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HAL Authorization

Screening tool for water quality improvements, flood risk management and urban regeneration through surface water flood reduction at a regional scale

Outil d'évaluation pour l'amélioration de la qualité de l'eau, la gestion du risque d'inondation, et le renouvellement urbain à travers la réduction de l'écoulement des eaux de surface à l'échelle régionale

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RÉSUMÉ

La côte de Fylde, autour de Blackpool au Royaume-Uni, a toujours eu du mal à respecter les normes européennes en matière de qualité des eaux de baignade. Suite à l'installation de volumes importants de stockage d'eaux de surface en souterrain à Blackpool, ce qui a en partie résolu le problème, le « Fylde Peninsula Water Management Group » a été mis en place pour aider à résoudre les problèmes et à trouver des solutions intégrées de gestion de la pollution des eaux de surface dans la région. Cet article résume une enquête qui a mis au point un outil de dépistage basé sur un SIG pour identifier des sites où des systèmes d'assainissement durables pourraient être réaménagés. Le but était d'éliminer de l'eau du réseau d'égout unitaire, réduisant ainsi la pression sur un système fonctionnant à pleine capacité, et de réduire le nombre de fois par an où le réseau d'égout unitaire déverse dans les eaux de baignade. L'outil de dépistage utilise des jeux de données standards et facilement disponibles, et examine une série de paramètres pour évaluer quantitativement et classer les sites dans la région de l'étude sur 1,900 km². Des sites présélectionnés et classés ont ensuite été vérifiés manuellement et un système de « feux de circulation » a été appliqué pour indiquer les coûts d'installation et de maintenance. Ces données ont été présentées au « Fylde Peninsula Water Management Group », qui les a utilisées pour identifier les sites prioritaires pour la conception détaillée de systèmes d'assainissement durables et pour constituer des sites pilotes.

ABSTRACT

The Fylde coast around Blackpool in the UK has historically struggled to meet European standards for bathing water quality. Following the installation of significant surface water storage volumes underground in Blackpool, which partly solved the problem, the Fylde Peninsula Water Management Group was set up to help address the problems and find integrated solutions for surface water pollution in the area. This work summarises an investigation which developed a GIS based screening tool to identify locations at which sustainable drainage systems (SUDS) could be retrofitted. The purpose was to remove water from the combined sewer network, thereby reducing pressure on a system running at capacity and reducing the number of times per year that the combined sewer network spilled into the bathing water areas. The screening tool utilised standard and readily available datasets, and considered a range of parameters to quantitatively assess and rank sites across the 1,900km² study area. The shortlisted, ranked sites were then manually checked, and a traffic light system of indicative installation and maintenance costs was applied. This data was presented to the Fylde Peninsula Water Management Group who used it to identify priority locations to be taken forward for detailed SUDS design as exemplar sites.

KEYWORDS

Flow Reduction, Screening, SUDS, Surface Water, Water Quality

1 INTRODUCTION

EU Bathing Water Directive (Directive 2006/7/EC and previously 76/160/EEC) and the Water Framework Directive (Directive 2000/60/EC) set out water pollution control policy and lay down new procedures for the identification of substances and development of control measures. The Directives are setting environmental quality and other standards for the substances which Member States must achieve by 2015, to ensure a 'good bathing quality status' and "good chemical surface water status".

Prior to achieving these objectives and identifying possible mitigation measures, an accurate knowledge on these substances at the different stages of the urban water cycle is required. There are number of studies that identify the occurrence and the significance of priority pollutants (PPs) in wastewaters (Rule et al., 2006a,b; Palmquist and Hanaeus, 2005). Some studies focused on the quality of wet weather flows within the sewers and combined sewer overflows (CSOs) (Gesperi et al, 2009).

Both point and non-point sources contribute to the surface water pollution. Although point source pollution has been significantly reduced in the past due to tightened legislation across UK, non-point source pollution was not tackled in the same way. These sources mainly include runoff from the agricultural land and runoff from urban areas.

CSOs help reduce urban flooding from combined sewerage systems and are an integral part of a well-managed and maintained sewerage system. The public health function that CSOs perform has to be balanced with effective – and financially proportionate – protection of the environment, as CSO spillages contribute significantly to the surface water pollution. Climate change is expected to produce more extreme weather at a greater frequency than those currently experienced. This will pose a challenge to water companies when it comes to the proper management and maintenance of their sewerage systems, including number of CSO spillages.

1.1 Historical problems with bathing water quality

The Fylde Peninsula (Figure 1), home to one of the country's most visited coastlines, suffers from a wide range of water management issues. Half the bathing waters in England and Wales that failed the Bathing Waters Directive in 2011 are on the Fylde Peninsula, however in the wetter 2012 bathing water season 32 bathing waters failed nationally, of which 3 were on the Fylde coast. The majority of drainage systems at the Peninsula are combined sewer systems and there are 3 CSOs that contribute to low bathing water quality. They are running at their capacity and the surface water flooding is a real issue. Collectively these issues have wider social and economic impacts that are increasingly under pressure from development pressures and climate change.

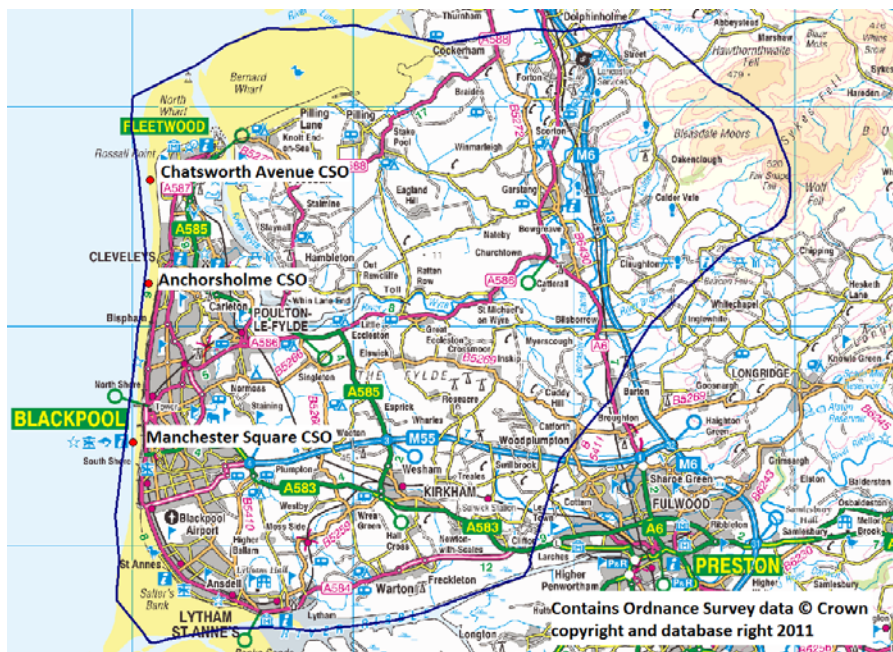


Figure 1: Fylde Peninsula study area

In addition to the CSOs, the major polluters are two rivers, Ribble and Wyre that carry bacteria from diffuse sources to the coast, where they can present a significant strain on bathing water quality

In 2010 (based on 2007 to 2010 bathing water quality data) the bathing waters of the Fylde Coast had a projected classification of 'Poor' under the revised Bathing Water Directive. For bathing waters which only meet the "Poor" classification in 2015, the Councils will have to display advice against bathing prior to the 2016 bathing season, along with information on the causes of pollution and the measures being taken to tackle the pollution.

1.2 Traditional solutions

A significant contributor to the improved bathing water quality was the construction of twin 60,000m³ storage tanks to intercept surface water, an investment of over £600 million by United Utilities. The tanks reduce immediate discharge and CSO spillages, instead passing the water for treatment at a Waste Water Treatment Works before being discharged to the bathing water. This led to the three bathing waters at Blackpool (North, Central and South) passing the Bathing Water Standards the first season after construction, and all beaches along the Fylde coast passing the following year. As identified by Myerscough and Digman (2008), the continual construction of additional storage is an unsustainable practice, and reduction of inflows offers a more holistic route to reducing the frequency of CSO spills. The revised Bathing Water Directive will pose even more stringent requirements and additional measures are needed to comply with the revised criteria.

1.3 Aim of the work

The Fylde Peninsula Water Management Group (comprising the Environment Agency, United Utilities, Blackpool Council, Wyre and Fylde Borough Councils, Lancashire County Council and Keep Britain Tidy) was created to provide a sustainable and integrated approach to managing coastal protection, water quality and surface water drainage. It has led the study of assessing the potential to retrofit the sustainable drainage systems (SUDS) in order to reduce the impacts of urban drainage flooding and pollution across the Fylde Peninsula and adapt to the inevitable consequences of climate change and needs to future development in the area.

In order to achieve this, a screening methodology was developed to identify sites at which SUDS could be retrofitted to reduce runoff volumes passing into the combined sewer network. By reducing peak flows, the project aimed to contribute to reducing the annual number of spills from CSOs.

Whilst other tools have used water quality indicators to identify potential SUDS sites (Mitchell, 2005), or for complex determination of combinations of SUDS options at a range of scales (Bach et al, 2012), no tools currently exist to identify significant opportunities for the retrofitting of SUDS for surface water flow reduction purposes.

2 METHODOLOGY

2.1 Consideration of suitable criteria for SUDS screening

A number of readily available industry standard georeferenced datasets and hydraulic model schematics have been used during the screening process. The criteria that were used and the classification factors applied are listed in Table 1.

Table 1: Criteria and classification approach

Criteria	Classification approach
Impermeable areas create greater runoff than permeable ones	The size of the site was a primary consideration as it offers greater opportunity for reducing flows. Buildings and manmade surfaces were identified from Ordnance Survey MasterMap data. The MasterMap dataset contains georeferenced vectors with associated land use attributes that can be used for filtering and searching. The polygons were ranked according to their size with larger areas scoring higher than smaller areas. Buildings and man-made areas with an area less than 5,000m ² were not considered in the screening process.
Surface water disposal and reduction	The georeferenced location of combined sewer pipes was extracted from the computer sewer model of the network. A series of distance buffers was then applied to the extracted polylines. Buildings and man-made areas were awarded a higher score for being close to a combined sewer pipe, as this would highlight that they are likely to connect to this system and therefore be a pressure on it. The preference was to identify sites connected to the combined sewer network rather than those with sewers that already separate the storm and foul sewage as these would give the greatest benefit in reducing the surface water flows.

Available land for SUDS	Open spaces were banded by size, and then buffers were created radiating out from these areas. Closeness to a large open area scored higher than closeness to a small open area, and the smaller the distance to the area, the higher the score. This reflects the potential for SUDS that these sites have, with larger sites able to handle a wider range and larger SUDS than small open areas and therefore potentially being of more interest. In addition, an open space close to a building or man-made surface could be easier and cheaper to connect to than one further away, and this was therefore also considered in the scores applied.
Disposal route (major)	Buffers were applied to main rivers, with higher scores being awarded for decreasing distance to the watercourse. This is because SUDS could discharge to a watercourse, and it is likely to be cheaper and more efficient to discharge to a nearby watercourse than one further away, providing that there is adequate capacity in watercourses to accept the additional flows. Scores for proximity to a main river are the same as for a medium sized open area as they are considered to have similar functionality.
Suitability of sites	As well as scoring positive points for the categories above, buildings and manmade surfaces were also screened for their location in relation to the 100 year floodplain. As SUDS are not permitted at ground level in the floodplain, any site which was located in the floodplain was assigned a value which reduced the likelihood of its consideration.

2.2 Traffic light system for costing SUDS installation and operation costs

To provide a quick and simple indication of the relevant costs (installation and maintenance costs) of various SUDS, an indicative traffic light system was developed. Under the system, different SUDS options were assigned either red (high cost), amber (mid cost) or green (low cost). As it is assumed that the design, planning, site investigation, land and risk contingency will be similar for all types of SUDS, comparison of installation and operational costs for SUDS provided additional criteria for SUDS selection.

The cost of constructing a SUDS scheme is inherently variable and will depend heavily on the size of the contributing catchment area and presence of other services. Installation costs include earth works (excavation, reprofiling and erosion and sediment control), materials, labour, equipment, planting and landscaping. Additional influencing factors on costs include soil type (higher excavation costs in rocky soils), groundwater (sensitive groundwater area zones may require expensive liners), access and space, location (varying labour costs and rainfall characteristics will affect design), runoff control requirements and clashes and diversion of other services. In general the total volume or area of a system is likely to be a strong predictor of cost; however economies of scale will affect construction costs. The cost estimate used in this study was generally based on the CIRIA Guidance (The SUDS Manual, C697, 2007).

SUDS require ongoing maintenance in order to ensure their operation and minimise risks to long term performance. Activities include inspection, monitoring and maintenance (could include regular, irregular and remedial). Costs will comprise labour and equipment, materials, planting (additional/replacement) and disposal (sediments and vegetation). Cambridge SUDS Design and Adoption Guide (2009), specified activities required for regular, periodic and replacement maintenance and gives indication of level of costs per activity.

3 RESULTS

3.1 Quantitative assessment

The tool was applied to an area greater than 1,900km². The quantitative element of the screening was implemented by assigning values to the selected parameters. As previously described, these were chosen to create higher scores for features exhibiting desirable characteristics. Key to successfully generating a useful ranking was to develop a scoring scheme in which different parameters were scored with different magnitudes. Thus highly desirable features (eg large building sizes) had a larger maximum score available than less desirable features (such as proximity to the main river). Similarly, reducing scores to create a range of values as the influence of the desirable feature reduced in magnitude was key to ensuring that a progressive scale was achieved.

The scored buffers and polygons were then overlaid onto the receiving polygon (building or man-made area) with attributes in the receiving polygon updated to record the score contributed by each considered parameter. This allowed the build-up of the total score to be visible later in the analysis if required. Where multiple buffer zones crossed the same polygon, the highest value contained in the buffer zones was assigned to the receiving polygon. When scores for all parameters had been assigned, the total score for each receiving polygon was calculated, with a ranking then applied to the total values generated.

3.2 Manual screening to generate shortlist

Once the rankings had been generated, the sites underwent a manual check. This was to identify any assets that should not have been identified (such as a railway line which scored highly but would be impractical to implement SUDS), locations where several assets were adjacent and should be considered together, and locations that were outside the study area or in areas unlikely to impact CSO spills. These factors were used to check the sensitivity of the output to give confidence to the screening approach.

To aid selection of the site for which a SUDS system was designed, some additional information was included (Figure 2). Surface water flooding maps (30 year return period) were displayed alongside the locations detailed in the flooding register of property flooding and the locations of non-main rivers, which may be suitable for receiving discharges from SUDS systems. This provided a good screening methodology to assess where SUDS retrofitting potential. It highlighted the areas that could contribute to the flood risk management and improve capacity in the existing drainage system. The screening has been also checked against Local Development Plans to assess the requirement for future developments and identify areas that would benefit from surface water removal to reduce pressure in existing drainage systems and provide capacity for future developments and economic growth.



Figure 2: Additional information included for manual screening

The limitation of the automated approach identified at the manual screening stage was where multiple small polygons can be considered as one site, or a site has been split in the MasterMap dataset into several polygons that fall just under the threshold of size for inclusion. The first of these scenarios was identified as having occurred at a location which historically had been a holiday village on the edge of Blackpool. The location was owned by a single landowner, however each holiday chalet was identified as a single polygon which was too small to be picked up by the screening exercise as the polygon areas were under the threshold set for consideration. However when considered as a whole, the site

became viable for consideration. This underlines the value of a manual check of the automated screening output in identifying additional sites for consideration. In addition, the manual check also offers the opportunity for council officers to identify any sites which have already had SUDS retrofitted, a dataset that is often not available as a georeferenced layer that can be included in the screening process.

3.3 Shortlisting of sites

Following shortlisting, SUDS options were screened for their actual feasibility on selected site. For the shortlisted sites, the traffic light system was employed to highlight the relative costs of installation and operation of the SUDS options suitable for each site to inform the final selection process. An extract of the table of first ten shortlisted sites for Fylde Peninsula has been presented in Table 2.

Table 2: Summary of shortlisted sites

Rank	Description	Area (m ²)	Potential SUDS application	Indicative installation costs	Indicative maintenance costs
1	Car park	25084	Porous pavements and/or street planters		
2	Supermarket	28247	Porous pavements of street planters for hardstandings, carparks, disconnection of roof drainage and diversion into the reservoirs located below porous pavements, potential for rainwater harvesting		
3	Industrial Estate	24023	Limited scope: porous pavements - depending on the type of industries on site. Potential for street planters		
4	Airport	20584	Diversion of some roof runoff into the adjacent open spaces: swales or a pond (depending on the scale of feasibility for disconnections), potential for rainwater harvesting or green roofs		
5	South Pier area	13456	Limited scope; porous pavements or street planters		
6	Space adjacent central pier	16624	Limited scope; porous pavements or street planters		
7	Building south of central pier	11912	Insufficient space for retrofitting, potential for rainwater harvesting to be considered depending on demand		
8	Hotel car park	10857	Porous pavements or street planters, potential of pond extension		
9	Man made space adjacent central pier	16482	Limited scope; porous pavements or street planters		
10	Hotel building	11788	Potential for green roofs, or disconnection of roof drainage and diversion into the reservoirs located below porous pavements, potential for rainwater harvesting, potential of pond extension		

A number of sites identified by the screening methods were already known to the Fylde Management Group members as sites with SUDS retrofit potential. Examples of this are the car parks in the centre of Blackpool, which had been identified by United Utilities as potential locations for disconnection from the combined sewer system. A significant number of new locations were identified that would both be suitable for SUDS retrofitting and offer potentially significant reductions in flows to the combined sewer system.

One such site identified was that of a large hotel which had a significant roof area, large car park area, was connected to the combined sewer network, has a pond in its grounds, and grounds of a suitable size to receive a number of SUDS options.

Sites such as the hotel and schools lend themselves to installation of specific features such as ponds and wetlands. These provide an aesthetic focus at hotels and leisure facilities, whilst at schools they are an excellent resource for teachers of a range of subjects such as biology. As well as reducing flood risk and improving chemical water quality (through natural treatment processes in the SUDS), if well designed these features will also increase biodiversity and can be linked into wider Green and Blue Infrastructure corridors, therefore providing opportunity for urban regeneration.

Other sites which consistently scored highly in the screening process were large supermarkets, hospitals, airport buildings and runways, and industrial units with connected car parks or works areas.

Concentrating on large sites creates the potential for significant reductions in flows from the sites, which will facilitate achieving a reduction in CSO spills, leading to improved water quality in the bathing water. Retrofitting SUDS at these sites also has the potential to reduce both property flooding and surface water flooding in these locations and adjacent areas, and depending on the selection of SUDS options also improve water quality with respect to heavy metal and other pollutant loads.

4 DISCUSSION

This tool has provided a platform for decisions making. Implementation of the project findings could be driven either by Councils or United Utilities. Fylde Council have already decided to implement a SUDS solution at one of their offices, to demonstrate the principles involved and highlight their commitment to the ideas. Further implementation at other sites could either be achieved by Councils funding schemes at sites they own or operate, acting as a stimulant to regeneration. Alternatively, pressing to meet legislative and policy requirements for regeneration through development or creation of Green Infrastructure projects could provide the catalyst and funding for additional retrofitting projects. Conversely United Utilities may determine on further analysis of project outputs that they have an economic case for implementing some of the suggested options at shortlisted sites, which would again stimulate regeneration and investment in the target locations.

Having proved the effectiveness and robustness of the screening process, further development of the screening process will lend it to application in different areas. For example the same principles can be used to aid early integration of SUDS options in Masterplans and identify scope for improving water resource management in water stressed areas. Furthermore, given the geographic basis of the analysis, it forms an excellent basis for integrating urban blue and green infrastructure requirements.

Blackpool suffers from a lack of green spaces, especially in and around the town centre and along the Promenade due to historic planning proposals and there are limited options as to what could be done. In order to create a viable strategy for future proofing SUDS retrofit in and around the town centre, it is essential that it is fully integrated with other spatial strategies, i.e. regeneration, green strategy, climate change, biodiversity or use of multipurpose open spaces including street and road corridors across the town. From the surface water point of view, this approach will not only add to the reduction of flood risk from surface water in some areas and reduce spillages of CSOs, but also unlock future development in and around the town centre and at the same time provide mitigation measure for diffuse pollution.

In order to be effective, the regeneration strategy including SUDS needs to be applied widely across the town centre and the funding is critical. As a starting point, having such integrated strategy would provide the evidence document needed to support any prospect application for funds through national or international sources, either for wider use or for funding individual pilot schemes.

5 CONCLUSIONS

The presented screening methodology provided a platform to analyse types of developments and open spaces across Fylde and draw general conclusions about potentials for SUDS retrofitting. It offers a simple and cost effective but versatile tool to identify suitable locations across large areas. Although other tools exist looking at environmental and planning impacts, at present no tool exists to identify significant opportunities for surface water flow reduction purposes. The presented tool highlights opportunities to reduce flooding, improve chemical water quality, improve bathing water quality where bathing waters are impacted by CSO spills and link into the development of green infrastructure.

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