LOW TECH FLUSHERS – OPTIMISING YOUR WASTEWATER NETWORK AND SAVE !

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ABSTRACT

Flushing is a simple solution used for centuries to maintain effective drainage systems. Pioneered during Roman times and widely used throughout towns and cities by the Victorian's. But unfortunately a technique that has been forgotten and replaced in modern times.

Replacement systems to keep networks clean involve on-going maintenance commitments, such as pressurized water jetting units that have only a limited affect, spatially and temporarily. The current operational responses to networks, exhibiting low tractive force (grade), sediment and Fats, Oil and Grease (FOG), amongst others is to derive a repetitive cleansing programme or use potable water flushing tank installations. Several water companies have now tended to replace these with targeted problem solving and blockage removal efforts, that help to minimise operation expenditure but can lead to a widespread network deterioration over time.

The paper will show how one low cost technological solution has helped UK Water companies to optimise the value of their operational efforts, introducing efficiency to the wastewater network and reducing on-going maintenance expenditure. The technology also avoids the need to incorporate the use of precious potable water resources, using the wastewater itself to cleanse the network.

The paper will present examples of installations across several Water Companies in the UK, showing the outcomes that have helped remove sediment, prevent FOG build up maintaining the drain in a free flowing effective condition. The technology has great potential for helping wastewater networks perform across New Zealand.

KEYWORDS

Level of service, flushing, wastewater, low-technological, operational efficiency, blockages, Fats Oil and Greases (FOG), sewer cleaning, jetting

1 INTRODUCTION

As sewer system networks age, the risk of deterioration, blockages, and collapses becomes a major concern. As a result there is an ongoing requirement to take proactive steps to maintain or improve performance levels of their sewer systems. Cleaning and inspecting sewer lines are therefore an essential tool that helps to maintain a properly functioning system that requires continued community reinvestment annually.

From the time of their first use, sewers have been affected by deposition of all types of solids and sediments that enter into them, either with wastewater or stormwater surface runoff. The presence of large amounts of sediments leads to significant hydraulic restrictions of the sewer channels reducing the design flow capacity and increasing the risks of surcharges or local flooding during intense rain events (Gent et al.,1996; Arthur and Ashley, 1997; Fan et al., 2003).

A periodical removal of the sediments is therefore necessary to avoid or reduce these problems. Ongoing and frequent cleansing of sewers through sweeping or use of swabs are costly to keep in place can require the presence of sewage-workers inside the sewer system. Recent techniques, mainly based on the use of hydraulic devices, represent an automated cost-effective solution for the cleansing of sewers.

The frequency and rate of cleansing is wholly dependent on physical factors such as sewer gradient, usage factors, including the volume, flow and type of effluent/liquid. Deposition is encouraged through ongoing or regular insufficient transport capacity of the flow (failure to achieve tractive force design). As a result, periodic cleansing is required to maintain their function and their hydraulic capacity, to avoid blockages, flooding, odours, gases production and other related nuisances.

In general, sewers will not maintain self-cleansing velocities at all times (Fan et al., 2003). The diurnal pattern of Dry Weather Flow (DWF) and the temporal distribution and nature of the sediments found in the sewerage network may result in the deposition of some sediments at times of low flow (Fan, 2003). The subsequent erosion and transport of these sediments at times of higher flow during a storm-flow event, either as suspended load or bedload, contribute to the 'first-flush' phenomena or polluted segment of Combined Sewer Overflows (Arthur et al., 1996, Arthur and Ashley, 1998).

During the dry weather periods, solids deposited in the sewer systems can generate H_2S and methane gases due to anaerobic conditions, which can then interact with the various below ground sewerage assets to deteriorate them quicker than their design life. These sediments can also be discharged to the natural receiving water environment causing a degradation in the quality and habitats therein. So in short, the on-going cyclical dry weather sedimentation, left unchecked can create hazardous/odorous conditions and encourage more rapid sewer degradation, but also contributes significant pollutant loads to receiving waters.

2 CLEANING SEWERS

Initially, cleansing was carried out manually, then latterly through the creation of hydraulic flushing devices through to the more recent utilisation of mobile jetting technologies. The earliest evidence for using hydraulic flushing, i.e. creating short but strong water waves aiming to scour sediments and to transport them downstream, dates from Roman Empire, with General Agrippa identifying the need to discharge water from several aqueducts through the sewer system of Rome. (Malissard, 1994).

To maintain its proper function, a sewer system needs a cleaning schedule. There are several traditional cleaning techniques used to clear blockages and to act as preventative maintenance tools as described in Table 1 of the United States Environmental Protection Agency, 1999 and summarised below

Mechanical	Rodding Bucket Machine
Hydraulic	Balling Flushing Jetting Pigging
Other	Scooter Silt Traps Greast Traps and Sand/Oil Interceptors Chemicals Public Education and Pollution Prevention

Table 1: Potential mechanisms for cleansing sewers or maintaining sewerage system flows (adapted from United States Environmental Protection Agency, 1999)

3 OVERVIEW OF THE SIMPLE NETWORK FLUSHER

Fan, 2004 identifies that flushing of sewers has been a concern since Roman Times. The concept of sewer flushing is to introduce an unsteady waveform by either rapidly adding external water or creating a 'dam break' effect by quick opening of a restraining gate. The cleansing efficiency of these periodical flush waves is dependent on the flush volume, discharge rate, sewer slope, diameter and length. The main aim of flushing is to wash the re-suspended, scour and transport deposited sediments to strategic and more accessible locations within the network for it to be removed.

The simple network Flusher comprises a balanced hinged gate with the same width as the sewer cross section. During low flows, the self-weight of the gate holds the gate in the vertical (closed) position and the sewer flow builds up behind the gate (Figure 1). The depth of flow continues to build up behind the gate (Figure 2) until the force created by the retained water becomes sufficient to tilt the gate (Figure 3).

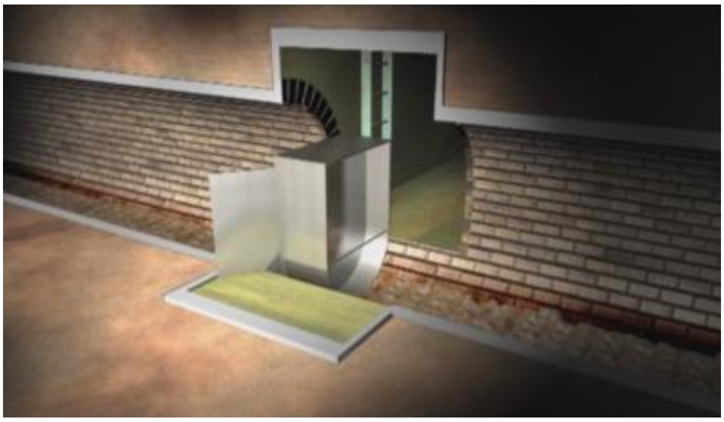

Figure 1 – Flusher gate in vertical (closed) position

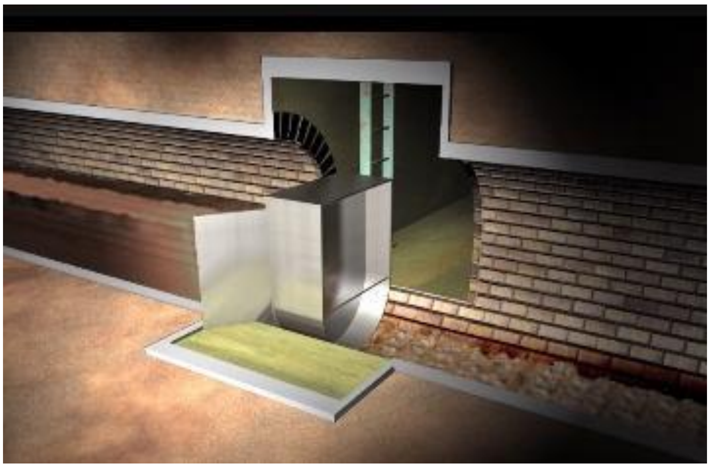

Figure 2– Flow building up behind flusher gate in vertical (closed) position

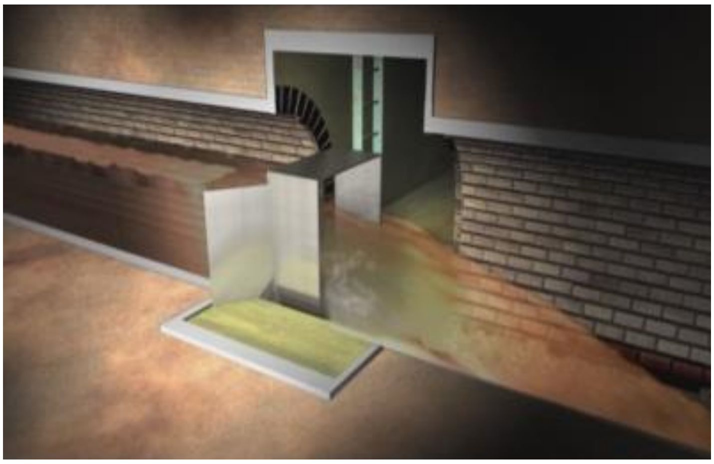

Figure 3 – Levels upstream of the flusher gate sufficient to overcome weight – Flush wave proceeds downstream

As the gate pivots about the hinge to a horizontal position, the sewer flow is released creating a flush wave that travels downstream and subsequently mobilises any deposited sediment from the invert of the sewer. The gate then returns to the vertical position and the cyclic process is repeated, thus keeping the sewer free of deposited sediment. It is advisable to position these Flusher gates at a series of intervals dictated by the nature, magnitude and location of the sedimentation problem.

The Flusher unit is a purely mechanical system that operates 24 hours a day, 365 hours a year. The unit requires no additional water other than the flow contained within the network and it is advisable for the gate to operate between 30 – 60 times per day gradually cleansing the network and then maintaining the free flow of the network. In addition, the constant changes of depth behind the flushing gate, helps to eradicate the conditions that allow Fats, Oil and Grease (FOG) compounds to accumulate within the sewerage system and hence provide further benefit to the network.

4 CURRENT UPTAKE & STUDIES

The longest running installation in the UK has been in place since 2009, installed in Ocean Road, South Shields for Northumbrian Water Limited (NWL). NWL provides water and sewerage services to 2.7 million people in the north east of England, covering the major population centres of Tyneside, Wearside and Teesside as well as several large rural areas across Northumberland and County Durham.

Ocean Road is a major thoroughfare within South Shields, consisting of residential dwellings and commercial units, with a high density of Food Service Establishments (FSEs), typical of urban centres across the UK.

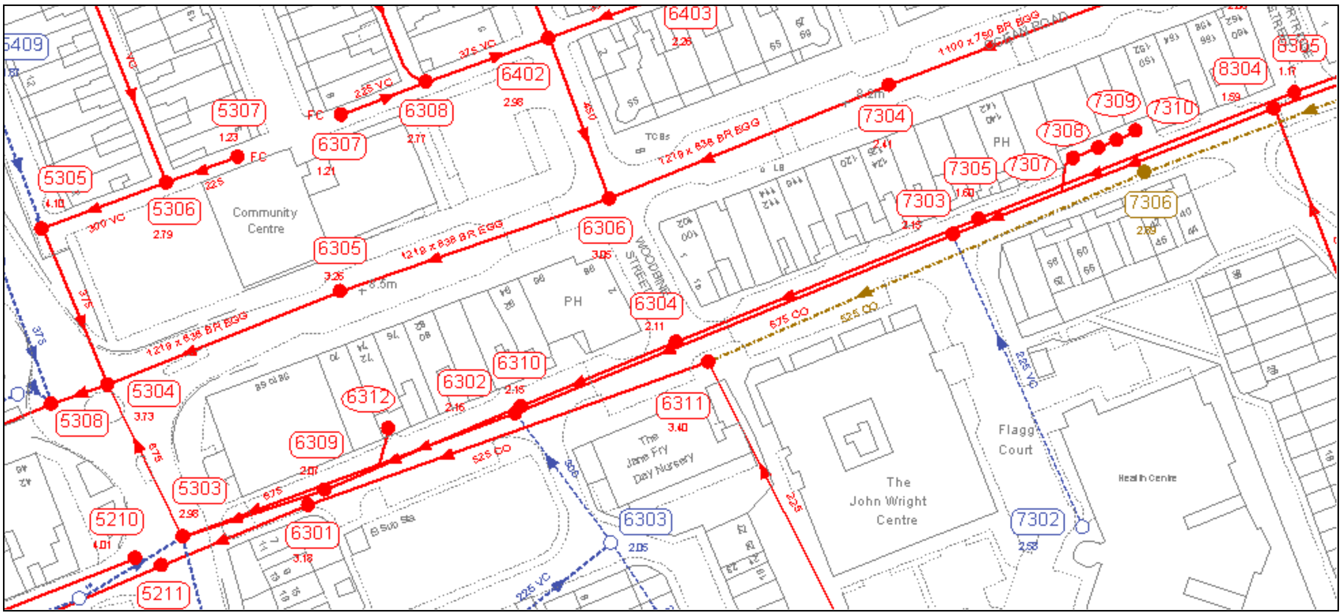

Figure 4 – Ocean Road, South Shields – Sewerage Assets (courtesy of NWL)

NWL prior to the trial in 2009 had a long history of service failures, with FOG blockages occurring every 6-9 weeks along the street. As a result, the assets on the street were cleansed every two months with the full catchment being cleansed annually.

Infotec installed a bespoke flushing gate unit (the Flusher), in 2009, within the 525mm sewer system along Ocean Road, shown in the images below, secured in place with expanding foam.

Figure 5 – A Flusher installed into a 525mm diameter wastewater sewer manhole.

During the trial, NWL cancelled the programmed cleansing works and undertook regular observation visits. The trial ended successfully with no reported blockages or other failures through Ocean Road and further down the catchment. Consequently, since 2010, there have been no service level failures, no reported blockages and no cleansing, including, significantly, further down the catchment.

It is conservatively estimated that this has saved NWL directly £30,000 per annum (inclusive of catchment cleansing, post-service failure cleansing, and the payment of Guaranteed Standards Scheme (GSS) penalties (where a company fails to meet the level of service standard required)) at an installed cost of £5,000. More importantly, the non-fiscal benefits should not be discounted at this point, including the increase in public confidence and the avoidance of the financial, social and environmental impacts of blockages.

Several other trials across the UK have had similar positive results including Ashford in Kent for Southern Water, Burton on Trent in Staffordshire for Severn Trent Water and several locations for United Utilities and Thames Water.

Additional evidence of the practicalities and usefulness of the Network flushers in providing the conditions to enable the mobilization of sediments throughout the network. An independent study undertaken by Atkins has identified that sited correctly the flushers could help to increase the peak velocities for over four kilometres.

Figure 6 below shows the results of a hydraulic modelling assessment undertaken on an example 150/225 mm diameter sewer prone to siltation at four separate locations. The sewers where silt occurs have been laid at gradients of less than 1 in 300, while the average gradient of the whole branch is approximately 1 in 120. The study investigated the effects of locating the flusher unit at five locations in the system and assessing the results.

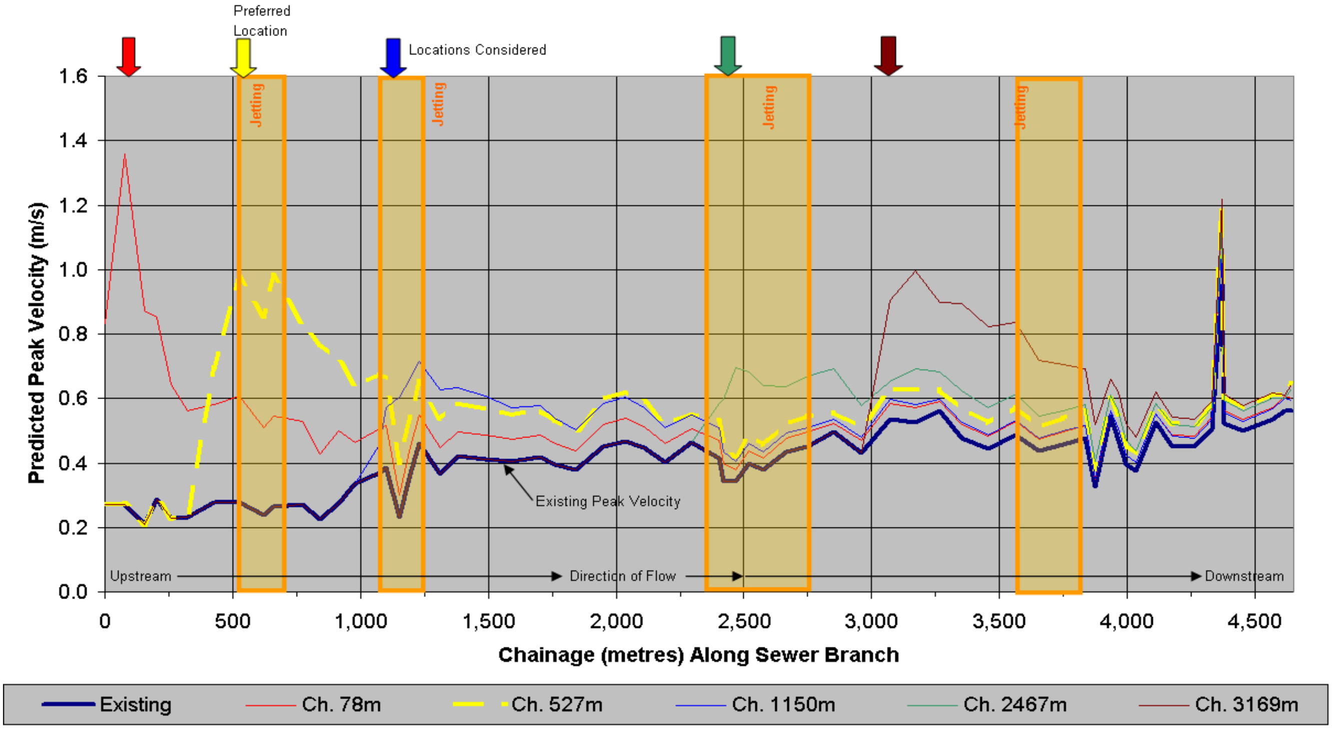

Figure 6 – Hydraulic analysis of flusher impacts on peak flow velocities across several locations.

The greatest increase in velocity occurs immediately upstream of the unit and within the first 500 m downstream. However, the units are responsible for an increase in peak velocity for up to 4.0 km downstream. Furthermore the increased velocity would be repeated for every operation of the Flusher unit which could typically be 50 times/day depending on the characteristics of the catchment, compared with perhaps twice per day at a lower peak velocity during the diurnal profile without a flusher.

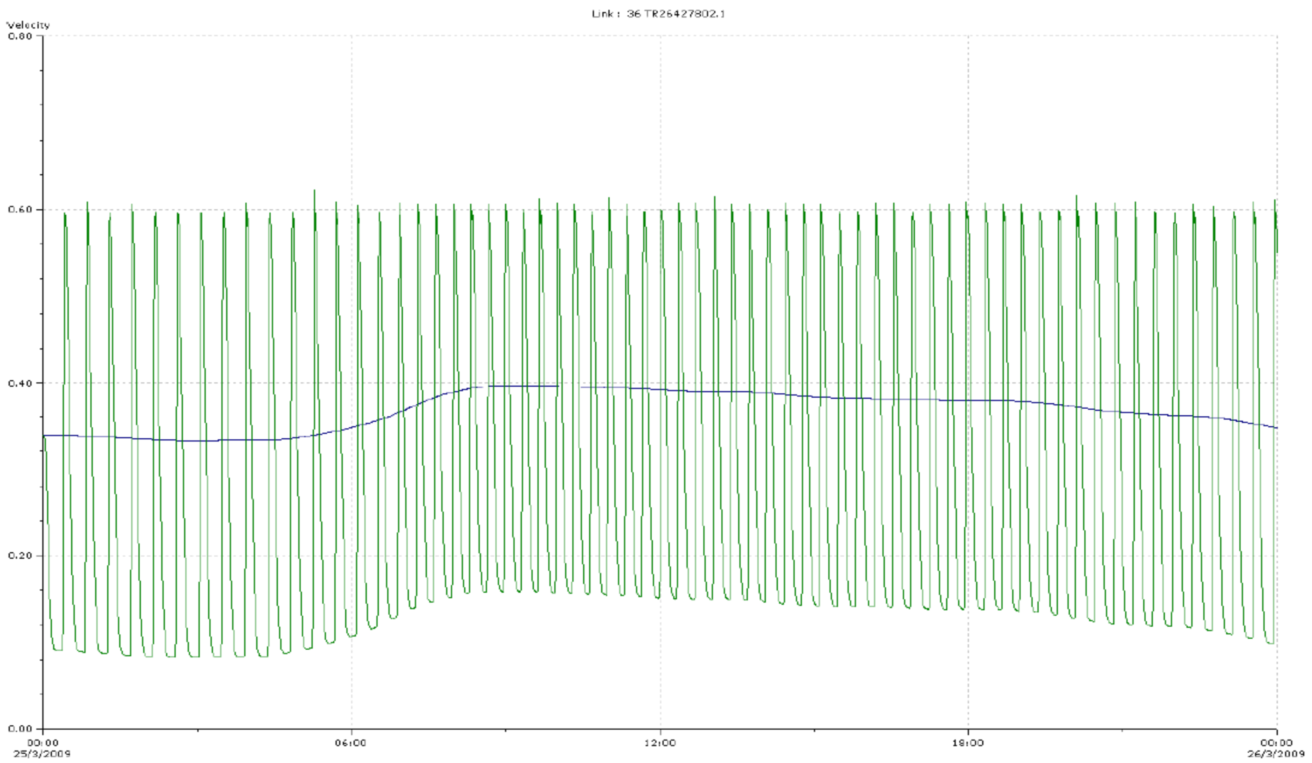

Figure 7- Modified Diurnal Pattern of Dry Weather Flow following installation of a network flusher (green)

It is predicted that the Flusher will operate 64 times in a typical day under dry weather flow conditions, therefore improving flow conditions to reduce or eliminate the conditions whereby sedimentation can take place. The daily peak velocity of 0.4 m/s occurring at about 9am is replaced by 64 occasions daily were peak velocities are greater than 0.55 m/s.

5 WHERE WOULD IT BENEFIT YOU

This low cost technology has the opportunity to deliver network optimisation of wastewater networks through actively removing the key aspects that reduce the levels of service, including sediments and FOG. It is recommended that there are a number of potential locations where installation should be actively pursued, such as:

- Locations which require regular cleansing, such as those with negative or low gradients, dips or misaligned joints.
- Locations not achieving tractive design force.
- Locations where there are large influxes of Fats, Oils and Grease from food serving establishments or processing plants
- Locations with long residence times where H_2S formation deteriorates the sewerage system and where odour issues are reported.
- Assets that require care to extend the lifetime of the asset, such as locations that are sensitive to traditional cleansing mechanisms such as the high pressure jetting equipment widely used. Examples of this include the less flexible pipe assets (i.e. clay pipes) remaining post-earthquake throughout Christchurch that are still operational but vulnerable to further deterioration from high pressure cleansing.

Furthermore, it is anticipated that with the increased focus on stormwater network performance that the network flushers could be equally as valuable for stormwater network assets and could help to maintain the hydraulic conditions, such that the capacity is available when required to help minimise the impacts of storm events.

In addition, the flusher assets could help attenuate storm flows through utilising the available storage within the network and twinned with improvements in flood forecasting and rainfall radar technologies could be utilised to help protect downstream locations from flooding and to help prevent unnecessary wastewater overflow discharges to sensitive receiving water environments.

6 LEARNING POINTS

The key findings from the pilot studies implemented across the UK indicate that the Flusher could offer a potential cost benefit solution under the right circumstances. The SWOT analysis below summarises the finding from installations to date:

Strengths

- Flushers are low cost technology that can be installed cheaply and efficiently and quickly.
- Cleans the network using rainwater and foul effluent passing through the system. Works 24 hours a day. 365 days per annum.
- The concept is adaptable. Pipe dimensions up to 600mm can be successfully accommodated but the most suitable installations for maintaining levels of service for wastewater networks are best accommodated in pipes with a diameter smaller than 225mm.

- Compared to modern traditional cleansing solutions, the flushers could provide a cheaper alternative for managing and maintaining wastewater networks.
- Can be used on storm water and waste water sewer systems.
- Existing infrastructure can be retro-fitted within minimal investment and help to protect vulnerable assets (eg. Clay pipes) from further deterioration from aqua-jetting.
- Reduced inspections and aqua-jetting of assets that require regular cleansing, such as those that are of low gradient (assets not achieving tractive design force) or subject to sewer misuse (such as Fats, Oil and Grease, wet wipes and sanitary products).
- Removes the conditions that lead to the build-up of Fats, Oil and Grease within the networks. Twinned with initial chemical dosing of the fat can help to remove and mobilise the hardened FOG debris to help restore the hydraulic capacity of the network.
- Variable flow conditions assist with reducing the potential for rodents within the sewerage networks.
- Low pressure system to cleanse assets particularly useful in areas with vulnerable and sensitive assets (such as lower flexibility pipe (ie clay) assets in earthquake damaged areas)

Weaknesses

- Not suitable for all applications and careful analysis to understand the pipe hydraulics is required to help avoid potential incidents.
- Introduces a potential blockage mechanism into the network if operation of the cantilever gate is compromised.
- Basic design does not remove silt and other sediments from the sewerage system, it assists with maintaining the tractive design force required to keep the sediments mobilised throughout the problem areas.

Opportunities

- Provides a real opportunity to extend asset life and improve levels of service in areas of slack gradients, providing a cost effective solution.
- Provides an opportunity to educate customers on wider messages regarding sewer misuse, overflow flooding and water efficiency.
- Could be integrated into wider network attenuation opportunities to help hold flow back within suitable networks to prevent flooding in downstream locations and could be utilised to help minimise unnecessary spills from overflows to the water environment
- Could be further developed to provide emergency attenuation for transport networks in areas where other storage and treatment devices are unable to be accommodated due to space

Threats

- Inclination of organisations to maintain them.
- Risk that operational staff could damage the equipment in the unlikely event of a blockage.
- Assets have an expected design life of 25 years and over that time it is likely that operationally they will have been forgotten or neglected if not on a semi-regular inspection regime. This in time could reduce the efficiency of the device as the assets are open to the conditions within these below ground assets.

7 FUTURE DEVELOPMENT AND NEXT STEPS

The focus of the works to date have been to deliver individual trial locations across several UK Water Companies to test the concept for future roll out. Based on the outcomes of these trials, it is clear that this technology represents a low cost and effective technology to help maintain serviceability of the sewerage networks in areas that are prone to blockage through poor design, installation, sewer misuse or other changes in catchment contributions (sediments and alternative effluents).

There are options to consider the potential of installing these devices within strategic locations of the stormwater and land drainage network can help implement small scale local catchment attenuation to derive benefit across the catchment. Additionally, future development is looking towards the benefit of adding these units to assist with spill response around space constrained transport networks, through developing automated locking capability to provide below ground attenuation of the pollutant to facilitate collection.

The studies have provided Water Companies with sufficient feedback to progress the concept further and wider catchment trials are being investigated to evaluate the long term effectiveness of the flushers in delivering improved network serviceability in areas

8 REFERENCES

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