

7. INTERMITTENT DISCHARGES

7.1 Introduction

7.1.1 Background

This chapter deals with intermittent discharges to receiving waters from the urban wastewater system: combined sewer overflows (CSOs); wastewater treatment works, storm tank overflows and pumping station emergency overflows (PSEOs). Direct stormwater discharges have been discussed or referred to in **Chapters 2 to 5** and continuous discharges from wastewater treatment works and from trade and industrial premises are discussed in **Chapter 8**.

Intermittent discharges normally occur under wet weather conditions (although emergency overflows can occur at any time due to operational failure such as mechanical breakdown) and are widely recognised as a major cause of unsatisfactory receiving water quality in urban catchments.

Legislation has been the main driver for improvements to intermittent discharges. Until recently, environmental legislation was based on 'beneficial uses' such as fisheries, recreation and water supply abstraction. The uses identified as being most likely to be affected by intermittent discharges are river aquatic life, bathing and general amenity. However, the Water Framework Directive (WFD) now requires at least 'good ecological status' for all surface waters. Details of the current legislative framework are given in **Chapter 2**.

The state of receiving waters in the Greater Dublin Area is reported in **Chapter 3** and the historical development of the drainage system is explained in **Chapter 4**. Knowledge of both of these aspects is relevant to the development of an appropriate policy for dealing with intermittent discharges.

The National Development Plan 2000 to 2006 provides for investment to improve continuous discharges by providing secondary treatment at wastewater treatment works. New or improved sewage treatment facilities serving catchments such as Ringsend, Bray/Shanganagh and Balbriggan/Skerries will undoubtedly improve water quality. However, once all the major crude discharges have been eliminated, there will be an increasing awareness of the need to address intermittent discharges in order to achieve further improvements to water quality.

7.1.2 Policy Objectives

The aim of the regional policy is to establish a consistent approach to the design, improvement and management of intermittent discharges to ensure that the needs of the region's receiving waters are met in a cost-effective manner.

7.2 Background

7.2.1 Definitions

Various types of intermittent discharges are listed in **Table 21** below. The definitions and comments assume a conventional foul/combined sewer system draining to a wastewater treatment works (WwTW).

Intermittent discharge type	Definition / Comments
Combined Sewer Overflow (CSO)	<p>A structure where excess sewage can be diverted from the combined sewer system either directly into a receiving watercourse or indirectly via a storm sewer system.</p> <p>The most common type of intermittent discharge, designed to operate under storm conditions when the capacity of the downstream system is exceeded.</p> <p>Should not be confused with a bifurcation, which is a structure where sewage can be diverted into a different part of the sewer system. Flow diverted at a bifurcation still reaches the wastewater treatment works whereas flow diverted at a combined sewer overflow does not.</p> <p>An overflow that can spill in storm conditions but is constructed on a separate foul sewer should be classed as a combined sewer overflow – the presence of inflow due to mis-connections means that the foul sewer is effectively combined.</p> <p>A single outfall point into a receiving water may receive flows from more than one CSO. Conversely, an overflow pipe from a CSO may diverge to more than one outfall point.</p>
Pumping Station Emergency Overflow (PSEO)	<p>An overflow designed to operate only in the event of operational failure at a pumping station (e.g. power, mechanical, electrical or control failure).</p> <p>The overflow may occur at the pumping station itself or at a chamber upstream on the incoming sewer. Because the overflow may operate in dry weather or discharge to a relatively small watercourse, the environmental impact can be larger than at CSOs.</p> <p>If the overflow operates in storm conditions it should be classed as a CSO rather than an emergency overflow. This can apply to overflows at pumping stations on separate foul systems due to mis-connections.</p>
Wastewater Treatment Works Storm Tanks Overflow	<p>An overflow at a wastewater treatment works which operates when storm tank capacity is exceeded.</p> <p>May share a common outfall with final effluent from the wastewater treatment works.</p> <p>Spills are normally less polluting than those from CSOs due to pre-treatment at WwTW inlet works and settlement in the storm tanks.</p>

Table 21: Types of Intermittent Discharges

7.2.2 Irish Experience

Many CSOs in Ireland have not been improved since their creation at the time of original sewer construction – more than a hundred years ago in some cases. Others have been modified by the addition of weirs, stoplogs, penstocks or some form of screening. However, unlike in the UK, there has been no national programme of improvements to intermittent discharges. Indeed, in some areas, even the location of CSOs may be unknown at present. In addition, new intermittent discharges continue to be created, either as part of new wastewater treatment schemes or when new pumping stations are constructed.

Information concerning CSOs in the Greater Dublin Area was obtained during work on the Greater Dublin Strategic Drainage Study and is included in **Appendix F**.

Traditionally, the minimum setting for CSOs has been six times dry weather flow. In the UK, this approach was replaced by “Formula A” following the *Report of the Technical Committee on Storm Overflows and the Disposal of Storm Sewage (HMSO, 1970)* and this formula has also been used for design in Ireland.

In 1994, the Department of the Environment issued a Circular – *Procedures and Criteria in relation to Storm Water Overflows* - which has guided designers in recent years. The circular drew on UK experience at the time and refers to, amongst others, the National Rivers Authority consenting policy, the *Urban Pollution Management procedure (UPM, 1st edition, FWR, 1994)*, the *Guide to the Design of Storm Overflow Structures (WRc Report ER304E, 1988)* and the *Sewerage Rehabilitation Manual (2nd Edition, WRc, 1986)*.

A related paper by G. Galvin of the DoE was presented to The Institution of Water and Environmental Management in 1994. This included a “Summary of Design Criteria for the rehabilitation of storm water overflows”. The criteria are reproduced as follows:

- Selection of appropriate spill locations and general rationalisation of the high number of existing overflows in order to discharge to receiving waters of adequate capacity (i.e. excluding small streams);
- Consideration of the maximum downstream hydraulic capacity in the sewer system and how this can best be exploited during storm conditions;
- The efficient design of each CSO to ensure hydraulic control and the maximum separation of gross polluting matters;
- Normally a continuing flow equivalent to Formula A is recommended with particular consideration to containment of high strength industrial wastes where these are discharged to the sewer. This requirement might be modified for very high dilutions where there is no adverse environmental impact;
- For discharge to bathing waters or water contact/recreational use waters, a restricted spill frequency during the bathing season should apply based on analysis using time series rainfall or other equivalent approach (once per season or three spills per season, as appropriate), unless it can be shown that the design will achieve the water quality standards of the Bathing Water Directive for at least 98.2% of the time;
- In general, consideration is required to be given to the containment of the “first foul flush” discharges, particularly to sensitive waters using a critical rainfall approach and time of concentration calculation or other modelling approach;
- For discharges to sensitive coastal waters or fresh waters classified as clean or with that objective, a higher standard than “Formula A” should be considered with the QUALSOC (mass balance) approach used to set a maximum BOD concentration for normal river low flows;
- For sensitive waters, where eutrophication is a potential problem, an overall analysis to limit both the frequency and volume of discharge to the receiving waters is required and can be achieved using Time Series Rainfall in conjunction with a calibrated network model. This can be used to limit the percentage of run-off spilled at the overflow (say 20% max). This will not necessarily ensure that the limit of 2 mg/l P will not be exceeded but will generally be consistent with an 80% reduction target which would be the minimum requirement for treated effluents.

Since presentation of this paper in 1994, there have been significant changes to the legislation driving water quality improvements and many of the UK documents on which it is based have been superseded or updated. There have been advances in modelling techniques (rainfall, sewers, receiving waters) and, in the UK at least, much more experience of the implementation of CSO improvement programmes and of the UPM procedure.

Other criteria have been recommended for specific schemes or where a Water Quality Management Plan has been prepared. For example, the *River Tolka Water Quality Management Plan (Dublin Corporation, 1995)* recommends, inter alia, that:

- Spill frequency be limited to 4 times per year, where practicable, to achieve maximum BOD limit of 20 mg/l, and;
- Monitoring of significant overflows should be carried out using automatic recording equipment to monitor spill frequency and duration.

In strong contrast to current practice in the UK, there has been a reluctance in Ireland to fund the addition of screens to existing or new CSOs, unless located at a pumping station. This is believed to be due to concerns over long-term maintenance requirements. This issue is covered in more detail in Section 7.6.

7.2.3 International Experience

United Kingdom

In England and Wales, water services are provided by a number of private companies whose actions are regulated by the Office for Water Services (OFWAT). Since privatisation in 1989, investment has been delivered in five year cycles known as Asset Management Plan (AMP) periods. Improvements to unsatisfactory intermittent discharges (UIDs) form a significant proportion of the investment. **Figure 54** below presents a summary of the programme. The pie charts show breakdowns of the AMP3 UID programme.

The AMP3 period in particular represents a major programme of investment in improvements to UIDs, over 85% of which are CSOs. Nearly half of all the UIDs in the AMP3 period are being improved solely for aesthetics (i.e. addition of screening). An average of 18 UIDs per week will need to be improved over the five year period.

The average cost per UID of €570k reflects the need for major new infrastructure such as trunk sewer replacement, storage tanks and powered screens. In some catchments, large diameter tunnels have been constructed to intercept existing CSOs and provide storage to limit future spills.

The scale of work required, together with the pressures on water companies to deliver improvements at less cost, means that much experience has been gained in recent years, from planning methodologies to modelling techniques to chamber design.

Another significant difference between the UK and Ireland is that of the roles played by the environmental regulators - the Environment Agency (EA) in England and Wales and the Scottish Environmental Protection Agency (SEPA) in Scotland. These agencies operate a 'Consents' system for all discharges into the environment. Every known intermittent discharge should have a discharge consent document which describes the location and sets out the conditions under which the discharge is permitted to operate. Existing consents are reviewed if a discharge is identified as "unsatisfactory" or in response to changes in legislation. New consents are required when discharges are changed or created.

The EA's policy on consenting intermittent discharges is set out in its *Discharge Consents Manual*. The manual describes the UK government's position for implementing the storm overflow elements of the Urban Waste Water Treatment Directive (UWWTD) and includes guidance notes on consenting discharges to freshwaters, estuaries and coastal waters. A range of assessment criteria are suggested depending on the 'significance' of the discharge. 'Significance' depends on dilution, population, interaction with other discharges and status of receiving waters. For the AMP3 period (2000 to 2005), the EA require application of the *Urban Pollution Management procedure (UPM Manual, 2nd Edition, WRc, 1999)*.

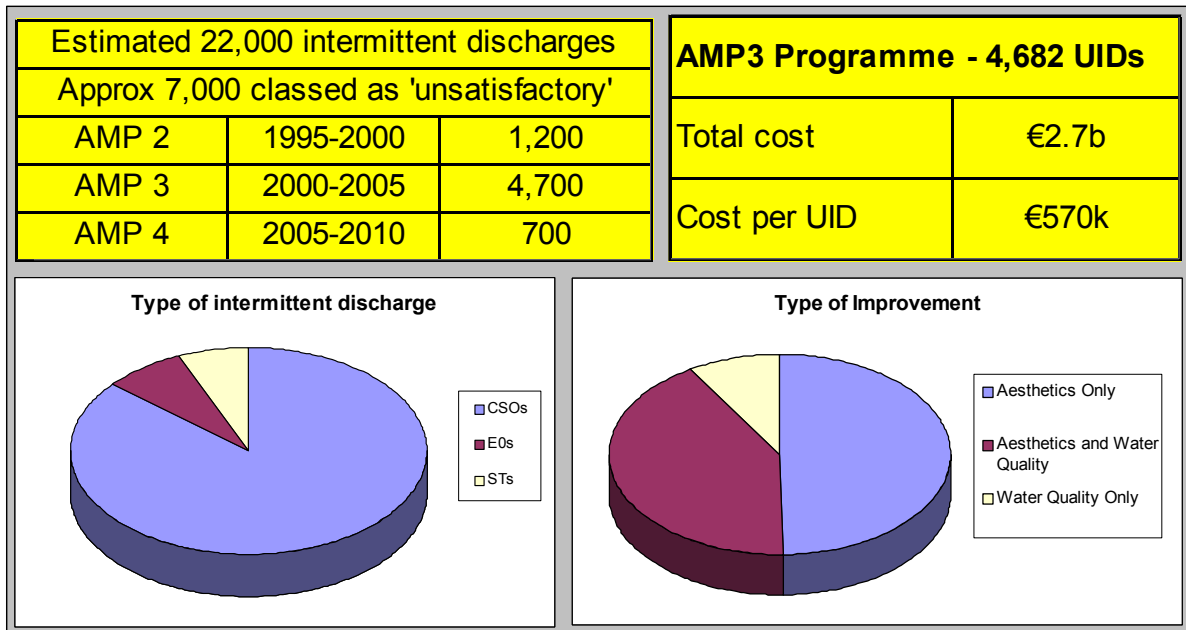


Figure 54: Improvements to Intermittent Discharges in England and Wales

The structure of water services provision, economic regulation and environmental regulation in the UK has certain disadvantages, not least of which is the short-term cyclical nature of investment. In addition, the strict separation of roles may not provide the optimum framework for a fully integrated approach to environmental improvement. However, there is much to be gained from the UK's experience in recent years.

Mainland Europe

Practices vary widely across Europe and even within individual countries. Efforts in recent years have been directed at providing wastewater treatment to meet the UWWTD requirements. When this has been achieved, it is likely that more attention will be focused on intermittent discharges, particularly where water quality standards required by other Directives, e.g. those governing bathing waters or shellfish waters, are still not met.

Sewerage practices, weather patterns and attitudes to pollution vary from country to country. The situation in Ireland is probably more similar to that in the UK than in other European countries. The UPM procedure has been applied to river studies in Belgium, Italy, Portugal and France. CSO problems have also had to be addressed in many coastal towns and cities with bathing beaches. Barcelona in Spain is an example – good bathing water quality was considered a high priority due to the large numbers of people using the city's beaches.

Case Study – Paris, France

A Real Time Control (RTC) system was installed in the sewerage system of Boulogne Billancourt (an urban district on the west side of Paris) in 1996. Combined sewer overflows were causing pollution of the River Seine during rainfall – a problem that had worsened over the years due to the extension of built-up areas. Rather than increase the size of the main trunk sewers or construct large storage tanks, the possibility of using RTC to make better use of the existing system was investigated.

The sewerage network was found to be particularly suited to the use of RTC because there was existing capacity in some areas that was not being used. In addition, there were already various measuring points on the network and some of the CSOs had automated movable weirs. Modelling of the sewer system showed that real time control would allow an 80% reduction in the annual volume of spills discharged to the Seine. The RTC system, as installed, collects water level data from the sewer system and rainfall forecasts from radar images. The hydraulic model is then used to determine the best control strategy to be applied and overflow weir levels are adjusted accordingly.

USA, Canada, Australia

Sewerage systems in these countries are mainly separate and there is an attitude that overflows should either not occur or be extremely infrequent. As a result, where overflows do occur, there is more emphasis on trying to reduce inflow by means of sewer separation or elimination of mis-connections.

USA

In the USA, policy is set out in the Environmental Protection Agency (EPA) *Combined Sewer Overflow Control Policy*. The policy contains four fundamental principles to ensure that CSO controls are cost-effective and meet local environmental objectives:

- clear levels of control to meet health and environmental objectives;
- flexibility to consider the site-specific nature of CSOs and find the most cost-effective way to control them;
- phased implementation of CSO controls to accommodate a community's financial capability;
- review and revision of water quality standards during the development of CSO control plans to reflect the site-specific wet weather impacts of CSOs.

The policy includes an initial requirement to implement a series of "minimum technology-based" controls – measures that are not expected to require significant engineering studies or major construction. Such measures include regular maintenance, maximum use of the existing collection system for storage and prohibition of overflows during dry weather.

Communities are also expected to develop and implement 'Long term CSO control plans'. These plans require: characterisation, monitoring and modelling of the combined sewer system; public participation; consideration of sensitive areas; evaluation of alternatives; cost/performance considerations; an operational plan; maximisation of treatment at WwTWs and an implementation schedule. Some points of interest from the detailed requirements for long term control plans are included in

Table 22 below.

The US EPA's policy with respect to the evaluation of alternatives is similar to that of the UK's UPM procedure in that there is a choice between simple and complex methods but the simple criteria must, by necessity, be conservative, i.e. include large in-built safety factors.

Case Study – Toronto, Canada

In Toronto, some of the beaches on Lake Ontario have to be closed to bathers for over 80% of the bathing season due to high levels of bacterial contamination. CSOs were recognised as one of the sources of bacteria that could be controlled, albeit at a price. Major storm detention tunnels have already been constructed but more may be needed.

Recognising the influence of a range of factors, a "wet weather flow master plan" was prepared. The first phase identified three major areas of choice: "separate the remaining 30% of combined sewer pipes, build more giant storm-water detention tunnels or decentralise collection and treatment of combined sewage overflow and stormwater with numerous, smaller facilities."

Separation may be too disruptive to traffic and is only part of the answer as storm water runoff is now known to sometimes contain nearly as much bacteria as sanitary sewers. Large tunnels are expensive and are now viewed in some quarters as an out-dated, end-of-pipe approach to the problem. The third option would mean connecting Toronto's 2,632 storm sewer outfalls and 79 combined sewers in some way in order to treat all contaminated sewage. These options are currently being evaluated in conjunction with public consultation.

Case Study – Sydney, Australia

In Sydney, the 2000 Olympics accelerated the pace of environmental improvements to Sydney harbour. In wet weather, operation of CSOs caused water quality and aesthetic problems, with discolouration of the harbour seen as a problem which needed rectifying before the tourist influx during the Olympics. Four major overflows accounted for most of the problem and an on-going programme of inflow and infiltration reduction was not considered sufficient to prevent spills from these.

The solution was a €250m, 20km long storage tunnel designed to limit spills to the harbour. The tunnel, which was designed and constructed within a three year period, intercepts numerous CSOs and drains to a wet well suction chamber 90m below sea level. A pumping station at sea level then lifts the influent another 70m to the inlet of the wastewater treatment plant.

Intermittent Discharge Type Element	Definition / Comments / Selected extracts
Characterisation, monitoring and modelling of the combined sewer system	<p>The permittee should adequately characterise through monitoring, modelling and other means as appropriate, for a range of storm events, the response of its sewer system to wet weather events including the number, location and frequency of CSOs, volume, concentration and mass of pollutants discharged and the impacts of the CSOs on the receiving waters and their designated uses.</p> <p>The monitoring programme should include necessary CSO effluent and ambient in-stream monitoring.</p> <p>A representative sample of overflow monitoring points can be selected that is sufficient to allow characterisation of CSO discharges and their water quality impacts.</p> <p>The EPA believes that continuous simulation models, using historical rainfall data, may be the best way to model sewer systems, CSOs and their impacts. Because of the iterative nature of modelling sewer systems, CSOs and their impacts, monitoring and modelling efforts are complimentary and should be co-ordinated. An overflow that can spill in storm conditions but is constructed on a separate foul sewer should be classed as a combined sewer overflow – the presence of mis-connections means that the foul sewer is effectively combined.</p> <p>A single outfall point into a receiving water may receive flows from more than one CSO. Conversely, an overflow pipe from a CSO may diverge to more than one outfall point.</p>
Consideration of sensitive areas	<p>Sensitive areas include waters with primary contact recreation, public drinking water intakes and shellfish beds.</p> <p>For such areas, the long term CSO control plan should: a) prohibit new or significantly increased overflows; b) eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable.</p>
Evaluation of alternatives	<p>EPA expects the plan to consider a reasonable range of alternatives. The plan should, for example, evaluate controls that would be necessary to achieve zero overflow events per year, an average of one to three, four to seven, and eight to twelve overflow events per year.</p> <p>The plan should adopt either a “Presumption” or a “Demonstration” approach. A programme is presumed to provide adequate control if a set of criteria are met. These criteria are provided because data and modelling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect water quality standards.</p> <p>Examples of criteria are: no more than an average of four overflow events per year; elimination or capture for treatment of no less than 85% by volume of the combined sewage collected in the combined sewer system during precipitation events on a system wide annual average basis.</p> <p>Alternatively, a permittee may demonstrate that a selected control program, though not meeting the criteria specified...above, is adequate to meet water quality-based requirements.</p>

Intermittent Discharge Type Element	Definition / Comments / Selected extracts
Cost / performance considerations	The permittee should develop appropriate cost/performance curves to demonstrate the relationships among a comprehensive set of reasonable control alternatives. This should include an analysis to determine where the increment of pollution reduction achieved in the receiving water diminishes compared to the increased costs. This analysis should be among the considerations used to help guide selection of controls.
Maximising treatment at the existing treatment plant	In some communities, treatment plants may have primary treatment capacity in excess of their secondary treatment capacity. One effective strategy to abate pollution resulting from CSOs is to maximise the delivery of flows during wet weather to the treatment plant.

Table 22: Selected extracts from the US EPA's requirements for Long Term CSO Control Plan

7.3 Planning Methodology

7.3.1 General

Intermittent discharges are widely recognised as a major cause of unsatisfactory receiving water quality. They also contribute to aesthetic problems. But how do we move from this recognition of the problem to a good, cost-effective solution? The manner and causes of wet weather impacts from urban catchments are complex. Which intermittent discharges are causing the problem and how should they be improved?

The historical piecemeal approach to the management of the different elements of the urban wastewater system has been shown to be ineffective. The answer is to adopt an integrated planning approach. Recognition of the benefits of such a strategy is needed at the highest level so that funding and timescales are appropriate to allow successful delivery of improvements.

This chapter covers the key issues relating to planning of improvements to intermittent discharges. It is recognised that it will not always be possible to follow an optimum planning approach. However, awareness of the broader planning issues may at least help to avoid any misconceptions concerning improvements to intermittent discharges.

Three key elements of the recommended planning approach are discussed in the following sections:

- understand the long term objectives on a catchment-wide basis;
- start with the requirements of the receiving water; and,
- integrate with other sewerage and sewage treatment works improvements.

7.3.2 Long-term Planning

Planning of CSO improvements should take account of the long-term effects of tightening environmental standards, increasing public expectations, advancing urbanisation and climate change. Effective improvements may involve new infrastructure such as tunnels or storage tanks, i.e. major investments for which a long-term design horizon is appropriate. A design life of 50 to 100 years would not be unreasonable for significant new sewerage assets.

It has been argued that the short-term investment cycles in the UK have resulted, in some cases, in additional expenditure and disruption by having to re-visit some CSOs that had been improved previously but to a lower standard – the problems of an incremental approach.

Environmental Legislation

One of the key drivers for improving existing CSOs is environmental legislation, which is, of course, subject to continual change. Much of the legislation in recent years has originated from Europe in the form of EC Directives. The WFD integrates many of the previous Directives affecting water quality requirements and requires “good ecological status” for waters by 2015.

The planning framework required by the WFD, i.e. identification of River Basin Districts and establishment of River Basin Management Plans (RBMP), together with the monitoring and investigative work required, will be beneficial for increasing understanding and awareness of the relative impact on receiving waters of intermittent discharges compared to other sources of pollution. As discussed in Chapter 1, pollution from separate surface water sewers may be more important than the effect of CSOs in some areas.

The RBMP approach should help the targeting and prioritising of expenditure within a River Basin District. The degree of influence of the WFD on CSO improvements will depend on the timing of any available funding for this purpose – the WFD “programme of measures” is only required to be operational by December 2012. In any event, awareness of the requirements of the WFD should inform the CSO improvement planning process.

Public Expectations

A situation considered acceptable today, may be unacceptable tomorrow – public expectations evolve. When one problem is sorted out, attention turns to the next. As an example, the EC Bathing Waters Directive requires member states to “endeavour to achieve” the Guideline water quality standard for identified bathing waters. This standard is one of the requirements for the coveted ‘Blue Flag’ status but is twenty times more stringent than the Mandatory standard. Additional National Limit Values are set which are generally taken to be somewhere between the mandatory and guidelines values. However, due to differing limit values and percentages required to meet compliance, there are cases that even though the EU guideline value may be achieved, the National Limit Value may not be. This is sometimes the case for compliance with Faecal Streptococci. However, it is public awareness of the Blue Flag scheme which will generate pressure for compliance with the guideline standard.

The current programme of wastewater treatment works improvements will undoubtedly improve bathing water quality but experience in the UK and elsewhere has shown that, in many cases, CSOs also need to be improved to increase the chances of achieving guideline water quality standard. Of course, improving CSOs alone gives no guarantee of success, particularly in cases where bathing waters are close to the mouth of a river. However, as point sources of pollution, CSOs are perhaps the next easiest target following improvement to the continuous discharges from WwTWs.

Sewage litter on river banks or beaches is another area where public expectations increase with time. Unscreened CSO spills are a primary source of this aesthetic pollution and, as point sources, may be considered as relatively straightforward to improve. Whilst this may not seem to be the most urgent environmental problem to be tackled, a long term planning approach would accept the need for improvement in this area.

Urbanisation

Increasing growth of urban areas puts increasing pressure on existing sewerage systems and on receiving waters. Assessing the potential future loading on sewerage systems is an important part of the planning process, particularly in the current period of rapid development. In addition, urbanisation can reduce river base flows and increase the rate and volume of runoff during rainfall. A long term planning view is therefore required, which takes account of both the extent and the effects of urbanisation.

Climate Change

The long-term effects of climate change may also influence the degree of environmental impact caused by intermittent discharges. Higher intensity rainfall may result in some overflows operating more frequently and with greater spilled volumes (*Climate Change and Potential Effects on Sewerage Systems, Hurcombe, 2001*). The effect of lower summer flows in watercourses will compound the problem. These long term effects need to be understood as part of the planning process for improvements to CSOs. Climate change parameters are covered in detail in **Volume 6** of the **Regional Policies**.

Long Term CSO Plan

In view of the above, development of a 'Long Term CSO Plan', integrated into the River Basin Management Plan required under the WFD, would appear to be a sound basis for dealing with the problems caused by CSOs. Such a plan would be based on a thorough understanding of the needs of the receiving waters, the requirements of legislation, the impact of each CSO and the costs of various levels of improvement. An effective means of producing the Long Term CSO Plan is needed and the Urban Pollution Management (UPM) procedure developed in the UK is considered appropriate. The content of the Plan will be determined by the outcome of the UPM process. This is described in the following section.

7.3.3 Urban Pollution Management

The *UPM Manual* (2nd Edition, FWR, 1998) describes a practical method of addressing the problems caused by wet weather discharges. The first edition of the UPM manual was referred to in the 1994 DoE Circular on *Procedures and Criteria in relation to Storm Water Overflows*, and the current edition has been adopted by the UK Environment Agency as the planning approach to be used for consenting intermittent discharges in the period to 2005. The procedure has also been successfully applied in other European countries.

Although initially perceived in some quarters as being too complex, in reality the procedure embraces the simplest as well as the more detailed methods. The approach recognises that there is a choice between simple and complex methods but that simple criteria must, by necessity, be conservative, i.e. include large in-built safety factors.

Urban Pollution Management is defined as "the management of wastewater discharges from sewer and sewage treatment systems under wet weather conditions such that the requirements of the receiving water are met in a cost effective way." It can be seen from this definition, that UPM considers all components of the drainage system, not just intermittent discharges as defined in Section 7.2. The procedure is, however, limited to wet weather conditions – dry weather performance is assumed to be satisfactory. Integration within the envelope of the River Basin Management Plan is therefore needed to bring these aspects together.

It is also clear that the process is driven by the needs of the receiving water – a point sometimes forgotten when sewerage improvements are carried out in a piecemeal fashion (the role of emission standards is, however, recognised where necessary and appropriate). The need for cost effectiveness is paramount – the procedure leads to the identification of "least cost solutions commensurate with meeting the needs of the environment".

UPM deals with both the rules (regulatory aspects) and the tools (modelling of rainfall, sewer systems, sewage treatment works and receiving waters). The procedure is illustrated in **Figure 55** below.

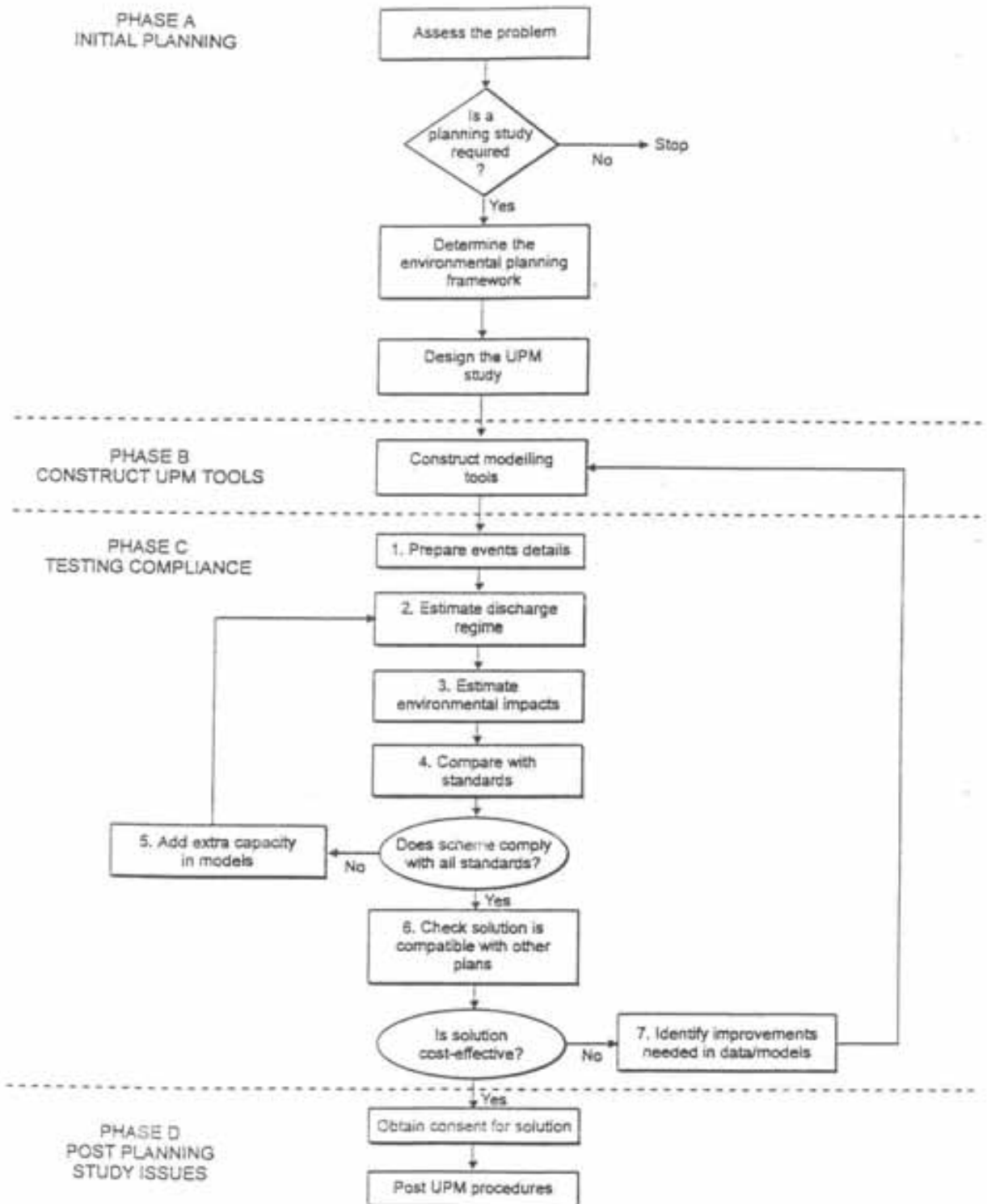


Figure 55: The UPM procedure (from Fig 1.1 UPM manual 2nd edition)

Much of the practical experience of implementing the UPM procedure in the UK has been obtained in relatively flat inland catchments where rivers are deep and slow moving. Problems have been experienced with data collection (timescales and coordination of quality sampling with rainfall events) and modelling (interaction between separate models for sewers and receiving waters). In practice, there has been limited modelling of sewage treatment works as the water quality response is not usually in the same timescale as CSO and stormwater discharges.

However, the structure of the procedure means that it is applicable in all situations and the discipline of the planning approach (particularly in the initial planning stage) gives confidence that appropriate standards, and methods of testing compliance with those standards, are selected. In many cases, the procedure may reduce to simply using a sewer system model with rainfall data to test against an emission standard such as an allowable spill frequency or to provide input to a simple mass balance river water quality model.

7.3.4 Integration with other Sewerage or WwTW Improvements

The *Sewerage Rehabilitation Manual (SRM) (WRc, 4th Edition, 2001)* and the *European Standard on Drainage (EN 752-2: 1997)* stress the importance of considering all rehabilitation needs together, i.e. hydraulic, environmental, structural and operational. This is because integrated solutions are the most cost effective. The SRM's Drainage Area Planning approach has been tried and tested and the benefits have been proven.

Often, one type of deficiency, e.g. property flooding, will be the dominant driver for the drainage area study and budgets or timescales may be insufficient for a full investigation of the other catchment deficiencies. In this situation, whilst the primary deficiency may be addressed, maximum value is not necessarily achieved. In the case of CSOs, either safe but expensive solutions are adopted or the environmental problems are not satisfactorily addressed and may have to be revisited at a later stage.

A further difficulty lies in the extent of the drainage area study catchment. For example, a bathing water may be affected by CSO discharges from more than one 'drainage area study' catchment as well as pollution impacts from other sources. It has already been established that environmental performance criteria should be based on the needs of the receiving water.

These difficulties emphasise the advantages of establishing a Long Term CSO Plan within the greater framework of the River Basin Management Plan. These will provide the background necessary to establish appropriate environmental performance criteria for application within individual drainage area catchments.

Where environmental deficiencies, e.g. unsatisfactory CSOs, are the primary driver for the drainage area study, it is recommended that the full drainage area planning procedure is followed so that maximum value can be obtained from the investment. This has commonly occurred in the UK where a great number of drainage area plans have been completed in recent years, having been initiated by the need to achieve CSO improvements. Due to the funding structure in the UK, solutions to the non-environmental deficiencies, e.g. highway flooding, are not always implemented by the water service providers, but the integrated approach to solutions development at least allows for the effects of potential future implementation.

Recommendations

- 69. Intermittent discharges should not be considered in isolation – a total catchment approach is needed. In the long term, it is expected that this requirement will be met through development of the River Basin Management Plans under the Water Framework Directive.**
- 70. Effective solutions may involve major new sewerage infrastructure, for which both careful planning and a long-term design horizon are appropriate. Proposals should be set out in the form of a Long Term CSO Plan (within the wider context of the RBMP).**
- 71. The Urban Pollution Management procedure provides a practical, structured method that can be followed to derive the most cost effective solutions to the problems caused by wet weather discharges.**
- 72. The use of ecological surveys is a practical and cost effective method of evaluating the impact of individual or groups of CSO's on a stretch or river. Such surveys can show the cumulative quality impact of such discharges.**
- 73. The Drainage Area Planning approach should be adopted to ensure that all other catchment sewerage deficiencies (e.g. flooding, structural and operational) are understood before CSO solutions are developed and implemented.**

7.4 Performance Criteria, Standards & Compliance Testing

As with other aspects of sewerage rehabilitation, adequate environmental protection requires specification of performance requirements. Trigger levels are required so that deficiencies can be identified for upgrading. Target levels are needed to define the aims of the upgrading and these are normally set out in the form of standards for protecting various uses such as river aquatic life, bathing or amenity. For an upgrading scheme to be developed and evaluated, it is necessary to be able to demonstrate compliance with the target standards – this is normally done using simulation models.

7.4.1 Trigger Levels

Under the 'Requirements for collecting systems', the *EC Urban Waste Water Treatment Directive* (UWWTD) states:

The design, construction and maintenance of collecting systems shall be undertaken in accordance with best technical knowledge not entailing excessive costs, notably regarding:

- (a) *volume and characteristics of urban waste water;*
- (b) *prevention of leaks;*
- (c) *limitation of pollution of receiving waters due to storm water overflows.*

Pollution of receiving waters caused by intermittent discharges therefore needs to be assessed in some way. This may be achieved by defining intermittent discharges as either 'satisfactory' or 'unsatisfactory'. 'Unsatisfactory' status is effectively the trigger level for upgrading. The following definition (modified from that used in the UK) is proposed, and further explanation is provided in the paragraphs that follow:

An intermittent discharge is considered as 'unsatisfactory' if it:

- (a) causes significant visual or aesthetic impact, with particular priority afforded to instances where these problems are the subject of public complaint;
- (b) causes or makes a significant contribution to a deterioration in receiving water quality (chemical or biological class) or ecological status;
- (c) causes or makes a significant contribution to a failure to comply with environmental standards or objectives, e.g. as set down in national Regulations or local Water Quality Management Plans;
- (d) operates in dry weather conditions.

For criterion (a) above, assessment of aesthetic impact can be undertaken formally using prescribed survey methods (*User Guide for Assessing the Impact of Combined Sewer Overflows, FR0466, Foundation for Water Research*). This approach involves surveys to count the amount of sewage litter present both up and downstream of an outfall. A visual assessment of fungus and dry weather operation (criterion (d)) can be made at the same time. In addition to field data, historical data, e.g. details of public complaints, should be obtained and used to classify the CSO. The level of public complaint depends on the location, who is affected and how long the problem has been occurring.

There is a requirement under the *Dangerous Substances Directive* to limit the release of Persistent Synthetic Substances (PSS). The plastics present in sewage debris come under this category, suggesting that any CSO which spills unscreened sewage containing plastics is effectively unsatisfactory, regardless of public complaints. (Of the 4,700 unsatisfactory intermittent discharges to be improved in the period 2000 to 2005 in England and Wales, about half were classed as unsatisfactory solely for aesthetic reasons.)

Criterion (b) requires an existing classification of water quality, identified by monitoring – this is covered in detail in Chapter 3 of this Volume. The reference to ecological status relates to the requirements of the WFD.

Case Study – Identification of Unsatisfactory Intermittent Discharges in Yorkshire, UK

A combination of methods was used by Yorkshire Water Services Ltd to identify deficient discharges for upgrading during the 2000 to 2005 investment period (Surradge, Tinsdeall and Rees, 2001). In addition to standard modelling techniques (hydraulic and quality) which address the 'cause' of CSO spills, both aesthetic and macro-invertebrate surveys were carried out to record the 'effect'.

The macro-invertebrate surveys were carried out in areas identified as containing water quality type deficiencies. Where possible, watercourses were sampled both upstream and downstream of each outfall and during three seasons: Spring, Summer and Autumn. Samples were analysed by biologists to give a formal assessment of biological water quality. In 95% of cases, the procedure permitted identification of which outfalls were having an impact. In a two year period, macro-invertebrate surveys were undertaken in the vicinity of 886 outfalls. Overall, the methodology was considered to have minimised the risks associated with identifying the true unsatisfactory discharges and allowed capital investment to be correctly prioritised.

Criterion (c) encompasses all national legislation governing receiving waters and any other adopted local/regional requirements such as compliance with a Water Quality Management Plan. A summary of the current legislative framework is given in Chapter 2. River aquatic life, bathing and shellfish are the three 'uses' which have been identified as most likely to be affected by intermittent discharges and the legislation relating to these is likely to be the major driver for improvements.

Legislation is regularly revised or updated so it is important that, when an assessment against trigger criteria is being undertaken, full details of both current and proposed legislation should be obtained. At the time of writing, current relevant legislation includes:

- The Water Framework Directive (2000/60/EC) – will permit phasing-out of several existing Directives (including the Freshwater Fish Directive and Shellfish Waters Directive) which currently define objectives.
- The Bathing Water Quality Directive (76/160/EEC) – defines standards required for identified bathing waters; currently being revised.
- The Local Government (Water Pollution) Acts 1977 and 1990 – allows for preparation of water quality management plans (WQMPs) in which specific water quality objectives are defined.
- The Local Government (Water Pollution) Acts 1977 (Water Quality Standards for Phosphorus) Regulations 1998 – provides biological water quality standards and complementary phosphorus indicator standards for rivers and lakes.

Legislation typically defines requirements in the form of an Environmental Quality Standard (EQS) to be achieved in the receiving water. The extent to which an individual discharge is contributing to causing a failure to meet the standard is not always obvious. As a result, a precautionary approach is commonly adopted. A simple assessment of spill frequency and volume will give an initial impression of the importance of an individual discharge.

7.4.2 Target Levels

Target levels of performance for upgrading of intermittent discharges are generally based on achieving specified standards for protection of river aquatic life, bathing waters, shellfish waters or amenity use.

Part II of the UPM Manual contains a detailed review of wet weather standards applicable in the UK, together with an explanation of their derivation. As many of the standards are based on meeting the requirements of various EC Directives, much of the material is considered equally relevant to Ireland. There are, however, some key differences and these are highlighted in the following paragraphs.

River Aquatic Life

The traditional approach of designing inland CSOs to pass forward Formula A is no longer considered appropriate because Formula A, although simple to apply, is not a strong indicator of CSO performance. CSO location and the characteristics of the local sewerage system are the key factors in determining spill frequency and volume. Thus, a CSO solution based solely on Formula A may actually be either over-designed (e.g. a cheaper solution with higher spill frequency would still allow water quality objectives to be met) or under-designed (e.g. resulting spill regime prevents achievement of water quality objectives). An approach is therefore needed which addresses the water quality needs of the river.

The EPA's national river quality classification system is primarily biological and is based on a scheme of Biotic Indices or Quality (Q) Values – Q5 to Q1. The scheme is further simplified into four quality classes: Class A (unpolluted) to Class D (seriously polluted). Q values are based principally on the results of macroinvertebrate surveys, usually undertaken during summer. Each sampling point is normally visited on a three year cycle.

Wet weather standards for protecting river aquatic life have not yet been specifically defined in Ireland, e.g. by the EPA or Local Authorities. It is therefore recommended that the standards set out in Section 2.3 of the UPM manual are used for guidance. The UK's River Ecosystem classification (RE1 to RE5) is believed to correspond approximately with Ireland's Quality Values (Q5 to Q1). Further comparison can be made by reference to the table 'General Characteristics of the Various Biological Classes' in **Appendix C** (from Table I.1 EPA, *Water Quality in Ireland, 1995-1997*).

The need for wet weather standards is explained in detail in the UPM manual and it is not intended to reproduce the arguments here. The key point is that intermittent discharges may be causing a problem even if the long-term water quality target (i.e. Q value) is being met in a particular stretch of river. In brief, there are two approaches:

- Fundamental intermittent standards (FIS) – directly related to the characteristics of events which cause stress in river ecosystems. These standards are expressed in terms of concentration-duration thresholds with an allowable return period or frequency.
- High percentile standards (such as 99 percentiles) based on an extrapolation of the 90/95 percentile thresholds used for protecting ecosystems which receive polluting discharges. Potential 99 percentile values are specified for BOD, total ammonia and un-ionised ammonia.

Unfortunately, the UPM manual does not provide much guidance as to which approach to use in different circumstances. It has, however, been suggested (Morris and Crabtree, 2000) that 99 percentile river quality could define the discharge standards required for the majority of simple intermittent discharges. This approach is simpler in terms of compliance testing but there are situations where more cost-effective solutions can be developed using the FIS. The choice of method will be dependent on the characteristics of the sewerage system, the characteristics of the receiving water and the environmental problems being addressed by a particular scheme.

The *Phosphorus Regulations, 1998* are aimed at reducing the problem of eutrophication and the general requirement is that water quality standards appropriate to supporting salmonid fish be aspired to through a programme of measures aimed at a reduction in nutrient load from point and diffuse source pollution. The target Q-values identified in the Regulations should be taken into account when addressing intermittent discharges using the methods described above.

For all surface waters, the WFD sets an objective of 'Good status' which is based on both biological and chemical elements. 'Good ecological status' is considered to be broadly equivalent to a Q-value of 4. This long-term aim should be considered in the context of preparing a Long Term CSO Plan.

Bathing Waters

Standards for protecting bathing waters are designed to ensure that the requirements of the *Bathing Water Directive (BWD)* are met. The BWD has been given effect in Ireland through the *Quality of Bathing Water Regulations* (1988), amended and superseded by Regulations made in 1989, 1992, 1994, 1996, 1998 and 2000. In addition to the Directive's Mandatory and Guideline values for various microbiological and physicochemical parameters, the Regulations also prescribed National Limit Values (NLVs). A table listing these requirements is included in **Appendix B**.

Where intermittent discharges affecting designated bathing waters are being created or improved, it is recommended that the current Guideline values are taken as the target standard because:

- (a) there is a requirement under the BWD for member states to “endeavour to achieve” the Guideline standards;
- (b) achievement of Guideline water quality is one of the requirements of the publicly recognised Blue Flag scheme; and,
- (c) the proposed revision of the BWD is expected to include a new minimum bathing water quality standard that is roughly equivalent to the Guideline standard of the current Directive (Revision of the BWD, DEFRA, 2002).

There are two potential approaches to meeting the required standards:

- risk based Environmental Quality Standards (EQSs) for bacteriological contaminants associated with sewage pollution; and,
- spill frequency emission standards.

In the UK, compliance for design purposes is based on exceedance of threshold concentrations of faecal coliforms (2000/100ml) and total coliforms (10,000/100ml) for a maximum duration of 1.8% of the bathing season. The exceedance period is taken as an average over ten years. These concentration thresholds correspond to the mandatory standards of the BWD but intermittent discharges alone are unlikely to cause failure of the Guideline values if these standards are met (*UPM Manual, 2nd Edition, FWR, 1998*). For these EQSs to be applicable for design purposes, it is also important that CSO outfalls are sited some distance offshore of Mean Low Water Springs (MLWS).

In Ireland, equivalent EQSs have not been specifically derived, e.g. for compliance with NLVs or based on alternative bacterial parameters. However, if it is accepted that the BWD Guideline standard is the required target level, the approach derived in the UK is considered equally applicable in Ireland.

As an alternative to the EQS approach, which requires modelling of coastal waters, a spill frequency emission standard may be used. In the UK, this standard, which requires that the outfall soffit of all CSOs is located below the level of MLWS, states:

“The maximum number of independent storm event discharges via the CSOs to identified bathing waters, or in close proximity to such waters, must not, on average, exceed the spill frequency standard of 3 spills per bathing season.”

With reference to this approach, the UPM manual states:

“A design which complies with this type of emission standard should ensure a low risk of non compliance with the requirements of the BWD. Thus, the standard has universal application and is easily applied and understood. However, a universal standard of this sort, which avoids the need for environmental modelling must necessarily have a large built-in safety factor. Guidance...should be sought to identify agreed interpretations of a spill, in terms of minimum spill size, interspill period and amalgamation of spills from the same or several CSOs.”

It is important to note that there are some significant differences between the UK and Ireland in terms of bathing season period and sampling regimes. These are set out in **Table 23** below.

As the Irish bathing season is approximately two thirds the length of that in England & Wales, a roughly equivalent emission standard for Ireland would be 2 spills, on average, per bathing season.

In the UK, the choice between the EQS and emission standard approaches is down to the environmental regulator and depends on the circumstances at individual bathing waters. In some open coastal areas, coastal modelling has shown that the EQSs can be achieved even with CSOs spilling well in excess of 3 times per bathing season – giving major cost savings due to reduced storage requirements. In others, schemes initially designed using the EQS approach have seen continued failures and have subsequently been upgraded to a 3 spills basis. Where bathing waters are known to be affected by bacterial loads from rivers (often from both CSOs and agricultural sources), the physical processes are complex and some regulators prefer the safety of the emission standard approach.

	Ireland	England & Wales
Bathing season	1 st June to 31 st August	15 th May to 30 th September
Effective bathing season (based on monitoring period which starts two weeks in advance)	15 th May to 31 st August	1 st May to 30 th September
Effective bathing season length	109 days	153 days
Sampling requirements	At least every two weeks. Minimum of 7 to be taken during the season. May be reduced to 4 if the water quality at the site for the previous two years has been of sufficiently high quality.	20 samples

Table 23: Comparison of bathing seasons and sampling requirements between Ireland and England & Wales.

In the investment period 2000 to 2005 in England and Wales, the majority of bathing water schemes have been, or will be, designed on the 3 spills basis. The 3 spills criterion has also been applied to inland CSOs and WwTW storm tank overflows which discharge to rivers that are known to affect bathing waters (an upstream limit based on a 6 hours time of travel from discharge location to the bathing beach has been applied in some cases). However, this use of the emission standard approach may have as much to do with the limited timescales imposed by the financial regulator as with the technical concerns of the environmental regulators. UK water companies have developed cost models to estimate required storage volumes and costs for meeting these standards – the impermeable area per head of population has been found to be a useful indicator.

In the GDSDS area, there are fifteen identified bathing waters – historical compliance with target standards is shown in **Table 10** and also on **Figure 17** (both of which can be found in **Chapter 3**). The Dublin Bay Water Quality Management Plan also requires compliance with the National Limit Values throughout the Plan area. Circumstances at individual bathing waters vary across the GDSDS area and it is therefore considered unwise to apply a rigid policy, such as using only the emission standard approach, throughout the region. A pragmatic approach, which could be followed during preparation of a Long Term CSO Plan, would be to initially assess costs for complying with an emission standard. Then, in circumstances where experience suggests there may be potential for cost savings, the alternative EQS approach could be evaluated.

Shellfish Waters

As for bathing waters, both EQS and emission standards can be used for designing solutions to meet the requirements of the EC Shellfish Directives. An emission standard of 10 spills per year has been used in recent UK schemes.

At the time of writing, there were no areas designated under *the Shellfish Waters Directive (79/923/EEC)* within the GDSDS area. There is a shellfish production area at Gormanstown, Co. Meath, but this has been classified as Category A under Directive 91/492/EEC, i.e. can be sold for direct human consumption, and would not therefore be a driver for water quality improvements.

The *Dublin Bay Water Quality Management Plan (Main Report, Part 2: The Studies 1986-1990)* states that “shellfish for human consumption are no longer gathered in Dublin Bay” and that “it appears unlikely that a shellfishery would be developed in the Bay in the foreseeable future”. The report also mentions that some shellfish are landed at Howth but that these are taken from north of Lambay Island and points further north in the Irish Sea.

On this basis, the water quality requirements applicable to shellfish waters would not currently be a target standard when upgrading intermittent discharges in the GDSDS area. However, it would be prudent, during preparation of a Long Term CSO Plan, to assess the cost implications of, say, a 10 spills per year emission standard for discharges that affect coastal waters. In some cases, a CSO designed to meet a 2 spills per bathing season standard may also achieve a 10 spills per year standard, although there could be difficulties with sewerage systems which experience seasonal and rainfall-induced infiltration.

Amenity Use

Amenity standards are applicable to the majority of receiving waters impacted by intermittent discharges. In the UK, emission standards have been set based on an Amenity use category – High, Moderate, Low or Non-Amenity. The standards in current use are included in **Appendix C – Table C-18** (from Table 2.6, *UPM Manual, 2nd Edition, FWR, 1998*). This table gives general definitions of the amenity use categories but agreement should be sought with the Local Authority on a case by case basis.

It is recommended that the Low or Non-Amenity use category is not used in the GDSDS area for two reasons:

1. The solids retention performance of chambers designed in accordance with “Good engineering design (FWR report FR0488, Balmforth et al, 1994) has been shown to be relatively poor (various studies reported in *The Design of CSO Chambers to Incorporate Screens, WaPUG, 2001*). Chambers designed to this standard may not therefore comply with the requirement under the Dangerous Substances Directive to limit the release of Persistent Synthetic Substances (PSS).
2. “In using any amenity use standards, all areas which could reasonably be affected by a discharge must be considered and the highest amenity category applied” (Section 2.5, *UPM Manual, 2nd Edition, FWR, 1998*). On this basis, and taking account of the characteristics of the GDSDS area, it is apparent that for the majority of discharge locations, a Moderate or High category would be appropriate.

For high and moderate amenity areas the required standards are 6mm or 10mm solids separation, depending on spill frequency. The Dublin Bay Water Quality Management Plan requires “an absence of visible signs of sewage-derived debris” and has a priority objective in relation to sewage solids of “improving the aesthetic quality of the beaches and shoreline waters of the Plan area by measures such as the interception of plastics and other solids of sewage origin”. It would seem reasonable, therefore, that a 6mm solid separation screening standard should apply to CSO spills, unless spill frequency is very low (4 times/year) when the lower standard could be accepted.

7.4.3 Compliance Testing

Compliance testing is the iterative process of using simulation models to compare the performance of a proposed scheme against target standards and amending the solution until compliance is achieved. The preferred approach is to initially use the simplest tools to identify solutions that are guaranteed to comply. Such solutions will, of course, be conservative. More refined (i.e. cheaper) solutions can then be developed by using more complex models, providing overall cost-effectiveness can be demonstrated. This method is referred to as the ‘iterative’ planning approach. Alternatively, a ‘confirmed’ planning approach can be adopted. This requires selection of one method at the outset and can be more appropriate when timescales are restricted.

The process is described in depth in Section 6 of the UPM manual and, rather than reproduce the details here, a number of observations are made, based on experience of implementing the procedure.

Sewer Systems

- Any existing sewer models should be carefully audited to assess their suitability for environmental assessment and for design of potentially costly upgrading schemes. The majority of existing models are unlikely to be suitable without further work.
- Dry weather verification of sewer system models is essential to ensure that base conditions are correctly represented at CSOs before rainfall events commence. It must be recognised that short-term flow surveys provide only a 'snapshot' of base conditions.
- The compliance testing process should take account of any infiltration in the sewer system and its variation, both during and after rainfall events, and over the long term (refer to Regional Policy, Volume 4).
- Rainfall-induced infiltration can have a significant impact on volumes of flow and correct representation is therefore important for design of solutions involving storage.
- Sewer system models must be able to replicate the performance of CSOs under a wide range of rainfall conditions. For good verification, flow monitoring and verification is normally required upstream and downstream of every CSO.

Rainfall

- Compliance testing of CSOs commonly requires simulation of sewer models with time series rainfall events. A rainfall time series has been produced for Dublin (*Dublin Time Series Rainfall, HR Wallingford, 2000*) based on forty years of data recorded at Dublin Airport.
- Various methods have been devised for estimating CSO spills using time series rainfall, most of which involve some form of simplification. However, the benefits of using continuous simulation of rainfall, over a bathing season or a full year, are now recognised. Recent improvements to computer hardware and software have also increased the practicality of this approach.
- Continuous simulation deals with the problem of 'storm sequencing'. CSO solutions often involve storage tanks and spills can occur if a 'follow-on' rainfall event occurs when the tank is still partially full from a previous event. On their own, neither event may be sufficient to cause a spill. Continuous simulation allows the drain down between rainfall events to be represented. This is particularly important for sewer systems which experience high levels of rainfall-induced infiltration.
- All CSOs in a catchment should be assessed in terms of spill frequency, duration and volume. It is often the case that a small number of CSOs are causing the majority of the impact.

Rivers

- Demonstrating compliance with 99%ile standards using a sewer model and a simple mass balance river model is the standard approach adopted. CSOs which spill for less than 1% of the time (i.e. < 88 hours in a year) automatically comply with this water quality standard.
- Demonstrating compliance with fundamental intermittent standards (FIS) requires modelling water quality in sewer systems and rivers and is considerably more complex than using the 99%ile approach. In certain circumstances, however, the FIS approach will lead to cheaper solutions.
- Using a single integrated model for both the sewer and river system would be more cost effective than having to build and verify separate models.
- The use of biological surveys and biotic indicators is seen as a practical and cost effective method of assessing whether CSO's make a sustained adverse impact on river water quality in the first instance.

Coastal Waters

- In the UK, emission standards are more commonly used than the EQS approach for protecting bathing or shellfish waters. Demonstrating compliance with an emission standard is relatively straightforward and requires only a sewer system model with relevant rainfall data. The EQS approach requires a model of the coastal waters to represent the effects of dilution, dispersion and decay. Where spills from CSOs are directly into shellfish waters or bathing waters, the emission standard approach is normally applied.
- For demonstrating compliance with bathing waters standards, the sewer system model should represent summer conditions. Models verified using winter flow survey data may include higher infiltration than normally occurs in summer. For shellfish waters, all year round compliance is required.
- For bathing waters, the UPM manual states: "Guidance...should be sought to identify agreed interpretations of a spill, in terms of minimum spill size, interspill period and amalgamation of spills from the same or several CSOs." Recent schemes in the UK have used 50m³ as minimum spill size unless spills are directly into the bathing water in which case 0m³ is used. Several discharges within a 12 hour period are regarded as a single spill. A spill lasting for more than 12 hours is considered as 2 spills, more than 24 hours as 3 spills, and so on.
- A bathing water may be affected by several CSOs, by WwTW storm tank overflows as well as CSOs, or even by CSOs in different catchments. If CSOs are improved in isolation to each meet a 2 spills per bathing season standard, it is possible that the bathing water could be affected on more than two occasions. This is because the rainfall events causing spills for one CSO might not necessarily be the same for another. A judgement on which CSOs should be considered together is normally made on a case by case basis.

Amenity

- Demonstrating compliance with amenity standards is relatively straightforward – screening provision must be appropriate for the expected annual spill frequency. For practical reasons, screens are commonly designed to deal with flows up to the 1 in 5 year return period event, with bypass provision made for excess flows.

Recommendations

74. The 'trigger' level for upgrading intermittent discharges should be the recognition of 'unsatisfactory' status, as defined herein.
75. 'Target' levels for improving intermittent discharges should be determined by application of the UPM procedure.
76. Targets for protecting river aquatic life should be either Fundamental Intermittent Standards or High Percentile Standards (99%ile). The River Ecosystem classification (RE1 to RE5), referred to in the UPM procedure, generally corresponds with Ireland's Quality Values (Q5 to Q1). The long-term aim of 'Good ecological status' is broadly equivalent to a Q-value of 4.
77. Targets for protecting bathing waters should be either Environmental Quality Standards (based on exceedance of threshold concentrations of bacteriological contaminants associated with sewage pollution) or spill frequency emission standards. Intermittent discharges alone are unlikely to cause failure of the Guideline values of the Bathing Waters Directive if they comply with an emission standard of 2 spills, on average, per bathing season.
78. Targets for protecting amenity use should be based on the amenity classification of the receiving water. Compliance with aesthetic standards normally requires some form of screening. Assuming basic hydraulic conditions are satisfied, CSO chambers should be designed around the selected screening standard.

7.5 Improvement Options

7.5.1 General

Improvements to unsatisfactory intermittent discharges may be needed to meet water quality standards, aesthetic standards or both. Compliance with aesthetic standards normally requires some form of screening if the discharge is retained and options are based principally on the choice of screening device. For compliance with water quality standards, there are three basic methods of reducing spills:

- reduce the incoming flow;
- attenuate/store the flow, and;
- increase the pass forward flow.

A fourth option is to extend/relocate the outfall to a position where lower standards apply, e.g. extending a sea outfall to beyond Mean Low Water Springs level.

These options are not exclusive, so a solution for one discharge may involve, for example, some storage as well as an increased pass forward flow. Where there are inter-related overflows, the number of permutations of the three basic options increase: for 2 inter-related overflows, there are 9 permutations; for 5 inter-related overflows, there are over 240 permutations. Identifying the best solution for a whole catchment can therefore be a complex process and one that requires experience.

The basic options are discussed in the next three sections.

7.5.2 Reduce Incoming Flow

This is the least commonly used option but one that should not be disregarded. In some networks, it may be possible to divert a proportion of the flow at some point upstream. For example, there may be a parallel trunk sewer with capacity to take additional flows.

Removal of surface water inputs to the combined system may be a viable option in some situations. Newer developments in areas served by combined sewers are sometimes provided with separate sewer systems but then both lines are connected to the combined trunk system. It may prove more cost effective to find an alternative disposal route for the surface water flows than to deal with the higher flows at the overflow itself.

Complete separation of sewers in a combined area is rarely viable due to costs and disruption. Separation has, however, been undertaken on a large scale in many cities in the USA. The increased stormwater discharges to local receiving waters could decrease the positive impacts of separation unless the discharges are mitigated in some way. Existing and future impacts to the receiving water should be evaluated before implementing sewer separation.

In some separately sewered areas, overflows may occur due to excessive inflow, i.e. direct inputs of surface water to the foul system. This can occur at pumping stations where 'emergency' overflows actually operate in storm conditions. These discharges are often to minor watercourses and can therefore have a significant environmental impact.

The most common causes of inflow are mis-connected roof, driveway and yard drains, either at the time of original construction or during subsequent building work. Identification and removal of inflow is a long-term process and requires a planned approach. The short-term nature of the UK's CSO improvement programmes mean that this option has often been disregarded despite its long term benefits.

Reduction of infiltration is another means of reducing incoming flows although, again, a long-term strategy is required. Rainfall-induced infiltration has the effect of maintaining flows at a high level for extended periods after storms. In the worst cases, this can make storage solutions impractical because tanks are unable to drain down sufficiently to prevent 'follow-on' spills.

On a smaller scale, peak flows can be reduced by means of water conservation (domestic and industrial), use of rainwater butts or other 'SuDS' elements. It is unlikely, however, that these measures alone would provide a solution for unsatisfactory CSOs. Rather, they could be considered as helping the situation if implemented for some other reason.

7.5.3 Attenuate Flow

Attenuation of flow is most commonly achieved by providing additional storage. There are numerous ways in which this can be provided but the most common is the on-line or off-line tank. Storage tank design is covered in detail in Section 7.7. Although tanks are normally sited underground, space is required and this may not be available in fully developed urban areas.

An alternative method of attenuating flows is to utilise storage capacity that may be available within the existing sewerage system. On a small scale, this may be done by means of fixed hydraulic controls, such as 'Hydrobrakes'. On a larger scale, Real Time Control (RTC) measures can be considered. RTC systems can be developed to different levels of complexity. Reactive systems measure water levels in sewers and adjust penstocks or overflow weirs accordingly. Predictive systems can use rainfall forecasting from radar images, in conjunction with sewer system models, to determine settings at control structures. For RTC to be viable, there clearly has to be available capacity in the existing sewers. There also has to be a high level of confidence in the sewer models if changes are going to be made to the manner of operation.

Extensive use of storage for controlling CSO discharges can lead to problems downstream in the sewerage system and at the WwTW (*Interaction between extended in-sewer storage and waste water treatment plant performance – a protocol to avoid problems, Ashley et al, 2001*). Prolonged in-sewer storage can potentially lead to higher WwTW effluent loads (particularly total suspended solids and ammonia) and/or poor biomass performance. Pumped storage systems may increase the risk of septic conditions, with resultant odour, corrosion and health hazard problems. In general, however, where systems are well designed and operated, the problems should not be insurmountable.

7.5.4 Increase Pass-forward Flow

Increasing the flow passed forward from a CSO can be achieved by renovating, replacing or reinforcing/duplicating the downstream/continuation sewer. Poor CSO performance may be due to a build up of silt or a structural deterioration in the continuation sewer. Renovation or replacement to the same diameter may be sufficient to achieve the desired improvement. It is more common, however, that incoming loads have increased due to development, or increased inflow/infiltration, and more flow must be passed forward.

The existing sewers can either be replaced with a pipe of a larger diameter or duplicated with a new, parallel sewer. The choice will depend on the condition of the existing sewer and construction practicalities. It is important to consider the impact of the increased flows on the downstream system and to ensure that there is no detriment to the level of service provided. Sewers may need to be upsized all the way to the WwTW where storm tank overflows may also need to be improved, e.g. to meet an emission standard for impacts on a bathing water. The increased flow from upstream may mean additional storage is needed at the WwTW. This illustrates why improvements to intermittent discharges should not be considered in isolation if the most cost effective overall solution is to be identified.

A variation on this option is to construct a new interceptor sewer to collect spills from a series of CSOs. The sewer can be sized to provide storage to limit spills from a single new overflow location. The existing CSOs effectively become bifurcations. A number of major tunnel interceptor sewers of this kind have been constructed in the UK in recent years, particularly in coastal resorts where spills have to be reduced to meet bathing water standards.

7.5.5 Rationalisation of CSOs

Some CSOs are isolated and have to be dealt with individually. However, in some catchments there are 'clusters' of CSOs. This often occurs where trunk sewers were built to intercept a series of crude foul discharges along a river or coast. Although all options should be evaluated on an economic basis, reducing the total number of CSOs in a catchment has certain long-term advantages, particularly in relation to access, maintenance and potential monitoring requirements.

Where CSOs are abandoned as part of an improvement scheme, care is needed to ensure that the sewerage system continues to provide an acceptable level of service against flooding. Again, the quality of the sewer model is of paramount importance. Where the consequences of out-of-sewer flooding are severe, consideration may be given to retaining an overflow facility, but one that would only operate in storm events of greater than, say, five years return period. The overflow could be fitted with a simple, fixed 10mm bar screen.

7.5.6 Reducing Sewage Litter

The case for providing screens on CSOs has been made in the previous section. CSO screens are designed to retain screenings within the flow passed forward to the WwTW. Powered screens at the WwTW inlet works then remove the screenings for disposal to a landfill site. Although sewage litter will never be eliminated, the problems it causes throughout the wastewater system can be reduced if the overall quantity is reduced. Public education campaigns have proved successful in the UK, Australia and elsewhere.

Recommendations

- 79. Models used for designing improvements to intermittent discharges should be of an appropriate standard. In particular, sewer system models should accurately replicate performance in both dry and wet weather conditions. Seasonal or rainfall influences on infiltration should be understood. Representation of 'delayed' or 'slow response' runoff is particularly important for the design of storage solutions. Continuous simulation of a historic time series of rainfall events is recommended for assessment of intermittent discharges.**
- 80. Instigate Public Education Campaigns on appropriate disposal of litter, including sewage litter.**
- 81. Consider groups of CSO's wherever practical for an integrated system.**

7.6 Chamber Design

7.6.1 Basic Design

The fundamental purpose of a CSO structure is to provide hydraulic relief of storm flows in combined sewerage systems. Many of the earlier installations were 'hole in the wall' type or simple weir arrangements without screens. The aesthetic impact associated with unscreened CSOs can be significant, and therefore the use of screens is now advised (Section 7.4.2)

CSO design has developed significantly during the last twenty years: from simple structures were developed "Good Engineering Design" structures, which are intended to maximise the retention of suspended matter without the use of screens. The principles for design of these structures were laid out in *A Guide to the design of storm overflow structures (WRc Report ER304E, Balmforth et al, 1988)* which was later superseded by *A Guide to the Design of Combined Sewer Overflow Structures (FWR Report No. FR0488, Balmforth et al, 1994)*. These have been used widely in recent years. They cover the design of high and low-sided weirs, stilling ponds and vortex drop-shafts. The design principles used ensure a smooth approach flow to the structure, and sub-critical flow within the chamber. The chamber has to be of sufficient length to allow a degree of settlement of the denser solids, and scumboards can be used to prevent the release of buoyant material.

However, experience and research has shown that the solids retention performance of chambers designed in accordance with "Good engineering design" is relatively poor (various studies reported in *The Design of CSO Chambers to Incorporate Screens, WaPUG, 2001*). Neutrally buoyant materials tend to divide in the same proportions as the flows. The use of coarse bar screens has also been of limited success, as the smaller materials tend to align themselves with the lines of streamflow, passing straight through, and the larger materials can cause blockages unless the screens are regularly maintained.

In effect, it is now accepted that screens are required to meet amenity use standards. Whilst the requirements of FR0488 can be readily adapted for screened CSOs, they are over-conservative and result in excessive chamber sizes in certain cases. The WaPUG Guide (*The Design of CSO Chambers to Incorporate Screens, WaPUG, 2001*), represents current best practice. This recommends that, subject to some basic hydraulic requirements, chambers are designed around the chosen screen.

Key elements of the CSO structure are the inlet and outlet channels, overflow weir, scumboards, screen and flow controls. The preferred configuration for chambers will be with smooth approach flows, smooth transition from inlet to outlet, and side overflow weir. The hydraulic control will be determined by a combined consideration of discharge flow control and weir capacity. Design of flow controls is discussed further in Section 7.6.3.

Most routine installations should be configured in the above manner. If existing pipe configurations result in constraints which are not readily adaptable (i.e. to FR0488 or WaPUG), then these should be more rigorously analysed using one of the currently available programmes for Computational Fluid Dynamics, to ensure satisfactory operation. If this cannot be achieved by modification of the existing structure, the chamber should be reconstructed to comply with the guidelines.

Flows

The starting point for CSO design is the pass-forward flow. This is the flow which passes downstream in the continuation pipe. Excess flows will be spilled over the weir and discharged to the receiving water body. The pass-forward flow at the point of first spill is referred to as the 'setting'. This is usually lower than the maximum possible pass-forward flow due to the head-discharge characteristics of the flow control.

Where an existing CSO is being improved, the current setting and maximum pass-forward flow need to be calculated. The new values will then have to be determined as part of the planning process described in the preceding sections.

The flow over the weir can be estimated by mass balance to be equal to the peak incoming flow less the pass-forward if the effects of storage are neglected. Model simulation predictions will vary slightly from this because of the effects of storage and the time lags between peak flows arriving at the structure and being discharged over the weir.

For practical purposes:

$$\text{Weir Flow } Q_w = \text{Peak Incoming flow } Q_p - \text{Pass forward flow } Q_s$$

Thus the weir length, L , can be determined by the weir equation:

$$Q_w = C_d \times (2g) \times L \times H_w^{1.5}$$

Where:

C_d refers to the discharge coefficient, g is the acceleration due to gravity,;

L is the weir length; and

H_w the upstream head over the weir.

Available headloss is crucial to the design and a value of H_w should be chosen so as not to cause upstream surcharging. This must be determined from the computer model as appropriate, or by analysis of the hydraulic grade line in the absence of a computer model. The calculation should take account of the fact that screens on weirs may be partially blinded, resulting in greater headloss.

Access

Chamber design must also allow for safe access to allow removal of any equipment and for changing elements such as motors and screen brushes, as recommended by the manufacturer. It is, however, preferred, that chambers be designed so that maintenance can be carried out from above ground – this avoids the need to enter confined spaces.

Other Design Considerations

Other considerations at the design stage include: power supply, water supply, telemetry, land availability and ownership, ground conditions, environmental impacts, security and planning constraints.

7.6.2 Screen Selection

The initial choice of screening/solids retention device for any particular location will be based on the required solids separation standard (**Appendix G**), the expected frequency and volume of spills, the chamber location and the potential maintenance regime.

Screen Aperture

Either 6mm or 10mm solids separation is required, depending on the location of the discharge and its expected spill frequency. As well as achieving the standard, screens must be practical to operate. Much experience has been gained in the UK in this field in recent years.

The current breed of CSO screens has evolved from those in use at WwTWs. The main difference is that CSO screens tend to be installed at more inaccessible locations, and are designed to return the screenings to the pass-forward flow, rather than to remove them completely (as is the case at WwTWs). They therefore have a tendency to enrich the screenings concentration and careful consideration should be given to this aspect where there is a high spillage to pass-forward ratio, in order to reduce the risk of blockages.

Bi-directional screening fabrics commonly in use are stainless steel, perforated mesh, and wedge wire screens. The stainless steel is, in some cases, polymer coated to provide low friction and reduce solids adhesion. Screens must be robust in nature to withstand the harsh operational conditions. Screens manufactured from lighter plastics and textiles have been found lacking in durability, and are not recommended for permanent application, although may be suitable in some cases for temporary solutions.

Powered or Non-Powered

Screens may be manually-raked or self-cleansing, powered or non-powered. Because of the tendency for screens to gradually blind, those installations which experience frequent or long duration spills should be self-cleansing. Manual screens are unlikely to be practicable for such locations.

The choice between manually raked or self-cleansing depends on the cost and availability of maintenance staff, the ease of access, and the general attitude towards maintenance. In the UK, a commonly adopted cut-off value for choosing a self-cleansing screen is >3 spills per annum although some water companies accept manual cleaning with frequencies as high as ten per annum.

Even though many manufacturers offer 10mm mechanical bar screens, their use in the UK has been limited, as they offer no significant cost savings over 6mm mesh screens, provide a lower standard of screening, and are more prone to hairpinning, i.e. materials becoming trapped on the bars. The flowchart in **Appendix G** summarises the logic for screen selection.

This policy document does not promote individual manufacturers. The market is continually changing, and new products are appearing frequently. A research project at a test centre in Wigan reviewed the performance of several types of screen, and documented the results in *Screen Efficiency (Proprietary Designs) (UKWIR Report 99/WW/08/5, Saul, 2000)*. There are other test facilities in operation in the UK but the results have only been made available to the funding organisations.

The simplest method of achieving an immediate improvement to existing unsatisfactory CSOs is by retrofit of screens where possible. Several manufacturers specialise in such installations. There is no common methodology for sizing all screens, and certain manufacturers are reluctant to divulge the finer details of their sizing criteria where considered commercially sensitive. Headloss characteristics are therefore best obtained from the manufacturer for each installation.

Having established whether the existing chamber is in compliance with recommended design guidelines (*WaPUG, 2001*) and is suitable for retrofit, or whether it requires replacement, an enquiry should be made with the manufacturer to determine the exact screen size and configuration for the specific location.

Screen types in current use include:

- Inverted fixed screens which provide a degree of backwash as the spill event subsides;
- Powered self-cleansing screens with rotary augurs;
- Powered self-cleansing screens with transverse brushes; and,
- Non-powered self-cleansing screens which backwash automatically by siphonic or vortex action during spill events.

The choice of screen type will depend upon such factors as power availability and headloss restrictions. Remote locations may favour the use of non-powered screens where the cost of a power supply is prohibitive, but sufficient headloss will therefore be required to drive the backwashing siphon or other mechanism.

7.6.3 Flow Controls

The choice of flow control will depend upon whether the CSO is designed to protect the upstream or downstream system. It may be the case that an existing CSO has been installed in the form of a low sided weir to relieve upstream flooding. In this case, the pass-forward control will be provided by the downstream system.

If the catchment planning methodology has determined a need for reduced pass-forward flows to protect the downstream system from flooding, or to redistribute CSO discharges, a flow control device will be required. There are several of these on the market, all of which have their own respective advantages. The most common include:

- Orifice plates;
- Orifice pipes;
- Float operated slide valves;
- Vortex controls;
- Penstocks.

Other proprietary mechanical devices use variations of the above.

Orifice Plates and Pipes

These are the simplest controls, being usually circular or square apertures sized to produce a restriction in flow. Orifice plates may be fixed in location or mounted in guides for easy removal. Because of the solids content of the flow, it is widely accepted that they are not suitable where the minimum dimension is less than 200mm - smaller sizes are prone to blockage. Their use is therefore limited to higher flow ranges.

The formula used for sizing a circular or square submerged orifice is;

$$Q_s = C_d A \sqrt{2gH}$$

Where:

C_d is the coefficient of discharge, commonly around 0.7;

A is the orifice area; and

H is the upstream hydrostatic head above the centreline of orifice.

For short lengths of pipe the friction losses can be neglected and the above formula used.

Penstocks

Penstock settings can be sized as for orifices, but should be used with caution, as the setting may be altered after installation. Use of orifices is therefore preferred. Penstocks also have the disadvantage of requiring periodic maintenance, which usually involves confined space entry.

Other Devices

Head discharge relationships for the various market products should be obtained from the manufacturers. It is preferable for the rating curve to have a steep initial gradient in order for the pass-forward flow to remain near constant from onset of spillage through to maximum weir flow.

Operational Concerns

A common problem with all controls is the tendency to block from time to time. Access for rodding or other means of clearance must be provided at the design stage. It should be remembered that the chamber may become flooded and therefore the clearance facility must be operable from outside the chamber. Measures such as flap gates, vent tubes and fixed pressure hose connections have been used with some success. Some of the proprietary flow controls are also fitted with bypass pipes, to allow draining down of the chamber in the event of a blockage.

7.6.4 Spill Monitoring

Monitoring of spills from improved CSOs is a facility that can be provided where it is particularly important to find out whether the structure is performing as designed. The UK's Environment Agency has, in some regions, requested monitoring of CSO spills that affect bathing or shellfish waters. The most straightforward approach is to use an ultrasonic level sensor in the chamber. A spill has occurred if the measured water level exceeds the weir level. Level monitoring may be required anyway for control of powered screens. It is important that the sensors are regularly checked/calibrated so that the data is reliable. Telemetry can be used to transmit the data.

7.7 Storage Tank Design**7.7.1 Basic Design Aims**

Storage tanks are a commonly used solution for reducing the spills from CSOs. Construction is limited to a single site so disruption is less than that for laying new sewers. Storage permits retention of the 'first foul flush' and containment of flows that would otherwise be spilled to the receiving water. The basic design considerations include:

- Volume;
- Land use;
- Sedimentation;
- Flow Control;
- Odour Control;
- Materials;
- Available Construction Methods;
- Drain Down Times;
- Geology and Water Table;
- Hydraulic Conditions;
- Ground Topography/Slope;
- Maintainability.

7.7.2 Layouts

Tank arrangements fall into two main categories, namely on-line and off-line, of which there are many further sub-classes.

On-line tanks are storage constructed along the route of the pipe in question, and share the same hydraulic gradient. On-line tanks (with perhaps the exception of emergency storage) always drain flows to the downstream sewer by gravity. On-line tanks would normally be preferred to off-line from an operational point of view, but require certain hydraulic conditions to be satisfied in order to present a viable option.

Off-line tanks are constructed along a route separated from the main sewer, and may return flows to the main sewer by gravity or pumping, again depending upon the hydraulic conditions.

The chart in **Appendix G** indicates some of the more common alternative arrangements possible at different locations. This summary should not be considered exclusive, as many variations on the same basic layouts will be possible.

Materials

Materials for tank construction may be concrete, GRP, plastic or coated steel. In-situ concrete is the most obvious choice for construction of specific designs, but certain applications will lend themselves to the use of proprietary products, e.g. large diameter plastic pipes, precast box culverts and modular thin walled plastic tanks with mass concrete surrounds. Structured wall plastic pipes should only be used with care, and the design should ensure adequate resistance to jetting pressures. In the UK, storage tanks are usually below ground and covered, other than those at WwTWs. In some European countries, a first stage of storage is provided below-ground and a second stage provided in un-covered above-ground tanks. The latter are cheaper to construct than the former, with glass-coated steel being a commonly used material.

On-line Storage

This is the simplest type of arrangement, and should be used wherever possible. Hydraulic conditions will determine the viability. The tank will need to operate within the hydraulic regime of the existing system – on-line tanks of any size will not be practical in very flat sewers, due to the large surface area requirement. On-line tanks become more practical with increased gradient, but on extreme slopes due consideration will need to be given to the greater pressures developed at the downstream ends, e.g. at pipe joints. (In such cases, consideration may be given to the use of backdrops and cascades of tanks).

An on-line tank will operate by surcharging as the flow approaches the predetermined pass-forward flow. This flow may be the capacity of the downstream sewer, as in Case 1 on the chart in **Appendix G**, or a lesser value to prevent downstream flooding, as in Case 2, whereby a flow control is required to limit the pass-forward flow. In both of the above cases, care should be taken to ensure a self-cleansing velocity to prevent sediment build up. In large diameter tanks with low base flows, this may be difficult. In such cases, a dry weather flow channel should be provided. It is recommended (*Sewerage Detention Tanks – A Design Guide, WRc, 1997*) that the longitudinal slope of the tank be kept to a minimum of 1:100 in on-line tanks and that side wall slopes into the centre channel are a minimum of 1:4. Care should be taken with benching in on-line and off-line tanks - this should be steel trowel finished with granolithic topping to prevent accumulation of solids. The on-line tanks shown in Cases 1 & 2 are shown without screens for simplicity.

Off-line Storage

Off-line storage with gravity return is shown in Cases 3 to 6 in **Figure G2 (Appendix G)**. This would typically be preferred where construction could proceed without the need for overpumping, or insufficient length is available for on-line storage. The storage may be provided in a single tank, an over-sized pipe/box-culvert or groups of pipes. Care should be given to flow distribution at the upstream end, and the order of preference in filling. As the tank may not be 100% filled on a regular basis, selection of a preferential flow channel will reduce the need for desilting operations.

Where screens are installed, as in Cases 4 to 7, it is preferable to retain the screenings in the main flow where possible, to prevent accumulation in the tank. However, flow control measures should be devised to prevent screenings entering the tank from the downstream end. A further refinement of this is shown in Case 6, where a variable flow control is provided, linked to a gauge of the downstream sewer reserve capacity.

7.7.3 General Considerations

Tides

An outfall in a coastal area could be tide-locked and may need to be pumped at various states of the tide. Tide flaps or valves should be fitted in such instances.

Drain-down

The content of storm tanks is dilute sewage and as such is prone to septicity due to oxidation processes. In order to avoid this, it is recommended that the drain-down time be limited to a maximum of 6 to 8 hours. Should the flow conditions dictate a longer period, then the catchment strategy should be carefully reviewed, as storage may not be the most appropriate solution. The problems caused by rainfall-induced infiltration in this regard have been referred to in Section 7.5.2.

If there is more than one tank in the system, the combined drain-down flows should be considered, as the overall draindown time will depend upon available reserve in the system. Continuous simulation modelling is recommended for such systems.

Sedimentation and Flushing

All storage tanks will attract sedimentation, and so the management of sedimentation must be addressed during design. Selection of appropriate gradients, particularly in tanks which drain by gravity, will be the first step in this process. Provision of mechanical means for flushing will also be required in many tanks, particularly those over 200m³ in volume. Flushing systems such as tipping buckets, tilting gates and vacuum flushers are available. As an alternative, the sediment can be kept in suspension by use of re-suspension pumps, aeration systems or mixers.

Odour Control

The potential for odours from storage tanks should also be addressed at design stage. Specialist advice should be sought on all but the simplest installations. Where there is sediment build up or septicity due to extended detention times, there will be odour potential. This may not be a problem in remote areas, but will be unacceptable in urban areas. Measures such as passive ventilation may suffice, but more likely, proprietary passive or active odour control systems should be installed.

Access and Operability

Tanks will always require operator access for maintenance. Site layouts should include access tracks or roads as appropriate. Compounds should be made secure, and lockable covers provided to chambers. Access points should be provided at either end of the structure to enable remote jetting and removal of items of equipment. Where practicable, access into the chamber should be avoided at all costs, and only by planned operation. For this reason, access ladders and step irons should not routinely be provided.

Loading classifications of all access covers should be appropriate to the duty of expected traffic loading. Even pedestrian and rural areas may be subjected to construction, operation or agricultural vehicle wheel loads, and should be designed accordingly.

7.8 Policy Summary

The following points summarise the key policy recommendations relating to intermittent discharges:

- Planning of improvements to intermittent discharges should start with the requirements of the receiving water. Intermittent discharges should not be considered in isolation – a total catchment approach is needed. In the long term, it is expected that this requirement will be met through development of the River Basin Management Plans under the WFD.
- An initial first step in determining whether improved CSO standards are required should be visual inspection for aesthetic nuisance and biological assessment upstream and downstream of the discharge point. These biological indicators reflect the overall quality in the watercourse and the cumulative effects of pollution pressures including intermittent discharges.
- Effective solutions may involve major new sewerage infrastructure, for which both careful planning and a long-term design horizon are appropriate. Proposals should be set out in the form of a 'Long Term CSO Plan'.
- The Urban Pollution Management (UPM) procedure provides a practical, structured method that can be followed to derive the most cost effective solutions to the problems caused by wet weather discharges.
- The 'trigger' level for upgrading intermittent discharges should be the recognition of 'unsatisfactory' status, as defined herein. Visual and biological surveys will form part of this assessment.

- 'Target' levels for improving intermittent discharges should be determined by application of the UPM procedure.
- Targets for protecting river aquatic life should be either Fundamental Intermittent Standards or High Percentile Standards (99%ile). The River Ecosystem classification (RE1 to RE5), referred to in the UPM procedure, generally corresponds with Ireland's Quality Values (Q5 to Q1). The long-term aim of 'Good ecological status' is broadly equivalent to a Q-value of 4.
- Targets for protecting bathing waters should be either Environmental Quality Standards (based on exceedance of threshold concentrations of bacteriological contaminants associated with sewage pollution) or spill frequency emission standards. Intermittent discharges alone are unlikely to cause failure of the Guideline values of the Bathing Waters Directive if they comply with an emission standard of 2 spills, on average, per bathing season.
- Targets for protecting amenity use should be based on the amenity classification of the receiving water. Compliance with aesthetic standards normally requires a screening standard (6mm equivalent). Assuming basic hydraulic conditions are satisfied, CSO chambers should be designed around the selected screening device.
- Public Education Campaigns should be instigated on appropriate disposal of litter, including sewage litter.
- Models used for designing improvements to intermittent discharges should be of an appropriate standard. In particular, sewer system models should accurately replicate performance in both dry and wet weather conditions. Seasonal or rainfall influences on infiltration should be understood. Representation of 'delayed' or 'slow response' runoff is particularly important for the design of storage solutions. Continuous simulation of a historic time series of rainfall events is recommended for assessment of intermittent discharges.
- The Drainage Area Planning approach should be adopted to ensure that all other catchment sewerage deficiencies (e.g. flooding, structural and operational) are understood before CSO solutions are developed and implemented.

7.9 Recommendations for Interim Standards and Detailed Studies

Without appropriate water quality models for receiving waters, it is necessary to adopt interim standards for development of Regional Policy on intermittent discharges. As indicated earlier, tight spill frequency standards would be relatively easy to apply using the models. However the results are likely to be over conservative. Their application, therefore, could involve unnecessary measures being proposed involving significant capital and operational costs, without significant environmental benefit. From available information, reasonable standards can be suggested at a strategic level, subject to further refinement at detailed design stage assisted by appropriate modelling studies.

The Dublin Bay Water Quality model (Centre for Water Resources Research) has been used to evaluate the impact of major effluent loads at the Ringsend outfall, Shanganagh outfall and other coastal outfalls from WwTWs. The model also considers effluent discharges at Grand Canal Dock. In general, the model predicts satisfactory water quality conditions with respect to bacteria concentrations in Dublin Bay generally. When a substantial load was introduced at Grand Canal Dock (treated effluent without disinfection), unsatisfactory conditions were indicated in the inner estuary and the upstream tidal reach of the River Liffey. It should be said, however, that this model does not accurately represent conditions in the estuary because of limited bathymetry and calibration data.

There has been no attempt to model the impact of CSO discharges given the absence of water quality modelling of spill loads. In general, compared with a continuous effluent discharge, their impact is likely to be small. Given that the Liffey transitional waters are classified as sensitive, limitations on nitrate loads apply. In this regard, the major loads are derived from the wastewater effluent and background river loads. In order to establish specific criteria for overflows in this area, it would be necessary to develop detailed water quality models, with simulation of CSO spill impacts. For overflows to rivers, an initial impact assessment based on biological status is recommended to determine any cumulative impact on overall quality which would be reversed by improvements to the CSO or group of CSO's.

In the absence of detailed models, it is necessary for the purposes of developing a Regional Policy on interim discharges to determine interim standards. These are generally minimum accepted standards. Any improvement on these standards would require justification on environmental and cost grounds. These interim standards are based on:

- No degradation of existing receiving water quality due to development or changes in the system.
- Recognition that existing water quality is impaired in the smaller fresh water rivers in the urban area (Tolka, Dodder, Camac, Santry, etc). This has been associated with the polluting effects of stormwater discharges plus CSO discharges at certain locations.
- For combined sewers, the minimum standard is taken as containment of "Formula A" flows. Spills above this level would be permitted to the transitional waters subject to debris control to 6mm standard solids retention in order to prevent aesthetic nuisance.
- For the freshwater rivers (non-tidal), a "Formula A" based approach would be a minimum standard. Aesthetically sensitive rivers with low base flows (Tolka, Dodder) may require a more conservative approach. Previous studies (North Dublin) used a standard of 12 spills per year from combined sewers in these circumstances. Adoption of this standard (if practicable) would be likely to give significant protection against pollution. However, where cost implications are high, it would have to be justified based on biological, confirmed by full 'UPM', surveys.
- Where overflows are required on separate systems in order to limit the flow carried forward downstream to the trunk sewers and for treatment, it is recognised that a very conservative standard should apply in order to protect receiving waters. At the same time given the level of stormwater connection to foul sewers, it is not practical or economic to retain the maximum flows (one in thirty years rainfall event) as far as the treatment plant. In these conditions, a standard of one spill in five years is proposed as being sufficient to protect receiving waters. This is based on the reasonable presumption that these receiving rivers and streams will have enhanced flows in these fairly extreme rainfall circumstances and will in any event be receiving significant pollution loads from stormwater discharged from the catchments. Given the lower stormwater to foul flow ratio in the separate systems, this standard should be achievable with reasonable storage volumes.

Ultimately, it is recommended that the detailed implementation of improvements to intermittent discharges should be determined based on the recommendations of the previous section, incorporating the application of the UPM procedure. In the meantime, the foregoing approach is considered reasonable and is used to develop this strategy.

7.10 References

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NOTE: References for legislation referred to in this chapter are provided in Chapter 2.