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# Initiatives and changing approaches to addressing misconnected drainage - Ian Myers & Jon Snowden, Environment Agency

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## Introduction

This paper focuses on the scale and impact that foul drainage misconnections have on the water quality of our rivers and coastal waters and the actions being taken over the years to address this issue.

The misconnections problem has emerged from being a marginal water quality issue into a recognised Significant Water Management Issue (SWMI)[1] which requires increasing attention and new approaches, if we are to achieve a sustained reduction in both the incidence and impact of misconnections.

The case for adopting a more proactive and preventative approach versus more conventional, reactive and regulatory approaches are set out in this paper.

## What are misconnections and why do they occur?

Misconnections, or wrong connections, are the terms applied to situations where drainage from a building or site has been connected to the wrong part of the sewer network. For the purposes of this paper a misconnection is defined as being: *"any direct discharge by third parties of foul wastewater to a separate surface water sewer, or of surface water or groundwater to a separate foul sewer".*

For about 50% of the UK properties, foul water is collected separately and taken for treatment with surface water from rainfall allowed to discharge directly to a watercourses or groundwater. This approach is based on the premise that surface water is relatively free from pollutants which are diluted by higher volumes and cause minimal water quality issues.

Unfortunately, over time, this separation of clean and foul drainage has created an unintended but direct pathway for pollutants, including those from misconnections, to enter water bodies with serious consequences in some areas. Over the last twenty years increasing development and 'urban creep' coupled with a trend for house improvements and a DIY culture has resulted in more and more misconnections.

The scope of Building Control and planning regulation is limited and doesn't extend to all drainage work so is not effective to prevent misconnections. In addition, awareness about the concept of separate sewerage systems amongst professionals, building trades and the public is not at all assured and perhaps reducing amongst some sections of the population (see details of Ipsos MORI report below).

There is also the problem of 'clean' misconnections which occur when roof drains and clean surface areas are connected to foul drainage systems. Historically, some watercourses have even been diverted to combined sewers as an easy solution to meet development pressures. Excessive flows of

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[1] EA (2013) Briefing Note *Misconnections - A nationally significant water management issue*

clean rainwater into foul or combined sewer networks not only takes up sewer capacity causing premature overflows to water bodies but adds to energy use and the costs of treatment and conveyance.

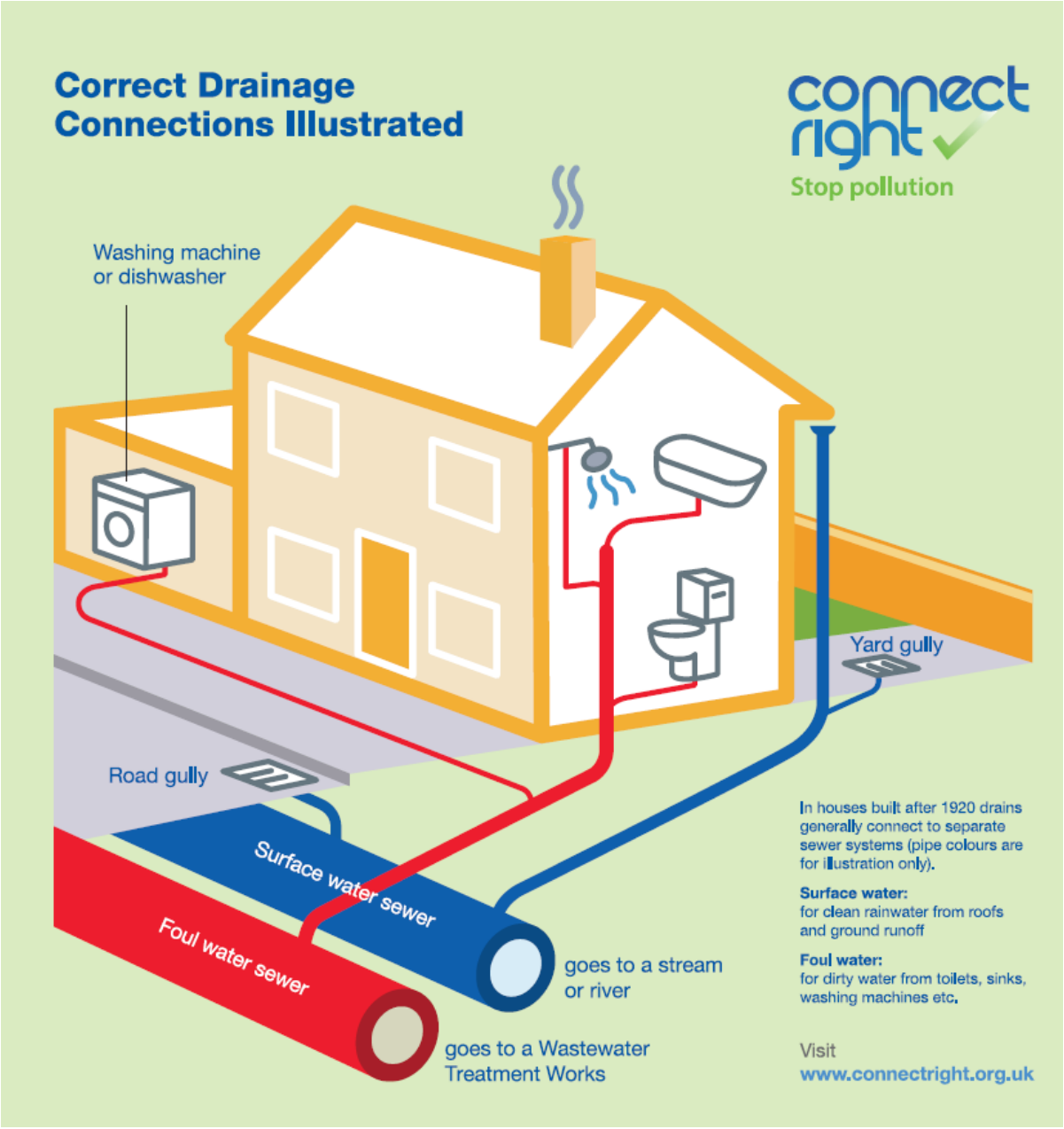


**Figure 1. Illustration to explain separate sewer systems with the correct drainage connections**

**What is the extent of the problem?**

There has been an extensive effort to investigate and rectify misconnections since the 1990s by the Environment Agency [and National Rivers Authority previously], water companies and local authorities, generally focused on the most obviously polluted outfalls. Despite this effort impacts from misconnections are still apparent.

The number of reported incidents of polluted surface water outfalls attributed to misconnections has increased steadily from 150 in 2008 to over 400 in 2013[2]. However, this data cannot be considered

[2] Environment Agency, National Incident Database, 2008-2013

comprehensive due to inconsistencies in recording incident sources and might exclude a significant number of incidents reported direct to water companies. In any case, the number of misconnections indentified by water company investigations greatly exceeds this annual figure. Unfortunately, it is a matter of 'seeking and thou shalt find'.

The true scale and impact of misconnections remains particularly difficult to quantify due to the complex nature of urban drainage and the masking provided by other polluting sources. Misconnections are often only one of several significant impacts on water quality.

There are various estimates of the extent of sewer misconnections. In 2007 the Environment Agency considered that as many as one in five properties in some areas have misconnections that discharge effluent into rivers. It is realised that the true scale of the problem and its impact on water quality is not fully known beyond local assessments[3].

A recent UKWIR project[4] estimated the potential number of misconnections in each of the water company catchments, see figure 2 below. This is based on the numbers of misconnections found from investigations, property housing stock, types of drainage system and incidents of polluted outfalls. Whilst the dataset was limited it does provide an estimate of the potential overall scale of the problem for water companies although these figures might be regarded as a conservative estimate.

| Source | Above ground external misconnection | Internal waste pipe to internal pipe | Underground misconnection within curtilage | Underground misconnection outside curtilage |
|---|---|---|---|---|
| Anglian Water | 15,900 | 6,700 | 600 | 900 |
| Welsh Water | 4,800 | 2,100 | 200 | 400 |
| Northumbrian Water | 6,300 | 2,500 | 200 | 500 |
| Scottish Water | 10,400 | 4,700 | 400 | 300 |
| Severn Trent Water | 28,400 | 11,700 | 1,000 | 1,300 |
| Southern Water | 10,600 | 4,300 | 400 | 500 |
| South West Water | 2,400 | 1,000 | 100 | 200 |
| Thames Water | 32,300 | 13,600 | 1,000 | 1,200 |
| United Utilities | 14,400 | 5,700 | 500 | 1,100 |
| Wessex Water | 6,500 | 2,900 | 200 | 300 |
| Yorkshire Water | 9,800 | 4,200 | 300 | 500 |
| TOTAL | 141,800 | 59,400 | 4,900 | 7,200 |

**Figure 2. Estimated number of potential misconnections by water company - UKWIR (2013)**

[3] EA (2007) The unseen threat to water quality, Diffuse water pollution in England and Wales report
[4] Dolata, M. Moore, R. & Orman, N R. (2013) UKWIR Report 13/SW/01/3 Sewer Misconnections – What Is The True Non-Agricultural Diffuse Water Pollution Impact?

**What is the affect of the problem?**

In the UK today it is estimated by the Environment Agency that around 15% of Water Framework Directive (WFD) water bodies and 9% of EU designated Bathing Waters are impacted by misconnections. This impact is significant because our rivers and coastal waters not only sustain wildlife but are important to our health and wellbeing, tourism and the overall UK economy.

Discharges from misconnections contain a wide range of indicator pollutants used to assess water quality compliance that are typically found in sewage. These include phosphorus, dissolved oxygen, ammonia, faecal indicator organism (FIO) and certain persistent chemicals. The following diagram provides a pressure analysis for the urban and transport sector for failing water bodies[5]. Excluding physical modification, the top four pressures can be linked to misconnections.

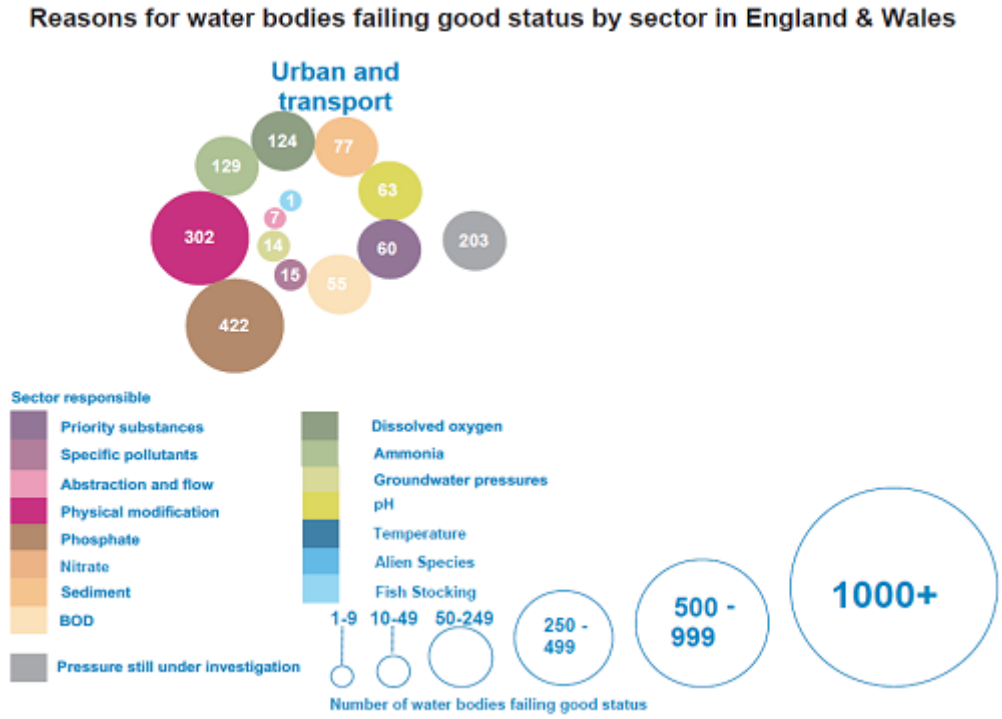


**Figure 3. Pressure analysis of water bodies failing 'good' status in England & Wales in 2012 for the Urban Transport Sector**

The contribution from misconnections to failing water quality standards with respect to sanitary determinants and nutrients is largely considered to be relatively minimal compared with other sources. However for some determinants and some water bodies misconnections might be the most significant issue to address. FIOs have been identified as a significant issue for the second round of river basin planning, because of their inclusion in 'Protected Areas' objectives for Bathing Waters and Shellfish Waters.

The seaside economy is hugely important to this country, contributing more than £3.6 billion[6] each year, so it is crucial that bathing water quality is protected and improved. The circa 160 million visitors to Britain's beaches want their sea water to be clean and safe[7].

[5] Environment Agency, 2011 update Reasons for Failure, v27.06.2012
[6] Sheffield Hallam University (2010)The Seaside Tourist Industry in England and Wales Employment, economic output, location and trends – BRADA report
[7] GB day visitors statistics for 2013 (produced by TNS) for Visit England, Scotland & Wales and Factors influencing beach visits Ipsos MORI survey 2012

Bathing water quality has improved significantly over recent decades. Over £2 billion has been invested by water companies to improve bathing waters since privatisation and there are over 300 schemes planned for 2015 -2020 to improve bathing waters. Compliance with the current Bathing Water Directive (cBWD) standards is good (99.5% of designated waters in England complied with mandatory standards in 2014). However, we must not be complacent as sustained compliance is not yet assured and those bathing waters 'at risk' where misconnections are known to be an underlying feature, will no doubt be difficult to improve. Furthermore, the introduction of the revised Bathing Water Directive (rBWD) in 2015 will see standards introduced that are twice as strict and overall compliance will consequentially decline.

Chemicals of particular relevance to misconnections are Nonyl-Phenols (NPs) and their Ethoxylates (NPEs) which are restricted under UK and EU legislation. These chemicals are commonly found in imported clothing and released into the aquatic environment via washing clothes. A very basic estimation suggests that chemicals from imported clothing might account for up to 20% of NP and NPE in UK rivers[8]. On average, based on water company investigations, circa 35% of all misconnections found are from washing machines or sinks which means that misconnected washing machines are a significant source of these chemicals. There are other key persistent priority and specific chemicals that are found in domestic sewage that are relevant to the impact from misconnections.

In addition to the WFD related failures, misconnections can also degrade our urban green spaces affecting the amenity and wellbeing of local communities. Visual impacts from misconnections are often made worse in drier weather when 'sewage fungus' or the effects of eutrophication become more apparent. Access and use of such urban green space also increases in warmer drier weather.

**The traditional 'find and fix' approach**

Sewerage managers have been faced with misconnections ever since separate sewer systems were introduced. The Water and Sewerage Companies have legal responsibility to investigate pollution from their assets. The cost of investigating sewer misconnections is therefore usually met through Water and Sewerage Companies' Asset Management Plans and water rate payers.

The cost of actually fixing misconnections once identified usually falls to property owners. Identifying misconnections especially in extensive surface water catchments can be very costly even though most drainage rectifications are usually relatively low cost to resolve.

Although national coverage is incomplete, data collated by the NMSG from Thames Water, Wessex Water and Severn Trent Water identify the average cost of tracing a misconnection is circa £1000. Although some business efficiencies can be made by having a dedicated team and standardised ways of working, the vast majority of this cost being simply staff time.

The extent to which this effort has resulted in achieving compliance with WFD standards is not yet clear although there are some notable local water quality improvements including urban rivers like the Brent and Rodin in London. Focussed investigation to ensure Bathing and Shellfish Water compliance is also occurring with the Environment Agency leading this work particularly in the North West and South West and working with Southern Water on some south coast investigation projects.

On average 2.3% of properties on networks investigated have some sort of misconnection. Of the misconnections found approximately 35% are due to above ground connections of washing machines, 10% dishwashers and 20% sinks with 5% being toilets and 1% being the whole property. A significant number of other problems are due to particular issues like dual manholes that can allow undetected cross contaminated of foul to surface or surface to foul. There is very little knowledge on the extent of clean misconnections.

[8] Environment Agency, Chemicals Compliance Team, Annual Enforcement Report 2011/2012, https://publications.environment-agency.gov.uk/PDF/GEHO0712BWSX-E-E.pdf

The data obtained from water company investigations is variable and incomplete. For instance, misconnections rates vary from <1% to 30% in some drainage catchments depending on housing stock and other factors. The percentage composition of misconnection types also varies for example with washing machines ranging from circa 20 – 50%.

The benefits of achieving a national data set have yet been realised due to inconsistencies in data capture, reporting and differences in the ways of working of water companies. To assemble this will require a commitment from water companies to harmonise reporting. Developing a more complete national picture will allow targeted intervention supported by a weight of evidence.

Investigation by water companies to find misconnections is only effective if they are consequentially rectified by property owners. Water companies do not have legal powers to rectify misconnections and so rely on others to enforce corrections. The extent to which local authorities have, and are still able to provide support to ensure rectifications is a key factor in making progress. Thames Water recently reported to the NMSG a current backlog of over 1000 misconnections which have been referred to London councils. The Environment Agency, supported by Severn Trent Water, has successfully completed a trial to assess how it might use its' own Anti Pollution Works Notices (APWNs) powers where property owners fail to act voluntarily. Regardless, legal action to rectify misconnections is costly, cumbersome and resource intensive.

**Bringing people together**

By 2008, with increasing water company activity and growing evidence, the misconnections problem was recognised as a national issue requiring a coordinated and strategic response. The National Misconnections Strategy Group (NMSG) was formed in 2008 as a national steering group comprising of the UK water and sewerage companies, Consumer Council for Water (CCW), Defra, Welsh Assembly Government (WAG), Environment Agency, Chartered Institute of Environmental Health (CIEH), Chartered Institute of Plumbing & Heating Engineering (CIPHE) and an independent communications expert. The aim of the NMSG was to actively and sustainably reduce the number of misconnections by promoting best operational practice and through influencing key stakeholders.

This approach has raised the profile and understanding of the misconnections problem, influenced the activity of other stakeholders, such as the WaterSafe initiative, and enabled an active work program delivering some key outputs including the ConnectRight brand and the Good Practice Guide (both discussed below).

The work of the NMSG and its' members has undoubtedly increased the profile and technical focus on misconnections. CIWEM has developed a Policy Position Statement[9] as part of this wider influencing. It is anticipated that this will be further enhanced and embedded in both the Defra Non-Agricultural Diffuse Pollution Action Plan and the Water UK 'sewerage roadmap'.

The forthcoming Defra Action Plan has been borne out of the earlier consultation paper on broader Non-Agricultural Diffuse Pollution. Specifically with regard to misconnections it will identify a number of potential measures to address the misconnections problem. The Action Plan is currently undergoing final review prior to Ministerial sign-off and is expected to be released in 2014.

This concept of 'bringing people together' to share evidence, expertise and resources can be applied in a broader context. As can be seen from later in this paper, the misconnections problem requires a coordinated and sustained approach and is dependent on a diverse range of skills and people. They include policy makers and regulators, planners, plumbers and engineers, communications specialist and of course, the public.

[9] http://www.ciwem.org/policy-and-international/policy-position-statements.aspx

**Prevention is cheaper than cure**

There is a stark contrast between the average cost of £1000 to trace a misconnection and the cost of fixing a typical above-ground misconnection, which often can be <£100 and resolved without professional contractors. Rectification costs of course vary greatly depending upon whether the misconnection is above or below ground and the complexity of any connection required.

The projected national picture is similar. UKWIR reported that a targeted programme to identify misconnected properties in the UK has been estimated at £190 million and rectification of misconnections will cost around £42.5 million once identified[10]. This is a clear steer that prevention is cheaper than cure.

One way of preventing misconnections occurring is to raise awareness about the issue and explain the unintended consequences of people's behaviour. First it is necessary to understand the barriers and motivation behind people's behaviour which leads to misconnected drainage.


**Figure 4. ConnectRight campaign leaflet**

**The ConnectRight campaign**

An Ipsos MORI research project[11] commissioned by the NMSG and completed in April 2009 to provide baseline measures of awareness and understanding of 'misconnections' issues amongst the pilot audiences in certain hotspots - London, Torquay and Birmingham. The study also explored

[10] Dolata, M. Moore, R. & Orman, N R. (2013) UKWIR Report 13/SW/01/3 Sewer Misconnections – What Is The True Non-Agricultural Diffuse Water Pollution Impact?
[11] Ipsos MORI Misconnection Research 2009

attitudes and perceptions about the impact of misconnections in terms of the effect on the environment and quality of life.

The study found that a third of respondents do not have any idea what type of drainage system their property had, with 15-34 olds and women least likely to know. Eight in ten respondents claim that most household installations were plumbed in by qualified tradesmen and nine out of ten felt this would have been done correctly. 55-64 year olds were most likely to correct bad plumbing if they found out about it. The youngest (15-24) are split, with some being the least likely to correct bad plumbing, claiming that it is not their responsibility. Women cited safety reasons as the main reason for correcting bad plumbing. Those in the London urban area appeared to be more insular and influenced by things that affect them directly, rather than their local area or community. 35-45 year olds and men more than women are most likely to say they would correct bad plumbing to avoid further damage. Overall, nearly seven out of ten thought that it was unlikely that they would be traced and fined for misconnected drainage.

The study provides an understanding of public attitudes and perceptions with some insight into how to convey key messages to target audiences. Considering this study, the NMSG launched the ConnectRight leaflet and website in 2009 with the intention of raising public awareness of misconnections. Although initially well received, by 2013 it was recognised that the website needed to be significantly updated as evidenced by dwindling visitor numbers.

To start this update a branding workshop was held in September 2013 to better understand key audiences, messages and possible barriers and motivations to act. At this point the scope of ConnectRight was expanded to include both public and professional audiences, recognising that plumbers and builders are responsible for causing around 80% of misconnections. The scope was also expanded to include related pollution from sewer misuse including blockages arising from 'unflushables' and fat, oils and grease as well as related urban drainage issues.

This event was a springboard to evaluate ConnectRight as a UK brand and public face of the NMSG. The objectives were to develop a nationally recognised brand and campaign along with a set of marketing products including the new website. This would deliver targeted 'call to action' messages and provide a 'one-stop-shop' source of reference to professionals and partners. In short, it seeks to *connect* people to their local environment and encourage them to do the *right* thing.


**Figure 5. Extract from home page of ConnectRight website**

The new ConnectRight[12] website has received widespread acclaim. It delivers, amongst other things, a five step tool for householders to check if they have a misconnection, 'professional pages' containing educational and campaign resources and 'local pages' to show case activity and events at a regional level for those with an interest in water pollution including the general public.

The ConnectRight campaign and new website was launched in February 2014 at an event attended by The Rt Hon Dan Rogerson MP Junior Minister for Water, amongst other keynote speakers.


**Figure 6. ConnectRight Campaign Launch in London February 2014**

The ConnectRight campaign is supported by a diverse range of partners and the suite of marketing material (available through the website) has proved particularly successful for community engagement including 'Love Your River' and bathing water engagement events. Support is growing, particularly with the third sector, but there remains a challenge to unite all stakeholders behind a single national brand. Until then, a sustained national campaign universally supported by the key stakeholders cannot be assured.

To be successful the ConnectRight campaign needs to bring about a national step change in awareness across a wide social and professional spectrum, using social marketing techniques similar to those used for other issues such as drink driving or seat belt safety. To do this a national approach is needed with organisations supporting the ConnectRight campaign working together and employing social marketing techniques to get these messages across rather than relying on the more traditional and local communication methods.

**Raising awareness amongst civil society groups**

There are approximately 300 environmental charities/civil society groups in England, otherwise known as 'the third sector'. As alluded to above, misconnected drainage can often be an emotive issue prompting local action. Indeed local knowledge, ownership and action are integral to Defra's Catchment Based Approach (CaBA) to securing WFD improvements to local water bodies.

Defra is working with civil society at a national level asking them to raise awareness amongst their members by sign-posting them to the ConnectRight website, encouraging them to check their own homes and properties belonging to their group or charity.

**Raising awareness amongst social housing providers**

This sector controls around 17% of England's housing stock. There are approx 4m[13] social rented homes in England, of which 0.5%[14] are estimated to be misconnected equating to around, 20,000

[12] http://www.connectright.org.uk/
[13] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285001/Dwelling_Stock_Estimates_2013_England.pdf

homes. This accounts for around 15% of misconnected properties in England. This concentration of ownership creates an opportunity to target a significant number of misconnected properties through a relatively small group of organisations for whom compliance with the law is especially important.

Defra is considering engaging with the social housing sector to raise awareness, explain the issues, and ask them to add misconnections to their maintenance register thereby addressing existing and avoiding future misconnections.

**Raising awareness amongst manufacturers and retailers**

Evidence from water company investigation highlights that of the total misconnections identified, on average, around 45% are from washing machines and dishwashers. This would suggest that manufacturers and retailers of 'white goods' hold a position of responsibility and influence in conveying awareness of misconnections to their customers.

Similarly, around a further 20% of misconnections can be attributed to both kitchen and bathroom sinks. These types of 'grey-water' misconnections are most likely to be above ground and perhaps channelled through rainwater downpipes for ease of connection and to keep cost down. These types of misconnections are also perhaps the most likely to be caused by the DIY enthusiast. This would perhaps further suggest that plumbing merchants and DIY outlets could also have a role in conveying awareness with their customers.

Previous discussions with white good manufactures and DIY retailers to help the cause have proved relatively fruitless. An aim of the NMSG and Defra is to engage the manufacturing and retail sectors with renewed vigour, getting their views on what should be done and how they could play a part. Possible options might include key messaging on/in packaging and at point of sale displays or 'how to' guides. These opportunities are best secured at a national-once level by engaging with trade bodies, to possibly develop a voluntary agreement providing the flexibility of a suite of options for members to use in reaching their customers.

**Raising awareness amongst professionals**

The misconnection problem has in the past been regarded as a matter solely for environmental regulators and water companies. However, in order to address and prevent misconnections other professionals need to become more involved.

Surveys by water companies of property owners have established that many misconnections they find are caused by professional builders and plumbers rather than 'DIYers'. Raising awareness across the construction and housing industry therefore has to be a key component of any prevention activity. This is often best done once, via national organisations and professional bodies utilising existing communication and training mechanisms.

The water industry has launched schemes such as the WaterSafe[15] approved plumber scheme that ensures a level of awareness about misconnections as part of any accreditation. It also provides reassurance for property owners and supports responsible businesses.

Partners on the NMSG include the Local Authority Building Control and the Chartered Institute of Plumbing and Heating Engineers and such groups are important in cascading good practice amongst their members. Recent initiatives have been taken with organisations such as the Royal Institute of Chartered Surveyors (RICS) and the National Association of Drainage Contractors to encourage property drainage surveys and develop training courses for members. Much more can be done to engage with other groups such as the Car Wash Association, the Royal Institute of British Architects

[14]Dolata, M. Moore, R. & Orman, N R. (2013) UKWIR Report 13/SW/01/3 Sewer Misconnections – What Is the True Non-Agricultural Diffuse Water Pollution Impact (Table 8 estimated number of misconnected properties).
[15] https://www.watersafe.org.uk/

(RIBA) and Local Government Association to develop solutions and raise awareness through their interactions with property owners.

**Good Practice Guide – technology and techniques**

In 2009 the NMSG developed the first version of the Good Practice Guide that identifies "an operational approach for investigation and resolution of pollution from surface water sewerage systems affected by misconnections" (Water UK, 2009)[16]. This guide delivered a more consistent approach and reflected the existing partnership working between the Environment Agency, water companies and local authorities.

The guide is currently under revision and will now set out more broadly, how pollution from surface water sewers needs to be addressed. It links to existing agreements between the Environment Agency and water companies on responding to incidents from surface water assets. As such the latest version reflects the new reality of having to prioritise limited resources to achieve the desired water quality compliance for rivers and coastal waters affected by the cumulative impacts of drainage from numerous outfalls.

The guide also includes information on new investigation techniques such as the use of fluorimeters that can quickly and easily detect pollution via surrogate determinants such as dissolved organic matter, optical brighteners or tryptophan, an amino acid found in sewage. Finding intermittent and low volume discharges from misconnections, such as washing machines, can be extremely time consuming and is therefore a key cost to reduce. In the past investigation activity has often been restricted to periods of low flow but with fluorimeters, pollution can be found more easily in periods of wetter weather. This should lead to faster, easier and more thorough misconnection detection. This is essential to help deliver the efficiency gains that are necessary given the future demands on resources.

The latest version of the guide has undergone consultation and is currently undergoing final revision prior to sign-off and publishing. It is hoped that the new guide can be 'rolled out' by the NMSG to key stakeholders in 2015 using a workshop approach.

**A proactive approach through 'hotspot' mapping**

Whilst water companies have renewed their commitment to investigate and identify misconnections in their business plans for the next Asset Management Plan (AMP6) period 2015 to 2020, it must be recognised that their resources are limited and might be better focussed on other activities or expenditure. Any evidence or tools that can be developed to determine the likely prevalence of misconnections, and thus help direct expenditure to best effect, should be pursued.

There are many data sets which provide evidence of either where misconnections are believed to occur and cause a known problem (i.e. reactive) or are likely to occur (i.e. proactive). These data sets include incident management records, 'reasons for failure' data, age, size and type of housing stock, sewer plans, infiltration plans to name but a few. Other data sets may be available and currently being used by key stakeholders such as water companies, local authorities and the Environment Agency in drainage planning, development planning and river basin planning.

Out of this evidence base is born the concept of 'hotspot' mapping where such data sets can be used in combination to risk assess the likely prevalence of misconnections. Where risk factors align, i.e. the greatest 'heat', this should point to the greatest likelihood and density of misconnection occurring. For example, misconnections are more prevalent in certain types and ages of property; 1950s semi-detached housing is a particularly problematic category. If these property types and ages could be mapped together with other risk factors, it should identify 'hotspot' areas where investigations and campaigns might be targeted.

[16] http://www.water.org.uk/publications/reports/investigation-and-rectification-drainage-misconnections

The long term objective would be to establish misconnections hotspot mapping into water companies' 'day job' thereby keeping it live and integrated into sewerage management planning technical work and reported in their Drainage Strategies (as per the Drainage Strategy Framework). The project will seek to demonstrate how this can be done and the benefits to water companies by better indentifying the resources needed to target these hotspots over subsequent business planning cycles.

Defra and the Environment Agency, working on behalf of the NMSG, have produced a specification for a project to develop a GIS mapping tool and 'best practice' guidance for the use of this technique. The project will be funded jointly and consultants working under the Defra Evidence and Measures Program are in the process of being appointed. Governance will be delivered through the NMSG and Water UK. The project is currently awaiting funding approval before commencement.

Water companies in particular are asked to support this project by sharing their data and expertise to help shape the project outputs. Representatives from two water companies have joined the project steering group and will be integral in shaping delivery and facilitating how this approach could be adopted by water companies.

**More holistic solutions – Sustainable Drainage Solutions (SuDS)**

Finding and fixing misconnections still deliver real benefits to water quality and it is recognised that such operational work has to continue and even increase in future. However the costs and complexities of investigating and rectifying misconnections are now better understood and have been set out above. In many cases experience demonstrates that despite extensive effort often water quality problems remain or return. Indeed, there is a propensity for this approach to become an iterative process because of new misconnections occurring. It can be concluded perhaps that other supplementary solutions are required to provide a safety net and/or address other diffuse pollution sources. That solution could take the form of Sustainable Drainage Systems, a generic term for solutions that extend from source to the end of pipe.

The use of SuDS should not be restricted to new developments but where appropriate, and mechanisms can be secured, proactive retrofit programmes should be encouraged. It is important that the water quality benefits of SuDS and a more progressive approach to Water Sensitive Urban Design is not forgotten. The retrospective installation of SuDS, perhaps driven by water quality objectives, needs to be considered as an alternative and/or supplementary solution to the 'find and fix' approach. This can be facilitated by guidance that takes account of the full range of pollutants, and the water quality and amenity consequences, expected to be found in urban drainage including misconnections where they might be expected to occur.

**Summary and emerging strategy**

Over the last 30 years our efforts and approaches to addressing misconnections have expanded in both depth and breadth. Misconnections were once seen as a marginal pollution issue that was largely localised, easily detected by the obvious visual impacts with activity focused mainly on removing foul drainage from surface water sewers. They were regarded as being caused by occasional mistakes by innocent builders or plumbers that had somehow slipped through the regulatory net. They were seen as an issue for environmental regulators and the water sector alone.

In contrast, thirty years on, the water quality impacts that result from both foul and clean misconnections across the extensive sewerage network infrastructure must now be regarded as an unquantified but significant economic and social issue. The impacts of misconnections are now so widespread that they have to be seen as a ubiquitous and endemic drainage problem. Water companies and environmental regulators have played an important role over the years to find and fix misconnections discharging from problem outfalls. Such investigation work has now become an almost routine operational activity and is likely to continue and even expand over the next few years if we are to gain sustainable reductions in the number of misconnections.

We are becoming increasingly aware that the prevalence and impact of misconnections, coupled with the general contaminated drainage from urban areas is a far more serious problem. Pollution sources

have become atomised and the cumulative effects of, amongst other things, persistent chemicals used in everyday activities, foul sewer incidents, litter, car washing and even atmospheric fall out add up to present a serious challenge in how we drain our cities and towns. As such, the responsibility for tackling and preventing this problem has to extend to businesses, organisations and even individuals far beyond the water sector and regulators. New approaches, skills and techniques now need to be employed to raise awareness and ultimately change behaviour.

A future strategy to address misconnections has to include three critical elements.

1. Finding and fixing outfalls with known misconnection problems will need to continue using targeted proactive strategies and efficient investigation techniques.

2. Widespread engagement is needed using the national ConnectRight brand to deliver a step change in awareness and behaviour across all business and organisational sectors including the general public.

3. More holistic drainage solutions need to be deployed that offer multiple benefits so as to ensure that the costs are manageable and water quality is improved and protected.

If you have any questions, comments or offers of support regarding this paper, please contact Jon Snowden using the contact details above.

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