10 YEARS EXPERIENCE OF CSO MANAGEMENT IN THE UNITED KINGDOM

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ABSTRACT
The United Kingdom’s ageing sewerage infrastructure meant that by the late 20th century the country was facing a major environmental problem associated with storm sewage discharges from more than 8,000 unsatisfactory combined sewer overflows (CSOs). Addressing this problem presented a major challenge to the UK water industry, but it is a challenge that has been met by a combination of farsighted measures which have included both reorganisation of the institutional arrangements of the industry and the development of sophisticated and integrated planning and management tools. As a consequence, the UK is now nearing the end of a multi-billion dollar investment programme which will see the end of the CSO problem in terms of both visual and water quality issues.

The paper reviews the key steps that have brought this about over the last decade and highlights the changes in approach that the industry and water professionals have had to make to allow it to happen. Finally, the paper considers the extent to which the lessons learnt could be applied beyond the UK and, in particular, in the U.S.

KEY WORDS
Combined sewer overflows; CSOs; integrated wastewater management; urban pollution management.

INTRODUCTION
The urban wastewater infrastructure of the United Kingdom has evolved since the dawn of the industrial revolution in the first half of the 19th century up to the present day. The open gutters and natural watercourses that drained early industrial conurbations evolved into the culverted watercourses and combined sewers which still constitute the core of the sewer systems that serve almost all of the UK’s major cities. Given the very different duties to which these conduits are now subjected, it is hardly surprising that in more recent years there have been numerous environmental problems associated with combined sewer overflow (CSO) and other wet weather discharges from urban wastewater systems. At the beginning of the 1990’s it was estimated that there were around 25,000 CSOs in England and Wales and that some 8,000 were causing pollution problems. The cost of improving these CSOs was forecast to be in the order of $4.5 billions.

The Urban Wastewater Treatment Directive (CEC, 1991) requires European Union member states to take action to limit pollution from storm overflows and to improve
unsatisfactory intermittent wet weather discharges from combined Sewer Overflows (CSOs) and storm tanks at Wastewater Treatment Plants (WTPs). In addition, there now is the wide reaching Water Framework Directive (CEC, 2000), which requires that all receiving waters achieve “good status” in terms of environmental and ecological targets by 2015. While there are no specific requirements, such wet weather intermittent discharges can influence the achievement of these targets and also contribute to failures to meet standards set by other Directives, such as the Freshwater Fish, Bathing Water and Shellfish Waters Directives. As a member of the European Union, the UK is obliged to meet the requirements of these, and all other Directives, emanating from the European Commission.

Historically, CSOs in the UK, if they were designed on any rational basis at all, were constructed to discharge at fixed multiples of the dry weather flow (dwf) in the sewer, usually 6 times dwf. Flows in excess of 6 times dwf would be spilled and the remainder carried forward to the treatment plant. Problems arising from this pragmatic approach were recognised as early as the 1960s when a more rational approach, known as ‘Formula A’ (HMSO, 1970), was proposed to calculate an acceptable pass forward flow from CSOs. This formula is still in use today as a minimum CSO spill setting criteria. Also, in the 1960s, new engineering designs for overflows structures incorporating the use of storage, and stilling pond or high side weir overflows were adopted to provide for retention of pollution in the sewer system. An early method for estimating storage requirements was developed in the late 1970s. Referred to as the Scottish Development Department method (SDD, 1977), this is based on a Formula A spill threshold, plus storage within the CSO related to the available dilution in the river and the upstream sewer population equivalent. Neither the Formula A nor the SDD approach can be used directly to ensure compliance with environmental quality standards in the receiving water.

Unsatisfactory performance of CSOs is currently defined in the UK on the basis of the following criteria (DETR, 1997):

- causes significant visual or aesthetic impact due to solids or fungus in the receiving water or there is a history of justified public complaint; or,
- makes a significant contribution to a deterioration in river quality; or,
- makes a significant contribution to a failure to comply with the quality standards set by the EC Bathing Waters Directive and Shellfish Waters Directive Quality Standards for identified bathing and shellfish waters, respectively; or,
- discharges in dry weather conditions; or,
- causes a breach of water quality standards.

This paper identifies the advances that have occurred in the UK in recent years to meet the challenges presented by the new legislation and raised public expectations for improved pollution control and environmental standards. The paper highlights the enhanced regulatory, financial and technological capabilities that have been made to allow progress to be made in the control of CSO discharges. In particular, it describes the Urban Pollution Management (UPM) Procedure that has been the principal vehicle by which these advances have been achieved in the UK. The paper also examines objectively the experience which has been gained, particularly in the last 5 years, in the practical application of this technology. In the latter part of the paper consideration is given to whether these developments could have application in places other than the UK, and in particular in North America.
The Water Industry of England and Wales was privatized in 1989. This was a major change in terms of how the industry was operated, regulated and funded. Since that time, the Environment Agency (initially the National Rivers Authority from 1989-1996) has had a responsibility to maintain and improve the quality of inland and coastal waters. The Agency has done much to develop and implement a comprehensive, objective and logical national policy for wet weather pollution management.

A major reason for the privatisation of the water industry in England and Wales was to free the industry from the constraints of public financial borrowing. Hence, the operational side of the water industry was passed to regional utility companies, or Water Service Companies which were, and are, effectively monopolies within their geographical areas. In addition to environmental regulation, an effective form of economic regulation is also necessary to represent and protect the interests of the customers. This role is performed by the Office of Water Services (Ofwat) that stipulates the amount of money above (or below) the rate of inflation that each company can raise from its customers to carry out its business over the following 10 year period. The water companies are required to produce Asset Management Plans (AMPs) for which, in effect, both the inputs (money) and outputs (performance targets) are fixed. Ofwat monitors and reviews each company’s performance over the preceding period relative to the companies’ Asset Management Plans and considers this, together with ongoing obligations and any new commitments that it may have for the coming period, in setting new limits.

Dealing with the backlog of unsatisfactory CSOs was identified as a high priority for the 10 year period commencing April 1995 (AMP2 and AMP3). It was recognized that it was not feasible to tackle all the remaining unsatisfactory CSOs and storm tank discharges in this period, but the funds allocated were anticipated to allow the majority of the CSOs to be rectified, particularly those where the greatest environmental benefit would accrue from the available investment. The remaining CSOs were planned be improved in subsequent investment programmes beyond 2005 (AMP4 and AMP5).

From a figure of zero improvements prior to privatisation, approximately 500 CSOs had been improved in England and Wales by 1996. This figure increased to 1,726 by the end of the AMP2 period in 2000, at an estimated overall cost of nearly $2 billions. A focus of this activity was to control CSO discharges to coastal bathing waters. In November 1999, the Secretary of State for the Environment announced a major environmental investment programme to be completed during the period 2000/2005 (AMP3). Overall, it was planned that approximately 4,000 unsatisfactory CSOs and 300 storm tank discharges would be improved to protect and improve the quality of almost 3,600 km of rivers to allow receiving water objectives to be met. The cost of these improvements was identified to be approximately $3 billions. Of the CSOs to be improved, over 25% were designated as unsatisfactory due solely to aesthetic pollution, i.e. visible sewage derived solids downstream of the discharge. In parallel, the industry implemented a large scale investment programme to improve the quality of continuous discharges from many wastewater treatment plants.

The outstanding stock of unsatisfactory CSOs, plus a considerable number of additional sub-standard discharges which came to light during the AMP3 programme – a total of around 2,000 in all - are included in the fourth AMP cycle which is currently in progress. Hence, by around the year 2010 it is anticipated the almost all unsatisfactory CSO in the UK will have been eradicated.
THE URBAN POLLUTION MANAGEMENT (UPM) PROCEDURE

The planning technology that has been developed as the principal tool to allow these ambitious improvement plans to be implemented is known as the Urban Pollution Management (UPM) Procedure. The roots of Urban Pollution Management (UPM) date back to the publication of the original Sewerage Rehabilitation Manual (WRc, 1983), which was itself produced in response to the problem of aging wastewater infrastructure. At that time of publication of the Sewerage Rehabilitation Manual, it was recognised that an integrated planning methodology was required that gave equal emphasis to all aspects of urban wastewater system performance, including environmental impact. An approach that considered all aspects of the urban wastewater system in an holistic manner would allow the maximum value to be derived from the limited funds available for asset improvement. The Sewerage Rehabilitation approach acknowledged the three facets of sewerage performance - flooding, structural and pollution – but was only effective in addressing the first two of these and considered only the sewer system, excluding the treatment plant.

The industry wide UPM research and development programme was commenced in 1984 and set out to meet the need for an integrated planning procedure for wet weather urban wastewater discharges for the whole urban drainage system in a comprehensive and objective manner. The complexity of the issues to be addressed meant that the programme took some ten years and several million dollars to complete. The principal product of the programme was the Urban Pollution Management Manual (FWR, 1994), which was revised and updated in the current, second edition that was published in 1998 (FWR, 1998). The major principles of UPM were established at a very early stage in the development process and have remained constant ever since. They can be summarized as:

- that the urban wastewater system, comprising the sewer system, the treatment plant and the receiving water, should be treated as a single entity in which change to one part has implications for the other parts that should be taken into account during the planning process;

- that the whole approach is underpinned by the need to achieve compliance with wet weather environmental standards; and

- that the form of modelling employed in a study should be appropriate to the technical needs of the study. The minimum level of modelling should be adequate to address the technical requirements of the study area and result in a “safe” solution that would be sure to meet environmental requirements. More sophisticated planning may be used to refine the “safe” solution and reduce overall costs without compromising the level of environmental protection.

The complete planning methodology, called the UPM Procedure, is based on a single procedure into which modelling tools of varying type and complexity can be fitted to suit the specific local circumstances. The overall framework, illustrated in Figure 1, shows the key steps in moving through problem identification to data collection and model building, via an iterative solution developing process, before the final consenting and detailed design aspects are considered. The key issues that underlay the application of the UPM Procedure are:

- the variability of discharge loads and their associated environmental impacts is large and result from many complex processes and interactions;
• limited financial resources require individually tailored solutions to pollution problems to avoid excessive and unnecessary expenditure;

• such solutions can only be identified from the standpoint of an adequate understanding of system performance which comes from the use of appropriate modelling tools; and,

• a hierarchical system of models allows an incremental approach to problem solving and aids the identification of cost-effective, integrated solutions.

The water quality simulation models used to support the UPM Procedure are described in the Manual. These include models for rainfall input generation, sewer system flows and pollutant concentrations; treatment works performance and river/marine impact assessment.

The benefits of the UPM Procedure are recognised to be:

• more cost-effective solutions that result in overall cost savings for the water industry;

• more environmentally robust solutions since the procedure is founded on consistent and reliable environmental criteria;

• more rapid agreement on discharge consents as common understanding speeds the process; and,

• familiarity and confidence in the technology which ensures consistent and effective solutions which will meet environmental needs.
A key element of the UPM Procedure is a range of wet weather standards to protect beneficial uses of receiving waters against the effects of intermittent discharges. The values presented in the UPM Manual are illustrative of the type of criteria that could be used. An environmental regulator may choose to vary the values identified in the Manual, or apply alternative forms of environmental criteria. Hence, the identification and agreement of environmental requirements by the environmental regulator and the discharger is one of the key initial planning steps in carrying out a UPM study.

For example, wet weather CSO discharges may affect river water quality for relatively short periods of time. However, short term, high concentration events can have a disproportionate impact upon river aquatic life. Furthermore, the quality of a river during these events may not be related in any simple fashion to the more general quality of the river. The current UPM Manual identifies two approaches to protect river aquatic life from wet weather pollution episodes. These are:

- **Fundamental Intermittent Standards (FIS)** that are 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 (99 percentiles)** based on an extrapolation of the 90/95 percentile thresholds from the Environment Agency’s Rivers Ecosystem (RE) classes that are used to plan and assess river quality.

The FIS were developed from ecotoxicological information based on field and laboratory trials. The approach is based on the objective of no long-term detrimental effects on an aquatic ecosystem and no fish mortality for wet weather pollution episodes up to a 1-year return period. FIS take the form of concentration/duration/frequency criteria to represent a concentration of Dissolved Oxygen or Un-ionised Ammonia that cannot be exceeded. Identified duration thresholds are 1, 6 and 24 hours and return periods (of the concentration and duration) identified are 1 month, 3 months and 1 year. The current UPM Manual identifies 3 sets of standards to provide the same level of protection to 3 ecosystem types:

a) sustainable salmonid fishery;
b) sustainable cyprinid fishery; and,
c) marginal cyprinid fishery.

An example of the Fundamental Intermittent Standards is illustrated in Figure 2.
Standards for the protection of other beneficial uses such as bathing waters and shellfish waters are specified in the relevant EU Directives. The UPM Manual reproduces these standards and provides methodologies for testing compliance in a robust and practical manner. Typically, as with inland waters, alternative approaches for establishing compliance are available. In the case of bathing and shellfish waters these are based on spill frequencies for simple schemes where the marginal cost of moderate over-design is not excessive, or on the exceedence on a percentile basis of specified threshold concentration values for stipulated periods of time for more complex schemes.

A final category of standard that is applicable to most CSOs is that of aesthetic impact in relation to amenity use. Here the emission of visible sewage derived solids from the wastewater system is managed in accordance with the public use of the receiving water. Figure 3 illustrates the matrix by which the level of solids separating performance at a CSO is managed in accordance with the amenity use of the receiving water and the CSO performance expressed as a spill frequency. Precise definitions of both the Amenity Use categories and the requirements for each solids emission standard are provided.

<table>
<thead>
<tr>
<th>Amenity use category</th>
<th>Expected frequency of spills</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Amenity</td>
<td>&gt; 1 spill/year</td>
<td>6 mm solids separation</td>
</tr>
<tr>
<td></td>
<td>≤ 1 spill/year</td>
<td>10 mm solids separation</td>
</tr>
<tr>
<td>Moderate Amenity</td>
<td>&gt; 30 spills/year</td>
<td>6 mm solids separation</td>
</tr>
<tr>
<td></td>
<td>≤ 30 spills/year</td>
<td>10 mm solids separation</td>
</tr>
<tr>
<td>Low Amenity &amp; Non-Amenity</td>
<td>-</td>
<td>Good engineering design</td>
</tr>
</tbody>
</table>

**High Amenity**
Areas where bathing and water contact sport (immersion), is regularly practised (e.g. wind surfing, sports canoeing).
Watercourse passes through formal public park or beside formal picnic site.
Shellfish waters.

**Moderate Amenity**
Areas used for recreation and contact sport (non-immersion e.g. boating).
Popular footpath adjacent to watercourse.
Watercourse passes through housing development of frequently used housing centre area (e.g. bridge, pedestrian area, shopping area).

**Low Amenity**
Basic amenity use only.
Casual riverside access on a limited or infrequent basis, such as a road bridge in a rural area, or footpath adjacent to watercourse.

**Non-Amenity**
Seldom or never used for any amenity purposes.
Remote or inaccessible area.

**6 mm solids separation**
Separation, from the effluent, of a significant quantity of persistent material and faecal/organic solids.
greater than 6 mm in any two dimensions. This should be applied to at least 80% of the spilled volume in a typical year, the remainder being subject to 10 mm solids separation. Alternatively, the hydraulic design of the 6 mm solids separation can be based on treating 50% of the volume discharged in a 1 year RP design event.

**10 mm solids separation**
Separation, from the effluent, of a significant quantity of persistent material and faecal/organic solids giving a performance equivalent to that of a 10 mm bar screen.

**Good engineering design**
Design of combined sewer overflow structures in accordance with the recommendations of FWR report FR0488 (Balmforth et al, 1994).

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**Figure 3 – Standards for Protecting Amenity Use**

Many of the modelling tools by which the UPM Procedure is implemented were initially developed under the UPM research and development programme. Subsequently market forces have dictated that a variety of commercial products have entered the market to meet the demands of the approach. Hence, the practitioner now has a choice of tools for most types of study and the basis of selection will be on the precise needs of the particular study and the preferences of local practice.

A particular tool which was developed as part of the UPM programme, and which is provided with the UPM Manual, continues to be an integral part of most UPM studies. The concept of simplified, integrated pollution modelling was introduced in UPM to allow solutions to wet weather pollution problems to be developed and solutions to hydraulic problems to be tested for long term compliance with the required environmental criteria over 10-15 year sequences of rainfall events and environmental conditions. This allows the compliance assessment to take account of the variability in all input conditions that may influence the impact of a wet weather discharge. Such extensive, stochastic compliance assessment is frequently impractical using conventional detailed models of individual wastewater system components. The spreadsheet model, SIMPOLv2 combines the key processes involved in wet weather pollution modelling, in a simplified way, so that many events can be simulated rapidly. It incorporates both deterministic and stochastic elements and is specifically designed to assist in the implementation of the UPM Procedure where compliance against environmental standards is required.

SIMPOLv2 has two main simulation modules. The sewer module is a simplified sewer flow/quality model that is designed to estimate all significant spill loads from an urban sewer system for a long rainfall time series. The river module has two routines:

- a simple mass-balance routine where spills can be mixed with river water to give estimates of mixed river concentrations for each storm event; and,
- a simple river quality model which can be used to route the contaminated river water along a variable downstream river reach to predict the worst impact.

**EXPERIENCE OF UPM WITH THE AMP3 CSO PROGRAMME**

As indicated earlier, the UK’s AMP3 CSO programme constituted a major effort to address in a relatively short timescale a problem that had developed over a very long period. As such, it was both ambitious and presented a major challenge to the UK water industry. As soon as the scale of the programme was known, concern was expressed in many quarters that, despite the much improved technology available to practitioners,
the sheer volume of work would tax the planning, modelling, design and construction resources of the industry to an excessive degree.

The AMP3 CSO output delivery profile is shown in Figure 4, which indicates the degree of back loading built in to the programme. Over 30% of the schemes were scheduled to become operational during the last 12 months of the AMP3 period ending in April 2005. This equated to an average of 23 schemes to be delivered each week. A remarkable statistic!

Despite the many forecasts to the contrary, the bulk of the programme was delivered on time. That this was achieved is a huge tribute to the UK water industry and to the tools and resources that they were able to bring to bear on the programme. However, it has also become clear that the scale of the AMP3 programme did indeed create a number of problems in the delivery process due to the sheer scale of the programme and some of the specialized requirements. Some the more significant problems were:

- The 5 year time scale from inception to completion of schemes imposed by the AMP cycle was very constrained for the number of potentially complex planning studies to be undertaken in addition to the actual construction phase;
- There was a lack of sufficient technical expertise available within the industry as a whole to undertake the specialized planning and modelling work in the available time scales; and
- There was a lack of sufficient manufacturing and construction capacity to provide the equipment and structures required.

These issues were addressed, at least in part, during the course of the programme by adopting new procurement strategies and supplier partnerships. However, it has become clear that time was a more important driver than cost in the development and delivery of many solutions. Clearly, these circumstances are not conducive to achieving optimum value for money, something that is a primary requirement of a privatised industry. These constraints also had important consequences for the way that the UPM Procedure was applied to plan solutions. Some examples of the modified approaches to the delivery of CSO improvement schemes that were adopted by various water companies are:
• The extensive use of simplified forms of UPM, usually without new site specific data collection;

• A focus on testing Formula A and SDD designed schemes against the environmental criteria;

• Limited attempts to develop integrated sewer and wastewater treatment plant solutions;

• In some areas, a procedural approach was implemented that has hindered the development of site specific solutions – one of the corner stones to achieving the benefits of UPM; and,

• In some cases, a temptation to ignore the UPM Procedure completely, despite its acknowledged benefits.

Notwithstanding these issues, UPM and, in particular, the use of simplified integrated modelling coupled with the use of extensive sensitivity testing rather than costly and time consuming project specific data collection can now be seen to have been a major factor in allowing the AMP3 outputs to be met for many schemes on both small and large scale catchments.

In addition to the planning issues, the time constraint issue also had a significant influence on the development of the engineering solutions for upgrading (retrofitting) schemes. A clear focus developed on the use of in-sewer storage to reduce spill volume and frequency to achieve the required environmental targets. Whilst such forms of solution are superficially attractive and cost effective in meeting environmental targets, a body of experience is growing that shows that elimination of the original problems may only result in creation of another set of operational and maintenance problems. There is also evidence to show that, in certain circumstances, notwithstanding the local improvement in polluting loads discharged to the environment, there may be little or no overall environmental benefit when the wider picture is considered.

In parallel to the use of storage to address water quality needs, there has been widespread use of screens at CSOs to satisfy the emission requirements for aesthetic pollution control. Post project appraisal work is showing that a worrying number of these installations are failing to perform in the manner envisaged by their designers due to a combination of design, construction and maintenance reasons. Generally speaking, there is growing concern amongst industry professionals about the long term technical and financial viability and, hence, the sustainability of these types of solutions. It is an interesting conjecture to question whether the anticipated environmental benefits from this investment will still be visible a decade from now!

Overall, it can now be concluded that, had the UPM procedure not been available to the UK water industry, delivery of a programme of CSO improvement as ambitious as the AMP3 programme would not have been possible. Or if it had been attempted, the result would have been either or both significantly higher spend and more schemes failing to achieve environmental targets. However, at the same time it should recognised that the time constraints inherent in AMP3 resulted in both the water industry and the environment not gaining the full benefits that could have been achieved for the investment by a more considered and comprehensive adoption of the UPM Procedure.
THE AMP4 CSO PROGRAMME

The current AMP4 CSO programme (2005-09) is very different to AMP3. If the AMP 3 programme had not preceded it, it would undoubtedly be considered a very challenging undertaking. Certainly the number of unsatisfactory CSO involved, at more than 2,000, is considerable. However, the bulk of these are relatively minor, usually isolated structures on smaller networks that have been identified late in the process. A few are carry-overs from AMP3. At the other end of the scale, there are also few major “hot spots” where the level of funding required to resolve the problem is so large as to fall outside of the current funding round. Principal amongst these is the central London system, where a major planning study has identified the preferred option for upgrading the performance of the 57 CSOs that discharge to the tidal River Thames to be a 22 mile long tunnel which, together with new treatment facilities, is costed at $3 billions.

As such, delivery of the AMP4 CSO programme should be rather more relaxed than the frenetic pace of the AMP3 and should provide an opportunity to put the lessons learnt in AMP3 into practice. In some respects this is indeed the case, but in others it is not. Inevitably, with the adherence to a 5 year planning cycle, the potential issue of time constraints remains, but without the same number of complex large scale schemes, this is a lesser factor. Another consideration is flexibility of approach to new knowledge discovered in the course of a UPM study. Such studies are frequently embarked upon with very imperfect knowledge of the true causes of a perceived environmental problem. In such circumstances, it is important to be able to modify the objectives and deliverables as appropriate during the course of the study to ensure that the correct issues are addressed and the best environmental value is achieved for the financial investment. The trend towards increasingly rigid regulation in which precise outputs are defined beforehand mitigates against this.

The ever increasing tightening by Ofwat of the finances allowed for delivery of schemes in AMP4, together with the relatively smaller scale of many of the remaining planning studies also means that there can be a reluctance to invest the appropriate resources into front-end planning activities. For the most part, such thinking is short sighted as the initial investment in planning is likely to be repaid many times over in savings on construction costs. However, it is important in any project to identify as early as possible when a UPM planning study is appropriate and when a simpler approach is justified.

TRANSFERRING THE TECHNOLOGY

The Urban Pollution Management concept and procedures have played a major role in bringing the problem of wet weather urban pollution in the UK under control. But is the technology unique to the circumstances pertaining in the UK, or does it have the potential to play a similar role in the U.S.?

Clearly, there are significant differences in the physical nature of the urban drainage systems. In much of the US, separate sanitary and storm systems are the norm – a situation that is rare for the majority of complete urban drainage systems in the UK. In the older east coast cities combined systems predominate. There are also differences in the environmental standards which are commonly utilized for the management of water quality and the impact of wet weather discharges. However, there is a higher degree of commonality in the underlying beneficial uses that the standards seek to protect, so it could be argued that there may be a case for a more consistent approach to setting standards – or at least for researching the relative merits of the alternative systems.
desire to protect fish life and recreational uses are universal, as is the need for control of aesthetic pollution appropriate to the degree of public access to the receiving water.

The organizational structure by which urban drainage systems are managed and regulated is also very different. In the UK there are a relatively small number of wastewater utility companies operating on a regional basis and only three national environmental regulators, all of whom operate in a similar and consistent manner. In the U.S. there is naturally a far greater diversity of both operators and regulators. However, perhaps the biggest potential impediment to implementation of UPM in the U.S. is the differing legislative position. Effective implementation of UPM is best supported by a teamwork approach between all stakeholders and focuses on the development of site specific solutions. This approach may be construed as being at odds with the need to be even handed with all dischargers. It is certainly at odds with any culture that seeks to resolve any issues through confrontation and litigation as a first measure!

On the positive side, it can be argued that the basic building blocks of the UPM approach are so fundamental that they transcend these issues. The concepts of treating the complete urban drainage system holistically, of driving the whole process from environmental needs and of using modelling tools that are appropriate to the specific needs of the issues experienced in the study area are so basic that they are surely applicable in any circumstances. No water industry professional would question the inherent ‘correctness’ of these concepts. Rather the question becomes ‘does UPM offer anything new, anything better than what is already standard practice’ in the U.S.?

Certainly in the UK, the answer to this question prior to the 1990’s was ‘Yes’. Prior to the development of UPM, solution development was driven by pragmatic ‘rules-of-thumb’ and engineering based criteria which owed more to economic stringency and the limitations of the available technology than the needs of the environment. By giving primacy to the needs of the environment and taking advantage of the technological opportunities offered by modern computers, UPM means that wastewater professionals are now able to design solutions that not only meet environmental objectives, but do so at the least overall cost. The additional benefit of improved understanding of fundamental system performance which derives from the UPM modelling process should also not be underestimated. UPM has been proved to work in the UK. Why should it not be equally effective in the U.S., if an appropriate culture to suit the specific requirements of the U.S. market can be developed?

CONCLUSIONS
In the late 1980’s, the UK’s aging infrastructure and growing population meant that there were major problems related to unsatisfactory CSOs arising from overloaded sewer systems. The unsatisfactory CSOs were the cause of widespread environmental problems, including unsightly sewage debris, fish kills and health hazards leading to public complaint and failures to meet legal obligations under European Union legislation.

Two measures were implemented to allow these and other related issues to be addressed:

- The UK’s hitherto public water industry was privatised to free it from the constraints of public funding and to allow the major investment required to occur, and
A major research and development programme was put in hand to develop the improved tools that were required to effectively plan and manage the improvements to CSO performance.

Now, some 30 years later, the fruits of this far-sighted planning are being gained. From the situation in 1990 of more than 8,000 unsatisfactory CSOs, the bulk of the problem has been resolved, with the residual to be completed by around 2010. The challenge that this ‘turn-around’ has presented to the UK water industry and its suppliers has been immense, but has for the most part been successfully met.

The situation of aging and overloaded wastewater infrastructure is not unique to the UK. Most developed nations experience similar problems to a greater or lesser degree. It is suggested that the experience gained, and the technologies developed, to address the UK problems, may be of potential value in other parts of the world to help resolve these issues.

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