Treating Discharges from Overflows

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1. Overview

The overall aim of this paper presentation is to build and establish a discussion on the potential to implement various forms of stormwater treatment methods in the UK, based on what forms of overflow discharge treatment are currently being utilised internationally, in particular in the US. In this case, stormwater treatment is defined as storm overflow discharges being treated via various methods prior to the flow entering a water body. The paper will also seek to understand how legislation and regulation could drive development of innovative technologies in the future. With a major focus on reducing discharges at all storm overflows, it is expected that treatment will become an increasingly used option.

Following recent collaboration with colleagues at Tetra Tech, it is evident that there is far more progression of overflow discharge technologies in other parts of the world. This investigation will open the discussion of whether technologies used elsewhere can be altered and adapted to suit the UK environment. A number of these treatment methods require large facilities, multiple support systems and prolonged contact time, hence descaling may be required and space constraints could potentially become a complication in future. Some form of decision-making framework will need to be designed and utilised to consider underlying factors such as land availability, and this would influence any treatment solution from being promoted here in the UK.

2. Legislation

The legislation within the UK is the main driving factor with regards to overflow discharge treatment.

Legislation – Storm Overflows Discharge Reduction Plan (SODRP) 2023

- The most recent legislation states that:
  - ‘*Water Companies need to **significantly reduce their untreated sewage discharges** from storm overflows. In some cases, it may be **better to treat discharges**, rather than reduce their frequency.’*
- To also protect public health in designated bathing waters:

- ‘*Water companies must significantly reduce harmful pathogens from storm overflows discharging near designated bathing waters, by* ***either: applying disinfection*** *or* ***reducing the frequency*** *of discharges to meet EA spill standards by 2035.*’

Legislation around the world

The US have a framework in place to compensate for more spills to occur when discharges are treated. This approach to improving water quality in sensitive locations could be more sustainable than attempting to reduce spills with current solutions, especially in countries regularly impacted by extreme weather. With climate change, population growth and increasing urbanisation, the likelihood of overflows discharges will increase. Could treatment offer a viable alternative to reduce the impact of increasing storm overflow discharges?

The Storm Overflow Discharge Reduction Plan

As stated in the Storm Overflow Discharge Reduction Plan (SODRP), “Storm overflows will not be permitted to discharge above an average of 10 rainfall events per year by 2050”. This is a very concise piece of legislation to instruct water companies to reduce discharges by a quantitative amount, however, could there be scope for alteration or adjustment in the future to consider overflow treatment? A consideration for the government and regulators could be to change legislation to give water companies greater clarity on how treatment may be used, rather than focusing solely on discharge frequency. This could also target the main harms that are presented following sewer discharge which include public health, as sewage contains high levels of harmful pathogens such as viruses and bacteria. Additionally, the environment is of course also under threat from contaminants, as spills from overflows can lead to ecological harm due to their impact on water chemistry.

Figure 1- Overflow discharging into watercourse.

3. Summarising treatment technology

There is an extensive variety of treatment technologies, and some methods are more effective than others, or focus on treating different types of pollutants.

The most common and well-known form of treatment is **Screening**, considered as a primary method to remove the solids. In the consideration of overflow treatment in future, the majority of screen meshes would not be small enough for the smaller pollutants such as e coli and other bacteria.

Storing and settling is another method of overflow treatment which is already seen in most treatment works within the UK. The duration of this process can vary depending on the incoming water quality so overflow discharges which have been heavily diluted may require less contact time than more concentrated discharges.

Secondary methods of treatment target finer pollutants such as bacteria but are ineffective against larger solids and sediments. The most common secondary form of treatment is **disinfection,** which is heavily utilised in other parts of the world such in the US. The main types of disinfectants include chlorine dioxide, peracetic acid and ozonation, which is already being used by UK water companies, potentially providing a base to integrate ozonation into storm overflow discharge treatment.

Ultraviolet (UV) radiation is another method of secondary treatment which breaks down small pollutants with UV light exposure. Figure 2 is an example of UV radiation being utilised in stormwater treatment within a facility outside of the UK.

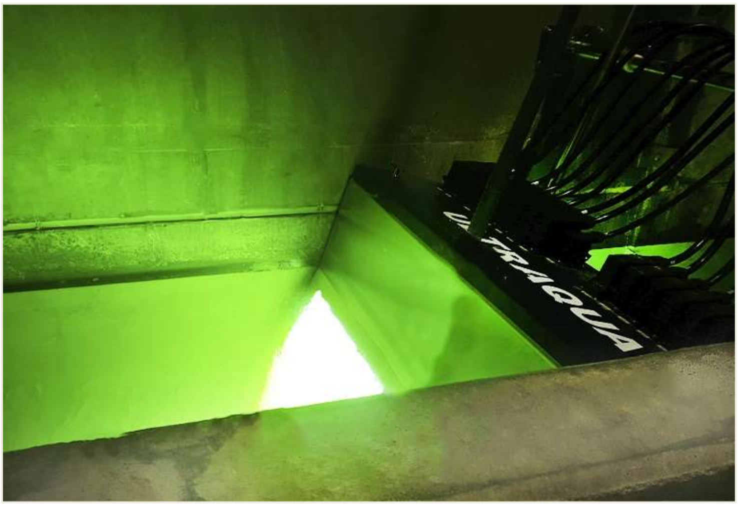

Figure 2 – Ultraviolet (UV) radiation facility being used for treatment.

A more common method of secondary treatment which could potentially be utilised in overflow discharge treatment in the UK are **constructed Wetlands.** Wetlands are common across the UK and greater adoption of this approach, utilising the natural environment to improve local water quality and reduce harm to biodiversity and human health, could potentially have wider benefits to stakeholders, regulators or members of the public (by providing new recreational space, for example).

Membranes have the potential to be implemented within constructed wetlands to aid with treatment, due to their versitility to grow in different environments. Funghi such as Mycelium act as a physical barrier stopping bacteria from passing but, with a light vacuum applied, water is pulled through.

To support the design, adaption and implementation of these treatment technologies in the UK water industry, it would be beneficial if government, regulators and stakeholders devised a framework to guide practitioners which overflow treatment methods are viable, and most suitable, for a range of circumstances.

4. The decision tree

A conceptual decision tree has been suggested as part of this paper to represent just a few underlying factors that will need to be considered when deciding which treatment techniques could be employed at overflow locations. Figure 3 gives an idea of what these influencing factors could be and what the initial consideration would be, which is what type of pollutant is being targeted at the given site. The top left table in the decision tree provides examples of the pollutant types and the corresponding methods of treatment that would effectively remove those pollutants. After the pollutant type has been distinguished at a location (this may require sampling or monitoring to capture when the overflow spills), the first treatment method can be taken through the decision tree to understand whether it complies with factors that would influence its suitability for use. The example used in the theoretical decision tree below is bacteria, which would require a secondary method of treatment, hence why UV, disinfectants and membranes have been listed in the next branch of the tree. One of the first considerations which would influence whether a treatment option can progress further in the decision-making process is whether the method is cost effective, hence a method of quantifying the benefits would be required, whether that is through the National Water Environment Benefit Survey (NWEBS) or another approach to management planning. The decision tree would then continue either to the next consideration or back to a different method of treatment if parameters such as contact time, spacing and support systems cannot be met. A similar concept to that presented below will need to be developed for water companies to discount methods of treatment at each location; to then identify the most suitable approach to improving water quality from overflow discharges.

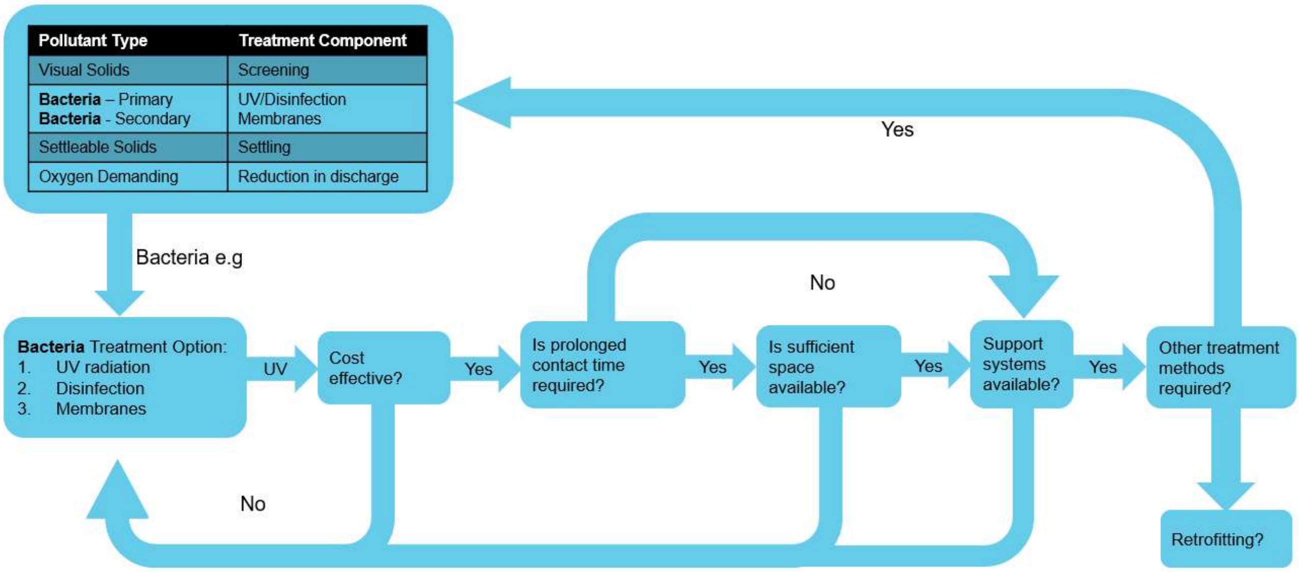

Figure 3 – A conceptual version of the decision tree to consider the parameters that would influence which, if any overflow treatment methods could be used.

4.1 Treatment train

Below is an example of a treatment train schematic of the treatment process within large facilities in other parts of the world, demonstrating the variety of support systems that can be required within these large treatment facilities. The complexity required is likely to be a key factor when implementing similar facilities within the UK, as the space and land availability for these systems may not be available, particularly in urban areas.

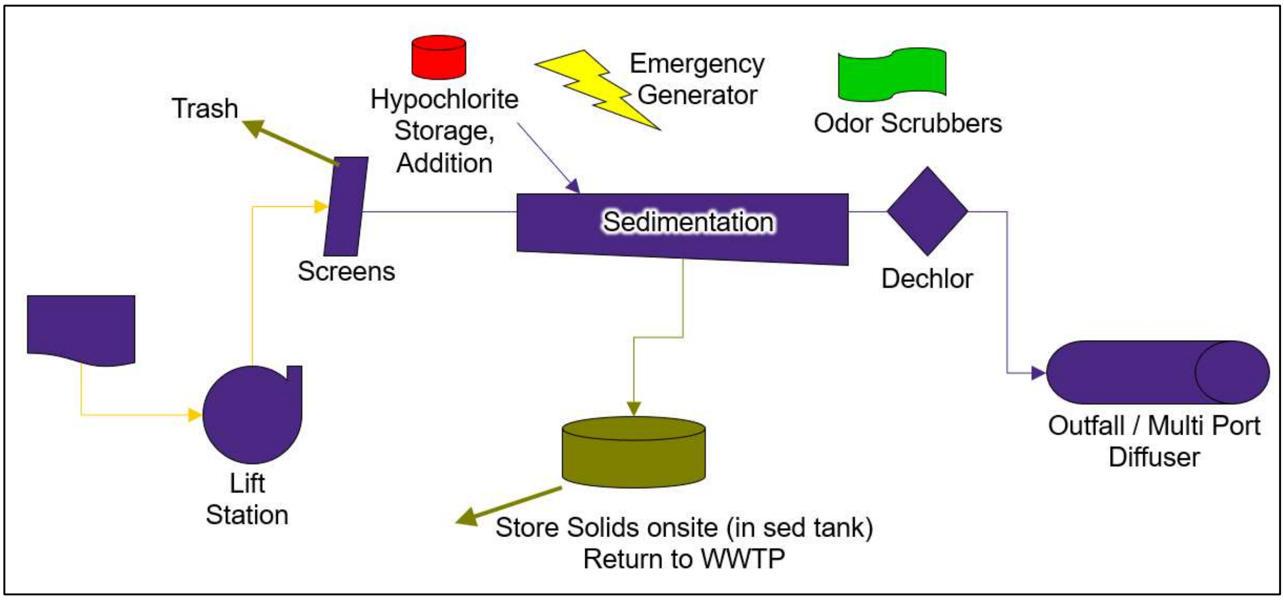

Figure 4 – An example of a treatment train for a typical storm overflow discharge treatment facility

5. Disinfection

Chlorine dioxide is an extremely effective wastewater disinfectant when introduced to flow as a gas during the treatment process. The main benefit of this type of disinfectant is that it is relatively easy and economical to produce, however this disinfectant, along with all others, are either hazardous to transport or should not be transported and therefore must be generated on site. This could lead to hurdles in the decision-making process, if the spacing or infrastructure is not available for generating these disinfectants on site. Ozone as a disinfectant is already being used by water companies in the UK at treatment works however, and so there could be potential to retrofit infrastructure at overflows or construct facilities to disinfect spills prior to entering a water body. Ozone requires a shorter contact time than other disinfectants and so would require less heavy infrastructure in the surrounding vicinity, which could potentially suit space-limited sites within the UK.

Figures 5 and 6 provide a degree of perspective on the scale of some sites around the world. As shown in Figure 4, these methods require suitable support systems which would demand a large plot of land. The space and land availability required for these facilities may prove difficult within the UK environment. However, if current infrastructure such as storm tanks can be retrofitted to mix chemicals for disinfection, then there is a level of opportunity.

Figure 5 – Large Disinfection facility (USA)

Figure 6 – Another large facility (USA)

6. Ultraviolet (UV) Radiation

UV treatment can provide effective disinfection by exposing wastewater to UV light. The main advantage of this type of treatment is that it requires short contact time and is effective against all known bacteria and viruses. Additionally, no hazardous chemicals are produced or released while treating discharges with UV; disinfection takes place without altering the physical or chemical properties of water. Although UV radiation is not harmful to the local environment, it is not effective in wastewater with high levels of suspended solids, therefore UV would only be considered as a secondary method of treatment.

6.1 UV Stormwater Treatment Facility Toronto

This treatment facility was constructed in the Sherbourne Common waterfront Park in Toronto in 2011. The nearby area is prone to storm overflow discharges during heavy rainfall which result in microbial contamination of water flowing into Lake Ontario. Ultraviolet (UV) water disinfection was chosen to treat discharges to make it suitable for human contact in Lake Ontario, as this area is used for recreational purposes. As a process, storm overflow discharges are collected in storage tanks for initial treatment, which removes the solids and sediments, then flows enter another large tank which acts as an artificial wetland to degrade the finer bacteria and viruses. The platform section of the facility has three voids for penetration of UV light for treatment after flow has been pumped out of the second tank. Treated water is then conveyed through a 240m long artificial channel which is accessible to the public. The channel also has biofiltration

Figure 7 – UV Stormwater treatment facility, Ontario

beds which further treat the water before discharging into Lake Ontario.

7. Membranes and wetlands

Membranes have the potential to be used in treatment as the fungal pore sizes are smaller than bacteria and particulate matter, so pollutants are prevented from passing onwards with the flow. There are different membrane pore sizes for removal of different pollutants, such as Micro, Ultra, and Nanobacteria.

Figure 8 – Mycofiltration for urban stormwater treatment

Mycofiltration is a treatment method already used in the UK which uses web-like tissue of mushroom-forming fungi like Mycelium to degrade pollutants such as e. Coli. Mycofiltration is a low-cost, low-impact method of treatment and requires relatively little installation space. In other parts of the world such as the US, it provides storm water managers with a tool to help them meet their legal obligations under the Clean Water Act. The main benefits of utilising membranes in wastewater treatment are the rapid capability to treat flows (two minutes). Unlike the other methods described above, a prolonged contact time is not needed for it to effectively degrade the pollutants. However, these membranes require very specific conditions to remain effective. If the membranes experience extreme freeze, then the flow bypasses them. Other extreme conditions can result in damage to the material over time, especially if the membrane is excessively used. Regular condition monitoring and maintenance of the membrane would be required for this method to remain effective, which would increase the associated costs of this option.

Engineered wetland systems are designed and constructed to replicate natural processes by using a combination of wetland vegetation, soils and associated microbial life to reduce contaminants and improve water quality. They are low cost compared to other more artificial technologies, but they are also ineffective in extreme conditions such as freezing temperatures, as the pore spaces can freeze, causing water to run off the wetland and bypass the treatment process. Floating wetlands can also be used. In these cases, plants are vegetated on a floating mat so that their roots extend down to the contaminated water below, acting as biological filters.

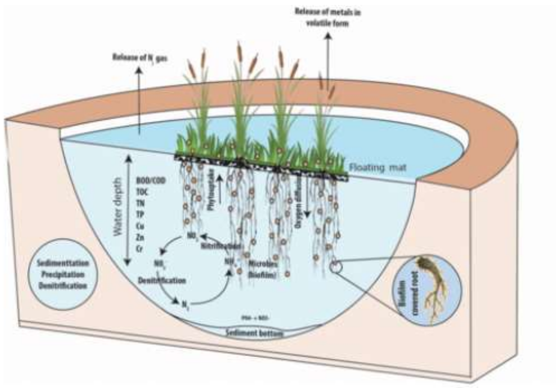

Figure 9 – Cross Section of a floating wetland

7.1 Innovation of Wetlands at Benfleet WRC

The flow being treated in this case study comes from storm overflow discharges. If this flow stayed in the system, it would pass forward to Benfleet Water Recycling Centre (WRC), where it would get directed to the storm tanks, which are at capacity, and likely spill to the Essex Estuary. Within the Benfleet Creek, there is a Site of Special Scientific Interest (SSSI) salt marsh which borders the WRC. Currently algal bloom is eating away at the marsh due to the build-up of pollutants in the marsh. In theory, by introducing mycelium to degrade pollutants, such as bacteria which allows algae bloom to flourish, this process will reduce the algae and allow the salt marsh to rejuvenate. Anglian Water are closely monitoring water quality in the marsh, enabling the comparison of the existing overflow discharges from the WRC storm tanks to understand the difference in water quality. Partners on this wetland include DEFRA, Southend on sea City Council, University of Essex and Kings College London. During this study, Anglian Water are also trying to acquire a very innovative style of sand that was analysed in The Netherlands which claims to absorb and remove organic matter.

Figure 10 – Benfleet Creek, Essex Estuary

8. Conclusions & Recommendations

To progress with more widespread implementation of stormwater treatment technologies in the UK, there are some key considerations.

- There are opportunities to learn from innovations currently implemented around the world and further investigations would be required to understand whether the UK can adapt/integrate such facilities in the UK.
- There are various methods water companies could consider when discussing approaches to reduce harmful pathogens and viruses generated from storm overflow discharges. It could be beneficial if some decision-making framework was defined to identify what types of treatment are viable and effective based on known constraints. This would serve to rule in or out various forms of treatment discussed in this paper.
- Is the current legislation clear enough or could water companies be given more precise instructions with regards to disinfection of storm overflow discharges? Discharges into bathing rivers would likely be a higher priority when deciding locations for overflow treatment going forward.

For development to be made, decision makers need a process which would allow them to identify and prioritise potential sites suitable for discharge treatment in the UK.