systems should operate by gravity. Stormwater Pumping Stations are not favoured, seen as presenting reliability and maintenance problems. However it was recognised that stormwater pumping stations could be needed to protect low-lying areas from flooding.

Policy will be developed to encourage stormwater systems to operate by gravity. Where stormwater pumping stations are unavoidable they should be taken in charge by the Drainage Department.

Ownership

Responsibility for SuDS installations after being taken in charge is unclear, but should be shared between Roads, Drainage and Parks Departments;

This policy will need to be agreed between the Council Departments, ideally on a Region-wide basis. Operation and maintenance of taken in charge SuDS installations should rest with the Department most suited to the work.

SuDS Installed in Public Lands

Favoured as requirement of Taking in Charge of major installations such as ponds, tanks, wetlands, etc. Above ground maintenance by Parks department;

Continue this Policy, which avoids any problems of ownership of land upon which SuDS installations have been constructed.

Table 4.3 summarises the Councils' views and experiences:

SUDS Type	DLRCC	DCC	FCC	MCC	BTC/ WWC	SDCC	KCC
Infiltration Systems							
Permeable Paving	Y	N	Y				
Infiltration Trenches	N	N					
Soakaways	N	N					
Roof Drainage to Gardens		N					
Filtration Systems							
Swales in Spine Roads	Y	N	N				
Swales in Local Roads	N	P	N			P	
Constructed Wetlands							
Small Ponds	Y	Y	Y			Y	
Large Ponds	P	Y				Y	
Stormwater Wetlands	P						
Retention Systems							
Retention Ponds							
Detention Systems							
Underground Tanks	N	N			N	P	
Underground Attenuation	P	N	Y			Y	
Oversized Pipes		Y			Y		
General Principles							
System Operation by Gravity	Y						
Stormwater Pumping Stations	N						
Ownership & Parks Dept. Maintenance	Y	Y					
SUDS Installed in Public Lands	Y						
Off Site Compensation						Y	

Table 4.3 Council Experiences with SuDS

(Y = Yes, acceptable; N = No, unacceptable; P = possibly acceptable)

4.5.2 Proposed Arrangements

We are mindful that local experience and confidence in SuDS is currently limited, but improving as developments using such systems progress. We therefore propose that taking in charge proceeds on the basis of systems that can be accepted now, systems that could be accepted in the future, and systems that cannot be taken in charge. Table 4.4 summarises these arrangements:

SUDS TYPE	TiC Timescale	Comments
Infiltration Systems		
Pervious Paving	Possible	Should be promoted in high-density urban areas, such as car parks for apartments, but should be private/management company responsibility. Can be used in association with underground attenuation. Outfall needed suitable for inspection.
Infiltration Trenches (linear soakaways)	Possible	Subject to suitable ground conditions. Can be used in association with underground attenuation.
Filter Drains	TiC	Constructed along roads with a dedicated outlet/inlet pipe.
Soakaways	Not TiC	To be encouraged in scheme design, subject to suitable ground conditions, being compliance with BRE Digest 365.
Filtration Systems		
Swales in Main Roads	Possible	Approval subject to ongoing maintenance agreement. Maintenance favoured by Parks Department.
Swales in Local Roads	Possible	Subject to successful trial on high quality developments, and successful maintenance.
Constructed Wetlands		
Ponds	Now	Maintenance by LA only if feasible, otherwise to be responsibility of owners. TiC depends on ownership.
Stormwater Wetlands	Now	
Detention Systems		
Detention Basins	TiC	Must be maintained to avoid nuisance, including football pitches.
Underground Tanks	Undesirable to be TiC	Some tanks have been TiC, but not recommended for future TiC due to maintenance issues.
Underground Attenuation	Not TiC	Not TiC if on private property.
Petrol/oil/grit separators	Not TiC	
Oversized Pipes, culverts	Now	Incorporate dry weather flow channel to discourage siltation.
General Principles		
System Operation by Gravity	Now	
Stormwater Pumping Stations	TiC	LA best suited for maintenance. Pumping stations to be used as a last resort.
SUDS Installed in Public Lands	Now	In accordance with Chapter 5 of Regional Policy on New Development.

Table 4.4 SuDS Aspects for Taking in Charge

4.6 Financial Arrangements

The Planning and Development Act, 2000 makes provision for the Planning Authority to charge development contributions in respect of public infrastructure benefiting the area.

Development Contributions that are payable include: general contributions payable under a scheme made under section 48, supplementary contributions under a scheme made under section 49, and special contributions for infrastructure for a particular development in respect of infrastructure benefiting that development under section 48(2). Contributions payable under Section 48 and supplementary contributions payable under Section 49 cannot be appealed to An Bord Pleanala. Special contributions under Section 48(2) can be appealed to An Bord Pleanala.

For general payments, the scheme shall state the contributions for the different classes of infrastructure, including drainage and treatment. Special contributions shall specify the particular works being carried out.

The Development Contribution Schemes came into effect in Dublin in 2004.

4.7 SuDS Specific Procedures

In order to implement the foregoing aspects, a procedure specifically for SuDS has been prepared as the enclosed flow diagram entitled “SuDS Specific Procedures”. These procedures are complementary to those in Chapter 3, and should be read in conjunction with them, in that they bring together the various aspects of Chapter 3 procedures as they affect SuDS. However they do not supersede the general requirements of Chapter 3, such as for vetting, monitoring, inspecting, etc.

4.7.1 Proposed Arrangements

The developer needs to be aware at the earliest opportunity of SuDS requirements for his site. With a small development, it may be that independent site-specific measures, such as infiltration trenches, etc only are required. For large developments, it may be that regional SuDS measures are required. These could be site specific, or may involve other developers on adjacent sites.

The Council thus needs to ensure that the developer understands the overall SuDS requirements for his site, and appreciates that SuDS installations are mandatory, unless he can demonstrate that SuDS are impractical, or can only be provided to a limited extent. For example it may not be practical to build infiltration trenches, swales, etc on a high-density inner-city site, but pervious pavement could be readily provided, even as a partial SuDS measure.

The Drainage Department would carry out vetting of SuDS drainage proposals on the same basis as for other drainage aspects. The developer also needs to understand the taking-in-charge arrangements for SuDS facilities, in order that maintenance arrangements can be agreed for facilities that are not to be taken-in-charge. Maintenance may be the householders’ responsibility, or the developer could arrange for maintenance to be carried out by a property management company.

Issue of Compliance Notices, site construction monitoring, etc would be carried out in common with other drainage aspects of the development.

Installation of facilities to monitor the performance of significant SuDS facilities should be required by the Drainage Department, to build up knowledge. Monitoring of SuDS performance would be carried out by the Drainage Department, together with maintenance of the SuDS installation database, held on the Planning Database.

The developer would be responsible for preparation and distribution of SuDS maintenance information and its issue to the householders. Copies of all such information should be held on the Planning Database, in order that information can be provided to subsequent householders, to ensure that the maintenance knowledge and practices are not lost in the future years of the development.

SuDS Implementation

All new development shall incorporate SuDS facilities, unless the developer can demonstrate that SuDS in impractical due to site circumstances. Where SuDS cannot be provided, the developer shall provide alternative means of dealing with pollutants

Implementation of SuDS shall be carried out in accordance with the procedures

5 FOUL DRAINAGE DESIGN

This section is to define the policy for the design of foul sewerage servicing new development within the Council areas.

Ideally the design approach and parameters should be uniform between Councils. Where common details cannot be agreed, then each Council's specific requirements should be stated in the policy document.

5.1 Current Arrangements

Requirements for the design and construction of foul systems are contained in "Recommendations for Site Development Works for Housing Areas" DoEHLG, 1998, "Code of Practice for Development Works – Drainage", Dublin City Council, 2002, and the Building Regulations for Drainage and WasteWater Disposal.

The documents generally comply with each other and provide very useful information on flows, sizes and gradients. They are very practical documents, and include systems within buildings, house connections and combined and private drains. They concentrate on systems serving smaller residential-type developments, for example providing flow rates from up to 30 dwellings.

There do not appear to be any design guides for larger and mixed-use developments, and Councils require developers to produce specific designs for such sites.

5.2 Proposed Arrangements

5.2.1 Small Residential Developments (up to 30 Dwellings)

It is proposed that the "Recommendations for Site Development Works for Housing Areas" and the Building Regulations for Drainage and Waste Water Disposal remain in place. They are readily understandable and practical documents, and the policy should be to ensure that design and construction comply with their requirements.

"Recommendations for Site Development Works for Housing Areas" requires that foul sewers be designed for six times an average daily flow of 1000 litres per dwelling per day. Assuming a generous discharge figure of 200 litres per person per day, this corresponds to an average occupancy of five persons. The current highest average occupancy rates in the Region are around 3 to 3.5 persons per house, and the planning predictions are that this figure will reduce towards typical European occupancy rates of 2 to 2.5 persons per dwelling.

It is therefore proposed that the average daily flow be reduced to 650 litres per dwelling per day, resulting in design flows of 3900 litres per dwelling per day. This figure corresponds with the recommended design flow of 4000 litres per dwelling per 24 hours contained in Sewers for Adoption, 5th Edition. No further allowance for infiltration should be made.

Pipeline design will be subject to the overall requirement that no gravity pipes below 225mm diameter are to be taken in charge.

5.2.2 Large Residential Developments

Design of main sewers in large developments should take account of the attenuation in peak flows resulting from large connected populations. Each situation will be different and the developer should provide particular designs, prepared by suitably experienced drainage engineers. Design sources include:

- IS EN 752: Drain and sewer systems outside buildings;
- Drainage Area Plans for the catchment;
- Proprietary drainage software.

In practice the design would be derived from a combination of such sources.

5.2.3 Commercial, Industrial and Institutional Developments

As with large residential developments, each project will be different and the developer should provide particular designs. The Developer should also provide design parameters to the Council's Drainage Department for such developments, with suitable justification for the values being used.

Table 3 entitled "Recommended Wastewater Loading: Rates from Commercial Premises" from EPA publication "Wastewater Treatment Manuals: Treatment Systems for Small Communities, Business, Leisure Centres and Hotels" contains useful guidance on flow and load parameters.

5.2.4 Pumping Mains

The diameter of the pumping main should be such that the velocity of the discharge is in the range of 0.75 to 1.8 m/s. The maximum velocity should not exceed 3 m/s.

Pumping main diameters below 100mm will not be accepted.

The roughness value used for the design of the pumping main should be shown in calculations, and should be in accordance with the latest edition of "Tables for the Hydraulic Design of Pipes, Sewers and Channels" published by HR Wallingford. Roughness values should generally comply with Table 5.1.

Flow Conditions	Roughness Value (ks)
For mean velocities up to 1.1 m/s inclusive	0.3mm
For mean velocities between 1.1 and 1.8 m/s	0.15mm

Table 5.1 Roughness Values for Pumping Mains

Table 5.1 provides the average roughness for rising mains, but these values can increase by an order of magnitude (i.e. up to 3.0mm and 1.5mm) for mains in poor condition. It is advised that where the velocity head is significant compared with the static head (say 25%), a precautionary position is taken with regard to the roughness value. The suggested roughness value should increase to 2.0mm and 1.0mm respectively. This situation is often found for long rising mains.

The design of pumping mains longer than 500m, and/or with undulating longitudinal profiles, needs to consider:

- Retention time and septicity. (It may be necessary to use chemical dosing or reduce retention times by using a smaller diameter main or a smaller pump);
- Effect of hydraulic surge and cyclic loading on the fatigue life of the pipe material;
- The effect of air coming out of solution at high points in the system (It may be necessary to install a separate air release valve);

- The drawing in of air after running pumps ('on snore' where it may be necessary to install a special air release valve);
- Access provisions for general cleansing and for operational maintenance of valves, washouts, etc;
- Washout facilities at low points, to drain the pipeline by gravity;
- Roughness values.

Gate valves should generally not be required to isolate lengths of pumping main for draining.

Pumping mains should discharge into the sewerage system at manholes or other purpose built chambers. Details of the entry arrangements should ensure that sewer maintenance operations could be undertaken without difficulty. Discharge arrangements should avoid disturbance, which could lead to gas formation and smell nuisance, and not cause surcharge or flooding.

5.3 Monitoring of Discharges from Developments

There is little or no monitoring of actual flows discharged from developments, especially for the detection of the presence of inflow and infiltration which compromises capacity in the downstream conveyance and treatment systems.

Monitoring facilities should be included in the design of the drainage system for significant developments, being those exceeding 1 hectare in area. These facilities should include:

- Manhole or chamber at the discharge point from the development, with access for man-entry and permanent access;
- Discharge pipeline into the manhole or chamber of at least 10 pipeline diameters straight upstream of the discharge point to ensure hydraulic conditions suitable for flow measurement;
- Manhole or chamber design to be suitable for installation of in-sewer flow measurement equipment;
- Manhole or chamber design to be suitable for the taking of samples of the discharge effluent.

Flow survey results, using in-sewer monitoring equipment capable of producing continuous flow and depth measurements, shall be supplied to the Sanitary Authority before the development is taken in charge. The measurement period shall be continuous and include a dry weather period and three significant rainfall events.

Requirements for licensing of discharges are contained in Chapter 8 of the Regional Drainage Policies – Volume 3 - Environmental Management Technical Document.

<u>Design Requirements</u>

Existing Guidelines for small residential developments should be retained

Current allowances for domestic discharge rates per dwelling should be reduced in recognition of trends in occupancy

Developers should continue to provide particular design details and parameters for large residential, commercial, industrial and institutional developments

Design for pumping mains should be adopted

Monitoring facilities for discharges from developments over 1 hectare in area to be provided

6 STORMWATER DRAINAGE DESIGN

One of the most important factors in designing sustainable stormwater drainage systems is the physical storage volume that needs to be provided to achieve flood control and minimise the pollution impact of urban stormwater runoff.

This section on stormwater drainage begins by examining the performance of current drainage systems and the conditions that lead to both flooding and poor water quality. Further information on the management of inflow and infiltration can be found in the Regional Drainage Policy on Inflow, Infiltration and Exfiltration.

Design and assessment criteria for sewers, rivers and SuDS measures are proposed together with design principles and procedures for estimating volumes of individual SuDS facilities. Appendix E provides an illustration of the approach for assessing stormwater storage requirements.

It is important to realise that all drainage systems are designed to a set of criteria that are subject to economic, social and environmental constraints. It is not feasible to design for all circumstances and there will always be instances when extreme events will exceed the design criteria. The design process therefore should be one of risk management, whereby the consequences of larger events than the design event are assessed for their cost and environmental impacts.

6.1 The Impact of Urban Stormwater Runoff

Rainfall runoff in an urban environment effectively takes place instantly for areas served by traditional drainage systems and nearly all the rain that falls on impermeable surfaces runs off. The rate of runoff and the volume of runoff are both important components in analysing the performance of a network. For storms above a certain magnitude the performance of the network downstream may be exceeded. Rainfall-related flooding of the drainage network, simply defined, is the concentration of stormwater to a point from which it cannot escape quickly enough to avoid ponding or passing on as overland flow.

In addition to the hydraulic behaviour of traditional drainage systems, their water quality management characteristics are poor and this problem is now recognised as a major issue in terms of polluting receiving waters. The quality of receiving waters and the types of main pollutants are covered in detail in the Regional Policy for Environmental Management.

The impact of rainfall in an urban environment is summarised below.

Foul Sewers – Inflow

Foul sewers, designed to be completely dedicated to wastewater, usually have a small proportion of impermeable surface (incorrectly) connected to them. If this is more than a small percentage of the total area, then the network becomes rapidly overloaded by even relatively small events, causing backing up and flooding either directly into houses or externally. Basements that are connected to the foul system are particularly susceptible to this form of flooding, and the social impact can be very high.

Normally, foul water is conveyed directly to WwTW after which it is discharged to a river or the sea. Flows passing to treatment works that are diluted by rainfall, result in reduced treatment efficiency at the works as well as discharging excess flows into storm tanks and, if these fill and spill, untreated effluent passes into the receiving waters.

Occasionally flood relief is provided to these sewers, due to the degree of impermeable area connected to them, by providing CSOs. The impact on the environment of spills to the river is significant and CSOs on separate foul systems should only be provided as an emergency measure.

Foul Sewers – Infiltration

Due to defects in the fabric of piped drainage systems, considerable volumes of groundwater often enter the foul system. This infiltration can be caused by a number of conditions. Infiltration can be due to temporary ground saturation due to recent rainfall, elevated groundwater levels caused by extended rainfall, or tidal influence in coastal low level systems. Due to their relatively small drainage capacity, it is possible for badly affected networks to become surcharged from relatively minor rainfall events.

For systems that are badly affected, infiltration can be more of a problem to treatment works than misconnected impermeable areas in that dilute flows will occur for extensive periods.

Combined Sewers

Water pollution and large discharges take place to receiving water bodies when combined sewers spill during wet weather. Pollution can be particularly acute during times of low river flow, particularly after prolonged dry periods when sediments, that have built-up in the pipe network, are scoured out in the first flush. For extreme rainfall, overflows of dilute sewage can be accommodated more easily in receiving waters, but they can be equally damaging due to the scouring effects of the very high discharge rates that can occur.

Stormwater Sewers

Stormwater sewers are designed to collect all run-off from paved areas and exclude foul sewage. When storm sewers are over-loaded, flooding can occur and this is particularly serious when internal flooding of properties takes place. The level of service provided by stormwater sewers is often much less than the initial design intended due to additional developments taking place either by in-filling existing urban areas or being extended upstream.

The polluting effects of stormwater runoff in streams or flooding in houses is not significantly different to flooding from foul sewers. The contaminated silts and other detritus from urban areas and the occasional illicit foul connection makes the impact of internal flooding equally unpleasant and damaging.

The high runoff rates which can occur, if unchecked, can cause erosion problems in receiving streams and also re-entrain polluted sediment from the riverbed. It is now recognised that surface water systems are a major cause of river pollution.

Open Channel Watercourses

While open channel watercourses, such as rivers and streams, normally have a greater hydraulic capacity than piped systems, the consequences of flooding are usually greater due to the scale of the event. This concern usually results in more conservative design criteria being used. The consequences of flooding from a culverted watercourse are usually far more dramatic than with river flooding. This is because the capacity of the river greatly increases as water levels rise, while the capacity of a culvert by comparison, once surcharged, only marginally increases with the increase in hydraulic head.

Culverting rivers also causes significant ecological loss, as well as producing negative aesthetic impact and other negative environmental effects. The water quality in open channel watercourses can be directly related to the catchment land use, either urban or rural. The base flows in watercourses in urban areas are reduced, peak flows during rainfall are higher and generally all measures of water quality show deterioration. This varies with land use type (residential, industrial and commercial areas), and depends on stormwater management techniques used. Spillages of toxic material in industrial estates can be particularly destructive.

6.2 Principles of Stormwater Design

The three principles behind the selection of design criteria are:

- Sustainability;
- level of service;
- cost-effectiveness.

Each of these three principles is expanded upon below. The drainage engineer should have a number of questions that are addressed by the proposed design. A non-exhaustive list includes:

- ♦ What are the normal operating and maintenance requirements of the design?
- ♦ What are the risks of failure of the proposed design and the consequences in terms of impact?
- ♦ What are the implications of failure for the rehabilitation of the system that will be needed?
- ♦ How effective will the system be in treating the stormwater?
- ♦ What are the social / aesthetic benefits of the proposed design?
- ♦ What are the environmental benefits / protection of the proposed design?

If consideration is given to all these questions it will generally ensure that a sustainable drainage system is designed.

Sustainability

Sustainability can be defined in a number of ways, but in terms of drainage it can be interpreted as:

- ♦ Drainage systems should utilise natural resources which can be reused and are energy efficient in terms of constituent products and construction process;
- ♦ Drainage systems should aim to replicate the natural characteristics of rainfall runoff for any site;
- ♦ The environmental impact of man should be minimised.

The concept of sustainability is now well accepted. This is resulting in a move away from traditional drainage methods, and the recommended use of SuDS systems to provide hydraulic, water quality and environmental benefits. In addition more attention is now being paid to the consumption of natural resources and the ability to recycle these materials. The issue of climate change is now of major importance and this draws attention to the energy aspects of construction. This includes not only the energy requirements to build the drainage system, but also the energy requirements for its maintenance and the energy needed to manufacture the components used in the system.

The design of the drainage system should try and replicate, in a general way, the same rainfall-runoff characteristics for the pre-development condition of the site. The runoff is much slower, less polluted and has virtually no runoff from ordinary rainfall events. The use of SuDS, particularly components which encourage infiltration, will enable this principle to be achieved.

The design of drainage systems needs to minimise water pollution and maximise environmental benefits. SuDS units are designed to address stormwater water quality as well as providing hydraulic conveyance. Consideration should also be given to what might happen if the drainage system “fails” as well as its performance during normal operation. Due to the nature of SuDS units, the consequences of failure tend to be less of a problem than failure of traditional drainage systems.

This is because failures of SuDS units tend to be incremental and not catastrophic as in the case of a pipe blockage or collapse.

Level of Service

- Flood protection should be provided to a minimum level of service;
- No negative aesthetic effects;
- Social benefits;
- Safety.

The principal objective of drainage is to provide protection from flooding due to rainfall on an area. The level of service provided is a function of society's expectations as well as the cost-benefit of the system based on the damage consequences due to flooding. Current design criteria normally require that no flooding occurs up to the 30 year return period, and properties are protected against flooding for the 100 year return period. The level of service for existing systems is usually a lower standard, with 5 years being considered as a minimum requirement.

Although aesthetics are rarely considered as an issue of level of service provision, considerable expenditure in the UK has been incurred in addressing aesthetic pollution from CSOs. As SuDS systems become more common, it is important to ensure that these are aesthetically acceptable as well as acting as efficient drainage systems.

Certain SuDS provide the opportunity for dual land use. Attenuation structures such as ponds have to have the ability to deal with events up to a 100 year return period. This requires large areas adjacent to these structures which are normally dry and can be used for other purposes.

Safety is not really a primary level of service issue, but it is clearly an essential aspiration in providing an appropriate design of any system.

Cost-effectiveness

- Principles of whole life costing (WLC) should be applied.

Drainage design should aim to provide the most cost-effective solution, particularly in terms of maintenance requirements. This requires consideration of whole-life costing of alternative options. Evaluation of the most appropriate system should include hydraulic, water quality and environmental benefits.

There is a limited, but growing data set of experience of the capital and operational costs of SuDS. In general, the cost of SuDS systems are believed to be comparable to traditional drainage systems. Long-term performance of SuDS units is still being investigated, particularly with regard to the extent of the maintenance needed.

"Failure" mechanisms (flooding and pollution) are more robust for SuDS than traditional systems. It should be recognised that any drainage system can fail, whether it is a traditional system or SuDS.

Attention to design detail is important to ensure easy and effective maintenance of all drainage systems.

6.3 Design Criteria

Drainage design criteria needs to consider the above principles in order to produce the most appropriate system for any location. Individual criterion can be developed to meet the various requirements of sustainability and levels of service.

Consideration of whole life costing does not result in specific criteria for design. Appropriate whole life costing requires appropriate weighting of maintenance against capital costs by applying a Net Present Value method. Sensitivity analysis should theoretically be carried out on various possible solutions to arrive at the most cost beneficial scheme rather than rigidly sticking to a specific design standard.

6.3.1 Sustainability

6.3.1.1 Energy and Use of Natural Resources

There are no design criteria that address the selection of appropriate drainage products and achieve the best design which meets energy and natural resource objectives. However certain features of drainage systems such as the use of pumping stations and large underground structures require considerable energy consumption in their construction and operation. There is less information available with regards to making the most sustainable choice when deciding between the use of one product over another. This is a complex area requiring a balance between costs, structural properties of drainage units, site specific aspects, maintenance and, in the long-term, the dismantling and disposal of the system.

Although there are no design criteria specifically addressing the minimisation of energy consumption and the use of natural resources, it is important for engineers to be aware that this is an issue which will become more important in the future.

6.3.1.2 Environmental Impact

Environmental impact of urban stormwater run-off is characterised by the high levels of sediment and other pollutants, both particulate and dissolved, together with the volume and rate of flow of the run-off causing flooding and erosion in the receiving water. Design criteria can be developed to address these various effects, but these are more easily considered by breaking down the various environmental impacts into their individual components and by comparing with the natural rainfall run-off processes which take place in the greenfield environment.

6.3.1.2.1 River Water Quality Protection

Run-off from natural greenfield areas (which are not farmed) contributes a nominal amount of pollutant and sediment in run-off to rivers. For most rainfall events, rainfall depths and intensities are relatively low and direct run-off to rivers does not take place with rainfall percolating into the ground. This water eventually supports the base flow in the river days and weeks after the event has taken place.

By contrast urban run-off, when drained by pipe systems, results in run-off from virtually every rainfall event with high levels of pollution, particularly in the first part of the run-off, with little of the rainfall actually percolating into the ground. This results in virtually no support for the base flows in rivers.

Table 6.1 summarises the differences in urban and greenfield run-off processes and provides an indication of the design criteria that need to be developed to enable urban run-off to more closely replicate the greenfield condition in protecting river water quality.

Greenfield response	Urban response
No direct runoff	Direct runoff
Baseflow support	Limited infiltration
No pollutants	Highly polluted

Table 6.1 The Contrast Between Urban and Greenfield Stormwater Response for Small Rainfall Events

Appropriate design criteria to address these differences are therefore:

- No run-off to pass directly to the river for rainfall depths of 5mm and up to 10mm if possible (interception);
- Use of infiltration drainage techniques;
- Use of stormwater treatment techniques.

In practice, there are a number of practical constraints in applying these criteria. 10mm of rainfall run-off from an urban area, especially with a high-density development, provides a considerable volume of runoff. Infiltration may be a problem for several reasons; the first being that the soil may be fairly impervious (clay), secondly groundwater levels may be high at certain times in the year and thirdly washoff from certain surfaces, particularly roads, often contains high levels of polluted sediment and, depending upon the maintenance regime, will usually result in blockage of infiltration units over a period of time.

The fact that it might be difficult to comply with these design criteria in all circumstances does not mean that these criteria are not valid. They should be applied wherever a reliable solution is possible. Where it is not possible to store and dispose of 10 mm of rainfall, it might be possible to intercept runoff from 5 mm, which will still provide considerable benefits. It should be noted that the issue of river pollution is particularly a problem in the summer when river flows are low and dilution is minimal. However this is the period in which infiltration units are most likely to be effective as the soil moisture deficit and evaporation rate is high.

Achieving zero runoff from the first 5mm or 10mm of rainfall is often not practicable, and therefore emphasis is also needed on achieving some treatment of the stormwater run-off. This ensures that any runoff discharged to the river is of significantly better quality than direct runoff from a pipe network.

The various advantages of the different SuDS units are described in some detail in chapter 4 of this document and also, more fully, in the Environmental Management policy document.

SuDS units that treat stormwater include filter trenches, swales, wetlands, retention ponds and detention basins. One of the most commonly used SuDS unit is the retention pond. The design of the wet pond in terms of depth shape and volume is covered in SuDS design manuals and also in the Environmental Management policy document. In terms of design criteria to provide treatment, the concept of the "treatment volume" (Vt) has been defined for the permanent pool volume of a retention pond. In the SuDS design manuals CIRIA C521 and C522 it is recommended that up to 4 times Vt is required to provide good treatment of the stormwater volume.

The formula for Vt is:

$$Vt\ (m^3/ha) = 9 \times D(SOIL/2 + (1 - SOIL/2) \times I)$$

Where:

I = fraction of the area which is impervious (30% impermeable area = 0.3)

D = M5-60 rainfall depth (5 Year Return, 60 minute duration)

SOIL = Soil Classification (Flood Studies or the Wallingford Procedure WRAP map)

Vt is thus a function of local hydrological characteristics, soil type and the level of impermeability of the catchment. The presumption is that the treatment volume (permanent pool) is sized to capture runoff from 90% of storms that occur each year. The value for the Dublin region would be an equivalent rainfall depth of around 20mm. Thus 4 times Vt would imply a storage volume of 80mm. This is a very large volume of water and recent research suggests that the advantages of large volumes of storage, particularly deep ponds, have limited benefits. It is becoming clear that long residence times can result in the production of high levels of ammonia, due to anearobic conditions in the sediments, which is very poisonous to river crustaceans and fish.

Shallow ponds, although providing less opportunity for these conditions, have a number of limitations. These are:

- For any given volume, the shallower the pond the larger is the area needed;
- Plants will grow in depths of up to around 1m. This depth of open water cannot be guaranteed for shallow ponds. This implies increased maintenance and also reduced aesthetic value of the pond.

It is therefore recommended that a figure of 15 mm of rainfall is used for the Dublin region to determine the permanent pool volume, until research provides clear evidence as to what constitutes best practice.

It should be noted that the Standard Percentage Runoff (SPR) indices for SOIL are different in the Flood Studies Report (FSR) from the values in the Winter Rainfall Acceptance Potential (WRAP) map (from the Wallingford Procedure). This formula is generally applied using the WRAP values, but the difference is not worth debating.

Flows from large storms should be diverted around treatment facilities, with only runoff from ordinary events being treated. However as retention ponds are used to provide both treatment and also hydraulic attenuation for extreme events, careful design is needed to prevent resuspension of sediments.

The design of pond water levels should take account of winter levels of groundwater. Lining a pond (if needed to protect the a sensitive groundwater area from pollution) where ground water levels are high in winter, should ensure that the design pond water level is higher than the groundwater or else the pond liner will “float” up. If the pond is not to be lined, the groundwater level in summer needs to be known to determine the likely minimum water level in dry summer periods. The range of the pond water level in the seasons should be taken into account in its design, particularly its impact on barrier planting vegetation. The fact that the water level may drop below the outlet control is not necessarily a problem as no direct runoff to the watercourse reflects the normal greenfield response in dry summer periods.

Although water quality and hydraulic design features are the principle focus when designing the drainage system, it is important to maximise the environmental benefits of any design. Thus appropriate use of vegetation borders to ponds using native plants which support local fauna is to be considered whenever designing a system. The gradient of the ground at the edge of the pond should be designed to be fairly flat even though this may not be the most efficient hydraulic solution and require some additional land.

Guidance on best practice design of retention ponds is available from SuDS design manuals. It is inappropriate to use environmental criteria as primary design criteria. However environmental benefits need to be considered when developing the design proposals.

6.3.1.2.2 River Regime Protection

Rural runoff to rivers, when it occurs, is slow. To try and replicate this, urban runoff must be heavily constrained. Unrestrained runoff causes high velocities and erosion, affecting the morphology of the channel and the flora and fauna in the river.

Relevant design criterion to address this issue is to:

- Restrain the rate of discharge to the receiving water to that of greenfield runoff for the site.

A range of formulae exist for predicting greenfield runoff. The simplest and the one considered most appropriate for applying to this criterion was developed by the Institute of Hydrology in their report 124 “Flood estimation for small catchments”, 1994.

The work was based on 71 small rural catchments. A regression equation was produced to calculate $QBAR_{rural}$ the mean annual flood.

$$QBAR_{rural} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$$

where:

$QBAR_{rural}$ is the mean annual flood flow from a rural catchment in m^3/s.

AREA is the area of the catchment in km^2.

SAAR is the standard average annual rainfall for the period 1941 to 1970 in mm.

SOIL is the soil index, which is a composite index determined from soil survey maps that accompany the Flood Studies Report.

QBAR can be factored using the Flood Studies Report regional growth curve for Ireland to produce peak flood flows for a number of return periods. Information on growth curves for UK and Ireland is available in Flood Studies Supplementary Report (FSSR) 14, 1987 produced by the Institute of Hydrology.

There is some indication that the Irish growth curve is not applicable for some Dublin rivers. Preliminary work carried out on the Carrickmines, Shanganagh and Tolka rivers has resulted in an alternative growth curve being proposed. The FSSR 14 growth curves together with the proposed regional curve for Dublin are shown in appendix C. These will be updated in due course when more research is made into this issue.

The formula for determining the peak greenfield runoff rate should not be applied to areas less than 50 hectares. As many developments are smaller than this size this constraint is avoided by calculating QBAR for 50 hectares and linearly interpolating flow rates for smaller areas.

6.3.1.3 River Flooding Protection

River flooding has serious consequences for affected properties and therefore return periods of 100 years are usually applied to determine the extent of floodplains and the risk to properties adjacent to watercourses. A return period of 200 years is normally recommended where flooding risk from the sea is possible. Flooding in rivers is exacerbated by urban runoff, particularly in catchments with a high degree of urbanisation. The floodplains provide a finite volume of storage, so not only is the rate of runoff from urban areas needing to be controlled, but also limiting the increase in volume of runoff compared to greenfield conditions should also be considered.

Relevant design criteria to address river flooding are to:

- Restrain the excess volume of runoff from urban developments to that of greenfield runoff;
- Avoid development on the floodplain.

6.3.1.4 Excess Urban Runoff Volume

It is important to realise that many river flood events are the result of multiple rainfall events and therefore it is unwise to try and design for the discharge to take place before or after the flood wave passing down the river. If all catchments are developed on the basis of reflecting the rural behaviour prior to development, both in terms of rate of runoff and volume of runoff, it is likely that the river will be protected effectively.

This additional volume of stormwater runoff is not a flooding issue in “normal” (frequent) rainfall events as long as runoff rates from sites are constrained. However in extreme events, where flooding is likely to occur in the river, it is important to limit this runoff volume. This can be achieved in the design of the drainage system by spilling from the attenuation storage system to an area which will drain very slowly, preferably by infiltration. As this is a rare event, by definition, this might be to a park or football field with appropriate land drainage provision at low points. This storage might be termed “long term” storage for river flood protection.

The river floodplain should generally be used as open space for ecological reasons as well as being a river flood corridor for extreme events. Planned development or even storage in the floodplain should generally be avoided. This is partly due to the fact that the storage attenuation system is bypassed by being flooded, and also creates a problem in terms of maintenance (depending on how frequently it is flooded). The likely consequence is that large volumes of sediment will be deposited in the storage systems by the floodwater when this occurs.

To achieve the necessary volumes of long term stored runoff, the return period at which runoff will start to pass to such an area will need to take place for events less than the 100 year event. However if flooding of the area occurs more often than say once in 10 years then the level of service for that public open space may be considered to be inadequate.

In some situations it might not be possible to achieve this approach. Also it requires detailed technical analysis to enable this to be designed accurately. The alternative is to provide for this volume in the form of infiltration which comes into effect for all storm events. This not only has the advantage of simplicity of design, but also provides good environmental benefits in terms of base flow support for rivers, and reduced runoff for small events (which replicates greenfield runoff). It should be noted that infiltration in extreme wet periods will be less effective than at other times, so infiltration storage should only be used where groundwater levels are known not to rise to the levels of the proposed infiltration units. Although detailed calculations can be carried out to establish the infiltration volumes needed by taking account of infiltration rates of the soil at the site, the soil moisture state during particularly wet periods will tend to be saturated and antecedent conditions may reduce the available storage volume. It is therefore suggested that the volume of storage normally provided as infiltration to meet this criterion is equal to the calculated value of the additional runoff volume. Detailed analysis, if carried out, can reduce this volume by taking into account the infiltration that will take place during the critical duration event.

It is possible that “long term” storage cannot be provided at certain sites. In these situations it is recommended that QBAR is used as the attenuation storage control requirement to ensure sufficient runoff is retained on site for extreme events. This will tend to be a less economic solution, but is the only way to ensure that urban runoff does not exacerbate flooding in a river. Where QBAR is a value which is less than 2 l/s/ha it is recommended that this figure is used to prevent excessive cost. Studies by HR Wallingford “Storage requirements for rainfall runoff from greenfield development sites” SR580 / SR591, 2002 showed that attenuation throttle rates needed to be less than 3 l/s/ha to be effective in limiting discharges to rivers during flooding.

In summary protection against river flooding by the provision of “long term” storage can be catered for in 3 ways:

1. Temporary flood storage spilling excess stormwater runoff to an infiltration area – probably public open space;

2. Provision of infiltration for excess stormwater runoff to come into effect for most or all events;

3. Attenuation storage designed with a limiting discharge throttle rate of QBAR for all extreme events (up to 100 years).

Assessment of the “long term” storage volume is detailed in section 6.7

Appendix E provides a worked example for illustration.

6.3.1.5 Development in the Flood Plain

Development in the floodplain creates a number of problems which is why developments within the floodplain are normally viewed as being unacceptable. This section therefore presupposes that all alternatives to development outside of the floodplain have been considered and rejected and that the local authority has allowed the development to be considered.

The risk of flooding the new development must be addressed and this is commonly avoided by raising ground levels. This creates potential problems both upstream and downstream by reducing river flood storage and raising water levels for a short distance upstream. For each individual development, this impact is virtually imperceptible, but development in this manner across the catchment will significantly modify the flow regime of the river.

To address this, where development is allowed to take place, it is important to provide compensation storage. Thus ground levels need to be modified such that the depth-area (and conveyance) relationship at any point on the river is the same before and after development.

Modification of the channel or development close to the main channel should be avoided. The morphology of any channel is a complex balance of erosion and deposition and changes will normally result in destabilising the channel. As development takes place upstream, even where stormwater controls are rigorously put in place, changes will occur in the channel which take into account the change in the river hydrological characteristics.

Another reason for avoiding development close to the river is that it provides a natural feature for both its social use as green space and a corridor for wildlife.

A third, and very important reason, in terms of drainage design, is that attenuation storage is normally needed to serve any development. This requires ponds or tanks to be provided, which, by definition, must be located at the lowest point in the site. This means that these structures often cannot avoid being built in the flood plain. This not only leads to difficulties in terms of operation (inflow, outflow and water level design), but also creates an increased risk of sedimentation problems if the river inundates the units. If this occurs early in the flood event, the drainage control of runoff from the site will have “failed” for that event, as unrestrained discharge will take place after the river floods the system. The lower the relative level of the drainage control system with respect to the top water level of the river in flood, the more difficult it will be to design the attenuation storage for the drainage system serving the development.

6.3.1.6 Extensive Catchment Development

Where development of the catchment is likely to be significant, application of these stormwater management principles will still result in some change in the normal behaviour of the river. In some catchments, particularly where compliance may be difficult to achieve for what ever reason, the local authority might chose to carry out a catchment study to check on the change in performance of the river to enable strategic decisions on drainage strategy to be made.

It should be recognised though that the effect of urban development across the catchment, particularly when SuDS is being used, is not well defined in terms of modelling representation. In addition, due to the need to consider the Water Framework Directive, the performance in the river should really be considered for both its “normal” state as well for extreme conditions.

Measuring the change in performance in the river on a site by site basis results in minimal change in the river state, especially if stormwater controls are being used. The exception to this rule is when the floodplain is being significantly modified by the development proposal, in which case a detailed model of the development proposals is appropriate. This should extend as far up and downstream as is necessary and should be compared to a model of the status quo.

6.3.2 Level of Service

There are four elements to consider for provision of adequate levels of service.

- Flood protection;
- Aesthetic effects;
- Safety;
- Climate change.

6.3.2.1 Flood Protection

Three criteria need to be applied to ensure against flooding. These are:

- Protection against river flooding;
- Protection against flooding from storage systems;
- Protection against flooding from overland flows.

It is recommended that the 100 year return period is applied to all these criteria for protection of flooding within properties. In addition a minimum level of flood nuisance to the community requires the selection of the 30 year return period, or similar, for the occurrence of any significant unplanned flooding anywhere on site. Figure 6.1 illustrates the level of service for the various components of the drainage system.

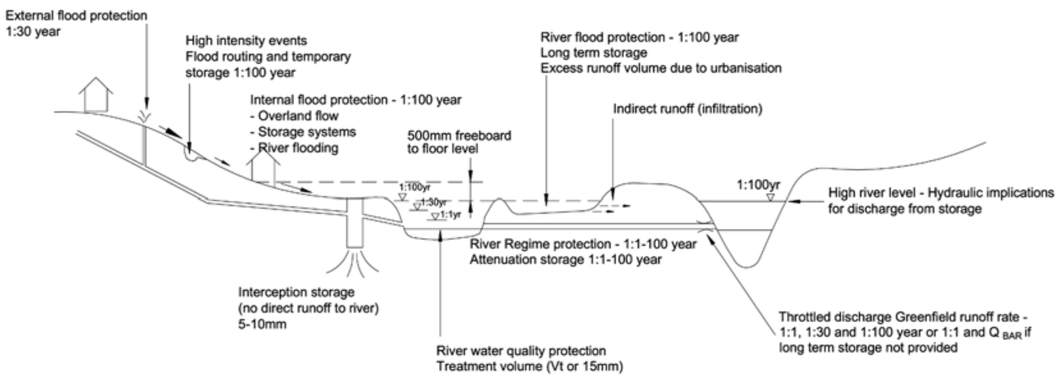


Figure 6.1 Level of Service and Flood Protection Principles

<u>*Protection Against River Flooding*</u>

The effect of river flooding is often severe and there is usually some degree of uncertainty with regard to the maximum flood level at any location for a particular return period. It is recommended that floor levels of all houses are at least 500mm above the predicted maximum 100 year flood level. This freeboard should be increased where there is a significant level of uncertainty and where predicted water levels are sensitive to the assumptions and analysis parameters being used. Flood maps are being produced for rivers in Ireland, but these may not exist for all locations or may be very approximate in their estimation. It is therefore important to investigate the likely accuracy of this information or assess it specifically as part of the planning and design process.

In addition to floor levels of dwellings, other aspects such as access and the location of sensitive and important buildings (hospitals) should also be designed taking into account flood risk.

In considering the maximum water level, appropriate precautions must be taken in assuming the scenarios which might affect the level of flooding. These include:

- Current and proposed urban development upstream in the catchment;
- Throttles and other attenuation features upstream due to bridges and dams need to be specifically considered. These may be removed over the course of time or may fail suddenly in flooding conditions;
- Floodplain storage upstream might be reduced.

A position needs to be taken on all these issues in determining maximum river water levels at any site. These should be defined by the local authority for the area based upon the local area structure plan or agreed with them in the early stages of considering a planning application. The general position that should be taken is that man-made obstacles are likely to alter in time, but that natural watercourse characteristics will be preserved by all future development. The level of future development upstream and the runoff characteristics will depend on the local authority's views regarding future development and the level of enforcement of SuDS techniques in that catchment with its particular soil and topographic characteristics. This should not be limited to the structure plan horizon which is often 20 years, though a longer term view of future development in the catchment may be difficult to arrive at.

Occasionally river and sea defences result in embankments. The location of houses behind these defences is a risk, which is a function of the water levels being restrained, the quality of the defence structure and the distance of the dwellings from the structure. There is limited guidance available for this situation, but it is important to carry out a risk analysis where this circumstance arises.

Storage Pond Flooding

Storage pond water levels are designed specifically, and therefore there is less uncertainty than for river flood water levels. However property floor levels must be provided with a safety freeboard and it is recommended that this is 500mm.

There are a number of less obvious aspects to consider related to storage ponds. These are:

- Hydraulic constraints to the pond outlet;
- Overflow provision and risk of failure;
- Hydraulic backwater effects at the pond inlet.

High water levels downstream of the storage unit may affect the top water level in the pond. This is a complex issue of joint probability (the river being high when the storage unit is full) and the relative levels of the water surfaces. A precautionary approach to the analysis should be assumed (possibly total dependency) to establish maximum storage water levels.

Similarly, flows into a storage unit which is full, may have a backwater issue for the inlet pipework serving the development which might result in local flooding upstream. This is only relevant for quite flat catchments, but generally this should not be too great a problem as the rainfall intensities in events where the storage is fairly full are generally not those which cause a pipe capacity problem.

The failure of a storage unit, particularly if it is embanked, can be dramatic, even if it is a relatively small reservoir. Reservoir design standards may be appropriate to consider in certain circumstances. Failure of the structure is not the only thing to consider. Very extreme events, much larger than 100 years, can occur. The design of overflow structures should be for a 200 year event and still providing a freeboard of at least 200mm.

Flooding from Overland Flow

Unlike the last two categories, which generally relate to long heavy rainfall periods, consideration needs to be given to short very high intensity thunderstorm type events. These events, often lasting for only 20 or 30 minutes, involve so much rainfall in this short period that the drainage system cannot cope with the runoff. In this situation water runs off down roads and overland through properties unless it is specifically taken into account. The impact of such events will generally be much less for SuDS based systems which tend to be based on provision of volume (swales, infiltration units etc).

Analysis of these situations requires careful examination of the topography of the proposed development and the layout of the roads system. A model is best used in this situation, particularly where piped networks are involved, as flooding can occur at a low point due to the drainage system and its hydraulic characteristics as much as due to flooding down roads due to gully incapacity.

Sites should take into account topography to maximise the benefits of low points for storage and avoid placing vulnerable structures and/or properties in these areas.

Basements are particularly at risk in these situations and they should be protected by the ground being suitably profiled to prevent entry of overland flows.

An issue that should not be overlooked is that of responsibility for flood flows and the rehabilitation related to it.

In general it is advised that the drainage system should be designed to cater for the 30 year event without causing any significant unplanned flooding, but that this should always be open to variation depending on the type of development being served and the drainage system proposed.

6.3.2.2 Aesthetics

It may not be immediately obvious why aesthetics is a consideration of design. Although it does not lead to a primary design criterion, the use of SuDS will require specific consideration of their visual impact. It will also draw attention to the maintenance requirements and thereby the costs for operating the units. A negative view of SuDS units will create problems in trying to get them generally accepted and used.

6.3.2.3 Safety

As with aesthetics, safety does not result in primary design criteria relating to the size of any unit. However the potential for accidents and the measures needed to limit such incidences requires drainage engineers to specifically consider this issue.

Underground storage volume facilities, if used, must be designed for safe access for maintenance. This will influence the minimum height within the structure, benching slopes, venting and other features. Drawdown facilities should be provided for all water retaining structures.

6.3.2.4 Climate Change

Climate change is acknowledged as taking place the world over. The GDSDS Climate Change policy document advises that rainfall event depths should be factored by 10% and that sea levels will rise by 400mm or more over the coming century. There is no specific advice for river flow rates, but the Defra advice in UK suggests a 20% increase in flood flows. The climate change policy also provides advice on the use of Time Series Rainfall.

If these criteria were not applied, and these predictions were found to be correct, then the level of service provided by the drainage system would be less than it was designed to achieve. It is therefore advised that climate change criteria are applied for the design of drainage systems for new developments.

Climate Change Category	Characteristics
River flows	20% increase in flows for all return periods up to 100 years
Sea level	400+mm rise (see Climate Change policy document for sea levels as a function of return period)
Rainfall	10% increase in depth (factor all intensities by 1.1)
	Modify time series rainfall in accordance with the GDSDS climate change policy document

Table 6.2 Climate Change Factors to be Applied to Drainage Design

As a precaution it is advised that the same uplift is not applied to the calculated flow rates from greenfield runoff. This provides a safety factor to the methodology. It can also be argued that the level of accuracy of the greenfield runoff formula and prediction of river behaviour warrants the addition of a safety factor anyway.

6.3.3 Other Design Issues

There are a few other issues which influence the generic design criteria discussed above. These are:

- Size of development;
- Environmental issues influencing storage design;
- Density of development;
- Location of development;
- Extending urban catchments.

6.3.3.1 Size of Development

To limit discharge to greenfield runoff rates usually requires a pipe or other form of throttle. These throttle sizes theoretically need to be quite small to achieve the required maximum rate of flow, especially for small developments. For operational purposes, it is recommended that the minimum throttle size for a pipe should be 150mm minimum diameter and any other orifice unit other than a pipe should be a minimum of 200mm diameter. This means that flows much below 10 l/s are rarely achievable. Thus small sites, by default, are often allowed a more generous discharge limit than larger developments. This can be partially re-dressed in three ways.

The first is to ensure the development area is planned on a catchment basis so that any development fits within a drainage strategy for a catchment.

Secondly building storage tanks and ponds in series can help in minimising peak flow rates.

Thirdly certain SuDS systems can result in significantly greater attenuation than just using a tank and orifice arrangement. Thus small sites should place particular emphasis on the use of unlined pervious pavements and infiltration units. Where the permeability of a soil is low and the use of infiltration is marginal, it should still be used, but systems should be designed with overflows to ensure against a level of service failure.

6.3.3.2 Environment Issues Influencing Storage Design

The previous section suggested that ponds should be built in series. There are strong environmental and other benefits for doing this. Although land take may be marginally greater, the following advantages are provided:

- maintenance is generally easier;
- desilting of the upstream units has minimal impact on the receiving water;
- greater flexibility in locating ponds;
- ecology gains with a range of different quality and physical characteristics of ponds.

It is therefore advisable to have a train of at least three ponds; the first providing a focus on sedimentation, the second on hydraulic attenuation and the third as a polishing pond, often a small wetland.

6.3.3.3 Density of Development

The drainage of any development, whatever size or location, should consider the opportunity to use appropriate SuDS techniques. However situations will exist where there will be limited opportunity to use SuDS or infiltration methods. Very high-density developments, usually planned for areas adjacent to primary traffic corridors of a city, may have very limited opportunity to use SuDS techniques. Specific consideration of using SuDS units should always be carried out, (and there are few circumstances where pervious pavements cannot be used), but it is possible that the use of a traditional pipe drainage system, with storage tanks (concrete or high cellular voids systems), may be the most appropriate drainage method to use.

6.3.3.4 Location of Development

There is a situation which is not really applicable to the generic approach described earlier. Developments that are proposed at the downstream end of a catchment, by definition, do not have to be concerned with worsening the river state downstream. In this situation, it may not be necessary to provide either “long term” storage or attenuation storage. Similarly issues such as river erosion might also not be applicable. Water quality may therefore be the only principle that needs to be considered in terms of the receiving water.

Applying the same principles detailed in section 6.2, it is there recommended that:

- Where there is little downstream to be concerned about with respect to flooding (discharging to the estuary or sea), criteria on flow rates and volumes of discharge are of little relevance. Water quality is the only issue needing to be addressed (primarily sedimentation);

- Where a river's morphological characteristics are important, but there are no developments downstream, water quality criteria should be applied, together with some flow rate control. However runoff for extreme events is of little concern. Therefore criteria would focus on both water quality elements and discharges from the site up to, say, the 10-year event.

In all cases levels of service for the development still apply.

6.3.3.5 Greenfield Developments and Infill Developments

New developments can take place in greenfield or brownfield locations. In theory design criteria need not be any different between these two situations. However, in practice, the precedent of existing high runoff rates from a previously developed site and the political and environmental value of re-using urban areas, often results in more liberal criteria being applied to these sites.

The contrary argument to this is that in locations where the urban drainage systems are particularly taxed (as would be demonstrated by frequent flooding or high spill frequencies from CSO's on combined systems), then onerous criteria will need to be applied to prevent existing levels of service reducing further. The choice of appropriate design criteria is a matter for the local authority to consider in the light of the current situation and flood risk downstream.

6.3.3.6 Extending Urban Areas

In some instances, particularly infill development on drainage systems, there may be downstream flooding already on the surface water system to which the development is to be connected. In these circumstances an alternative discharge location although desirable, may not be available. On the basis of the principle that there should be no detriment to the existing level of service to those downstream, it is likely that runoff constraints will need to be very strict with emphasis on the use of infiltration where possible. In addition there may be a need to provide flood alleviation solutions to locations downstream to minimise reductions in levels of service.

Assuming all options of runoff reduction have been considered and used, the attenuation discharge limit needs to be as onerous as reasonably can be applied to minimise the downstream impact, if the level of service downstream is less than a return period of 30 years. In this situation, subject to minimum throttle size constraints, 2l/s/ha should be considered as the throttle criterion. As the urban flooding criterion is 30 years, this would be applicable for determining the attenuation storage requirement, subject to meeting the requirements for the site and downstream flood protection for extreme events as discussed earlier. Extreme events must be addressed to prevent flooding of adjacent urban areas.

6.3.4 Summary of Design Criteria

Table 6.3 summarises the design criteria for the design of drainage systems. In principle these criteria should be applied to all sites, but certain practical limitations (throttle sizes for achieving low flow rates) and minimal consequences of non-compliance (draining to the estuary or coast) mean that an intelligent approach should be taken in applying these criteria. These criteria are explained further in Appendix E.

Climate change needs to be applied to all relevant elements of the design parameters used.

Figure 6.1 shown earlier schematically summarises all the criteria for drainage design.

Criteria	Sub-criterion	Return Period (Years)	Design Objective
Criterion 1 River water quality protection	1.1	<1	Interception storage of at least 5mm, and preferably 10mm, of rainfall where runoff to the receiving water can be prevented.
	1.2	<1	Where initial runoff from at least 5mm of rainfall cannot be intercepted, treatment of runoff (treatment volume) is required. Retention pond (if used) to have minimum pool volume equivalent to 15mm rainfall.
Criterion 2 River regime protection	2.1	1	Discharge rate equal to 1 year greenfield site peak runoff rate or 2l/s/ha, whichever is the greater. Site critical duration storm to be used to assess attenuation storage volume.
	2.2	100	Discharge rate equal to 1 in 100 year greenfield site peak runoff rate. Site critical duration storm to be used to assess attenuation storage volume.
Criterion 3 Level of service (flooding) for the site	3.1	30	No flooding on site except where specifically planned flooding is approved. Summer design storm of 15 or 30 minutes are normally critical.
	3.2	100	No internal property flooding. Planned flood routing and temporary flood storage accommodated on site for short high intensity storms. Site critical duration events.
	3.3	100	No internal property flooding. Floor levels at least 500mm above maximum river level and adjacent on-site storage retention.
	3.4	100	No flooding of adjacent urban areas. Overland flooding managed within the development.

Criteria	Sub-criterion	Return Period (Years)	Design Objective
Criterion 4 River flood protection (criterion 4.1, or 4.2 or 4.3 to be applied)	4.1	100	"Long-term" floodwater accommodated on site for development runoff volume which is in excess of the greenfield runoff volume. Temporary flood storage drained by infiltration on a designated flooding area brought into operation by extreme events only. 100 year, 6 hour duration storm to be used for assessment of the additional volume of runoff.
	4.2	100	Infiltration storage provided equal in volume to "long term" storage. Usually designed to operate for all events. 100year, 6 hour duration storm to be used for assessment of the additional volume of runoff.
	4.3	100	Maximum discharge rate of QBAR or 2 l/s/ha, whichever is the greater, for all attenuation storage where separate "long term" storage cannot be provided.

Table 6.3 Criteria for New Development Drainage

This process should be an integral part of design.

6.4 Hydraulic Design of Drainage Components - General

The design of a storm sewer network and determining its performance requires the use of network modelling tools, rainfall information based on the Flood Studies Report (FSR) and detailed network and ground level information. As climate change is now accepted as taking place, a precautionary position has been taken to cater for its effects. Details of these allowances are contained in the Regional Policy on Climate Change.

The design of a stormwater drainage system is expected to involve the use of SuDS. However in nearly all situations, pipes will also be involved to provide much of the conveyance of the runoff. The attenuation aspects of SuDS, together with the perception of possible premature failure of SuDS, need to be taken into consideration in the design of the supporting pipe system. Risk of sewer system failure can be due to:

- Structural failure;
- Pipe sedimentation / blockage;
- Inadequate capacity.

Design of sewers must therefore consider design for:

- Construction details;
- Velocity (to avoid sedimentation);
- Hydraulic capacity;
- Predicted performance using a simulation model.

Issues relating to pipe materials and the structural and construction requirements of drainage systems are addressed in Chapter 7. The following sections address the hydraulic issues of pipe design.

Design aspects relating to both SuDS design and quantifying site discharge constraints are also provided.

6.4.1 General Issues Related to Drainage Design

6.4.1.1 Site Constraints

Pipework routing and levels are often determined by site constraints, including topography (and the need to maintain cover to pipes whilst not entailing excessive excavation), other services and contaminated ground. All site constraints should be identified as soon as possible in the design process including areas of site not available due to temporary works.

By definition storage tends to be located towards the lower parts of the site. Flooding and overland flood routing can occur at any point of the site, but will then migrate towards low points. Due consideration of the space requirements for such issues needs to be given in the initial stages of the site layout and design.

6.4.1.2 Services Conflict

Foul and stormwater drainage are just two of the many services laid in the roads and footpaths in a new development. Care should be taken to ensure that services do not conflict. Most of the other services are placed above the sewers and therefore there is generally little risk of conflict.

Problems of level between the two sewer systems are also normally avoided as stormwater pipes are generally laid at flatter gradients than foul sewers. In general foul systems are therefore deeper than stormwater networks. Where steep catchments dictate pipe gradients, it is again preferable to put foul sewers below storm pipes; this both minimises the risk of foul pollution in the stormwater system and minimises trench depths for the larger pipes, making it cheaper to construct.

In general it is considered good practice not to have the foul and surface sewer in the same trench above each other. This causes obvious problems at manholes. The use of a single wide trench with the surface sewer off-set, benched at a different level, tends to cause more problems to build than digging a separate trench.

6.4.1.3 Temporary Drainage

The need for temporary site drainage during the construction phase should be considered. This can take the form of temporary ditches or the use of the designed storage system as long as re-instatement of these units is carried out at the end of the contract.

Settlement tanks or ponds will be required to prevent pollution of watercourses and siltation of existing drainage systems. Poor control of silt during construction can cause premature failure of infiltration systems. Consideration should be given to the use of a temporary drainage system until the development is complete and vegetation established.

6.4.1.4 Safety and Design

Design has a direct bearing on the Health and Safety risk for the construction, operation and dismantling of any structure. A significant category of Health and Safety concern is the collapse of trenches. However there are a whole range of possible hazards and thought should be given to considering what hazards exist. Once a hazard has been established and the level of risk estimated, efforts should be made to minimise or remove the hazard by posing appropriate questions.

- Can the design be changed to avoid the risk?
- Can the design be modified to reduce the risk – combat at source?
- What controls can be applied to reduce the risk to an acceptable level (minimal or low)?

This process should be an integral part of design.

6.4.1.5 Drainage Separators

Although rarely an issue for new residential development, separators will normally be required for certain commercial and industrial sites to address runoff polluted with light oils, heavy oils or grease.

Currently BS 8301 Building Drainage:1985 provides guidance on the use of these units and this will be replaced by the European Standards when they are issued. The Environment Agency UK also provides guidance. They have produced a series of documents entitled Pollution Prevention Guidelines. PPG3 is “The use and design of oil separators in surface water drainage systems”. This document itemises sites that normally do and do not require oil separators, gives general design criteria and a method for calculating separator size based on 6 minutes retention and catchment area.

6.5 Stormwater Pipe Design

6.5.1 Pipe Sizing for Standard Stormwater Networks

Design of surface water pipes, particularly small systems of up to 450mm diameter pipes, is often carried out using the Rational Method or the Modified Rational Method. They are normally subsequently analysed using a hydrograph method to check for flooding performance. Alternatively approximate pipe sizes can be quickly determined for small sites by using a rule of thumb approach of assuming a constant rainfall intensity of 50mm/hr.

Whatever approach is used to size pipes, this should only be done to provide an initial assessment of the network, and more detailed analysis should be carried out to justify/modify the pipe sizes and gradients to ensure an adequate level of service. This normally requires simulation modelling to enable an assessment of the flood risk for extreme events. Table 6.4 summarises the criteria which apply to the Dublin region.

Parameter	Surface Water Sewers
Minimum depth	1.2m cover under highways 0.9m elsewhere
Maximum depth	Normally 5m
Minimum sewer size	225mm
Runoff factors for pipe sizing	100% paved and roof surfaces 0% off pervious surfaces
Rainfall for initial pipe sizing	50mm/hr rainfall intensity
Minimum velocity (pipe full)	1.0m/s
Flooding	Checks made for adequate protection * No flooding for return period less than 30 years except where explicitly planned Simulation modelling is required for sites greater than 24ha**
Roughness – ks	0.6mm

Table 6.4 Surface Water Design Criteria

** It should be noted that a check for adequate protection against flooding cannot be made without simulation. Thus in practice nearly all systems are modelled to demonstrate that their performance is adequate for protection against flooding.*

*** The runoff model normally used for simulation is the New UK PR model, but the fixed runoff model can also be used.*

6.5.1.1 Private Sewers (those not vested)

Sewers serving individual properties can be 100mm. However pipe sizes and gradients are based on pipe capacity and velocity dictated by the criteria in Table 6.4.

Minimum cover to pipes can be reduced to 900mm when under lightly trafficked areas such as driveways, though this is very much a function of pipe material and vehicle loadings. In other circumstances cover should not be less than 600mm unless suitably protected.

6.5.1.2 Minimum Pipe Size and Gradient

The concept of pipe full design criterion is largely redundant in practice, as flooding is usually the controlling criteria. The use of pipe full criterion helps guide the designer in achieving pipe sizes which are likely ensure this condition. Although simulation modelling is not required for sites less than 24ha, flooding can only be predicted using computer simulation. The development of very small sites may not warrant the expense of assessing flooding.

6.5.1.3 Roughness

Guidance on the roughness of sewers for various materials is based on work carried out at HR Wallingford (1982). Guidance on pipe roughness is more fully advised in “Tables for Hydraulic design of pipes, sewers and channels” – volume 1, 6th edition from HR Wallingford.

6.5.1.4 Roughness and Velocity

CIRIA report 141 "Design of sewers to control sediment problems" has been produced to provide an alternative design approach based upon the solids carrying capacity of flows in sewers. This is applicable to both foul and surface water sewer design. It allows sewer gradients to be designed specifically for sediment loads for any pipe size. It is important to note that self-cleansing velocities increase with increasing pipe size. Very large sewers require high self-cleansing velocities (in excess of 3 m/s). Large sewers (those in excess of 1m diameter) should therefore be designed to allow a small amount of sediment deposition and should be specifically analysed using CIRIA report 141.

6.5.1.5 Runoff

Although the Wallingford Procedure uses a different runoff model to the fixed rates given in Table 6.4, in practice this is not a particular issue as the runoff volumes tend to be fairly similar for normal urban environments. Figure 6.2 illustrates the differences between the two models and shows that, for fairly high development densities, the assumptions in Table 6.4 of 100% and 0% runoff for paved and pervious areas respectively are conservative in predicting volumes of runoff.

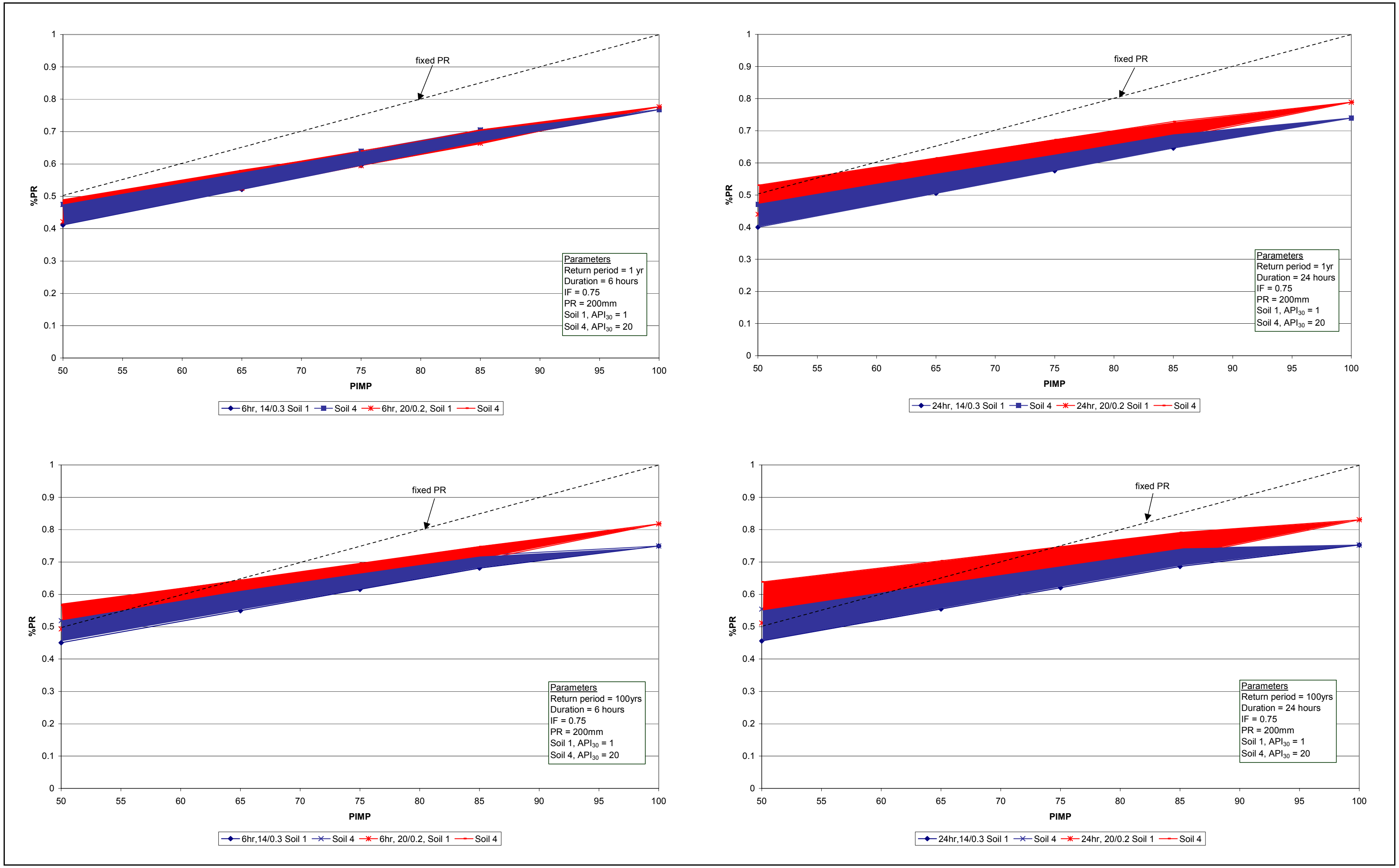


Figure 6.2 Comparison of PR between the Variable Wallingford Procedure Runoff Model and the Use of 100% and 0% Used for Initial Pipe Sizing

6.5.2 Pipe Sizing for Stormwater Systems Incorporating SuDS

There is concern in certain quarters that SuDS do not have an established track record in terms of performance. In addition as they are often landscape features, the opportunity to modify them, and hence adversely affect their operation, is much greater than comparable alteration of a traditional pipe system. For example driveways in private properties might be designed to be unlined pervious pavements, and these might subsequently be sealed.

Discharge rates and volumes from these surfaces could therefore dramatically change. Where pipe systems are used to pick up and convey these flows, the subsequent level of service provided will be much reduced.

For these reasons it is proposed that pipes should be sized assuming the SuDS units continue to work correctly, but to assess the risk of change and add appropriate safety factors accordingly. The risk assessment should also evaluate the consequences of these changes occurring.

Runoff from some SuDS units such as swales and pervious pavements will normally be significantly attenuated and reduced in volume. This means that flow depths and velocities will be low for pipes laid at traditional gradients. Fortunately these discharges will normally have very little sediment and therefore self-cleansing flows should not be an issue. In this situation a velocity of only 0.3m/s is likely to be sufficient. However any pipework which receives runoff, where the sediment loading is not addressed effectively by the SuDS unit, should apply traditional velocity criteria.

6.5.3 Discharge to Watercourses from Attenuation Storage in Floodplains

As discussed in 6.3.1.5, storage systems that cannot avoid being built in the floodplain have to take account of the relative water levels in the storage system and the receiving water. It is important to design the outlet characteristics to meet the discharge constraints which are defined by the drainage criteria. Simple assumptions regarding water levels in this situation can rarely be made. For instance if one assumes the river level is normally low then if it is actually high when discharge is taking place from a tank, (which is highly likely in very wet periods) then run-off from a tank storage structure will be less than the design flow rate. This means that the tank will completely fill for a smaller rainfall event than designed and will have insufficient capacity for the design storm. However if the opposite is assumed (that the river level is high for the operation of the tank), then discharge from the tank when the river is low will be too high. The closer the difference in the water levels between the storage unit and the river becomes, the more difficult this problem is to solve.

There are two ways in which this problem can be addressed. The first is to assume a low water level in the river and design the storage system appropriately so that the maximum discharge from the tank will never be exceeded. Then evaluate the performance of the tank assuming the river level is at its maximum height. This will show the additional volume needed to meet this extreme assumption. Where this additional volume is not particularly great, then the design can be considered to be appropriate. In fact it has the significant advantage in that the worst-case scenarios are all catered for.

The second approach is to make some assumption with regards to the dependency between the river water level and the water level in the storage system. This method requires the existence of models for both the site drainage system and the river. These water levels are varying continuously and are relatively different for different rainfall events, due to the catchment response characteristics compared to the development site run-off characteristics. In practice the important event is the design extreme event which requires the largest volume of storage on site. The hundred year return period is the only event needing to be considered. As the critical duration event for the storage system on the site is likely to be in the region of 24 hours, this is likely to be fairly similar to the critical duration of the river unless it is a major national river. It is therefore suggested that the precautionary position of total dependency is assumed in terms of rainfall events. However if the site discharge constraint is fairly generous in terms of throttle rate, the critical duration event may well be between 2 and 6 hours, in which case the assumption of total dependency can be relaxed.

A range of duration events for the 100 year return period would then be run on both models with the predicted water level of the river at the location of the storage outfall being used as the downstream water level. This methodology will result in a less conservative estimate of the additional storage volume needed to cater for periods of high river water levels.

It should always be borne in mind that the use of design storms does not necessarily reflect what happens in reality. These are current best practice methods used to arrive at a solution giving appropriate provision for situations that might take place. The consequence of failure should always be a part of an engineer's design approach to ensure a full appreciation of the proposed system design.

6.6 Attenuation Storage Design

This section details the methods and equations to be used to enable the determination of storage volumes for development sites.

The approach should always involve the use of a hydrograph method. Time series rainfall (TSR) is theoretically better than design events, particularly for frequent event criteria, as a complex mix of SuDS units will have runoff characteristics which will not be accurately reflected by the use of design storms. However, the computational effort, and the lack of an extended series suitable for any particular region, makes this approach relatively impractical. So although design events will be the normal approach for system design and analysis, where a suitable time series exists, a check on the system performance is recommended. Empirical design rules also exist for sizing certain SuDS items.

The method for finding the stormwater attenuation volume is:

Step 1 Find the greenfield peak runoff rate for the site;

Step 2 Apply this rate as a throttle to the model of the development and run it with a range of duration events for design return periods in accordance with the design criteria.

Assessment of the storage requirement using models is normally carried out by applying the maximum discharge flow rate as the discharge limit. This method provides a reasonable estimate of the volume needed. However depending on the configuration and design of the storage system, this will under-predict the volume by as much as 20 or 30% due to the variable head-discharge curve for any throttle if this is not represented in the model. Thus it will be important to be aware of the potential under-prediction and to prove the adequacy of the storage provision at the detailed design stage by building an accurate model which takes into account the depth-storage relationship together with the head-discharge relationship of the unit.

6.6.1 Assessment of Greenfield Site Rate of Runoff

There are numerous hydrological techniques currently in use to estimate green-field runoff rates. This section briefly reviews the techniques most commonly used by drainage engineers. Most of these methods have been developed in the UK, but they are considered applicable to Ireland. (The exception is the Rational Method, which in its original formulation is generally acknowledged to have been defined by an Irishman, Mulvaney). The methods include:

- Agricultural Development and Advisory Service, Report 345 (ADAS) (1982);
- Techniques based on the Rational Method;
- Prudhoe and Young, Transport and Road Research Laboratory, Report LR 565, (TRRL, 1973);
- Flood Studies Report (FSR) statistical and rainfall runoff – various methods (National Environment Research Council, 1975);

- Flood estimation for small catchments, Report no. 124 (Institute of Hydrology, 1994);
- Flood Estimation Handbook (FEH) (Institute of Hydrology, 1999).

The last method is mentioned due to its importance in the UK. However it has no applicability in Ireland as it is based on multiple regression characteristics for every location (1 km grid) across the UK, and therefore is not discussed further. Its only relevant feature is that the FEH rainfall analysis of data for UK has resulted in some significant changes in rainfall depths for various durations and return periods compared with FSR. This implies that the FSR values for Ireland might be equally in need of correction.

The proposed method used for determining peak flow rates for small greenfield catchments is *IH Report 124, Flood estimation for small catchments*. A direct comparison between this method and the ADAS 345 method, which is also commonly used in UK, is not easy, due to the different parameters used, but in general the differences have been found to be relatively small for most typical catchments. The other methods are thought to be less appropriate.

In theory FSR-based methods are limited to catchments greater than 50 ha while the ADAS method is only to be applied to catchments which are smaller than 30 ha. However for simplicity it is proposed that Report 124 is applied to all catchment sizes by applying it to a 50ha site and linearly interpolating the result for smaller areas.

6.6.1.1 *Agricultural Development and Advisory Service (ADAS) Report 345 Technique*

The Agricultural and Development Advisory (ADAS) Report 345, produced in 1982, details a technique which is primarily aimed at providing information to determine the size of pipes required for field drainage systems. This is an important distinction as the attenuation process of soil percolation will reduce the catchment response rate. The method is based on measurements taken on a number of small rural catchments.

The equation to estimate runoff from a site is of the form:

$Q = S_T F A$

Where:

Q is the peak flow in l/s.

S_T is the soil type factor, which ranges between 0.1 for a very permeable soil to 1.3 for an impermeable soil.

F is a factor, which is a function of average slope, maximum drainage length and average annual rainfall. The F number can be estimated from a nomograph included in the ADAS report.

A is the area of the catchment being drained in hectares.

Guidance on the values of the above variables is given in the ADAS report, together with a nomograph that can be used to estimate the flow. The predicted peak flow resulting from the ADAS equation for “grass” should be taken as being the one year return period flood and not the mean annual flood for the catchment. The other 2 curves represent the return periods of 5 and 10 years. Flow rates for higher return periods can then be calculated by using the appropriate regional growth curve.

6.6.1.2 *Flood Estimation for Small Catchments (Institute of Hydrology report no. 124)*

The Institute of Hydrology Report No. 124 was published in 1994 and describes research on flood estimation for small catchments. The research was based on 71 small rural catchments (< 25 km^2). A new regression equation was produced to calculate $QBAR_{rural}$ the mean annual flood. $QBAR_{rural}$ is estimated from the equation:

$QBAR_{rural} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$

Where:

$QBAR_{rural}$ is the mean annual flood flow from a rural catchment in m^3/s.

AREA is the area of the catchment in km^2.

SAAR is the standard average annual rainfall (for the period 1941 to 1970 in mm).

SOIL is the soil index, which is a composite index determined from soil survey maps that accompany the Flood Studies Report.

QBAR can be factored by the regional growth curve to produce peak flood flows for other return periods.

Table 6.5 provides typical values of QBAR per hectare for a typical SAAR value for Dublin of 750mm for SOIL types 2, 3 and 4. QBAR growth curve factors from the proposed growth curves for the Dublin region are provided in Table 6.6.

	SOIL type 2	SOIL type 3	SOIL type 4
QBAR/ha (l/s/ha).	2.0	3.1	5.2

Table 6.5 Typical Values of QBAR for Dublin (based on 50ha)

Return period (years)	Growth curve factor
1	0.85
QBAR	1.0
10	1.7
30	2.1
100	2.6
200	2.9

Table 6.6 Proposed Growth Curve Values for QBAR for Dublin (interim)

Appendix E provides a worked example for the storage requirement related to this design criterion.

6.6.2 Assessment of Development Runoff Rate

Runoff from positively drained paved areas is effectively instantaneous by comparison with greenfield runoff. The runoff rate therefore reflects the intensity of rainfall with a little attenuation being provided by the filling of depression storage, surface runoff routing and pipe routing. This is true for all high intensity short storms up to around 20 to 30 year return period events. Above this return period, short duration “summer” storms have intensities which are so great that temporary flooding takes place due to the inadequate capacity of the pipe system and gullies to cope with the volume of water. It is therefore unimportant to determine peak flow rates from the site for evaluating the volume site storage.

6.7 "Long term" Storage Design

The objective of providing "long term" storage is to protect the river from effects of the increased volume of runoff compared to greenfield conditions. Peak flow rates are addressed by the use of attenuation storage, but it is also important to minimise the additional volume of runoff created by the development.

As discussed earlier, the primary aim is to protect the river at times of flooding, and therefore this long-term storage volume need not be mobilised for small events. Although relatively difficult to design to operate in this way, (together with the additional uncertainty of design storms representing all real storms), it is possible to design long term flood storage areas which come into effect for larger events and only drain by infiltration. This volume can be quite large depending on the catchment soil type and density of development, so flooding of the "long term" storage unit(s) needs to start taking place at return periods significantly less than 100 years to ensure the volume retained at the 100 year event meets the criteria. Therefore consideration must also be given to meeting levels of service criteria.

Alternatively, and more simply, this volume can be provided in the form of infiltration volume around the site which comes into effect for all events. In this case it is particularly important that the soil characteristics and water table levels are suitable as there must be a reasonable expectation that much of this storage volume is available for an extreme event.

To determine a storage volume requires the selection of an event duration for the 100 year return period. Six hours has been selected as the duration of the design event to compute the additional storage. In theory, the river should be protected for its critical duration at the point of the development. However for simplicity and practicality it is proposed to use a duration which is appropriate for shorter rivers. This is not only relevant for those in the Dublin Region, but also it is these smaller rivers which are going to be more sensitive to the effects of development runoff.

The estimation of the "long term" storage volume is a simple calculation of finding the difference between the runoff volume generated by the development site and that for the greenfield site using the 100 year 6 hour event.

6.7.1 Assessment of Development Runoff Volumes

There are two Wallingford Procedure runoff models which are based on statistical correlation and the fixed percentage runoff model usually used when applying the Rational Method. The two Wallingford Procedure runoff models are described in Appendix D.

Although the Wallingford Procedure New UK PR equation is generally regarded as the most appropriate runoff model for simulation modelling, there are certain situations, particularly for developments in areas with SOIL type 4 (clay), where it will actually predict less runoff for extreme events than the formula used for predicting greenfield runoff volume (FSSR 16, *FSR Rainfall Runoff Model Parameters Estimate Equations Updated, December 1985*). Intuitively this seems unlikely, as paved surfaces have around 70 to 80 percent runoff, whereas the FSR analysis cannot give values much greater than around 55 percent. There are a number of arguments which can be made to support the Wallingford Procedure runoff model. The main one is that the land form in urban areas is heavily modified with many obstructions (garden walls, buildings, undrained low points) which prevent runoff from occurring from some paved and unpaved surfaces. However for simplicity and taking a precautionary position, it is proposed that a fixed runoff model for the paved surfaces and an allowance for runoff from the pervious surfaces, that is consistent with the analysis for the greenfield runoff volume approach, is used.

It is proposed that an 80% runoff is assumed for impervious surfaces and the SPR value of the soil is assumed for the pervious area based on the local soil type.

6.7.2 Assessment of Greenfield Runoff Volumes

The estimation of runoff volume from pervious areas using FSSR 16 is detailed in Appendix D. However this closely approximates to an assumption that runoff volume is equal to the SPR value for the soil type. Table 6.7 summarises the SPR value for the 5 soil types used in the FSR procedure.

SOIL	SPR value (% runoff)
1	0.1
2	0.3
3	0.37
4	0.47
5	0.53

Table 6.7 SPR Values for SOIL (pervious surface runoff factor)

6.7.3 Estimation of the Difference Between Greenfield and Development Runoff Volumes

Two extreme assumptions can be made with regard to greenfield runoff volumes after site development. The first is that there is no runoff from pervious areas due to urbanisation effects impeding runoff from these surfaces, and the second is that all the pervious area continues to contribute in the same way as it did prior to the site being developed. In practice the reality is somewhere between the two and is dependent on the design layout. For example a park area might be designed to positively not drain to the drainage system or river. In this case it would be reasonable to assume that no runoff allowance need be made for this area.

The following general formula provides an estimate of the “long term” storage volume. This calculation of excess urban runoff takes account of any surfaces, either impervious areas or pervious areas, which are not served by the drainage system.

$$\mathrm{Vol}_{xs} = \mathrm{RD.A.10}\left[\frac{\mathrm{PIMP}}{100}(\alpha 0.8) + \left(1 - \frac{\mathrm{PIMP}}{100}\right)(\beta.\mathrm{SOIL}) - \mathrm{SOIL}\right]$$

Where:

Vol_{XS} is the extra runoff volume (m^3) of development runoff over Greenfield runoff.

RD is the rainfall depth for the 100 year, 6 hour event (mm).

PIMP is the impermeable area as a percentage of the total area (values from 0 to100).

A is the area of the site (ha).

SOIL is the “SPR” index from FSR.

α is the proportion of paved area draining to the network or directly to the river (values from 0 to1).

β is the proportion of pervious area draining to the network or directly to the river (values from 0 to1).

If all the paved area is assumed to drain to the network and all the pervious areas are landscaped not to enter the drainage system or river, this formula simplifies to:

$$Vol_{xs} = RD.A.10\left(0.8\frac{PIMP}{100} - SOIL\right)$$

But where all pervious areas are assumed to continue to drain to the river or network the formula becomes:

$$Vol_{xs} = RD.A.10\left(0.8\frac{PIMP}{100} - \frac{PIMP}{100}.SOIL\right)$$

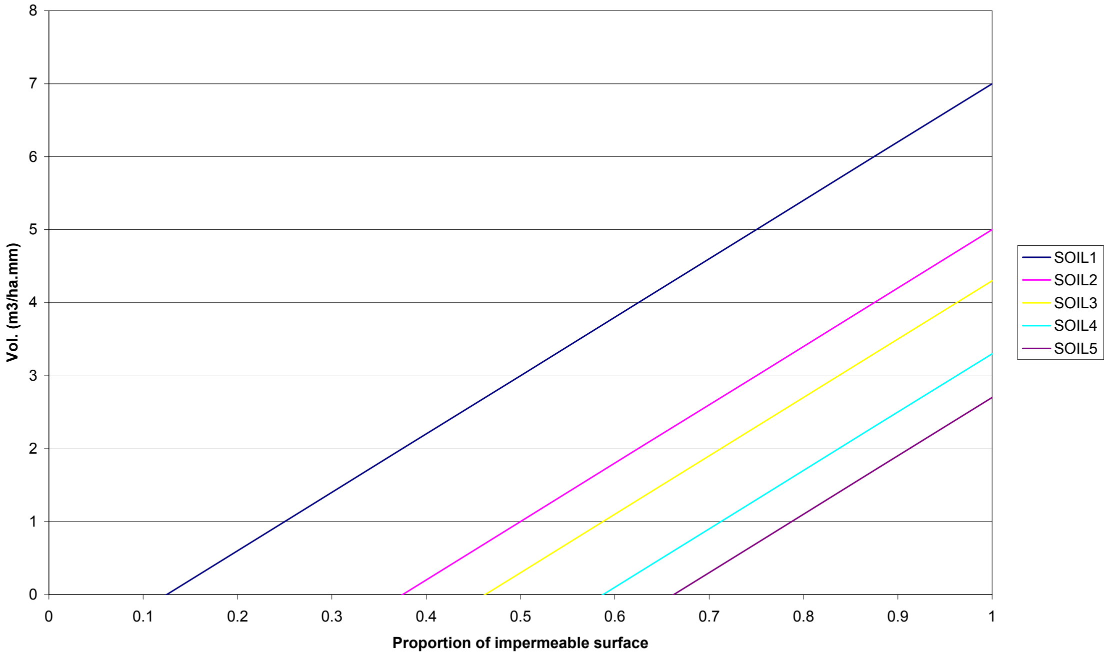


Figure 6.3 Long-term storage for developments where all pervious areas are assumed not to drain to the drainage network or river

Figures 6.3 and 6.4 illustrate the “long term” storage volumes that these two extremes (disconnected/connected pervious surfaces) represent for developments for different soil types for any development density. These figures demonstrate the importance of soil type, the use of infiltration to disconnect impermeable areas from the drainage network and the need to be efficient in designing the general landscape.

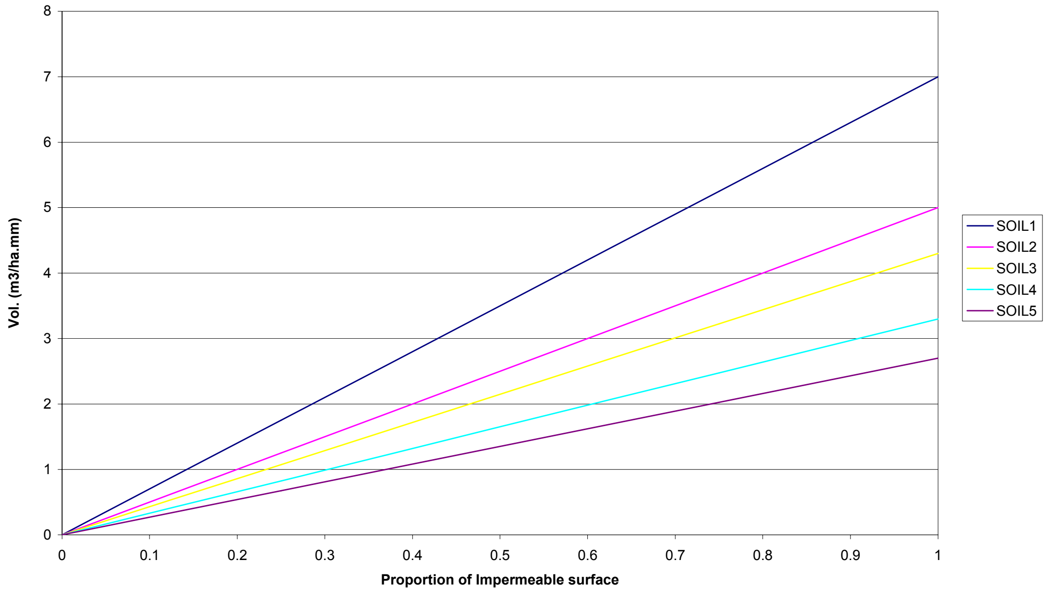


Figure 6.4 Long-term storage for developments where all pervious areas are assumed to be drained to the drainage network or river

There are elements of conservativism in these assumptions in not allowing for depression storage and evaporation or infiltration taking place during the event, but it does provide a rapid and robust method for assessing the maximum additional volume of runoff generated by a development.

For ease of reference the 100 year 6 hour event for the Dublin area is given in Table 6.8.

Location	M5-60 (mm)	Ratio "r"	Rainfall Depth (mm)
North Dublin and City centre	15	0.25	58.7
South Dublin	17	0.30	60.9

Table 6.8 Rainfall Depths for Dublin; 100 year 6 hour event

South Dublin is differentiated as the mountains make the rainfall characteristics for the region slightly different. However it can be seen that although the rainfall characteristics are different, the actual rainfall depth for the design event happens to be very similar. It is therefore recommended that a figure of 60mm is used throughout the Dublin region. It should be noted that soil type is a far more important variable in this regard and that although much of Dublin is categorised as SOIL type 2, in practice some areas might be closer to SOIL type 4. As this makes such a big difference to the "long term" storage requirements, it is important to carry out site tests on soil characteristics to choose an appropriate SOIL category.

Although slope is not a function of the procedure (and not included in the assessment of peak runoff rate in the greenfield peak discharge formula), the rate and amount of runoff from the greenfield site is going to be influenced to some degree by the slope. An intelligent and flexible approach in the application of these equations and criteria is therefore needed. Recognition and compliance to the key principles underpinning the drainage criteria is the important feature of this drainage design philosophy.

As this criterion is a relatively arbitrary one, it is considered inappropriate to modify it to take account of climate change.

6.8 Hydraulic Design of SuDS Systems

Sustainable Drainage Systems (SuDS) cover a range of methods used in the design of modern drainage systems. The objective of SuDS is to attenuate and reduce stormwater runoff volume and reduce pollution impact due to urban development. General criteria for selection of SuDS options are contained in the Regional Policy on Environmental Management. This section considers the hydraulic design aspects of SuDS. Their hydraulic characteristics are summarised in Table 6.9.

Drainage System	Rate of Discharge	Volume of Discharge
Direct Pipework	Very fast	No reduction
Swales (standard)	Fast – Medium	Limited reduction
Storage Tanks	Fast – slow	No reduction
Lined and unlined Ponds	Fast – slow	Potential for limited reduction
Detention Basins	Fast – slow	Limited reduction
Wetlands	Fast – slow	Limited reduction
Lined sub-pavement storage	Medium	Limited reduction
Unlined sub-pavement storage	Medium	Significant reduction
Filter drains	Medium	Limited reduction
Swales (under-drained)	Medium – slow	Significant reduction
Soakaways	Effectively none	Large reduction
Infiltration trenches	Effectively none	Large reduction
Infiltration from temporary storage*	Effectively none	Large reduction

Table 6.9 Hydraulic Characteristics of Drainage Systems (for large rainfall events)

**Land allocated for temporary flooding to meet "long term" storage requirements.*

The use of the term fast and slow here is only a qualitative statement relating the speed of runoff for piped systems (very fast) to greenfield behaviour (slow).

It must be recognised as a limitation of SuDS systems even though SuDS tend to have greater volumetric storage than pipe based systems, that extreme events, with large volumes of runoff, can overwhelm SuDS units as much as traditional pipe systems. In such circumstances, their performance in terms of attenuation and stormwater volume reduction is not necessarily any better than pipe based drainage systems. This should not be regarded as a failure, but as a normal consequence that should be explicitly catered for in the design process, with emergency overflow and flood routing arrangements included which direct flow away from properties. This is no different than the design process which should be followed for areas drained by pipe networks.

Hydraulic modelling assumptions for SuDS units are dependent on the site conditions (rate and proportion of runoff). Modelling of pervious pavements is still in its infancy and therefore a precautionary approach should be taken with its representation, but for most SuDS units their representation is relatively obvious in terms of the modelling approach and values to be used.

6.8.1 Hydraulic Categories of SuDS Components

The stormwater design procedure has defined the criteria to enable storage volumes and discharge limits to be calculated. However, these calculations need to be applied in reality using a range of drainage components. In each case there are practical issues that need to be considered to enable an effective hydraulic design of the drainage system to be built. This section deals with each component, providing guidance on the hydraulic aspects affecting their construction and proposed use.

It is important to be aware that design of these units for hydraulic performance needs to take a precautionary approach especially when selecting infiltration rates for soils which need to work during wet winter conditions.

Design of these units should comply with the Design Manuals for SuDS, CIRIA C521 and C522 and other relevant and subsequent publications, including the GDSDS Environmental Management policy document.

There are effectively three categories of SuDS units:

- Attenuation only - Retention and Detention Ponds, Tanks;
- Runoff reduction and attenuation - Swales, permeable pavements and filter trenches;
- No runoff –Infiltration systems.

6.8.2 Retention / Detention Ponds and Tanks

These types of stormwater units are aimed at providing storage and attenuation and some degree of treatment. The design of ponds and tanks uses the inflow/outflow hydrograph process. The actual volume required is defined by a matrix of parameters that are summarised as:

- Depth / area storage relationship;
- Head / discharge relationship;
- Throttle rate;
- Effective contributing area;
- Rainfall characteristics of the area;
- Level of service;
- Safety.

Some of these aspects have been addressed earlier and are therefore not discussed here. The hydraulic design requirements are considered below. Other aspects (safety for instance) are dealt with in the Environmental Management Policy document.

6.8.2.1 Depth / Area Storage Relationship

The depth / area storage function is largely dictated by topography and outfall levels. However other issues such as treatment processes in ponds will dictate depth requirements. Volumetric allowances for vegetation should also be provided for in ponds, which might be as much as 20 percent for heavily vegetated systems.

6.8.2.2 Head / Discharge Relationship

Structures are normally designed to a specified maximum discharge rate and this is usually achieved when the storage structure is full. This means that the outflow at lower water levels is passing less flow forwards making the effective volume needed larger, but theoretically approximately reflects the increasing greenfield peak flow rates for lesser events. This additional volume requirement can often be minimised by having the storage structure as an off-line pond, but this has disadvantages for water quality treatment. As this criteria involves 3 flow rates (1, 30 and 100 year return periods), analysis for attenuation storage needs to be carried out in 3 stages.

This analysis could result in the use of 3 orifices to achieve a good fit to the discharge requirements for the 3 return periods. In practice it should result in 1 low level orifice and a second outlet which might be an orifice or slot of some kind. It is important to make sure the final design is practical as well as effective. The flow rate control system should aim to approximate to the calculated system, but common sense must be exercised in finding the most practical solution.

Storage systems are often located near the river to which they discharge. River levels will provide backwater effects, which will modify the discharge at times of high water levels. This has been discussed in some detail earlier.

6.8.2.3 Throttle Sizes and Discharge Rate

There are practical difficulties in meeting hydraulic criteria for very low flow rates, as local authorities rarely take in charge orifice controls or pipe sizes with diameters less than 150mm. Although there are vortex devices which can reduce the flow through a throttle unit, but still provide a free bore of 150mm, developments below a certain size will not be able to throttle the flow sufficiently to meet the stated criteria. For example if 2l/s/ha is used for the 1 year throttle rate, and the minimum flow rate is considered to be 10l/s, then the minimum drainage area served is 5 ha.

This criterion for minimum orifice size, although a constraint for the authorities, need not necessarily apply to private owners. Systems such as pervious pavements, due to the very limited risk of obstruction, can be designed with orifice sizes of 75mm or even smaller.

This constraint draws attention to two aspects of good drainage practice. The first is that areas should be drained in an integrated manner, so that even if a single developer is only developing a 1ha site, it should fit into a larger drainage strategy. The second is that this element of storage may be better achieved by other drainage components, particularly those which have slow release characteristics for “small” events. SuDS units such as lined or unlined permeable pavement car parks or under-drained swales can provide low discharge rates.

6.8.3 Swales

Swales, Permeable Pavements and Filter Drains can be designed in various ways, and are therefore difficult to categorise hydraulically. In terms of their hydraulic behaviour, they generally fall into a composite group that provide both attenuation and runoff reduction. Their relative merits in each of these two categories is a function of their design, topography, the soil type and size of rainfall event. It is therefore important not to be too prescriptive about their generic attributes, but to consider for each their characteristics depending on the site situation and the type of rainfall event.

For clarity each of these units is considered separately, although the same hydraulic issues affect their design and performance. Aspects such as maintenance and operation and water quality are not dealt with here, but are covered in the Environmental Management policy document. These issues are:

- Runoff attenuation and reduction;
- Hydraulic & physical constraints;
- Level of service.

In terms of hydraulic and physical constraints, all infiltration structures should be built at least 1.0m above the maximum groundwater level. Infiltration structures must only be built where groundwater classification in that area allows. Sites located close to drinking water borehole abstraction points should carefully be considered in terms of the pollution risks related to the use of infiltration related units.

A major concern is knowing the design soil condition. Wet periods in winter are common and are predicted to become more frequent. The soil characteristics and its capacity to infiltrate in these conditions is not easily determined. Caution is required in selecting design infiltration rates for units relying on the ability to infiltrate which may cause a problem, if surcharged. CIRIA report 156 “Infiltration drainage – Manual of good practice”, 1996, provides guidance on how and when to use infiltration. The normal cut-off point for use of infiltration is 0.001 mm/s. With the emphasis now on maximising infiltration, its use should still be encouraged for percolation rates found to be around this value as well as at locations where better soil conditions occur. In locations where “failure” of a unit would cause a problem, overflow facilities should be provided.

Swales are effectively shallow wide ditches in which grass is grown and regularly maintained. Inflow into swales is usually by continuous distributed runoff from road surfaces, although these can be made semi-continuous with numerous point inputs.

6.8.3.1 Hydraulic and Physical Constraints of Swales

Swales are very susceptible to erosion and low flow pathways developing. To avoid this, gradients need to be minimised wherever possible. Recommended gradients for standard swales are between 1:20 and 1:300, to avoid erosion and ponding respectively. Point inflows should be avoided. Kerbs are often put in for safety reasons or to preserve the verge. Entry points for runoff should be as frequent as possible to avoid local erosion.

Pipes connecting swales under driveways or roads provide a focal point for erosion and sediment deposition. Conduits should be as large as reasonably possible and not sized on the basis of pipe capacity. Alternatively pipes may be selected as throttles to try and restrain flows. However as 150mm pipes are normally the minimum size acceptable, and as swales tend not to be very long, to prevent high flows developing, the use of 150mm pipes as throttles will not normally be very effective.

Overland flooding from swales that are full, due to extreme conditions or steepness of the catchment, needs to be assessed. Overland flow routes must be considered to ensure that flooding of properties does not take place. Houses located below the road level are especially at risk from major events and particular care is needed (whether or not swales are used) to ensure these properties are not flooded by extreme events.

Considerable variation occurs with regard to outflow design. There are three main methods:

- Invert level outflow;
- High level outflow;
- Infiltration outflow (under-drainage).

Each method is discussed with regard to attenuation and reduction of runoff.

6.8.3.2 Swales with Invert Level Outflows

With outflows at the invert of the swale, its hydraulic behaviour is the same as a rough channel with water level being either a function of normal depth, or if the outfall pipe is a constraint, the level is a function of the throttle and storage relationship.

In this situation, some attenuation is achieved and this varies with the return period of the event and the degree of throttling of the outflow. Volume reduction may be slightly enhanced, but in long wet winter periods, ground saturation may result in virtually no reduction of runoff. These types of swales therefore cannot be relied upon to meet either volume reduction or attenuation targets for large events.

6.8.3.3 Swales with High Level Outflows

A swale designed to have a high level outflow is effectively a combination of a mini retention basin and conveyance channel. The “deep” water allows low values of conveyance velocity to be determined which will minimise scour.

An important parameter for this type of swale is the permeability of the soil. Application of this method in clay soils will result in die-off of the grass due to long periods of saturation. In terms of the hydrological benefits, the effective reduction of runoff volume might be less than the volume of storage theoretically available due to antecedent conditions, especially if the soil is not very pervious.

The use of this type of swale is therefore more appropriate where soil conditions are relatively permeable or where enhanced infiltration in the base of the swale is provided. In these situations the volume of storage within the swale (below the outfall) could be used to assess the reduction in runoff volume. If all roads (which were appropriate to drain using swales) were designed in this way, the volume of runoff would be significantly reduced as well as contributing to water quality improvements.

6.8.3.4 Swales with Piped Under-Drainage

The difference between this type of swale and the previous two types is that it is not meant to function as a conveyance channel. The objective is to use the swale as a retention basin and for runoff treatment, with flows passing to a perforated drainage pipe below the swale. This enables the swale to be designed as a balancing system with a controlled outflow based on the pipe size serving the system of swales. The great advantage of this system is that there is considerably less risk of erosion from flows passing along the swale as they will tend to be short individual lengths. The physical problems related to pipe connections, which are needed to pass under roads and driveways crossing the swale, are also avoided.

Inflow / outflow design should be based on infiltration techniques and the hydraulic constraint of the receiving pipe. In addition the under-drain is likely to have a continuous low flow during wet winter periods and some account of this should be made in checking on the possible range of the system performance. Design therefore requires careful application to make the most of this drainage system.

If no under-drainage is provided and natural or enhanced infiltration into the soil alone is being used, the volume reduction achieved is 100% (until the swale is full). The use of these swales needs to be constrained to locations where saturation of the soil is unlikely and winter groundwater levels remain well below the bottom of the swale. If there is doubt about drain-down of the swale between winter events, reduction in available storage volume needs to be made.

The limited experience in UK has shown under-drained swales to be very effective. Their use in Germany is extensive.

6.8.4 Pervious Pavements

Although pervious pavements are traditionally made using granular material for the sub-structure into which the water percolates, there are a range of high voids-ratio plastic media products also available. Voids ratios range from 30 to 95%.

The water quality outflow from these pavements is generally high. It is thought that the treatment is mainly achieved by the geo-textile membrane (preferably unwoven) placed immediately below the blockwork. This requires aerobic conditions for the bacteria to be effective. Therefore although geo-textile might usefully be placed at the bottom of the structure for other reasons, it is unlikely to contribute to treatment of the surface water at this location.

Several permeable pavements have been monitored in UK and elsewhere in the world. The volumetric reduction is largely a function of whether the pavement is lined or not, and seasonal effects. Short storms in summer often have only a nominal outflow, while long wet winter events do not achieve a significant volume reduction compared with standard drainage.

The performance of unlined pavements is a function of both the receiving soil type and construction technique, as it has been found that permeable surfaces can have their porosity significantly reduced by the construction process. It is reported that unlined pavements, even in clays, still achieve considerable reductions of runoff for ordinary events.

For systems designed to only drain by infiltration, it is important to provide a relief pipe to cope with excess runoff in case of reduced infiltration rates and / or very extended wet periods, where surcharge would be a problem. Reduction of runoff over a season of rainfall may be very great, but hydraulic design of these units should be based on their performance under extreme conditions.

Lined pavements are built where there is a concern to protect the groundwater from pollutants. For lined systems, runoff reductions are still significant although less than unlined systems. During long wet winter periods, runoff volumes might only be reduced by 30 percent in lined permeable pavements, though average annual figures have been found to be up to 55 percent.

Observed runoff rates from these units, even in the wettest periods, are low, usually below 2l/s/ha, for much of the storm runoff volume. The maximum flow rates recorded are in the order of 25l/s/ha, but these may have been constrained by the outlet pipe system. The figures suggest that these units are very effective in limiting the impact of runoff on receiving streams and urban drainage systems.

6.8.4.1 Hydraulic and Physical Constraints

Pervious pavements often cover very large areas, such as supermarket car parks. In this situation it is possible to design the outfall pipe to act as a throttle for extreme events.

The use of pervious pavements in private driveways cannot be relied upon not to be modified, particularly by sealing (to avoid weed growth), as householders may seek to minimise maintenance effort. The use of permeable pavements on common car parking areas for groups of houses is more likely to remain as designed as these will probably be managed by either the local authority or a management contractor.

Permeable blocks are susceptible to clogging due to oils (from cars) and sediments (from flowerbeds and construction techniques). The industry has therefore now moved away from these products and use a construction gap between solid blocks of around 3mm to ensure hydraulic performance in the long term.

Point input of inflows into the sub-base should be avoided, unless the flow is known to have minimal sediment load, since clogging may take place in due course at these locations. Additional inflows can be introduced into a pervious pavement area from adjacent roof runoff, subject to adequate sediment protection provision. The design of the additional area that can be served is a function of the effective storage volume and design criteria applied.

It is advised to keep to traditional car park gradients (fairly flat), where possible, to minimise excessive hydraulic loading at the lower edges of the permeable pavements. Also the hydraulic outflow behaviour relies upon the base of the unit being flat and so creating a minimal hydraulic gradient towards the outflow pipe, if there is one.

6.8.4.2 Level of Service

The depth of sub-base storage zone needs to relate to the design rainfall depth taking into account the voids ratio of around 30 percent (for gravel based fill units). If this is less than the critical 30-year event (probably 6 to 12 hour duration), the overland flow or flood depth across the car park should be specifically designed. In practice with a design depth normally of 350mm at 30% voids, the depth of rainfall that it can serve is in excess of 100mm; more than a 100 year event even with no outflow.

Outflow pipework should be hydraulically designed for both the collector system and the high level relief, although the acceptable minimum pipe diameter is likely to be the main constraint if the unit is to be vested.

6.8.5 Filter Drains

Filter Drains are trenches adjacent to roads with flows passing into the soil from a trench filled with a coarse stone mix. A perforated pipe usually passes along the length of the trench, to ensure water levels are kept well below the road subbase. The depth of the trench below the perforated pipe can be selected to meet storage design requirements.

In wet winter conditions if the soil is saturated, it is likely that Filter trenches will work in reverse acting as drainage systems, contributing to runoff. The assessment of their hydraulic design performance both in terms of attenuation and runoff reduction is therefore site specific.

6.8.6 Infiltration Units – Soakaways, Infiltration Trenches and Flooding of Public Open Spaces

These are the only systems that do not have some runoff contribution to a receiving water. Where the soil conditions exist and groundwater classification allows, soakaway systems can minimise the impact of development runoff and maximise water resource recharge.

6.8.6.1 Soakaways and Infiltration Trenches

Soakaways have been in existence for many years. They range from rudimentary, rubble filled pits to large tank structures serving large areas of runoff. Their design is well covered by manuals, two of which are generally applied across the UK. These are the CIRIA report 156 and BRE 365.

Although soakaways have been applied to Highway drainage, their use for anything other than roof water is generally not advised, as the high sediment loads from road runoff usually cause blockage problems within 20 years. These problems can be avoided by appropriate upkeep, which involves routine removal and replacement of sand layers on an annual basis, but this philosophy of high maintenance levels is not attractive to local authorities. The whole life cost evaluation of this approach would probably not make this drainage solution the most cost effective approach for most situations.

All soakaway structures should be evaluated for extreme event exceedence and provided with overflow pipework where a certain level of service cannot be assured and there is a risk of flooding as a result. Consideration of topography is important to ensure overland flows are directed away from properties.

Infiltration trenches are an alternative to soakaways. They tend to be more effective in many instances as they allow much greater efficiencies to be achieved, due to the units having greater surface area per unit volume. Also as the bottom of the trench tends to be nearer the surface than the base of a soakaway, this reduces the risk of direct interaction between the infiltration unit and the groundwater table.

The use of Infiltration trenches in private properties to serve roofs is at some risk due to landscaping and gardening activities. They should be located at sufficient depth to ensure that they are unlikely to be damaged. They should not be located on common boundaries as construction of fences and hedges will damage the drainage system.

The location of filter drains should theoretically be constrained in the same way as soakaways, and should be at least 5m from the property in compliance with Building Regulations. However as they are not deep, it is suggested that the minimum distance should be at least three times the depth of the trench, assuming adjacent buildings have appropriate foundations.

In the UK, where pervious pavements have been used as infiltration units, these have been located as close as 1m from the property where the soil is highly permeable.

A 10 year event is commonly used for design of property infiltration systems. However this might be increased significantly if they are seen as one of the mechanisms for meeting the requirement for “long term” storage.

These units should individually serve only one or very few properties. This is needed to avoid flow taking place along a trench to a low point and focussing all the potential flooding in one garden / location.

6.8.6.2 Flooding of Public Open Spaces

Infiltration in public open spaces is not a recognised SuDS system, but is included to represent those areas where flooding is planned to take place only in extreme events to deal with either overland flooding or “long term” storage.

Parks and other types of open spaces need to be carefully contoured and provided with suitable under-drainage to ensure they dry out effectively. However, to comply with the principles of long-term storage, it is important that this is not rapid and therefore not connected directly to the main drainage system.

Design Requirements

Developers should continue to provide particular design details and parameters for large residential, commercial, industrial and institutional developments

Design criteria for stormwater drainage for both runoff attenuation and reduction should be used for drainage design for New Developments

7 SPECIFICATIONS

There is currently no Irish specification for construction of drainage works, or water supply works. There are several publications that give guidance on drainage works, such as the Building Regulations, "Recommendations for Site Development Works for Housing Areas" and "Code of Practice for Development Works – Drainage". Otherwise specifications are produced for specific projects from the designers' own knowledge and previous experience.

The risk in this approach is that drainage projects are built to a variety of standards, and that design standards will stagnate, as designers reproduce specifications from previous projects.

For drainage works in the UK, the Civil Engineering Specification for the Water Industry is published by WRc, and regularly updated to account for developments in technology and experience in the industry. This specification covers the following topics:

- General: Setting up and maintenance of the site, public liaison, safety and standards;
- Materials: detailed specifications for items used in the construction of the drainage works and associated buildings;
- Excavation, backfilling and restoration: working standards for these and associated activities, such as use of compressed air;
- Concrete and formwork: mixes and working standards for concreting, together with construction of formwork, joints and finishes;
- Construction of pipelines, tunnels and ancillary works: working standards, tolerances and record keeping;
- Testing and disinfection: cleansing and testing of pipelines and water retaining structures;
- Roadworks: working standards for bituminous and concrete roads associated with drainage construction;
- Sewer and water main renovation: general requirements for works in accordance with the techniques in the "Sewerage Rehabilitation Manual" and "Water Mains Rehabilitation Manual".

This specification would be a good document from which to produce an Irish specification for the water industry, covering major construction works for drainage, sewerage and sewage treatment.

Further specification for SuDS installations, such as planting and landscaping, will be needed.

The existing documents entitled "Recommendations for Site Development Works for Housing Areas", the Building Regulations for Drainage and WasteWater Disposal, and their variants, contain much valuable practical information. The various sections of EN 752 "Drain and sewer systems outside buildings" also provide useful information.

Sewers for Adoption has been produced in the UK, as the design and construction guide for developers. This document specifies materials and working standards for more modest projects. It is also regularly updated to reflect changes in the industry, the latest 5th edition introducing SuDS.

Specification for the Irish Water Industry

A Specification Committee should be set up, containing members from the Client Authorities, to produce a particular specification for materials and working standards within the water industry

This specification to be applied to all water construction projects in Ireland, and regularly updated to reflect developments in technology and working practices in the water industry

Once the main specification for water construction projects has been prepared, the need for a particular specification for systems serving smaller residential-type developments should be considered.

Notwithstanding the above, Appendix F contains proposed specifications for particular aspects of sewerage and drainage contained in the Policy Document. These are:

- Cleansing and Testing;
- Connections to Existing Drainage Systems;
- Standards of Construction and Workmanship.

7.1 Pipes, Materials, and Fittings

Although the proposed particular specification will include the requirements for pipes, materials and fittings, the policy needs to be agreed on types of these items to be used in particular circumstances.

7.1.1 Current Arrangements

There are various statutory specifications in place, including:

Table 5 of the Building Regulations, which lists pipe materials for:

- sanitary pipework as cast iron, copper, galvanised steel, unplasticised polyvinylchloride (PVC-u), plastics ABS, MUPVC, and polyethylene;
- gravity drainage as fibre cement, vitrified clay, concrete, grey iron and PVC-u.

“Recommendations for Site Development Works for Housing Areas” permits foul and surface water sewers and drains to be PVC-u, spigot and socket concrete, clay, glass reinforced plastic (GRP) and glass composite concrete (GCC). Rebated concrete pipes and fittings may be used for surface water sewers and drains only.

The “Code of Practice for Development Works – Drainage” produced by Dublin City Council requires that PVC pipes are not to be used in the construction of main pipelines, and connections from gullies or private drains to the public sewer.

Designers for larger water schemes will select pipe materials to suit overall design requirements. For example steel pipelines would be necessary for large diameter pressure applications where ductile iron pipes are not manufactured.

7.2 Proposed Arrangements

It is proposed that pipe material for sewers and drains be separated from the lists in the Building Regulations, which of necessity include building pipework. The proposed lists are:

Pipe Materials for Gravity Sewers and Drains

- Concrete, using sulphate resisting cement;
- Vitrified Clay;
- Ductile Iron;
- Glass Reinforced Plastic (GRP);
- Structured Wall Plastic, subject to further investigation.

Pipe Materials for Pumping Mains

- Ductile Iron, subject to appropriate protection;
- Polyethylene 80;
- Polyethylene 100;
- Steel, for large diameters.

Pipes, Materials and Fittings

The proposed list of pipes, materials and fittings should be agreed

The agreed list should be periodically reviewed by the Specification Committee and updated to reflect changes in technology and drainage practice

Designers are to be permitted to use other pipes, materials and fittings to suit particular projects and applications, supported by technical justification

7.3 Sewerage and Drainage Details

Standardisation of manhole and pumping station details has long been a goal of drainage engineers, and it has not yet been reached. For example, even though Sewers for Adoption is in its 5th Edition, the committee has been unable to produce definitive details for such basic components of drainage systems.

7.3.1 Current Arrangements

Dublin City Council currently leads the region with its Standard Manhole Details covering pipeline diameters up to 750mm and depths up to 6m. The Council's insistence on in-situ concrete and brick/blockwork construction for watertightness has drawn criticism about long construction times.

Other councils favour the use of pre-cast concrete rings with concrete surround for manhole wall construction.

7.3.2 Proposed Arrangements

Mindful of the lengthy debate that standardisation will produce, we propose that a committee be set up to agree construction details among the Client Authorities. In the meantime Dublin City Council's Standard Details, as contained in Appendix G, should be adopted by all Councils, subject to flexibility of choice in manhole wall construction.

Sewerage and Drainage Details

The Specification Committee should agree construction details among the Client Authorities

Health and safety aspects of safe access and ingress in manholes and chambers shall be included with high priority

Where agreement cannot be reached the various requirements for each Authority should be documented

7.4 Building Over or Near Sewers

Under the Public Health of Ireland Act of 1878, it is not permissible to construct a building over a public sewer, and hence construction of sewerage and associated manholes and chambers, is generally not permitted by the Councils under or near buildings. Building over sewers causes major problems with access for maintenance and renewal of drainage assets. Sewers for Adoption, 5th Edition supports this principle, and the current Policy should remain.

Where access to a sewer is to be restricted on both sides, the clear distance required is a minimum of 6m, being normally 3m either side of the centreline. Where the clear distance does not contain a public right of way of sufficient width for plant access, typically 3m, the clear distance should ensure satisfactory access and support arrangements.

Where the depth to invert exceeds 3m, the boundary of the clear distance shall not be within the 45-degree line of influence from the base of the pipeline trench.

Foundations and basements of adjacent buildings shall be designed to ensure that no building load is transferred to the sewer. The nearest point of the building or basement must not fall within a 45-degree line of influence from the base of the pipeline trench.

This policy covers permanent clear distances required in connection with pipe-laying and subsequent maintenance, for both public and private drainage systems. The policy excludes temporary working areas used during construction.

The reasons for the policy criteria are:

- The clear distance of 6m typically coincides with the minimum compensation per unit length of pipeline acceptable to the farming community in general;

- The minimum clear distance of the 45-degree line of influence from the base of the pipeline trench is deemed reasonable for maintenance of the pipeline, assuming the presence of buildings on both sides. These clear distances allow for storage of excavated material and access for excavation and pipe-laying equipment;

- The clear distances derived from depth to invert are intended to prevent loads from buildings, etc, being imposed upon the pipeline.

Dimensions below these minima should only be accepted where there are particular on-site restrictions, which would otherwise prevent drainage from being constructed.

Building Over or Near Sewers

Clear distances for public and private drainage will have minimum widths of 6m

Where the depth to invert exceeds 3m, the boundary of the clear distance shall not be within the 45-degree line of influence from the base of the pipeline trench

7.5 Monitoring of Construction

This Policy must achieve the practical balance between the Council's Drainage Inspector monitoring every aspect of drainage construction, and the Inspector being satisfied that construction is of adequate quality and fitness for purpose. The former situation could require the Inspector to be full time on site, which is not practicable in terms of provision of manpower or recovery of costs from the developer.

It is therefore proposed that testing be carried out on a priority basis, being:

Priority 1: Mandatory requirement for all sites;

Priority 2:Mandatory requirement for all sites exceeding 1 hectare in area.

The proposed checking regime is:

Item	Priority	Comments
Construction Drawings and Specifications available on site	1	Held by Contractor, access for Inspector
Materials and Equipment Test Certificates to be available on site	1	Materials for the Works Plant And Equipment Manufacturers' Pump Tests Electrical safety
Pipelines		
Trench Excavation & Backfilling	2	Responsibility for H&S remains with Contractor
Cleansing and Testing	2	Initial Backfill, Joints Exposed
Back-filling and temporary reinstatement in roads	1	By LA Inspector after back-filling complete
Final Reinstatement	2	By Roads Inspector
Manholes		
Watertightness Test	1	Visual Internal Inspection
Connection with Pipeline	1	Visual Internal Inspection
Pumping Stations		
Sump Watertightness Test	1	Visual Internal Inspection
Pump Drawdown Test	1	Individual tests for each pump and in combination
Electrical safety Test	2	Responsibility for H&S remains with the Contractor

Table 7.1 Monitoring Regime for Drainage Construction Works

The actual frequency of visits by the Drainage Inspector will depend on his confidence and trust in the developer and his contractor to construct to the agreed standards. Where there is less confidence, there will be the need for additional visits.

Monitoring of Construction

Drainage and related construction work shall be monitored on site in accordance with the agreed schedule

A Drainage Inspectorate shall be set up to carry out this work on behalf of the Client Authorities

Private drainage shall be supervised and checked to the same standards as systems to be taken-in-charge

The developer shall be responsible for all construction, supervision and checking of drainage works

7.6 Cleaning and Testing of Sewerage and Drainage Systems

7.6.1 Current Arrangements

Requirements for cleaning and testing of sewers and drains are contained in "Recommendations for Site Development Works for Housing Areas", the "Code of Practice for Development Works - Drainage" and the Building Regulations. These documents require that developers clean to the satisfaction of the local authority, with the option of sewer condition surveys, using CCTV surveys.

Both air and water tests for sewers and drains are permitted. The type of test is to be determined by the Drainage Inspectorate for each location or by Local Authority or Regional Regulation, according to the approved specification.

7.6.2 Proposed Arrangements

The proposals for cleaning and testing have been prepared against the background of concerns about poor workmanship, leading to inflow and infiltration (I/I) flows reducing the available hydraulic and treatment capacity in the systems. Such problems have been suspected by Council drainage engineers for some time. Results from the GDSDS modelling work have proved these suspicions to be correct, in that high levels of I/I have been measured, discharging from predominantly separate systems of recent construction. The proposed arrangements should therefore comprise thorough regimes for cleaning and testing as the means of improving workmanship, and hence reducing I/I risks in future new development.

The proposed detailed specifications for cleansing and testing of sewers, drains, manholes, chambers and pumping stations are contained in Appendix F.

Cleaning and testing is the responsibility of the developer, and the Drainage Inspector is only responsible for monitoring the process.

<u>Cleaning and Testing of Sewerage and Drainage Systems</u>

Sewerage and Drainage systems and related construction work shall be cleaned and tested in accordance with the agreed specification

The requirements of Appendix F should be met pending the introduction of an agreed specification

7.7 Connections to Existing Drainage Systems

<u>Connections to Existing Drainage Systems</u>

Connections shall be carried out in accordance with the agreed specification

The requirements of Appendix F should be met pending the introduction of an agreed specification

7.8 Standards of Construction and Workmanship

Standards of Construction and Workmanship

Standards shall be maintained in accordance with the agreed specification

The requirements of Appendix F should be met pending the introduction of an agreed specification

8 POLICY IMPLEMENTATION

This chapter presents the guiding principles and methods by which the policy recommendations identified throughout this document can be practically implemented.

8.1 Details of Implementation

The proposed means of implementation for each policy presented is contained in Table 8.1. Numbering for policy topics refer to the section reference in the report.

Report Section	Policy Topic	Implementation Details
2.2.1	Separation of Foul and Storm Drainage	Existing Policy to be maintained
2.2.1	SuDS to be mandatory for all new development	Revision of Stormwater Management Policy in accordance with recommendations herein
2.1.2	Objectives for Drainage Planning of New Developments	Policy to be adopted by Drainage and Planning Departments, and included in Council Development Plans
2.2	Drainage Involvement in New Development	The four procedures for Development Plan Liaison, Planning Application Procedures & Approvals, Drainage Construction and Connection, and Taking in Charge be adopted by Planning and Drainage Departments
2.3	Inter-Local Authority Discharges	The Policy of charging for cross-border contributing sewage flows to WwTWs to continue
2.4	Liaison between Councils	Liaison Committee to be set up to implement Study recommendations and agree drainage matters for the Region
2.5	Liaison with the GDSDS	Liaison Committee to be set up to encourage maintenance of drainage data and support future drainage strategy for the Region
2.6	Development on Floodplains	Drainage Departments to produce flood risk mapping. Drainage and Planning Departments to categorise development areas into low, medium, high and unacceptable levels of flood risk. Development plans and planning applications to include flood risk categories. Development sites to operate agreed Sediment and Water Pollution Control Plans. Where flood risk maps are not available, the developer will be required to assess the flood risk to his own site
2.7	Development near Riparian Corridors	New development not permitted within 10m to 15m strips either side of all watercourses. Redevelopment to create riparian buffer strips
2.8	Basements in New Development	Planning applications include surcharge risk assessment and hydraulic isolation of basements from drainage systems

Report Section	Policy Topic	Implementation Details
2.9	Ransom Strips	Use of ransom strips to be curtailed, under drainage inspectors' vigilance
3.1	Development Plan Liaison Procedure	Planning and Drainage Departments to liaise on compatibility of Development Plans and Drainage Infrastructure Strategy. All departments to use compatible mapping software, e.g. MapInfo and standardised symbols as Appendix G
3.2	Planning Application Procedure and Approvals	Planning Department to set up and maintain shared Planning Databases to track progress of planning applications. Drainage Department to have shared data access for viewing and recording drainage related aspects. All applications to be filtered and vetted by Drainage Department
3.3	Construction and Connection Procedure	Planning and Drainage Departments to maintain relevant aspects of the Planning Database Current policy on connections being carried out by Councils or approved agents to be maintained The Drainage Inspectorate in the Councils (or their agents) to be strengthened to undertake checking and approval of drainage construction Regional Drainage Inspectorate of a specialist team for best cost-effectiveness to be assessed
3.4	Taking in Charge Procedure	After drainage connections have been made, developments to have a minimum one-year maintenance period Specific requirements for taking in charge submissions to be applied All drainage systems to be monitored to similar standards as for those to be taken-in-charge
3.5	Taking in Charge Requirements for Sewerage and Drainage	List of sewerage and drainage facilities to be taken in charge to be agreed by Councils
4.4	Implementation of SuDS Measures	Councils to increase awareness of the public, developers, in SuDS principles, using fact sheets, site visits, seminars, etc Councils to set up SuDS Regional Working Party to promote implementation and resolve issues Development Plans to stipulate that new development must incorporate SuDS, and make appropriate land use allowances. Responsibility for inclusion of SuDS rests with the developer

Report Section	Policy Topic	Implementation Details
		SuDS information sheets and design and best practice manuals be adopted for use in the Dublin Region
4.5	Taking in Charge Situation for SuDS	Taking in charge arrangements for SuDS facilities listed. Specific procedure for SuDS
5.1 & 5.2	Foul Sewerage Design	Existing Guidelines for small residential developments to be maintained Current allowances for domestic discharge rates per dwelling to be reduced in recognition of trends in occupancy Developers to continue to provide particular design details and parameters for large residential, commercial, industrial and institutional developments Pumping main designs to adopt stated principles
5.3	Foul Sewerage Design	Facilities for monitoring of discharges to be included in significant developments
6	Stormwater Drainage Design	The principles of sustainability, level of service and cost-effectiveness to be adopted Design criteria 1 to 5 for drainage design to be adopted and parameters agreed. New runoff and storage volume design methods to be adopted Hydraulic design of SuDS systems to be adopted Stormwater management policy documents to be updated accordingly
7.1	Specifications	Specification Committee to be set up to produce a particular specification for materials and working standards in the Irish water industry The need for a separate specification for developers to be reviewed
7.2	Pipes, Materials and Fittings	The proposed list to be agreed, and thereafter periodically reviewed and updated to reflect changes in technology and drainage practice Designers to use other options to suit particular projects and applications
7.3	Sewerage and Drainage Details	The Specification Committee to agree construction details among the Client Authorities Details to be documented for each Authority

Report Section	Policy Topic	Implementation Details
7.4	Building Over or Near Sewers	Proposed parameters to be adopted
7.5	Monitoring of Construction	Supervision and checking to be carried out on a priority basis Regime for supervision and checking to be adopted Drainage Inspectorate (or agents) to be set up to carry out the agreed regime Drainage construction to be monitored to a consistent standard, irrespective of whether it will be taken-in-charge
7.6	Cleaning and Testing of Sewerage and Drainage Systems	Proposed specification for cleaning and testing to be adopted
7.7	Connections to Existing Drainage Systems	Proposed specification for connections to be adopted
7.8	Standards of Construction and Workmanship	Proposed specification standards to be adopted
Appendices A and B	Applications for Planning Approval and Taking in Charge	Requirements for submissions by developers to be agreed by Planning and Drainage Departments
Appendices C, D and E	Stormwater Drainage Design Methods and Information	Recommendations to be adopted by Drainage Departments
Appendix F	Construction Specifications	Recommendations to be agreed by Drainage Departments
Appendix G	Standard Drawings Format and Details	Recommendations to be agreed by Drainage Departments, and further details supplied

Table 8.1 Implementation of New Development Policies

8.2 Actions and Responsibilities for Implementation

Implementation actions and responsibilities can be grouped as follows:

- Development Plans: Planning Departments to agree that adoption of SuDS be mandatory, and that areas of flood risk and basements be defined;
- Promotion of SuDS: SuDS Regional Working Party to be set up, comprising all stakeholders;
- Maintaining existing policies: DCC Stormwater Management Policy (and similar versions) to be updated to incorporate the proposed design changes. Other policies, on foul and storm separation, inter-Council charging, connections, etc, to remain;
- Adopting of new policies: the identified Departments will need to agree the content of the policies, and their respective roles in implementing the agreed policy;
- Adopting of new procedures: the involved Departments will need to agree the content of the procedures, and actions to be taken by each department for its implementation;
- Drainage Liaison Committee: the Client Authorities will need to set up this committee, and confirm its brief;
- Standardisation: Council Departments will need to agree common standards for mapping, symbols, etc, using the Drainage Liaison Committee;
- Database and GIS Standardisation: Council departments will need to agree common standards and data sharing arrangements for the Planning Database, which will need to be compatible with the recommended Regional Drainage GIS;
- All new construction to be inspected irrespective of being taken-in-charge;
- Drainage Inspectorate: staffing in Council Drainage Departments (or their agents) will need to be increased to comply with the new policy for supervision and checking of site work, the advantages of a Centralised Drainage Inspectorate to be examined for the Dublin Region;
- Taking in Charge Requirements: the proposed list of sewerage, drainage and SuDS facilities will need to be agreed, and periodically reviewed by the Drainage Liaison Committee;
- Sewerage and Drainage design Requirements: the proposed reduction in allowances for domestic discharge rates per dwelling will need to be agreed; the proposed design principles for pumping mains will need to be agreed;
- Specifications: Specification Committee to be set up to produce a particular specification for the Irish water industry, and review the need to a specific specification for new development;
- Particular Specifications: the proposed specifications will need to be agreed by the Liaison Committee.

9 REFERENCES

1) Sewers for Adoption, 5th Edition, a design and construction guide for developers, Water UK/WRc plc, 2001;

2) Building Regulations 1997, Technical Guidance Document H, Drainage and Waste Water Disposal;

3) Local Government (Sanitary Services) Act, 1948;

4) Recommendations for Site Development Works for Housing Areas, DoELG 1998;

5) Planning and Development Act, 2000 (Number 30 of 2000);

6) Sustainable Urban Drainage Systems: Design Manual for England and Wales, CIRIA, 2000;

7) Sustainable Urban Drainage Systems: Best Practice Manual, CIRIA, 2001;

8) Stormwater Management Policy for Developers, Dublin Corporation, 1999;

9) Stormwater Management Policy Technical Guidelines, Dublin Corporation/DSA Consulting Engineers Ltd, 1998;

10) Sediment Management in Urban Drainage Catchments, Report R141 CIRIA, 1996;

11) Earth Summit: Agenda 21: United Nations Division for Sustainable Development, 1999;

12) Towards Sustainable Local Communities: Guidelines on Local Agenda 21, Ireland, Department of the Environment and Local Government (DoELG) 2001;

13) Watercourses in the Community, Scottish Environment Protection Agency (SEPA) 2000;

14) Design of containment systems for the prevention of water pollution from industrial incidents (CIRIA, 1997);

15) Sediment management in urban drainage catchments (CIRIA Report 134,1995);

16) Control of pollution from highway drainage discharges (CIRIA, 1994);

17) Water Environment and Water Services (Scotland) Bill, as passed 2003;

18) Framework for Sustainable Drainage Systems (SuDS) in England and Wales, draft 2002;

19) Policy and Practice for the Protection of Floodplains, (Environment Agency, UK);

20) Development and Flood Risk, UK Government Planning Policy Guidance PPG 25;

21) Code of Practice for Development Works – Drainage, Dublin City Council Drainage Division, January 2002.

Appendix A

Planning Applications

DOCUMENTS TO BE SUPPLIED WITH PLANNING APPLICATIONS

Mandatory information is shown in **bold** type

Information Required (6 copies)	Scale or Date	Notes
State Proposed Method of Foul Drainage		
State Proposed Method of Surface Water Drainage		
Developer's Programme **Estimated Construction Start Date**		
Location Plan	1:2500 (minimum)	
Site Plan showing: **All levels related to Malin Head OSi Benchmark** **Site boundary** **Roads** **Existing and proposed sewers, drains and rising mains** **Pipeline information, including diameter, levels and gradients** **Pumping Stations including compound** **Road gullies/highway drains** **Watercourses and Flood Risk** (Category 1: Low Risk Category 2: Medium Risk Category 3: High Risk Category 4: No Development) **Flood routing for extreme rainfall events** **Site contours, including regrading** *Supplementary information will/may include:* *Proposed buildings, including basements* *Ground floor levels* *Private drainage*	1:500	Flood Impact Assessment for Categories 2 and 3 Basement Risk Assessment as applicable

Storage/attenuation *Outfalls/headwalls* *Borehole locations* *Existing sewerage and drainage* *Nature of ground to be excavated*		Physical and Chemical nature
Longitudinal Sections {sewers & rising mains) showing: **Levels, gradients and chainages** **Cover and Invert levels** **Pipe material** **Pipe strength** **Pipe diameters** **Bedding classification & details** **Air valves and washouts** *Supplementary information will/may include:* *Existing services* *Borehole information* *Groundwater/watercourse flood levels*	1:500 Horizontal 1:100 Vertical	
Copies of hydraulic design calculations **Foul water (including trade effluents)** **Surface water (including impermeable area plan and SuDS details)** **Design parameters used** **Construction details showing:** **Manholes** **Pumping stations** **Manhole schedules** *Supplementary information will/may* *include:* *Attenuation tanks* *Ancillaries*		

<u>**Pumping Stations information showing:**</u> **General arrangement details** **Wet Well capacity/storage/time to spillage** **Rising Main Capacity** **Surge calculations** *Supplementary information will/may include*: *Structural calculations & drawings* *Flotation check* *Pump manufacturer's design* *Pump head discharge curve* *Emergency overflow details and consent* <u>**Project Supervision Requirements**</u> It is likely that the majority of development sites will be bound by the Safety, Health and Welfare at Work (Construction) Regulations 1995, S.I. 138 of 1995. Much of the information required to approve taking in including the supplementary information listed above, should be readily available to either: ♦ the Client or ♦ the Designer ♦ the Project Supervisor ♦ The Principal Contractor, appointed by the Client as competent, responsible persons under the Regulations. Before any Council staff visit the site for inspections, the Council must be provided details of: **the Designer** **the Project Supervisor** **the Project Contractor**		
<u>**Estimated value of sewerage construction work**</u>		

Estimated value of Pumping Stations and Rising Mains (inc. overheads, profit, insurances, etc.)		
Details of full rights to discharge to: **Watercourses** **Canals etc. (consents/licences)**		
Details of Wayleaves and Access Arrangements with Others	1:2500	Details of lands involving Others
Details of Land Transfers and ownership	1:2500	Details of all land to be conveyed to the Council

All submissions shall use the format and standard details contained in Appendix H.

Appendix B

Taking in Charge Submission

DOCUMENTS REQUIRED FOR TAKING IN CHARGE SUBMISSIONS

Mandatory information is shown in **bold** type

Information Required (6 copies)	Scale or Date	Notes
Location Plan	1:2500 (minimum)	
Site Plan showing: **All levels related to Malin Head OSi Benchmark** **Site boundary** **Roads** **Existing and proposed sewers, drains and rising mains** **Pipeline information, including diameter, levels and gradients** **Pumping Stations including compound** **Road gullies/highway drains** **Watercourses and Flood risk** **Site contours, including regrading** *Supplementary information will/may include:* *Proposed buildings, including basements* *Ground floor levels* *Private drainage* *Storage/attenuation* *Outfalls/headwalls* *Borehole locations* *Existing sewerage and drainage* *Nature of ground to be excavated*	1:500	(a) The following sewer information should be supplied: Manhole x and y co-ordinates, Cover level, Invert level, Pipe diameter, Pipe material and Direction of Flow. (b) The layout should be accurately positioned (+/- 300mm relative to local detail) on the latest published version of the ordnance survey 1:1000 series. (c) All dimensions should be metric. (d) All levels should be relative to ordnance survey datum to an accuracy of +/- 5mm, and state which benchmark has been used. (e) A list of National Grid Co-ordinates (accurate to +/- 300mm) for manholes should be supplied. Flood Impact Assessment as applicable Basement Risk Assessment as applicable Physical and Chemical nature
Longitudinal Sections {sewers & rising mains) showing: **Levels, gradients and chainages** **Cover and Invert levels**	1:500 Horizontal 1:100 Vertical	All drawings to be prepared to specified format and supplied electronically and in hard copy

Pipe material **Pipe strength** **Pipe diameters** **Bedding classification & details** **Air valves and washouts** *Supplementary information will/may include:* *Existing services* *Borehole information* *Groundwater/watercourse flood levels*		
<u>Copies of hydraulic design calculations</u> **Foul water (including trade effluents)** **Surface water (including impermeable area plan and SuDS details)** **Design parameters used** **<u>Construction details showing:</u>** **Manholes** **Pumping stations** **Manhole schedules** *Supplementary information will/may* *include:* *Attenuation tanks* *Ancillaries* *Flood Routing* **<u>Testing Results including:</u>** **CCTV records and interpretation** **Test certificates for materials and construction**		
<u>Pumping Stations information showing:</u> **General arrangement details** **Wet Well capacity/storage/time to spillage** **Rising Main Capacity**		

Surge calculations *Supplementary information will/may include*: *Telemetry/flow/raingauges* *Results of pump draw-down tests* *Structural calculations & drawings* *Flotation check* *Pump manufacturer's design* *Pump head discharge curve* *Emergency overflow details and consent* *Project safety file if applicable* **Project Supervision Requirements** It is likely that the majority of development sites will be bound by the Safety, Health and Welfare at Work (Construction) Regulations 1995, S.I. 138 of 1995. Much of the information required to approve taking in including the supplementary information listed above, should be readily available to either: ♦ the Client or ♦ the Designer ♦ the Project Supervisor ♦ The Principal Contractor, appointed by the Client as competent, responsible persons under the Regulations. Before any Council staff visit the site for inspections, the Council must be provided details of: **the Designer** **the Project Supervisor** **the Project Contractor**		
Estimated value of sewerage construction work **Estimated value of Pumping Stations and Rising Mains** (inc. overheads, profit, insurance's, etc.)		

<u>Details of full rights to discharge to:</u> **Watercourses** **Canals etc. (consents/licences)**		
<u>Details of Wayleaves and Access Arrangements with Others</u>	1:2500	Details of lands involving Others
<u>Details of Land Transfers and ownership</u>	1:2500	Details of all land to be conveyed to the Council

All submissions shall use the format and standard details contained in Appendix H.

Appendix C

FSSR 14 Regional Growth Curves with Irish River Data

and

FSSR 16 (Greenfield) Rainfall – Runoff Model Estimation

C1 FSSR 14 Growth Curves with Irish River Data

The Irish FSR growth curve is reported against the 10 curves for regions in UK in FSSR 14. The Irish curve is an average for the whole country and for all rivers. Provisional analysis of local rivers in the Dublin region, which are all relatively small, have been analysed and show a significantly different growth curve. These are plotted, along with the River Boyne curve analysis, in Figure C2. Figure C1 provides the UK regions that relate to the UK individual curves.

The results of the Dublin rivers can be seen to fit closely with eastern UK rivers and therefore some degree of confidence can be held in the findings.

It is recognised that further more detailed work is warranted to look into this subject, as the implications for drainage design are quite significant. However for the purpose of carrying out drainage design for new developments, it is proposed that the recommended curve in Figure C2 is used in the Dublin Region until a more definitive study is carried out.

In Figure C2, the scale on the lower “X” axis is the Reduced Variate, which is a form of plotting return period curves. The return period is shown on the upper “X” axis. The “Y” scale is a dimensionless scale factor, to multiply the Qbar value (return period of 2.3 years) for flows of any other return period.

Figure C1 UK Hydrological Growth Curve Regions

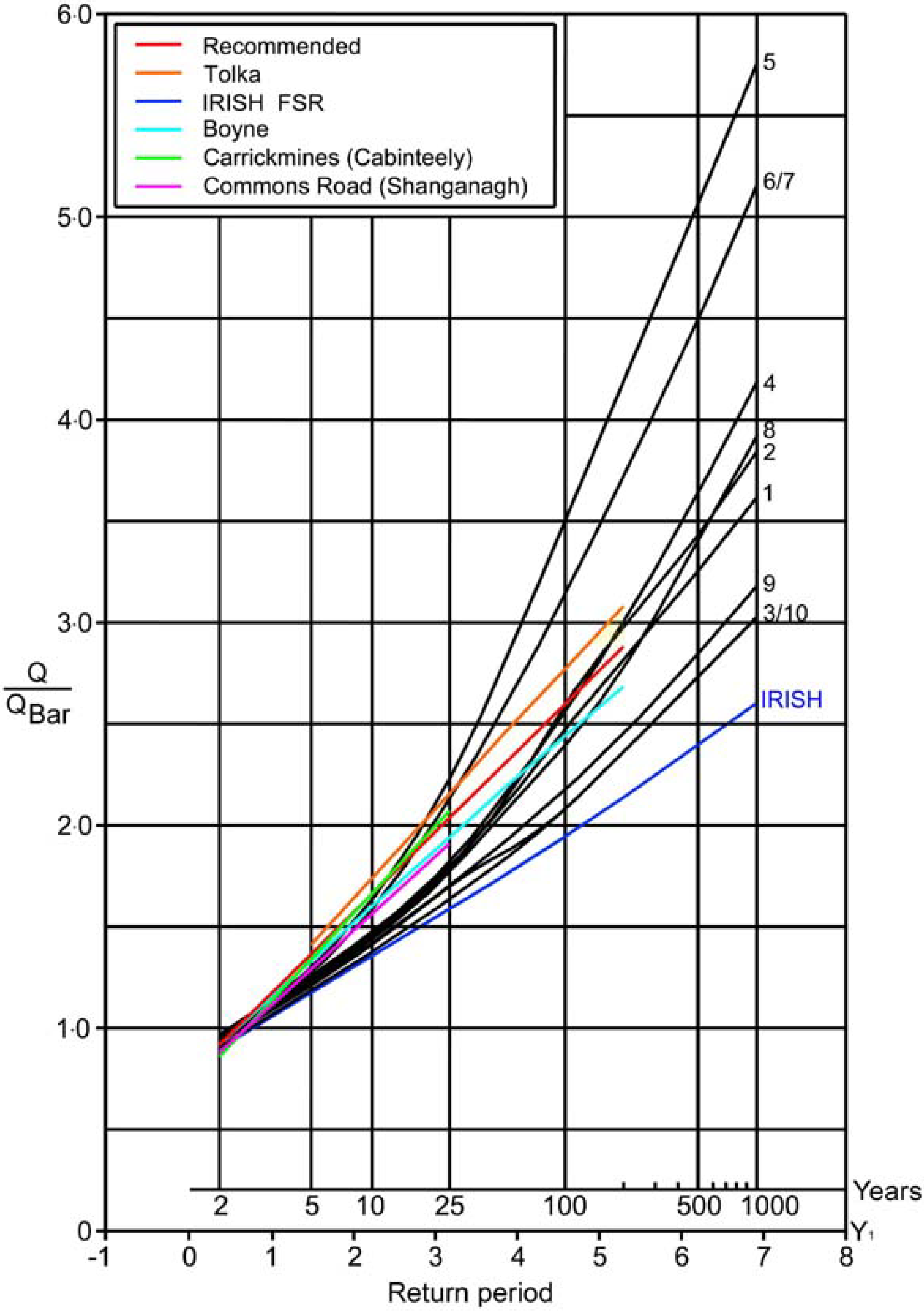


Figure C2 FSR Regional Growth Curves with Dublin Area Rivers

C2 Greenfield Runoff Volume

A simple assumption has been made in the design for long-term storage that the runoff from a greenfield site is equal to the SPR value for the soil type. There are a number of formulas produced by FSR and subsequent work that can be used to derive volumes of runoff, but FSSR 16 is both easy to use and is the most recent output in the FSSR series addressing this problem.

The FSSR 16 formula is:

$PR_{RURAL} = SPR + DPR_{CWI} + DPR_{RAIN}$

Where:

SPR is the standard percentage runoff, which is a function of the five soil classes S_1 to S_5

$SPR = 10S_1 + 30S_2 + 37S_3 + 47S_4 + 53S_5$

DPR_{CWI} is a dynamic component of the percentage runoff. This parameter reflects the increase in percentage runoff with catchment wetness. The catchment wetness index (CWI) is a function of the average annual rainfall. The relationship is shown in Figure C3.

$DPR_{CWI} = 0.25\ (CWI - 125)$

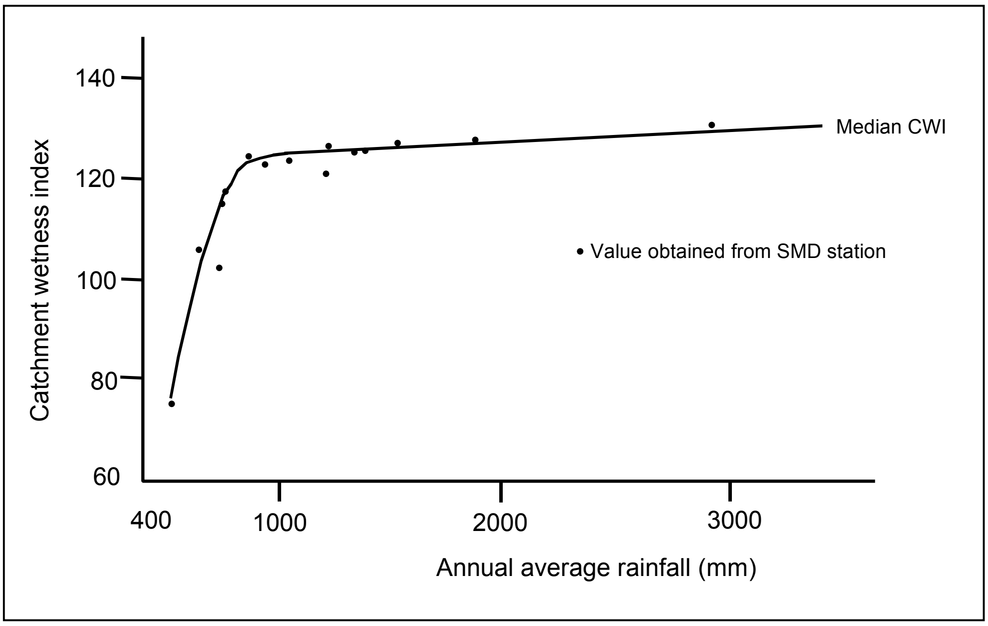


Figure C3 CWI vs. SAAR – Flood Studies Report

The DPR_{RAIN} is the second dynamic component that increases the percentage runoff from large rainfall events.

$DPR_{RAIN} = 0.45(P - 40)^{0.7}$ for P > 40 mm

$DPR_{RAIN} = 0$ for $P \leq 40$ mm

Where P is the rainfall depth

It can be seen from the formula that the runoff proportion is slightly greater than the value of SPR for all areas where the AAR value is greater than 800mm. As much of Dublin is between 700 and 800mm, the formula slightly reduces the proportion of runoff. However as it is being applied to a storm of 60mm, this is counter-balanced by the rainfall depth term, as it is more than 40mm.

The derivation of this equation is for extreme events and for catchments that are significantly larger than those of development sites. Its accuracy therefore is to be treated with caution. However if account is to be taken of the volumetric effects of development, this is one of the accepted methods for assessing greenfield runoff volumes. It has the advantage of simplicity and therefore a rapid assessment of the impact of development can be made with respect to runoff volume.

The key feature of this formula is the important influence of soil type. In practice it indicates that developments on sandy soils create massive additional runoff compared to the pre-development condition, but development on clays do not. This is obvious, but it has very significant implications for the cost of developments in terms of the storage provision. Other parameters have very little influence.

Tests of the local soil permeability and relating it to SOIL type are therefore desirable.

Appendix D

The Old and New UK PR Equations

Appendix D – Comparison between Old and New UK PR Equations

D1 Old UK PR Equation

The Old UK PR equation was derived by statistical analysis from data from 33 catchments. It should be noted that the equation is entirely statistical and takes no account of topography.

$$PR = 0.829\,PIMP + 25.0\,SOIL + 0.078\,UCWI - 20.7$$

where:

PR = *percentage runoff*
PIMP = *percentage impermeability*
SOIL = *an index of the water holding capacity of the soil*
UCWI = *Urban Catchment Wetness Index.*

A brief explanation of the meaning and derivation of these parameters follows.

PIMP
This parameter is the percentage imperviousness of the catchment obtained by dividing the total directly connected impervious area (both roofs and roads) by the total contributing area.

SOIL
The soil index SOIL is based on the Winter Rain Acceptance Parameter (WRAP) included in the Flood Studies Report. The index broadly describes infiltration potential and was derived by a consideration of soil permeability, topographic slope, and the likelihood of impermeable layers. Five classes of soils are recognised as shown in Table D1 below and Figure D2.

SOIL	WRAP	Runoff	SOIL Value	Soil Characteristics
1	Very high	Very low	0.15	Sandy, well drained
2	High	Low	0.30	Intermediate soils (sandy)
3	Moderate	Moderate	0.40	Intermediate soils (silty)
4	Low	High	0.45	Clayey, poorly drained
5	Very low	Very high	0.50	Steep, rocky areas

Table D1 Different Classes of Soil

UCWI
UCWI is the Urban Catchment Wetness Index, which is a composite of two antecedent wetness parameters and is given by:

$$UCWI = 125 + 8\,API5 - SMD$$

where:

API5 = *five day antecedent precipitation index (mm)*
SMD = *soil moisture deficit.*

The value for UCWI is calculated from these parameters for specific events, but design values are provided by referring to a figure relating UCWI to the Standard Annual Average Rainfall (SAAR) for that location (Figure D1). Values are provided for both winter and summer conditions.

For specific events, API_5 is calculated using the following procedure. First determine the rainfall depths (in mm) for the five days prior to the event. The API_5 value at 0900 on the day of the event is then defined by

$$API5_9 = \Sigma_{n=1,5} P_{-n} C_p^{n-0.5}$$

where:

P_{-n} = *rainfall on day n before the event*
C_p = *decay coefficient = 0.5*

Finally the API_5 at the time of the event is given by

$$API_5 = API5_9 C_p^{(t'-9)/24} + P_{t'-9} C_p^{(t'-9)/48}$$

where:

t' = *time (hours) of the beginning of the event*
$P_{t'-9}$ = *rainfall depth between time t' and 0900.*

The soil moisture deficit is calculated from a similar equation

$$SMD = SMD_9 - P_{t'-9}$$

where:

SMD_9 = *soil moisture deficit at 09:00 on the day of the event*

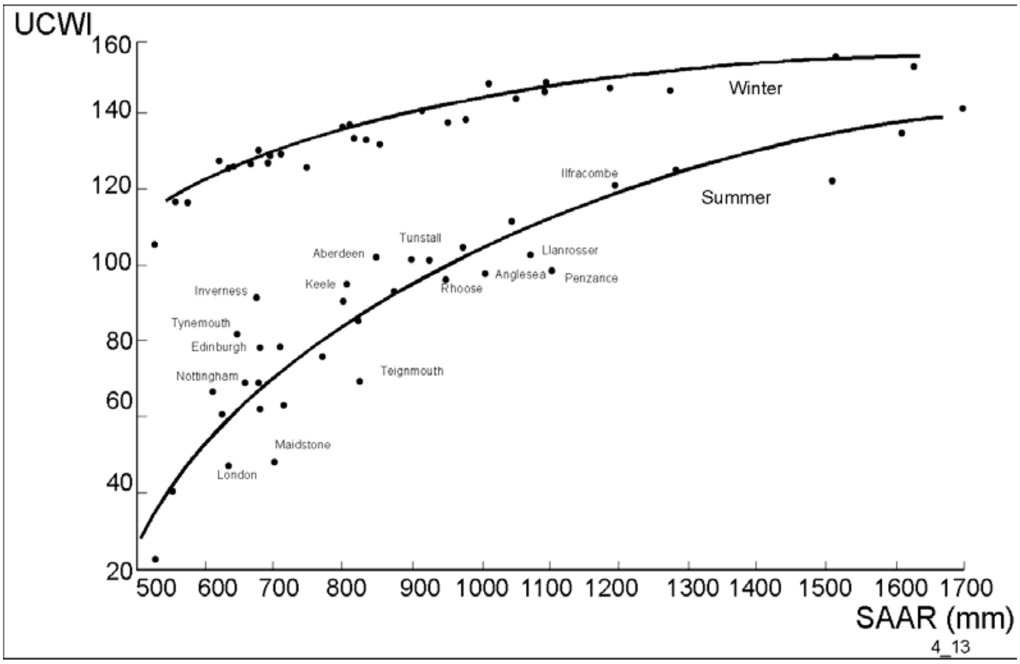


Figure D1 Seasonal UCWI Relationship with SAAR

The SMD_9 value (known as ESMD) was obtainable from the UK Meteorological Office until 1997. It was calculated from a water balance between daily rainfall and an estimate of evapotranspiration based on the use of Penman's equation, assuming a notional catchment under short rooted vegetation (50%), long rooted vegetation (30%) and riparian areas (20%). Since the development of the Wallingford Procedure, the Meteorological Office has ceased the routine issue of ESMD and issues a new SMD value based upon the use of a different calculating system (MORECS), which is a modification of the Penman equation by Monteith. This is further confused by the fact that the Irish calculation of SMD is again different. However there appears to be little practical difference between the use of the various methods, particularly as the PR equation is not significantly influenced by this parameter.

Inspection of the Old UK PR equation indicates that for low values of PIMP, SOIL and UCWI, low or even negative values of PR can be predicted. Consequently, a minimum value of PR_{paved} of 20% together with a maximum of 100% is specified. It should be appreciated that unrealistic PR values can be predicted with low values of SOIL (e.g. 0.15) in combination with both low values of PIMP (e.g. PIMP < 30%) and UCWI because the correlation equation was derived for catchments with reasonably high values of PIMP. Its application on sewers with partially separated systems or lightly urbanised areas is therefore generally inappropriate. Figure D2 illustrates how PR changes with PIMP and SOIL.

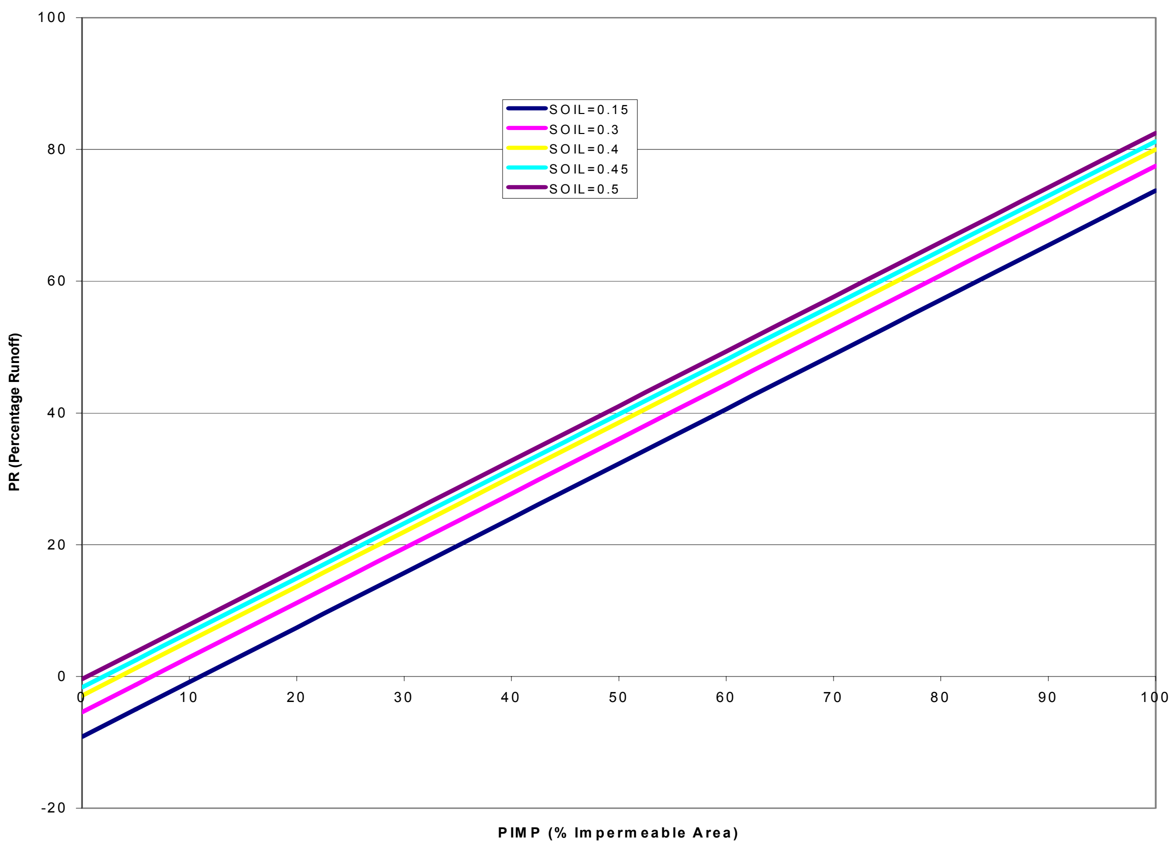


Figure D2 PR as a function of SOIL and PIMP (Old UK PR Equation)

D2 The New UK PR Equation

The new UK PR equation was developed jointly by HR Wallingford, the Water Research Centre and the Institute of Hydrology with support from NorthWest Water PLC. It has been designed as a replacement for the familiar Old PR equation described previously. It is now becoming more commonly used and is recommended for use in Ireland.

The new equation was designed primarily to overcome some of the difficulties experienced in practical application of the first equation, namely:

- The Old UK equation defines PR as being a constant throughout a rainfall event irrespective of catchment wetness. Clearly for long duration storms, losses towards the end of the event may be much reduced as the catchment becomes saturated;
- Problems have been encountered in applying the PR equation to partially separate catchments and to catchments with low PIMP and low SOIL values;
- The assumptions of the flow split between paved and pervious runoff is clearly inappropriate for catchments with significant rural components to the runoff.

To overcome these problems, various new model forms were investigated using a subset of the original data.

It should be noted here that the Old UK PR equation, although still used, is now less popular than the New UK PR equation. It is recommended that the New PR equation be adopted for the Dublin Region.

The dangers of applying the Old UK PR equation for low values of PIMP are graphically illustrated by Figures D3 and D4 where it is assumed that 1 ha of paved surface has a variable amount of pervious surface. The graphs show the effect of 10mm and 80mm of rainfall on SOIL types 1 and 4. The curves for the New UK PR equation graphically illustrate the effect of high runoff contributions from the pervious surfaces.

It also indicates that verifying models using the New UK PR equation against small storms does not draw attention to volumes of runoff from pervious areas, but with large events considerable runoff is predicted to take place. The figures are provided in log and normal scales to provide a clear understanding of the effects.

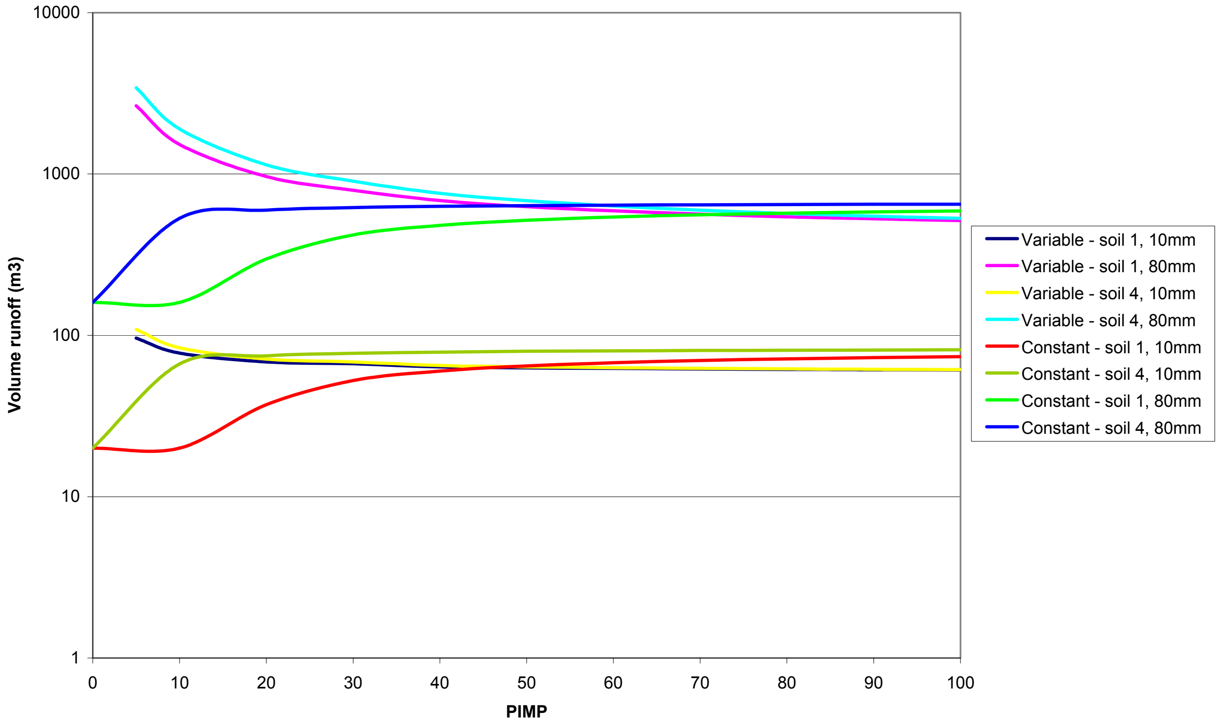


Figure D3 Volume of Runoff (log scale) – 1 ha paved, variable pervious area: (Old & New UK PR Equations)

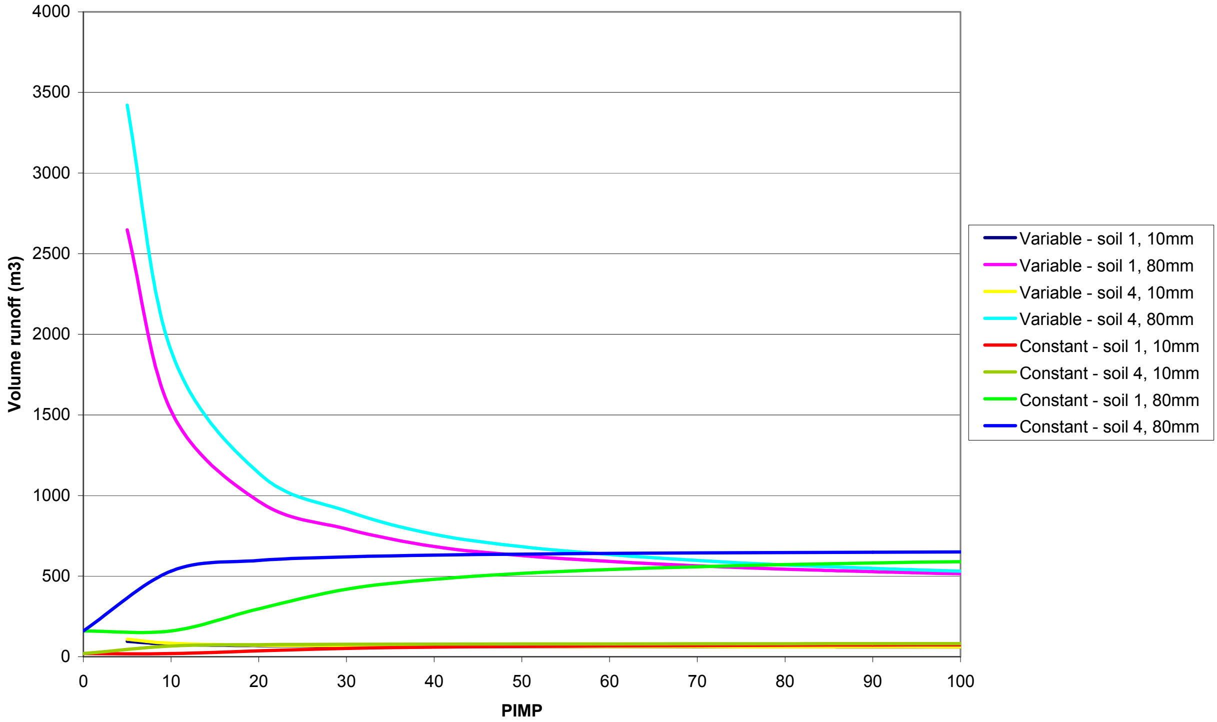


Figure D4 Volume of Runoff (linear scale) – 1ha paved, variable pervious area: (Old & New UK PR Equations)

The recommended model derived by this analysis is of the form:

$$PR = IF * PIMP + (100 - IF * PIMP) * \frac{NAPI}{PF}$$

where
IF = *effective impervious area factor*
PF = *moisture depth parameter (mm)*
NAPI = *30 day antecedent precipitation index*

This equation divides PR into two elements. First, the impervious area runoff is obtained by using an effective contributing area factor, IF. Therefore after initial losses on impervious surfaces, remaining losses are given as a constant fraction of rainfall volume. Recommended values of IF are indicated in table D2 and can be compared with the PR_{imp} values for the individual catchments derived using the Old PR equation. One of the principal features of this equation (and a possible drawback) is that engineers have to choose a value by using their judgement as to what is appropriate.

Surface Condition	Effective impervious area factor, IF
POOR	0.45
FAIR	0.60
GOOD	0.75

Table D2 Recommended Values of IF

The losses on pervious surfaces and also non-effective impervious areas are represented by the second term of the equation. The first part of this term represents the total percentage of the catchment occupied by pervious and non-effective impervious areas. The losses from this area are dependent on the function NAPI/PF.

NAPI is defined as a 30-day API with evapotranspiration and initial losses subtracted from rainfall. As for API_5, API_{30} is given by:

$$API_{30} = \sum_{n=1,30} P_{-n} C_p^{n-0.5}$$

The constant value C of the API has been made dependent on the soil type to reflect the faster reduction of soil moisture on lighter soils. The relationship between C and soil type is shown in Table D3.

Soil Type	C
1	0.1
2	0.5
3	0.7
4	0.9
5	0.99

Table D3 Relationship Between Soil Type and C

The moisture depth parameter, PF, was calibrated using the data described above. A value of 200 mm was obtained (which compares well with the available water capacity of soils with grass vegetation). It is dangerous to modify this value without careful consideration of the consequences.

Figure D5 illustrates the effect of increasing rainfall on percentage runoff using the New PR equation. This should be compared to Figure D4 above showing the difference between the Old and New UK PR equations. For information, the assumptions used in the figure are as follows:

Old PR

PIMP	= 50 percent
SOIL	= 1 - 5
UCWI	= 100

New PR

PIMP	= 50 percent
SOIL	= 1 - 5
NAPI	= 0mm at start of the event
PF	= 200mm
IF	= 70%

Rainfall

$M_5 60$	= 20mm
Rainfall ratio “r”	= 0.4
Depth	= 50 year 18 hour summer event (78mm)

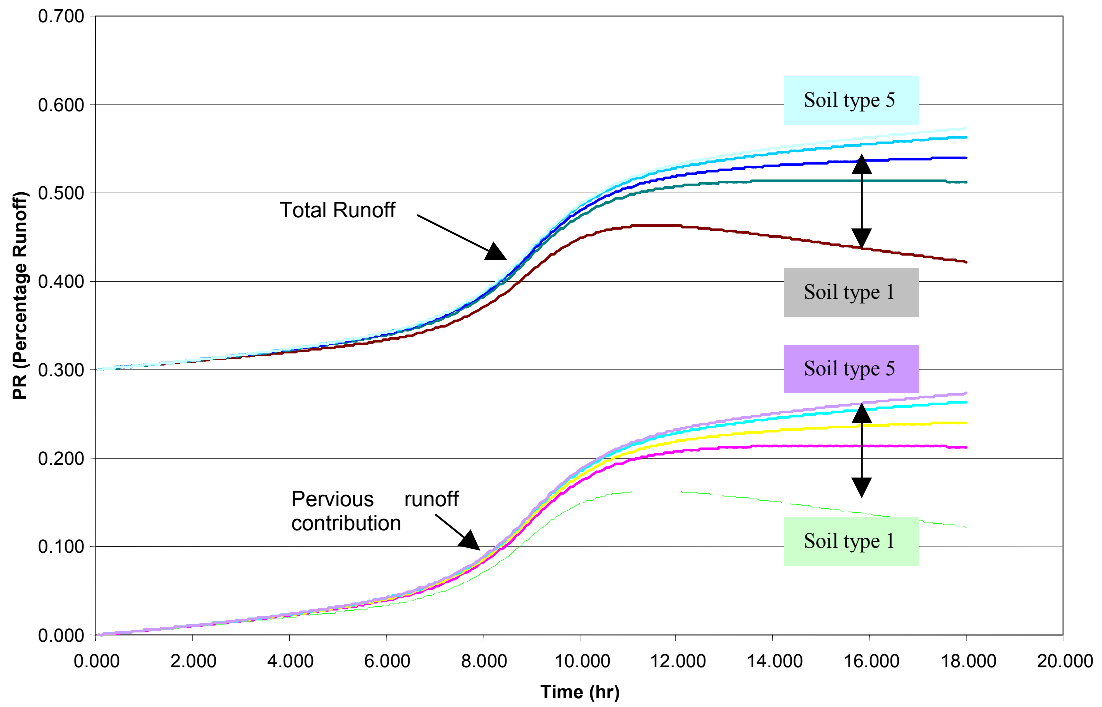


Figure D5 Percentage Runoff as a Function of Rainfall Depth using the New PR Equation

Rainfall profiles exist in the form of summer or winter profiles. These are symmetric and are respectively defined as being 50 percentile and 75 percentile storms. The summer profile provides a maximum intensity, which 50 percent of real storms exceed for that specific return period and duration. Similarly this applies to the winter profile. The design rainfall profiles that are in current urban drainage software are derived from the Flood Studies Report, 1975.

Appendix E

Design of Stormwater Storage

E1. DESIGN OF STORMWATER STORAGE

This appendix contains an illustration of the drainage requirements, particularly storage, for a theoretical site in the Dublin region. It also provides a brief over-view statement as to why storage is needed.

This method provides quick and easy approximations of storage needs for a site to be evaluated. It is anticipated that most sites of any significant size would carry out detailed modelling of the proposed drainage systems to demonstrate the effectiveness of the drainage proposals and refine the results.

E1.1 Storage Requirements Over-View

Rainfall runoff from greenfield areas (whether agricultural land or virgin land) has very different characteristics to development runoff. These differences can be summarised under three main categories:

- Volume of runoff
  - No runoff for small events
  - Less runoff for large events

- Rate of runoff
  - Slower, later runoff for all events

- Quality of runoff
  - Cleaner runoff (BOD, sediment, pathogens, metals, hydrocarbons)

The objectives of the storage criteria are to address these three aspects and to design the urban runoff to mimic, as much as possible, the original greenfield behaviour. To do this, storage volumes should be specifically and separately calculated to address each of these criteria, and the means by which this may be achieved is briefly explained below.

E1.1.1 Volume of Stormwater Runoff – Small Rainfall Events

The volume of rainfall runoff is important at each end of the rainfall spectrum. Around 30 to 40 percent of rainfall events (probably in excess of 50 events a year in most areas) are sufficiently small that there is no measurable runoff taking place from greenfield areas into receiving waters. By contrast, runoff from developments takes place for virtually every rainfall event. The difference between the two states means that streams become more “flashy” and groundwater recharge is often lower, thus reducing base flows in the streams between events. (The related issues of water quality are addressed under quality of runoff). Where it is possible to provide replication of this behaviour (described as Interception) by preventing runoff from rainfall events of around 5mm, (by infiltration or other means), this should be provided. Certain SuDS features such as Swales and Pervious Pavements do provide runoff characteristics that reflect this behaviour to some degree.

E1.1.2 Volume of Stormwater Runoff – Large Rainfall Events

The total volume of runoff from extreme rainfall events (depths of around 40mm or more when river flooding might occur) from a developed site is typically between 1 and 10 times the runoff volume from the same site in a greenfield state. It is important to control this additional volume from the developed site as floodplains have finite storage volumes, and even if the runoff is attenuated over the period that greenfield runoff occurs, by definition there must be greater depths of flooding if more water is discharged (see Figure E1).

The criterion for Long Term Storage is a pragmatic approach to calculating an appropriate volume which should be retained and either discharged at sufficiently low flow rates (<2l/s/ha) to the receiving water, such that there is limited impact on exacerbating flooding downstream, or disposed of by infiltration. Theoretically, this form of storage needs only be mobilised at times of extreme rainfall. However in practice it is difficult to mobilise this storage only during extreme events. Figure E2 illustrates the effect of Long Term storage and demonstrates the reduced volume of runoff contributing to a river at times of flooding that this can achieve. The basis of calculating the Long Term Storage volume is to use a 6-hour 100-year event and the soil type of the site. Discussion on these criteria is given in Chapter 6.

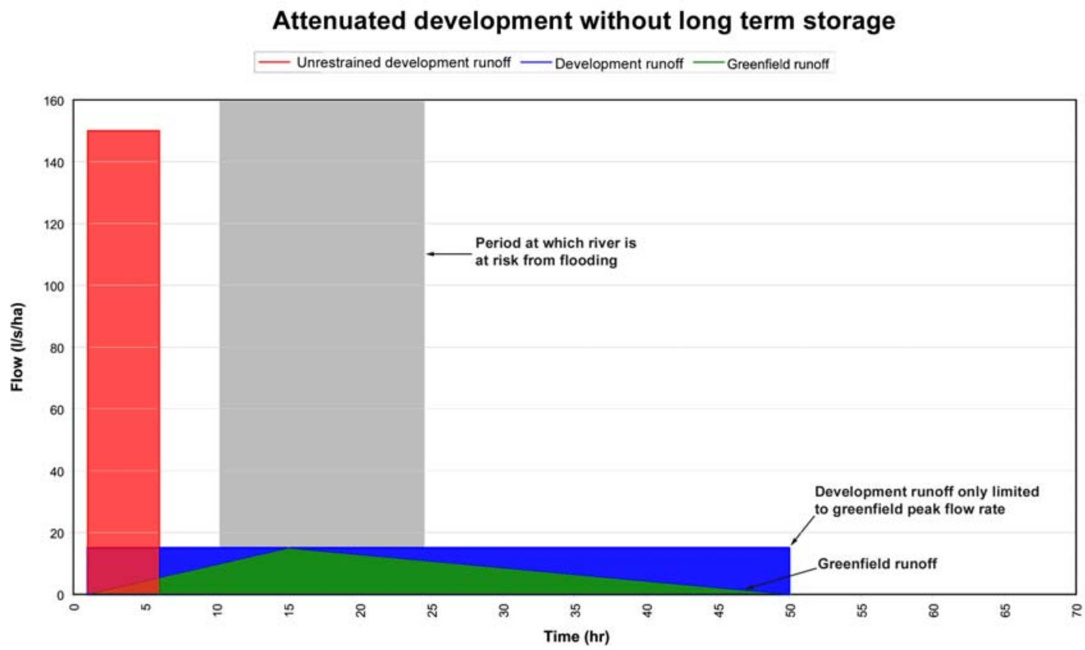


Figure E1 ***Schematic Illustrating River Flooding Protection using Greenfield Runoff Rate Criterion Only***

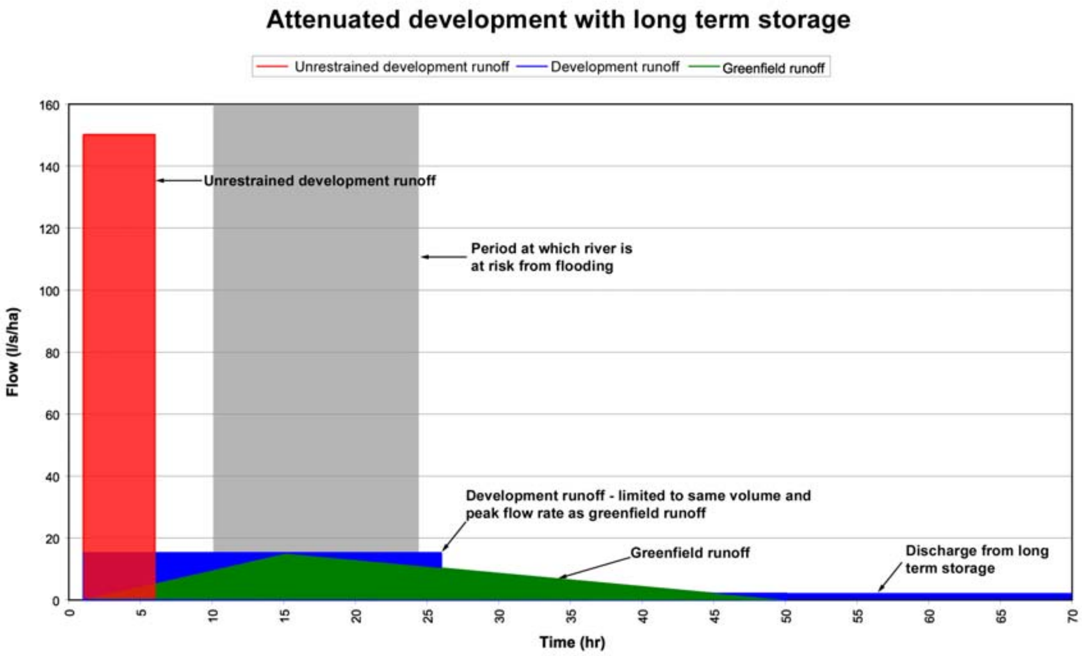


Figure E2 Schematic Illustrating River Flooding Protection using Long Term Storage

E1.1.3 Rate of Stormwater Runoff

Whatever the event, development runoff through traditional pipe networks, if allowed unchecked, will discharge into receiving waters at orders of magnitude greater than the undeveloped site. This causes flashy flow in the river that is likely to cause scour and erosion that may seriously affect the morphology and ecology of the stream.

Attenuation storage is provided to limit the runoff from the site to minimise these effects. The design principle is to limit the runoff for events of equivalent frequency of occurrence to the same peak rate of runoff as that which would take place from greenfield sites. However to achieve an exact equivalence of individual events would require a very complex approach to design and analysis. This is not justified based on water quality and hydraulic grounds, and also due to the limited accuracy of predicting the actual runoff from greenfield sites. To illustrate this, it is quite likely that a 50 year 15 minute event will not fill a storage unit designed to cater for the 1-year critical duration event, which might be a 12-hour event. Thus outflow from the site will be constrained to less than the 1-year flow rate. In terms of the greenfield runoff from the site, it is uncertain what the actual flow rate would be. Thus the 1-year storage provision actually controls an envelope of events that are equal to or larger than 1 year where the event durations are different to the 1-year critical duration.

In practice the actual rate of runoff is immaterial as long as it is appropriately low for the majority of events (river morphology), and not excessive for large events using the predicted greenfield runoff rates as a guide. Therefore the 1 and 100 year greenfield runoff rates are used for this purpose, with the 100-year event being used to define the maximum runoff rate from the site. The use of 30 years is really only a level of service criterion to ensure water levels are appropriately considered in the design process, but it can be used to provide an intermediate flow rate. Purists would like to see that the runoff rate for the critical duration event for any return period is equal to the runoff from the greenfield site calculated for the same return period, but the example above illustrates that this is an unreasonable requirement.

E1.1.4 Quality of Stormwater Runoff

The quality of stormwater runoff is an issue for frequent small events. This is due to the flush of debris and sediment from the catchment surface in the first part of the event together with any sediment deposits in the pipe network. This is compounded by the fact that this highly concentrated initial flow may enter the receiving water that is still flowing at base flow conditions, thus providing a minimum level of dilution. For large events, or during periods of high river flow, this water quality impact is much reduced, so the key period of concern is the summer months of low river flows and the small events that take place on a regular basis.

The concept of Treatment Storage is to provide a body of water in which dilution and partial treatment (by physical, chemical and biological means) of this runoff can take place. This is effectively the volume of water that remains in ponds during the dry weather periods between rainfall events. The amount of storage normally provided is often defined in terms of the equivalent volume of runoff from a rainfall depth, usually 10mm or 15mm, or a function of Vt (see section E2.1.2).

This storage should not be confused with the concept of Interception referred to earlier in this section in the discussion on the volume of runoff. Clearly if no runoff takes place for small events, maximum water quality protection is being achieved.

It should be stressed that drainage of a site should be designed using the treatment train concept using appropriate drainage mechanisms. Reliance on only a single pond prior to the outfall is not regarded as best practice in providing the best water quality protection for the receiving water. In some cases a wet pond (providing treatment storage) may not be the most appropriate solution. In this situation, treatment of surface water runoff would be achieved using other SuDS techniques.

E1.1.5 Drainage Design Process Flow Chart

Figure E3 summarises the main drainage design stages as a graphical flow chart. Figures E4 to E8 illustrate in more detail the analytical process that needs to be carried out to implement the design criteria in Table 6.3 in Chapter 6 of the document. Each figure details each of the sub-criteria in each of the 4 main criteria, which are:

- River water quality protection
  - Interception
  - Treatment volume
- River regime protection
  - Limit of discharge to receiving water, at 2 discharge rates
- Level of service
  - Flooding on the site
    - Internal protection against flooding of property
    - Temporary flooding from rare events, short intense storms
    - Long duration storms
- River flood protection
  - Long-term flood storage

Runoff models that are suggested for analysis of these various criteria are:

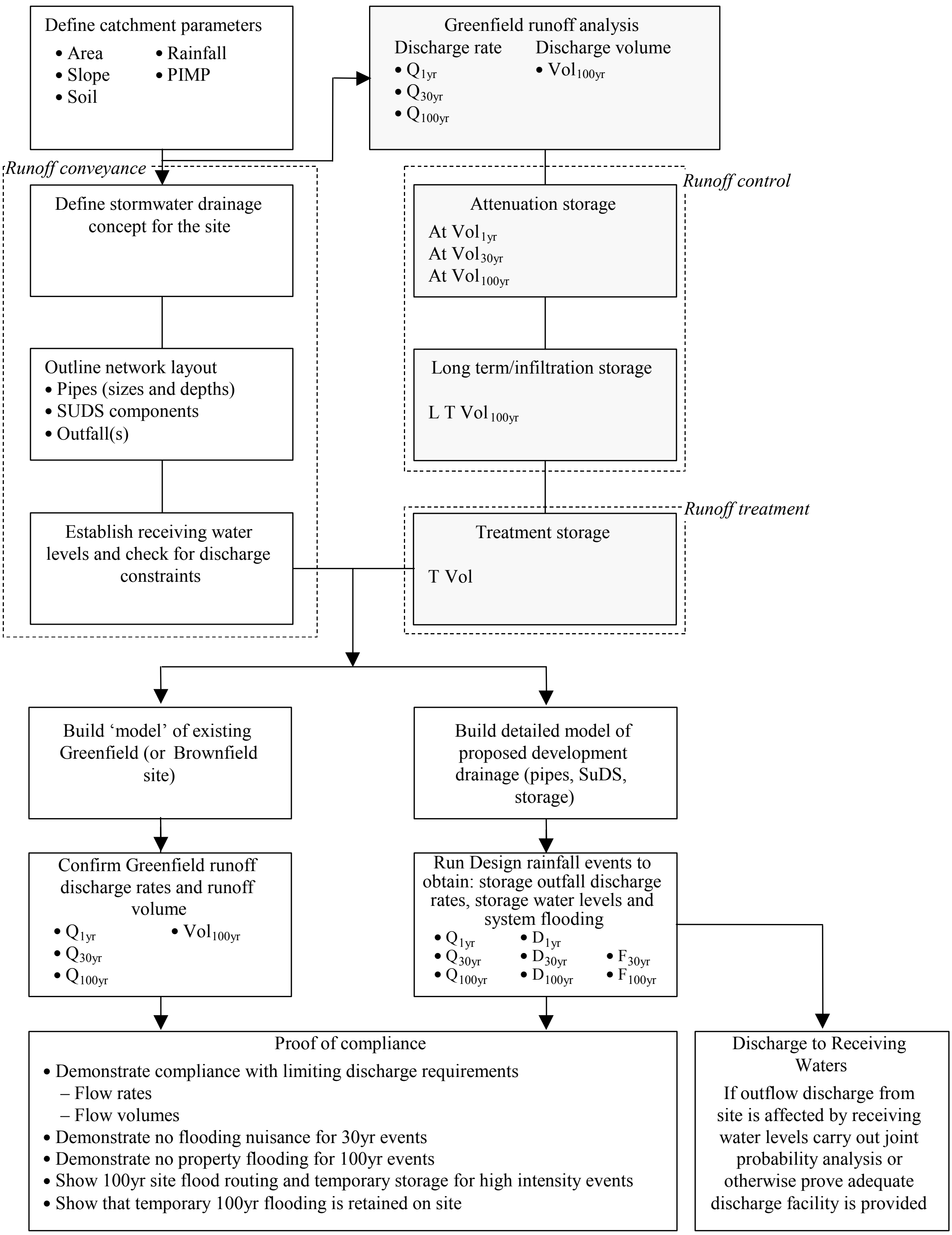
"Small" events

Criteria	Storage Type Assessment	Runoff Model (percentage rainfall-runoff)	Type of Event
River water quality	Interception & Treatment	80% paved, 0% permeable	Small events
River regime	Attenuation	100% paved, 0% permeable or New UK PR equation	Big events
Level of service	Temporary flooding and routing	New UK PR equation (detailed network model)	High intensity and Big events
River flood protection	Long term	80% paved & Soil SPR% for surfaces connected direct to drainage system	Big event

It should be noted that:

- these volumes are not cumulative.
- the provision of Interception storage also constitutes provision of Long-term storage by the amount provided.
- both long term storage and Interception storage reduce the Attenuation volumes by approximately the same amount, unless the model analysis explicitly excludes areas that are expected to contribute to these volumes separately.
- Treatment storage is not storage for attenuation of rainfall runoff. It is the permanent wet pond volume.
- Treatment storage can be reduced proportionately by any Interception storage volume provided. If Long-term storage is provided by infiltration (effective for all events) and not flooding from the attenuation pond, then treatment storage can be further reduced.
- Detailed simulation of the network and storage system is advised at detailed design to check all elements perform as expected.

Figure E5 below provides the alternative of using either 15mm or Vt to calculate the Treatment storage volume. It is recommended that 15mm is used for the Dublin region.



Notes:

Q_{1yr}	Peak discharge rate for 1 year return period
D_{1yr}	Depth of water for 1 year return period
F_{30yr}	Flooding volume (and location) for 30 year return period
Vol_{1yr}	The volume of storage for 1 year return period
Vol_{100yr}	The volume of storage for 100 year return period
PIMP	Percentage of the catchment which is impervious (roofs and roads)
(shaded box)	Storage related analysis

Figure E3 Initial and Detailed Design of Stormwater Drainage for New Developments

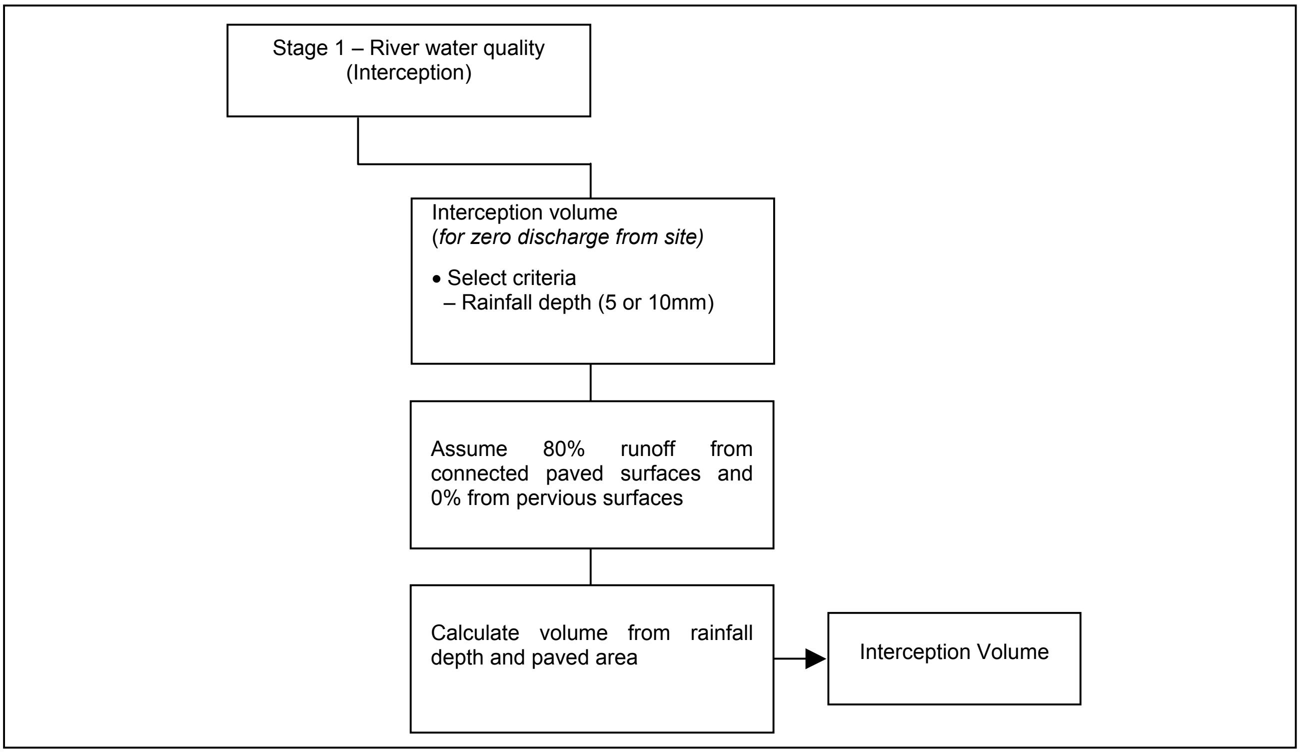


Figure E4 River Water Quality – Criterion 1.1; Interception Storage

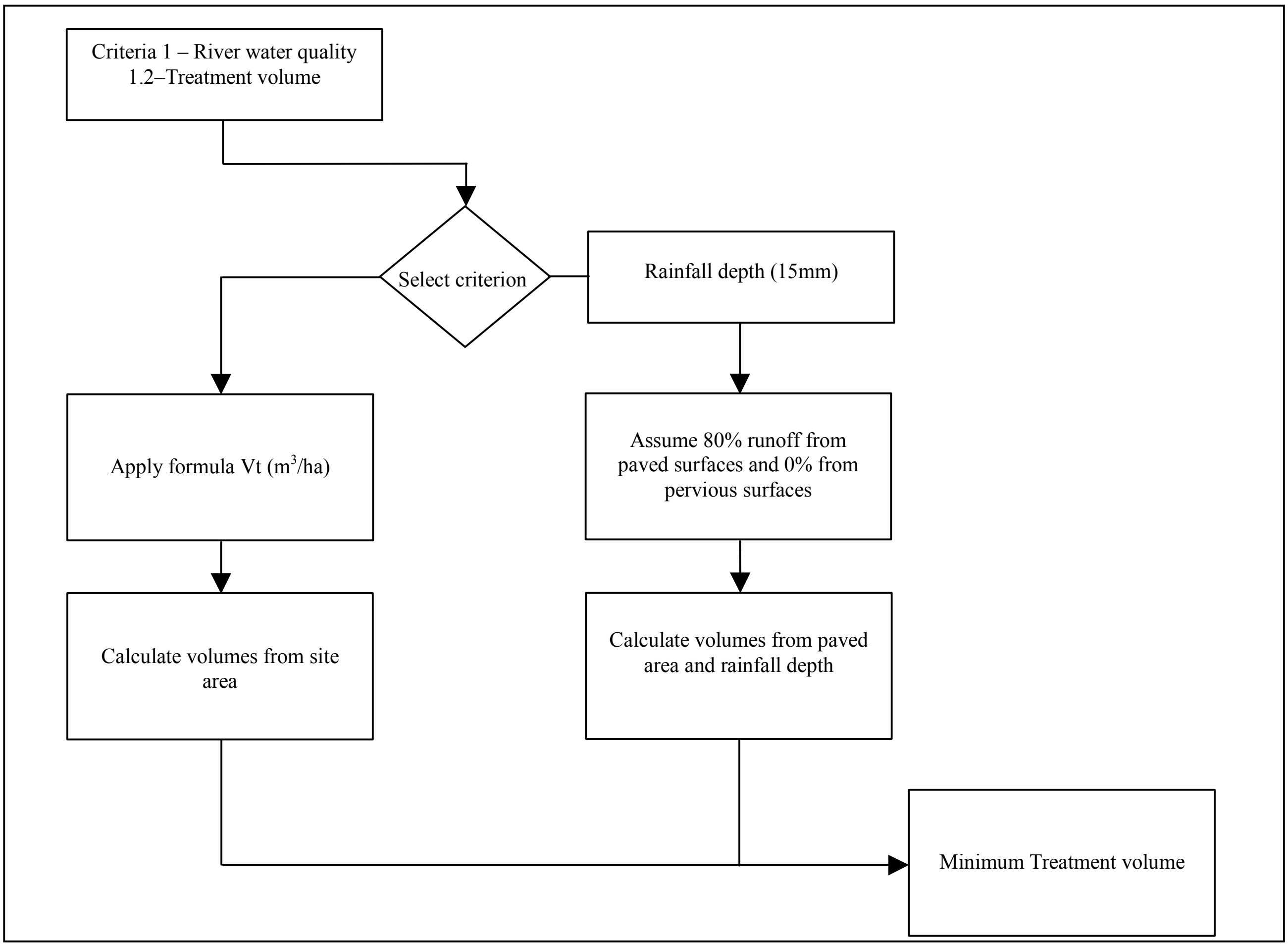


Figure E5 River Water Quality – Criterion 1.2; Treatment (wet pond) Volume

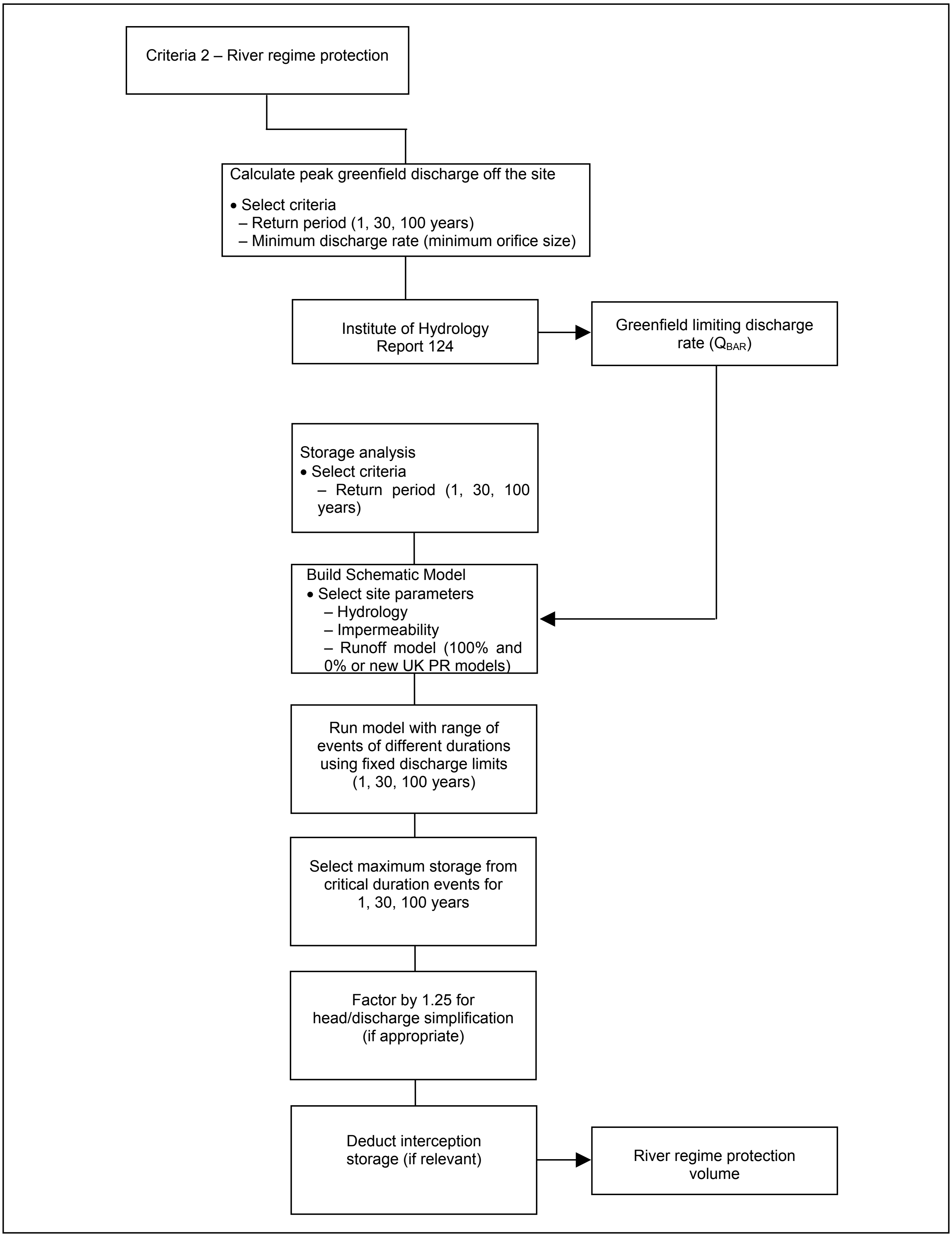
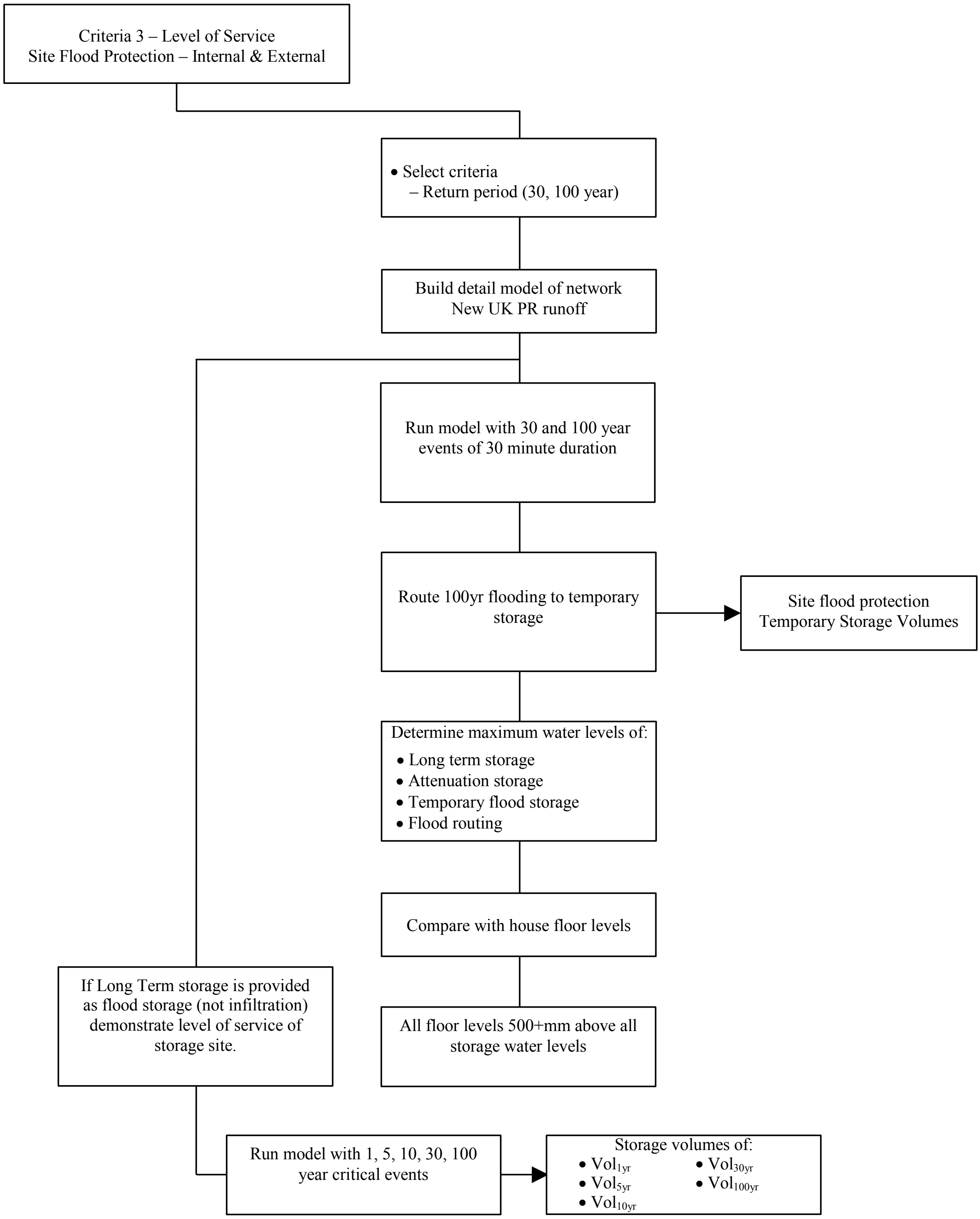


Figure E6 River Regime Protection – Criterion 2; Attenuation Storage



Notes: The model is built with the storage volumes evaluated for Criteria 1 and 2
Temporary flood storage is unlikely to be built as a formal storage unit, but use car parks or areas of open space

Figure E7 Levels of Service – Criterion 3; Flood Routing and Temporary Storage Operation

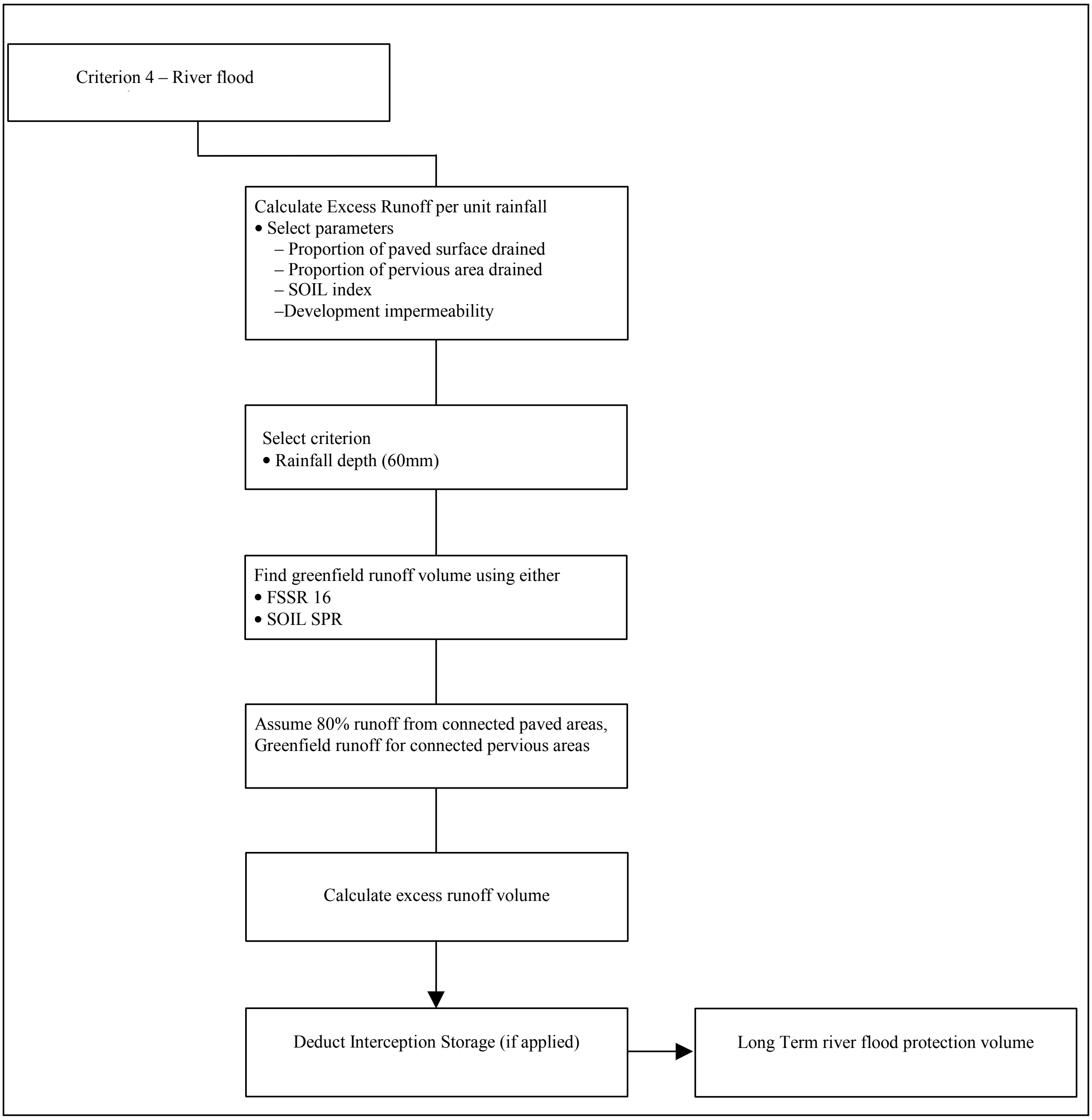


Figure E8 Storage Design – Criterion 4; River Flood Protection

E2. WORKED EXAMPLE

The following example is an illustration of the process of applying the design criteria for stormwater storage for discharge attenuation and volume reduction. The example does not illustrate design of pipe systems nor does it look into the treatment train process in terms of effectiveness of the SuDS system in protecting the environment from urban pollution washoff.

Catchment Characteristics

Site Area	= 70ha
SAAR	= 750mm
SOIL	= 3
M5-60	= 17mm
r	= 0.30
PIMP	= 65%

In addition it is assumed that:

- climate change factor for rainfall is 1.1 (10% increase)
- 25% of the paved surface drains to infiltration, and
- 60% of the pervious area is positively drained by the drainage system

The remaining 40% of the pervious area is assumed to infiltrate with surface flow paths preventing runoff from entering the drainage system.

E2.1 River Water Quality Protection – Criterion 1

Water quality protection (Figure E4) is provision of either interception and/or treatment volume. Both are calculated below.

E2.1.1 Interception – Criterion 1.1

Assume 80% runoff from paved surfaces and 0% from pervious surfaces for the first 5mm of rainfall. This is a conservative value for applying to small rainfall events. The paved runoff proportion is actually likely to be around 60% for most small events with the first 0.5mm of rainfall being lost in depression storage and evaporation before any runoff takes place. Interception volume is calculated in Table E1.

Table E1 Calculation of Interception Volume

Item	Measurement / calculation	Comment / clarification
Paved surfaces connected to the drainage system	0.75 x 0.65 x 700,000 = 341250 m^2	75% of the paved area 65% of the site is paved 70ha development in m^2
Volume of interception storage	341250 x 0.005 x 0.8 1365m^3	Paved area directly drained 5mm rainfall depth 80% paved runoff factor

Interception could be achieved by a number of means. These include infiltration and pumping to treatment.

Pumping to treatment is highly unlikely to be feasible as it is costly in terms of the infrastructure required, the running costs and, most importantly, very difficult to manage to ensure that only the first 5mm is catered for.

Infiltration using infiltration trenches for roof runoff and filter trenches for road runoff is probably the most effective way of meeting this criterion. Direct runoff into soakaways is generally not regarded as sustainable without a high level of maintenance provision. However soil type needs to be considered and in this example SOIL type 3 may be considered to be unsuitable for infiltration.

Pond top water level design may be a useful way of addressing part or all of this volume. The period when water quality is most an issue is in summer when dry periods between events are measured in days or even weeks and river levels are low. If a pond liner is finished 150mm below the outfall invert, the pond perimeter can be designed to maximise infiltration, it is likely that the top water level of the pond will be below the outlet level for many events, especially those in summer. It is quite possible that a retention pond serving 70ha might amount to around 10,000m^2. Assuming 7 days of dry weather with an evaporation rate of 3mm/day and an equivalent loss from infiltration of 5mm/day, this amounts to 560m^3 of storage. Although this is less than 1365m^3, it goes some way to providing much of the storage needed.

Different surface types have different pollution characteristics. Paved surfaces served by SuDS (such as swales and pervious pavements) may be considered to have relatively clean runoff compared to runoff from roads served by pipes. Interception volume should therefore be focused on serving these areas, which are more of a pollution problem.

E2.1.2 Treatment Volume – Criterion 1.2

For events larger than 5mm, and in situations where "Interception storage" cannot be provided, surface water runoff treatment is provided using a retention pond or wetland in accordance with the CIRIA design manual C521. This storage volume is the permanent wet pool of the retention pond.

The approach (Figure E5) proposed is to use a 15mm event, while the accepted formula for Vt in CIRIA 521 can also be used.

The treatment storage (wet pond volume) needed for 15mm is shown in Table E2.

Table E2 Calculation of Treatment Volume

Item	Measurement / calculation	Comment / clarification
Paved surfaces draining to river	0.75 x 0.65 x 700,000 = 341250 m^2	75% of the paved area 65% of the site is paved 70ha development in m^2
Volume of treatment storage	341250 x 0.015 x 0.8 4095m^3	Paved area directly drained 15mm rainfall depth 80% runoff from paved surfaces

If the use of Vt is preferred:

$Vt\ (m^3/ha) = 9 \times D(SOIL/2 + (1 - SOIL/2) \times I)$

$Vt = 9 \times 17\ (0.4/2 + (1 – 0.4/2) \times 0.65 \times 0.75)$

$Vt = 90m^3/ha$

Therefore Vt for a 70ha site is 6300 m^3

This is effectively asking for around 20mm of rainfall as the treatment volume. The CIRIA document suggests 4Vt for extended retention ponds to ensure a good level of treatment is achieved. This would amount to over 25,000m^3 being required for this 70ha site. Until it is demonstrated that 4 times Vt is much more effective in treating surface water runoff, it is recommended that the normal requirement should be 15mm.

E2.2 River Regime Protection – Criterion 2

River regime protection is achieved by limiting the discharge to greenfield runoff rates for return periods of 1, 30 and 100 years which therefore requires attenuation storage to enable stormwater discharges to meet this criterion. This is best evaluated using a simulation model to calculate this volume by using the estimated greenfield runoff rates as fixed throttle rates for these three return periods.

Before carrying out the calculations, a few notes on using simulation models are given.

E2.2.1 General Comments on the Use of Models

The New PR Equation
As detailed in Appendix D, it is normal to use the New UK PR equation when doing detailed modelling. However much of this analysis is more easily carried out using fixed percentage runoff assumptions as defined earlier and detailed modelling is only normally applied for the Level of Service stage where the actual performance of the system needs to be established in detail. The New UK PR model allows for some contribution from pervious areas, which increases with event size. As storms become larger, this is a reasonable premise to make. This pervious term is controlled by the parameter NAPI (Net Antecedent Precipitation Index).

NAPI increases with rainfall depth during the event and therefore PR also increases. Design values for NAPI are a function of SOIL type and selected (usually) on the basis of the mean winter value from analysis of a rainfall time series for attenuation storage analysis. Values for Dublin are assumed to be:

SOIL type 1	1mm
SOIL type 2	5mm
SOIL type 3	10mm
SOIL type 4	25mm
SOIL type 5	40mm

The moisture depth parameter (PF) is a standard default value of 200mm.

Use of Hydrodynamic Models
When modelling to determine the approximate storage required, the pipe system is often modelled with a limit of discharge throttle and an overflow, and using either a fixed percentage runoff model or the New UK PR model. The volume passing over the overflow is the storage needed. A range of different storm durations is used to determine the maximum volume. This is done three times, each time the storage for the lower return period is included as storage in the node from which the overflow takes place.

This method under-predicts the volume of storage needed, as the head-discharge relationship of the hydraulic control(s) is not being represented. An additional allowance of 25% should therefore be applied to this first estimate of storage to allow for this approximation. This will be partially offset by the use of the conservative results found if the fixed percentage runoff model (paved 100%, permeable 0%) is applied. Detailed design, using the actual head-discharge relationship, will be needed to check whether the storage provision has been estimated correctly.

E2.2.2 Greenfield Runoff Rate Analysis

The formula from report IoH 124 is:

$QBAR_{rural} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$

The site is greater than 50ha; therefore apply the formula for the actual site area.

$QBAR_{rural} = 0.00108 \times 0.7^{0.89} \times 750^{1.17} \times 0.37^{2.17}$

$QBAR_{rural} = 0.00108 \times 0.728 \times 2311 \times 0.116$

$QBAR_{rural} = 211l/s$

Therefore $QBAR_{rural}$ / ha is 3.0l/s/ha

Note that the FSR SPR value for SOIL type 3 is 0.37.

To get the 1, 30 and 100 year throttle rates the growth curve advised for use for developments, which is shown in appendix C is needed. Proposed values for Dublin are:

1 year factor	0.85
30 year factor	2.10
100 year factor	2.60

Therefore greenfield limiting discharge rates are:

1 year throttle	2.55 l/s/ha (178l/s)
30 year throttle	6.30 l/s/ha (441l/s)
100 year throttle	7.80 l/s/ha (546l/s)

E2.2.3 Attenuation Storage Analysis Using a Computer Model

Assuming that 25% of the paved surface does not contribute direct runoff even in the 100-year event, build a simple model of 70ha with an impervious connected area of 48.8% (0.65 x 0.75).

Figure E9 illustrates the modelling process.

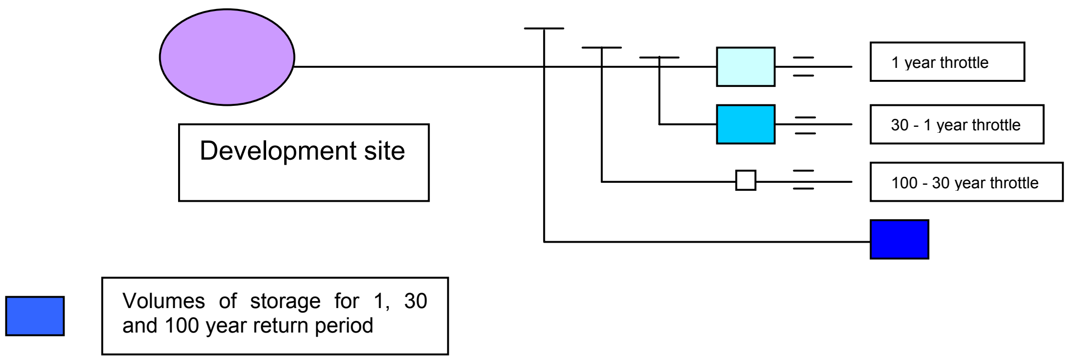


Figure E9 Modelling for River Regime Protection

Figure E9 illustrates the nodes, links, throttles and overflow structures that are represented in the model. The process of the model construction and analysis is discussed below.

Create rainfall files for range of durations (6, 12, 18, 24, 36 hours) for 1, 30, and 100-year events.

Factor all hyetograph (rainfall intensity) values by 1.1 to allow for climate change.

Use fixed discharge rates as calculated for greenfield runoff rates for 1, 30 and 100-year events.

<u>Run 1</u>
Run model for 1-year event with storage node set with a nominal volume ($1m^3$) with 1-year throttle of 178l/s.

Spill volume = $5250m^3$

Run 2
Alter 1st storage node in model to provide 5250m^3 before spill occurs from overflow. Run model for 30-year event with 2nd storage node set at nominal volume (1m^3) with outflow rate equal to 263l/s (441 – 178). This is the 30-year throttle minus the 1-year throttle rate.

Spill volume = 5820m^3 from second overflow

Run 3
Alter 2nd storage node in model to provide 5820m^3 before spill occurs from overflow. Run model for 100-year event with 3rd storage node volume of 1m^3 with outflow rate equal to 283l/s (546 - 441). This is the 100-year throttle minus the 30-year throttle rate.

Spill volume = 2990m^3

Therefore total storage volume is approximately equal to:

1-year	5250m^3
30-year	5820m^3
100-year	2990m^3
Total	14060m^3

An allowance to account for the simplifying assumption of head – discharge relationship of 1.25 may then be needed depending on the design of the storage structure. This is because the model assumes the maximum flow rate can be mobilised immediately for each design return period.

Therefore an estimate of the attenuation storage of (14060 x 1.25) = 17575m^3 is required. This figure would be refined at the stage of detailed design.

Analysis then needs to be undertaken to evaluate the impact of high river levels on the discharge arrangements for the attenuation storage. This is described in the main document in chapter 6 and is not illustrated here. This needs to be carried out at detailed design, but some analysis at initial design is appropriate if it is clearly evident that river water levels will influence discharges from the site.

E2.3 Levels of Service – Criterion 3

There are four criteria for levels of service. These are:

Criterion 3.1 - No external flooding except where specifically planned. (30-year high intensity rainfall event).
Criterion 3.2 - No internal flooding. (100-year high intensity rainfall event).
Criterion 3.3 - No internal flooding. (100-year river event and critical duration for site storage)
Criterion 3.4 - No flood routing off site except where specifically planned. (100-year high intensity rainfall event)

Criteria 3.1 and 3.2 can only be analysed using a detailed drainage model of the proposed system. (Current models are still not sufficiently developed to do this as accurately as is really needed, but these will be developed in due course).

Criterion 3.3. Assessment of river levels requires either good knowledge of local flood levels or the use of a suitable hydrodynamic river model to predict them. On site retention storage levels can only be defined at detailed design stage when ground levels and storage unit arrangements have been defined in detail.

Criterion 3.4. Similarly detailed topographical information is needed to evaluate runoff routing. Detailed modelling work from criteria 3.1 and 3.2 will provide information on the relevant flood volumes.

Where Long term flood storage is to be provided by diverting flows from the Attenuation storage system, this needs to be checked by running the proposed storage system arrangement with a range of events to check how frequently and to what extent the Long term storage comes into effect.

E2.4 River Flood Protection – Criterion 4

The volumetric analysis for "River Flow Protection" is purely a comparison of pre- and post-development runoff volumes and can be described as "Long term" storage volume. The objective is to limit the runoff discharged to the river after development to the same as that which occurred prior to development.

There are three ways of ensuring that this volume is prevented from passing to the river. These are criteria 4.1, 4.2 and 4.3 respectively.

The first assumes that this volume can be designed to come into effect during extreme events only. This requires very careful modelling and analysis. Although design storm events can be used to evaluate the design proposals to check that long term storage is mobilised effectively and does not come into operation too frequently, it should be recognised that real rainfall is only being approximated by these profiles. Theoretically a check should be carried out using time series rainfall that is sufficiently long that suitable extreme events are represented. However as high resolution recorded data does not extend for more than a few decades, even if there are suitable gauges locally, there are unlikely to be sufficient extreme events to carry out a comprehensive check. New stochastic rainfall tools are being developed which will enable this type of testing of proposed solutions to be carried out more easily.

The second approach assumes that the Long Term storage volume is provided in the form of infiltration volume that provides sufficient storage at the time of an extreme event occurring. In the case of this example of a site with SOIL type 3, it is probable that much of the infiltration volume provided might only have a small proportion of the volume available if such an event took place in a wet period. Although both approaches have difficulties to overcome, it does not alter the need to try and address the requirement to provide long-term storage.

However if it is considered that either solution approach is not possible, a third approach allows for long term storage to be ignored, but that all runoff should be limited to QBAR (approximately 2 year return period), or 2 l/s/ha which ever is the greater. This should ensure sufficient stormwater runoff retention is achieved to protect the river during extreme events. In this case QBAR is 211l/s and would be used rather than 2l/s/ha (140l/s).

The formula for long-term storage is:

$$\mathrm{Vol}_{xs} = \mathrm{RD.A.10}\left[\frac{\mathrm{PIMP}}{100}(\alpha 0.8) + \left(1 - \frac{\mathrm{PIMP}}{100}\right)(\beta.\mathrm{SOIL}) - \mathrm{SOIL}\right]$$

where:

- Vol_{XS} is the extra runoff volume (m^3) of development runoff over Greenfield runoff
- RD is the rainfall depth for the 100 year, 6-hour event (mm)
- PIMP is the impermeable area as a percentage of the total area (values from 0 to100)
- A is the area of the site (ha)
- SOIL is the "SPR" index from FSR
- $\alpha 0.8$ is the proportion of paved area draining to the network or directly to the river (values from 0 to1) with 80 percent runoff
- β is the proportion of pervious area draining to the network or directly to the river (values from 0 to1)

If it is assumed that 60% of the pervious area can be positively drained:

Vol_{xs} = 60 x 70 x 10 [(0.65 x 0.75 x 0.8) + (1 – 0.65) x 0.6 x 0.37 – 0.37]

Vol_{xs} = 42000 [0.39 + 0.078 - 0.37]

Vol_{xs} = 4116m^3

This volume is not additional to the attenuation storage volume, but it is effectively an element of it. This point is discussed further below.

It should be noted that this calculation assumes that the 25% of paved area is drained by infiltration and is not contributing any direct runoff. It can be seen by inspection that SOIL type 2 (with an SPR value of 0.3 rather than 0.37) would have significantly more volume to be stored while SOIL type 4 (SPR of 0.47) would need none.

If this Long term storage is not provided then the attenuation volume increases from 14060m^3 to 20450m^3 (calculated using the 1 year and QBAR throttle rates for the 100 year event in accordance with criterion 4.3 described above. The storage volumes are respectively 5250m^3 and15200m^3). This is assessed using the same approach described in E2.2.3. As before, this volume may need to be increased by 25% to take account of the head-discharge curve affects. This therefore could increase the total attenuation storage volume up to 25562 m^3 (20450 x 1.25).

E2.5 Storage Solutions for the Site

Having calculated all the elements of storage needed to comply with the various stormwater control criteria, the actual drainage solution needs to be developed. From the points made earlier as to difficulties that can exist in providing various forms of storage, 2 options are described below which illustrate two sets of drainage solutions for this example situation.

E.2.5.1 Option 1

Assume that Interception storage (criterion 1.1) and long term storage (criterion 4.1) can be provided and that the long term storage is in the form of flooding from the attenuation pond during extreme events.

Criterion 1 – River water quality protection

1. Interception storage = 1365 m^3 from Table E1

2. Treatment volume = 4095 –1365 = 2730 m^3 from Table E2

Treatment storage is reduced by 1365 m^3 as Interception storage has been provided.

Criterion 2 – River regime protection

3. Attenuation storage (5250 x 1.25) + 5820 + 2990 – 4116 = 11256m^3 from Section E2.2.3. The following explains the volumes calculated above.

It has been assumed that the additional provision of 25% due to head-discharge assumptions in the model is only needed for the 1 year event and that the design of the pond inlet structure mobilises the 30 year discharge rate immediately once the 1 year storage volume has been exceeded. Similarly the same assumption is made when the water level in the pond rises above the 30-year level. Figure E10 illustrates this assumption.

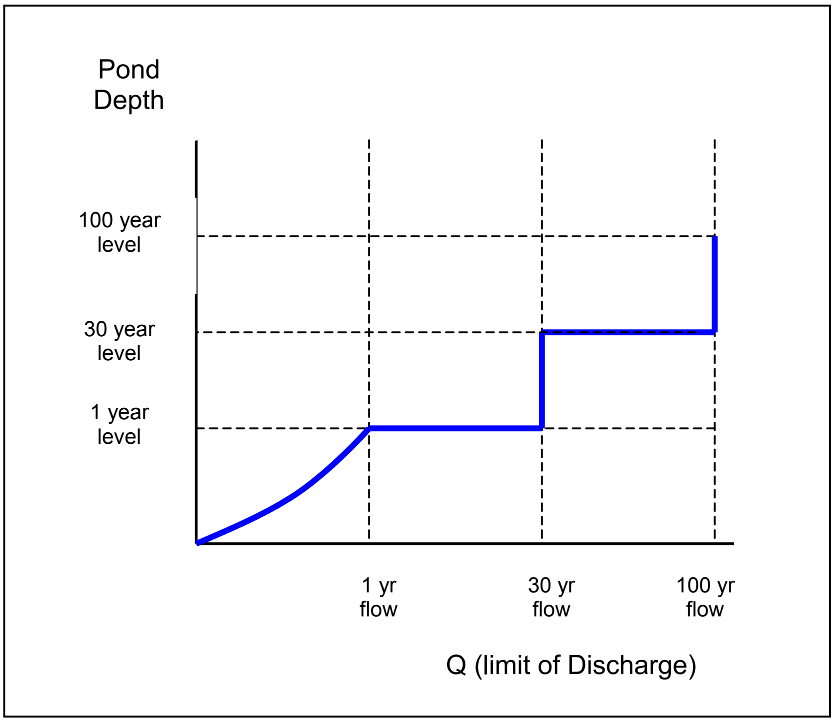


Figure E10 Flow Rate Increase to 30-year Limit of Discharge for Events Longer than 1-year Return Period

In addition, a reduction in the attenuation storage volume can be made equal to the Long Term storage volume of 4116 m^3 (criterion 4.1) as this volume of water is being stored elsewhere. At the detailed design stage these estimates would be checked in more detail using the actual head-discharge and depth-storage relationships.

The assumption that the attenuation storage above the 1-year event can avoid the variable head-discharge due to storage depth presumes that:

1. The authority allows discharge to increase to the 30 year rate immediately after the 1 year storage volume has been mobilised
2. The water levels in the pond and receiving water allow for a hydraulic design that enables this to be achieved.

In the case of the first assumption, it seems reasonable to discharge the 30-year flow rate once the storage has filled above the 1-year storage volume. The river flows are likely to be fairly high by this stage and the important morphological protection would have been provided for the vast majority of events. Many events of greater magnitude than the 1-year event will also be controlled to the 1-year criteria where the duration of the event is significantly different to the critical duration used for determining the 1-year storage. Thus a significant step in runoff (around 2.5 times) does not contravene the concept of protecting the river.

The second assumption is needed because the design approach to achieve this step change in discharge could require a flow control arrangement that involves headloss to mobilise the additional flow effectively.

Criterion 4 – River flood protection

4. Long Term storage 4116 – 1365 = 2751 m^3 from Section E2.4

Long-term storage is reduced by 1365 m^3 as Interception storage has been provided.

It can be seen by inspection from the figures for River Regime Protection, that to mobilise 2751 m^3 for Long term storage, the flooding will have to start coming into effect at about the 30 year return period. This is because the volume needed for attenuation storage between the 30 and 100-year events is only slightly larger at 2990 m^3. If interception storage is not provided and all the long-term storage (of 4116 m^3) is to be mobilised from flooding from the attenuation storage structure, it will start coming into effect for events that are significantly less than a 30-year return period.

E2.5.2 Option 2

The drainage assumptions (interception and Long term flood storage) made in the first option may not be possible. This second option looks at providing a drainage solution that does not utilise interception storage and that long-term storage cannot be provided as either infiltration or extreme event flood storage.

Volumes to be provided would then be:

Criterion 1 – River water quality protection
1. Treatment storage = 4095m^3 from Table E2

Criterion 2 and 4 – River regime and flood protection
2. Attenuation storage (5250 x 1.25) + 15200 = 20,662m^3 from Section E2.4

Attenuation storage is based on criterion 4.3 of using Qbar for the throttle rate for events greater than 1 year. This is used as long-term storage is not being provided.

This example and the 2 solution options demonstrate the importance of using the greenfield runoff rates of 30 and 100 years to minimise storage volumes.

E2.5.3 Options 1 and 2 Storage Summary

To assist in illustrating the differences between the two drainage solution options, table E3 has been produced which provides the information more succinctly.

Table E3 Storage Requirements Summary for Options 1 and 2

Criterion	Storage for Option 1	Storage for Option 2	Calculated storage for each criterion
1. River Water Quality Protection			
Criterion 1.1 "Interception storage"	1365 m^3	-	5mm – 1365 m^3
Criterion 1.2 "Treatment" Storage	4095 – 1365 = 2730 m^3	4095m^3	15mm – 4095m^3 (Vt – 6300 m^3)
2. River Regime Protection			
Criteria 2.1 & 2.2 "Attenuation" Storage	5250x1.25 + 5820 + 2990 – 4116 = 11256 m^3	See River Flood protection	1year – 5250 m^3 30year – 5820 m^3 100year – 2990m^3
3. Level of Service for the Site *			
Criteria 3.1 to 3.4	defined at detailed design	defined at detailed design	-
4. River Flood Protection			
Criterion 4.1 "Long term" Storage	4116 - 1365 m^3 = 2751 m^3	-	100yr, 6hr = 4116 m^3
Criterion 4.3 "Attenuation & Long term" Storage	-	5250x1.25 + 15200 = 20,662 m^3	1year – 5250 m^3 Qbar – 15200m^3

** Level of Service requires detailed modelling to determine network performance, flood routing, temporary storage volumes and locations and operational characteristics of long-term flood storage*

E2.6 Time Series Rainfall (TSR) Analysis for Long Term Storage Performance Evaluation

To test the operation of the long-term storage volume that was designed to come into effect during extreme events, a time series rainfall analysis was run. A schematic model of the proposed storage system (not the illustration above) was built with the intention of the long-term flood storage coming into operation for events greater than a 5-year return period. It was designed to provide the full amount of long-term storage for the 100-year event. The reason for the Long term storage to start coming into effect at the relatively low frequency of 5 years is that the site comprised type 2 SOIL and therefore the volume of storage was quite large. The model was run with 21 years of recorded time series rainfall.

The result was that the long-term storage was mobilised 15 times in the 21 years. This is more frequent than expected, slightly less often than once a year. 11 of the 15 events, in which the long-term storage area was mobilised, were events where flooding occurred in the river (flows were above the Q_{10} flow rate). One event fully mobilised the long-term storage volume requirement for a 100-year event (1540m^3).

This example illustrates the need for careful design of the long-term storage provision, but effectively illustrates the application of the principle. Figure E11 below shows the long-term storage volumes that were mobilised for each of these events. It also demonstrates that time series rainfall can produce different results to design rainfall events. It also draws attention to the problems of not having a sufficient duration of data to test for extreme events. This is one of the reasons why stochastic series rainfall (generated by software) is important in being able to evaluate certain aspects of drainage system performance.

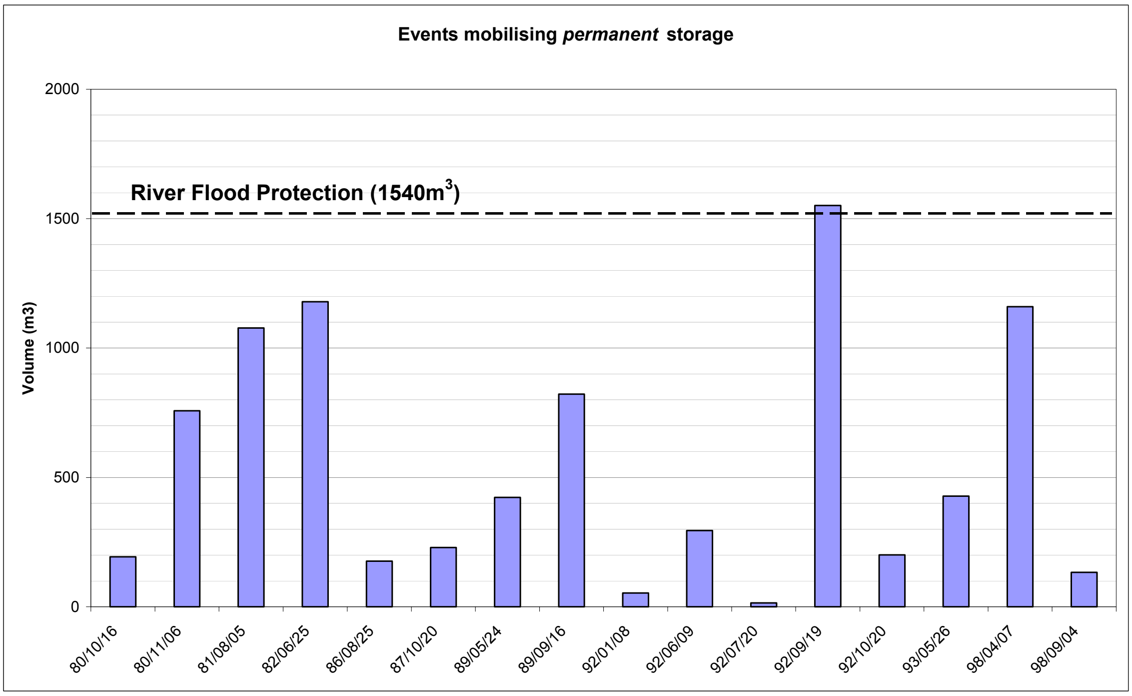


Figure E11 Time Series Rainfall Check for Events Mobilising Long-term Storage

Appendix F

Construction Specifications

1 CLEANSING AND TESTING

1.1 Cleansing of Gravity Sewers, Drains and Manholes

On completion of construction, internal surfaces of sewers, drains and manholes shall be thoroughly cleansed to remove all deleterious matter, without such matter being discharged into existing public sewers or watercourses. The sewers, drains and manholes shall be maintained in a clean and serviceable condition until they are taken in charge as public sewers.

All cleaning and testing shall be the responsibility of the Developer.

1.2 Precautions Prior to Testing Pumping Mains

Before testing any pipeline the Developer shall ensure that it is anchored adequately and that thrusts from bends, branch outlets or from the pipeline ends are transmitted to solid ground, or to a suitable temporary anchorage.

Open ends shall be stopped with plugs, caps or blank flanges properly jointed.

Testing against closed valves will not be allowed.

It will not be permissible to transfer the thrust onto a complete length of pipeline or onto existing mains from which the pipeline is being filled.

Before pressure testing is carried out, the trench shall be sufficiently filled to ensure that the requisite anchorage is provided for each pipe, to prevent movement during the testing period.

1.3 Testing of Gravity Pipelines

Pipelines shall be tested and inspected for infiltration and exfiltration as laying proceeds, to facilitate relaying or replacement of any faulty pipes or joints as work proceeds. This initial testing should being applied before any sidefill is placed, using the air test to provide rapid checks for every three or four pipes laid, and to avoid the need to drain and dispose of test water.

Non-pressure pipelines laid in open cut shall be acceptance tested after they are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability whilst under test.

For acceptance testing the pipeline shall be tested from manhole to manhole. Any short branches should be tested with the main line, but branches longer than approximately 10m should be tested separately.

The method for acceptance testing shall be:

- For pipelines up to and including 600mm in diameter, the water test shall be applied;
- For pipelines greater than 600mm, but not exceeding 900mm in diameter, the air test shall be applied;
- For pipelines greater than 900mm in diameter, a visual examination shall be applied.

1.4 Water Test for Gravity Pipelines

The test pressure shall not be less than 1.2m head of water above the pipe soffit or ground water level, whichever is the higher at the highest point, and not greater than 6m head at the lowest point of the section. Steeply graded sewers shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the section were tested in one length.

The pipeline shall be filled with water and a minimum period of 2 hours shall be allowed for absorption, after which water shall be added from a measuring vessel at intervals of 5 minutes and the quantity required to maintain the original water level noted. Unless otherwise specified, the length of sewer shall be accepted if the quantity of water added over a 30-minute period is less than 0.5 litres per linear metre per metre of nominal diameter.

1.5 Air Test for Gravity Pipelines

Pipelines to be air tested shall have air pumped in by suitable means until a pressure of 100mm head of water is indicated in a U-tube connected to the system. The pipeline shall be accepted if the air pressure remains above 75mm head of water after a period of 5 minutes without further pumping, following a period for stabilisation. Failure to pass the test shall not preclude acceptance of the pipeline if a successful water test is subsequently carried out.

1.6 CCTV Inspection of Pipelines

Where internal inspection of pipelines by CCTV is required, the Developer shall provide all necessary equipment, including suitable covered accommodation for viewing the monitor screen, together with personnel experienced in the operation of the equipment and interpretation of results.

The intensity of illumination within the pipe and the rate of draw of the camera shall be such as to allow a proper examination of the inside of the pipe. Provision shall be made for the movement of the camera to be stopped and its position recorded, and for permanent photographs to be taken at any point as requested by the drainage inspector.

The Developer shall be responsible for initial signing-off of CCTV results.

1.7 Infiltration and Exfiltration

Infiltration causes an increase in the legitimate flows in the sewerage system, due to groundwater entering through defects in the pipework, manholes and chambers. Exfiltration causes reduced flows in the foul system, due to leaks and outflows from faults and openings in the fabric of the system, Exfiltration of foul flows results in contamination of the surrounding soils and possible pollution of groundwater. Infiltration and exfiltration often occur together, resulting in erosion of the surrounding soils, and possible collapse.

Non-pressure pipelines and manholes shall be inspected and tested for infiltration and exfiltration, after backfilling. All inlets to the system shall be closed, and any residual flow shall be deemed to be infiltration.

The pipeline and manholes shall be accepted as satisfactory if the infiltration, including infiltration near manholes, in 30 minutes does not exceed 0.5 litres per linear meter per metre of nominal diameter.

Notwithstanding the satisfactory completion of the above inspection or test, if there is any discernible flow of water entering the pipelines or manholes which can be seen either by visual or CCTV inspection, the developer shall take such measures as are necessary to stop such infiltration. The presence of infiltration and/or exfiltration will result in refusal of taking-in-charge.

1.8 Watertightness of Manholes

All such structures shall be inspected to ensure that they are watertight, with no identifiable flow of water penetrating the chamber.

1.9 Watertightness of Chambers, Sumps and Wet Wells

As well as inspection for watertightness, all structures intended to retain water for long periods, such as sumps, interceptors and tanks, shall be water tested to confirm no measurable loss of water and external sign of leakage.

1.10 Testing of Pressure Pipelines (excluding Thermoplastic Pressure Pipes)

The entire pipeline shall be pressure tested.

Pumping mains shall be tested by the developer after that are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability under test.

Gauges used for testing pumping mains shall be either of the conventional circular type, not less than 200mm diameter, calibrated in metres head of water, or shall have a digital indicator capable of reading increments of 0.1m head. Before any gauge is used, the developer shall arrange for it to be checked independently, and a dated certificate of accuracy shall be provided.

Before testing, valves shall be checked and sealed, the sections of main filled with water and the air released.

The pressure in the pumping main shall then be raised steadily until the specified test pressure is reached in the lowest part of the section, and the pressure shall be maintained at this level, by pumping if necessary, for a period of at least 1 hour. The pump shall then be disconnected, and no further water shall be permitted to enter the pumping main for a further period of 1 hour. At the end of this period, the original pressure shall be restored by pumping, and the loss measured by drawing off water from the pumping main until the pressure as at the end of the test is again reached.

The permissible loss shall not exceed 2 litres per metre nominal diameter per kilometre length per meter head (calculated as the average head applied to the section) per 24 hours.

The developer shall provide, and subsequently dispose of the water required for the test. Discharges to sewers shall not take place without the consent of the drainage inspector.

Test pressures for pumping mains shall be 1.5 times the maximum operating pressure at the lowest point of the main, or the maximum operating pressure plus the maximum surge pressure, ever is the greater.

1.11 Testing of Thermoplastic Pressure Pipelines

The Clauses for Testing of Pressure Pipelines (excluding Thermoplastic Pressure Pipes) shall apply, except that testing shall be carried out in accordance with the procedures in “A guide to testing of water supply pipelines and sewer rising mains” published by WRc.

1.12 Records of Inspection and Testing

The records of all inspections and tests shall be recorded in the Regional Drainage GIS. Responsibility for entering and maintaining such records rests with the Drainage Department.

2 CONNECTIONS TO EXISTING DRAINAGE SYSTEMS

Pipe saddles for concrete or clay pipelines shall be bedded in mortar, and a mortar fillet formed to give a cover of at least 50mm to the base of the saddle. Pipe saddles for PVC-u pipelines shall be purpose made from PVC-u and shall be either a mechanical clip-on type or shall be fixed with appropriate solvent cement.

Where an appropriate saddle or junction unit is unobtainable a connection to the existing drainage may be made with a pipe of similar material, cut to give an oblique junction, so that the discharge is in the direction of flow in the main sewer. The connecting pipes shall be of such a length that the socket of the cut pipe rests on the outside barrel of the sewer, with no projection inside the main sewer. The pipe joint shall then be pointed in mortar externally and internally where practicable. Alternatively purpose made junctions may be used by cutting out sections of pipe, fitting a junction and securing with repair couplings.

Where junction pipes for future connections are required, they shall be inserted as necessary during construction of the sewers, and the ends of connections and pipes not needed for immediate use shall be effectively sealed. The position of all joints shall be recorded by the developer by measurement from the centre of the manhole cover immediately downstream, and marked on the as built record drawings.

3 STANDARDS OF CONSTRUCTION AND WORKMANSHIP

3.1 Pipelines

3.1.1 General Construction

Where socketed pipes are required to be laid on a granular or sand bed, or directly on a trench bottom, joint holes shall be formed in the bedding material or formation to ensure that each pipe is uniformly supported throughout the length of its barrel and to enable the joint to be made.

Pipes shall be laid on setting blocks only where a concrete bed or cradle is used.

Where pipes are required to be bedded directly on the trench bottom, the formation shall be trimmed and levelled to provide even bedding of the pipeline and shall be free from all extraneous matter that may damage the pipe, pipe coating or sleeving.

Pipes and fittings shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying.

Suitable measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent flotation or other movement before the Works are complete.

Where pipeline marker tapes are specified, they shall be laid between 100mm and 300mm above the pipe. Where a tracer system is specified, it shall be continuous and adequately secured to valves and fittings.

Construction shall be carried out in general accordance with IS EN 752 Drain and sewer systems outside buildings.

3.1.2 Pipe Bedding

Bedding for pipes shall be constructed by spreading and compacting granular bedding material over the full width of the pipe trench. After the pipes have been laid, additional granular material shall, if required, be placed and compacted equally on each side of the pipes, and where practicable, this shall be done in sequence with the removal of the trench supports.

Where support from the side of the trench cannot be guaranteed, such as in old town and city streets, a bed and surround of concrete shall be provided.

Control of flow of groundwater is the developer's responsibility. Where, in the opinion of the drainage inspector, the flow of groundwater is likely to transport fine soil particles, water stops of puddles clay or 20N/mm^2 strength concrete, extending up through the bedding and sidefill shall be placed across the trench at each manhole, and immediately downstream of any temporary works. These water stops shall be positioned to prevent the development of a linear sub-surface watercourse parallel and outside the pipeline.

3.1.3 Concrete Protection to Pipes

Pipes to be bedded on or cradled with concrete shall be supported on precast concrete setting blocks, the top face of each block being covered with 2 layers of compressible packing.

Concrete provided as a protection to pipes shall be 20 N/mm^2 strength, and placed to the required depth in one operation. Where pipes with flexible joints are used, concrete protection shall be interrupted over its full cross-section at each pipe joint by shaped compressible filler.

Where pipes are protected by a concrete cover slab placed above the pipe, this shall extend across the full width of the trench and there shall be a minimum of 150 mm of surround between the crown of the pipe and underside of the slab.

3.1.4 Completion of Pipe Surround

After completion of the relevant operations above, fill material shall, where required, be placed and compacted over the full width of the trench in layers not exceeding 150 mm before compaction, to be finished thickness of 250 mm above the crown of the pipes.

Subsequent backfilling shall then be carried out as specified elsewhere.

3.1.5 Pipe Jointing Generally

Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care should be taken to ensure that there is no ingress of grout or other extraneous material into the joint annulus after the joint has been made.

Laying and jointing of pipelines is the developer's responsibility. Where, with the agreement of the drainage inspector, pumping mains are laid to curves, the deflection at any pipe joint as laid shall not exceed three-quarters of the maximum deflection recommended by the manufacturer.

Site fusion jointing in polyethylene pipelines shall be undertaken in accordance with the relevant provisions of WIS 4-32-08.

3.1.6 Cutting Pipes

Pipes shall be cut in accordance with the manufacturer's recommendations. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used.

Where ductile iron pipes are to be cut to form non-standard lengths, the Developer shall comply with the manufacturer's recommendations in respect of ovality correction and tolerances to the cut spigot end.

Where concrete pipes are cut, any exposed reinforcement shall be sealed with an epoxy resin mortar.

3.1.7 Thrust Blocks

Except where self-anchoring joints are used, thrusts from bends and branches in pumping mains shall be resisted by Grade C20 concrete thrust blocks cast in contact with undisturbed ground.

Any additional excavation required to accommodate thrust blocks shall be carried out after the bend or branch is in position, and the thrust face shall be trimmed back to remove all loose or weathered material immediately prior to concreting.

Thrust blocks shall be allowed develop adequate strength before any internal pressure is applied to the pumping main.

Rapid hardening cement shall not be used in concrete for the protection of plastic pipes.

Plastic pipes shall be wrapped with 3 layers of plastic sheeting being surrounded by concrete.

3.1.8 Tolerances in Gravity Sewers and Pumping Mains

The position of the internal face of any sewer and pumping main shall not deviate from the line and level described in the drawings or agreed variation by more that 20 mm, provided that no sewer shall have a reverse gradient.

3.2 Manholes, Chambers (including Non-Man Access Chambers) and Wet Wells

3.2.1 Brickwork and Blockwork

Brickwork and blockwork construction shall be in accordance with the relevant provisions of BS 5628: Part 3. Within Dublin City Council boundaries, high-density blocks, faced with engineering bricks shall be used for all construction work on foul and combined sewers.

Brickwork and blockwork shall be built in English bond. Bricks and blocks shall be set in mortar with all bed and vertical joints filled solid; exposed work shall be flush pointed as the work proceeds. The moisture content of the bricks and blocks shall be adjusted so that excessive suction is not exerted on the mortar.

Bricks and blocks in each course shall break joint correctly with the bricks/blocks underneath. The courses shall be laid parallel, with joints of uniform thickness, and shall be kept straight or regularly curved as required. Brickwork and blockwork shall be gauged to rise 300mm in 4 courses. Vertical joints shall be in alignment as required by the bond and shall have an average thickness of 10mm. Bricks and blocks forming reveals and internal and external angles shall be selected for squareness and built plumb.

Brickwork and blockwork shall rise uniformly; corners and other advanced work shall be racked back and not raised above the general level more than 1 m. No brickwork or blockwork shall be carried up higher than 1.5 m in 1 day. No bats or broken bricks or blocks shall be incorporated in the work unless essential for bond.

Further requirements are contained in Appendix G Standard Drawing Format and Details.

3.2.2 Corbelling

Oversail corbelling shall not exceed 30 mm on each course.

3.2.3 Bricklaying and Blocklaying in Cold Weather

Materials used in bricklaying and blocklaying shall be frost-free, and no bricks or blocks shall be laid when the ambient temperature is below 3°C, unless special precautions are taken. Completed work shall be protected adequately during cold weather.

3.2.4 Precast Concrete Manholes, Chambers and Wet Well

Precast concrete manhole sections for manholes shall be constructed with steps, ladders and slabs aligned correctly.

The jointing material for precast units shall be mortar or a proprietary bitumen or resin mastic sealant, with the concrete surfaces prepared in accordance with the manufacturer's recommendations.

Joints shall be made so that the required jointing material fills the joint cavity. Any surplus jointing material that is extruded inside the manhole, chamber, or wet well shall be trimmed off and joints shall be pointed on completion.

Concrete surrounds to manholes, chambers and the wet well shall be Grade C20 and the height of each concrete pour shall not exceed 2 m. Each construction joint shall break joint with the precast sections by at least 150 mm.

3.2.5 In-Situ Inverts and Benchings

Inverts and benching in manholes, chambers and the wet well shall have a screeded ridged finish and shall have a smooth, high strength concrete topping applied with a steel trowel before the concrete has set.

3.2.6 Pipes and Joints Adjacent to Structures

A flexible joint shall be provided as close as is feasible to the outside face of any structure into which a pipe is built. The design of the joints shall be compatible with any subsequent movement.

The recommended length of the next pipe (rocker pipe) away from the structure should be as shown in the table below:

Nominal Diameter (mm)	Effective Length (m)
150 to 600	0.6
675 to 750	1.0
over 750	1.25

Stub pipes into structures shall be of rigid material.

3.2.7 Setting Manhole Covers and Frames

Manhole frames shall be set to level, bedded and haunched externally over the base and sides of the frame in mortar in accordance with the manufacturer's instructions. The frame shall be seated on at least 2 courses of Class B engineering bricks, or on precast concrete masonry units or on precast concrete cover frame seating rings to regulate the distance between the top of the cover and the top rung to no greater than 450 mm below surface level. Within Dublin City Council boundaries, the final lift from cover slab to manhole cover shall be constructed in concrete.

A mortar fillet shall be provided where the corners to an opening in a slab are chamfered and the brickwork is not flush with the edges of the opening.

The positioning of the opening shall be such that the rungs do not protrude vertically below the opening, and the first rung shall be less that 450mm below surface level.

3.2.8 Non-Man Access Chambers

Non-man chambers shall comply with relevant provision of BS EN 752-3.

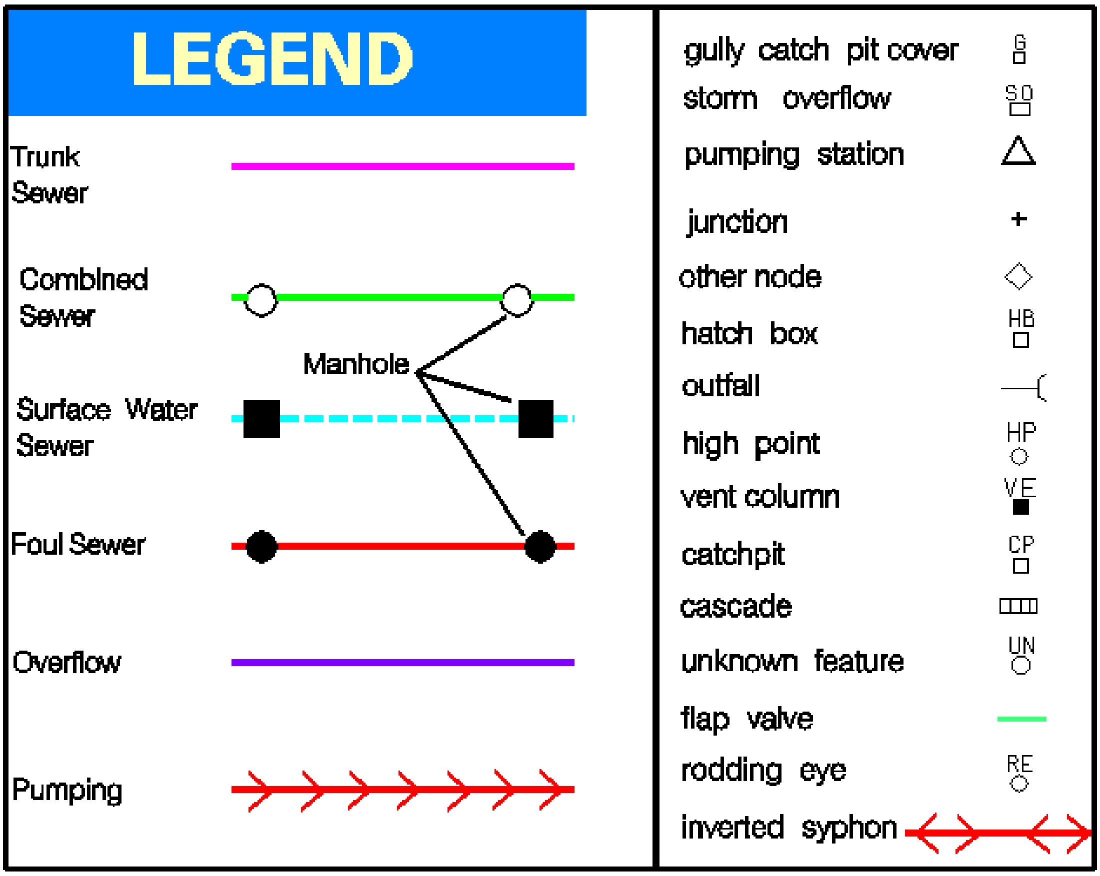
Appendix G

Standard Drawing Format and Details

1 STANDARD DRAWING FORMAT

All drawings shall be prepared to a standard format including the following:

1. All levels shall be to Ordnance Survey Ireland (OSi) Datum “Malin Head” to an accuracy of +/- 25mm;
2. The OSi benchmark used shall be stated with details;
3. The layout shall be accurately positioned (+/- 300mm relative to local detail) on the latest published version of OSi 1:1000 scale maps;
4. The national grid co-ordinates (accurate to +/- 300mm) for manholes and other drainage structures shall be shown, together with cover level (CL), invert level (IL) pipe diameter (dia), material and direction of flow (arrow);
5. All dimensions and levels shall be metric;
6. North sign shall be shown;
7. All as-constructed drainage details shall be submitted in an agreed digital format, with one hardcopy print
8. Drawings shall be prepared to the format shown on the Legend, and the Legend shall be included in the title box for each drawing.



2 STANDARD DRAWINGS

All sewerage and drainage drawings shall incorporate the following standard details:

1. Standard Manhole Details: Type A Manhole
2. Standard Manhole Details: Type B Manhole
3. Standard Manhole Details: Type C Manhole
4. Standard Manhole Details: Type D Manhole
5. Standard Manhole Details: Type E Manhole
6. Standard Manhole Details: Type F Manhole (Ramp)
7. Standard Manhole Details: Type G Manhole (Backdrop)
8. Standard Manhole Details: Type H Manhole
9. Standard Manhole Details: Standard Rung and Safety Chain Detail
10. Standard Manhole Details: Notes on Manhole Details

Greater Dublin Strategic Drainage Study

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