Drinking water quality in England

The position after 25 years of regulation

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A report by the Chief Inspector of Drinking Water

Drinking water quality in England: the position after 25 years of regulation

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Drinking Water Inspectorate
Area 7e
9 Millbank
c/o Nobel House
17 Smith Square
London
SW1P 3JR

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Drinking water in England

The Chief Inspector of Drinking Water for England regulates the quality of water supplied by water companies and also carries out checks to ensure that local authorities are meeting their responsibilities for the regulation of private water supplies. The powers of the Chief Inspector (and inspectors) were created by the Water Act 1989 and are set out in the consolidated Water Industry Act 1991. Inspectors are collectively known as the Drinking Water Inspectorate (DWI) and have various powers to obtain information as part of any investigation, including the rights of entry, and are able to take enforcement action, by serving Notices and directions, or by initiating prosecution proceedings in the courts. This report summarises the development and improvement of the water supply arrangements in England since the establishment of this regulatory regime 25 years ago.

Drinking water quality standards are set out in regulations and must be met at the point where consumers draw off water for use. In England, the regulations for public supplies are the Water Supply (Water Quality) Regulations 2000. The equivalent regulations for private water supplies are the Private Water Supply Regulations 2009. Most of the standards derive from the European Drinking Water Directive 98/83/EC.

Water companies and local authorities take and analyse a prescribed number of samples, and drinking water inspectors check the results independently. Inspectors assess whether the actions taken by water companies and local authorities in response to any failures, operational events or consumer complaints are appropriate and sufficient to prevent a recurrence. Where improvements to water supplies are needed, this is confirmed in the form of a legal notice that must be complied with by the water company or by the relevant person in the case of a private water supply.

Drinking water in England comes from a number of natural sources. These all require protection from contamination and treatment, where this is shown by a risk assessment to be necessary to ensure that the water is safe and acceptable to consumers. Although the extent and type of protection and treatment is site specific, all public supplies must be disinfected to remove harmful micro-organisms. Disinfection involves either the use of ultraviolet (UV) light, membrane or other filter types, or oxidising chemicals (such as ozone or chlorine) in a tightly controlled and monitored process. Private water supplies rely on the same type of natural resources, face the same risks to quality and safety, and therefore require the same safeguarding arrangements as public supplies. Summary facts about the water supply arrangements in England are shown below.

Figure 1: Water supply arrangements in England

338 surface water sources

1,947 groundwater sources

1,176 treatment works

3,974 storage points

316,199km water mains

37,717 private water supplies

Today, the water industry comprises 27 companies in England and Wales operating 1,249 works, 4,430 service reservoirs and over 347,500km of mains. Using these assets they provide over 14,492 million litres of water to 57 million customers every day. This contrasts with the industry in 1990, which was made up of more companies (39) supplying less water (16,500 million litres a day) using more assets (1,817 works and 4,924 service reservoirs), but a smaller distribution network (307,000km).

Table 2: Comparison of the water industry 1990–2014

	1990	2014
Number of companies	39	27
Number of treatment works	1,817	1,249
Number of service reservoirs	4,924	4,430
Length of distribution network (km)	307,000	347,500
Number of zones	2,536	1,633

Today's water industry draws on infrastructure and knowledge that has evolved over a long time span. After the First World War, industrial demand and population growth resulted in the development of water supplies to meet local needs and there was no regional or centralised planning or control. This led to a wide variation in access to piped water supplies and service levels throughout the country. At the end of the Second World War, to enable recovery and economic development, the first Water Act was passed by

Parliament in 1945. This created the basis of today's water supply management framework with the aim of improving access to piped water supplies which at that time were estimated to serve 70% of the population. Following a drought in 1959 and flooding in 1963, a more co-ordinated approach to managing and conserving water resources based on abstraction licences was introduced (Water Resources Act 1963). However, throughout the late 1960s there were continued problems with planning and demand forecasting resulting in further reform. The Water Act 1973 created 10 regional water authorities (one in Wales) based on water catchment areas, with local authorities represented at board level. These regional water authorities took over responsibility for water resource management and the supply of water, and the collection and treatment of sewage. Services were funded through water charges with central government having overall control of performance, planning and the financing of long-term infrastructure development. However, by the 1980s it was evident that the regional water authorities could not meet the environmental standards being demanded by public opinion and embodied in new European legislation. This deficit was partially addressed by the Water Act 1983 which moved some control away from government enabling access for capital to the financial markets. However, this did not go far enough to ensure European environmental and drinking water standards were brought into law or that there was adequate investment plans to enable these to be met. Therefore, a further Water Act was required in 1989, privatising the regional water authorities and creating the comprehensive framework of privately owned water companies, standards, regulations and independent regulators that comprise today's water industry.

Over the next 25 years, there have been changes in the number and size of water companies as a consequence of market forces relating to the cost of capital finance and customer service standards, overseen by the economic regulator (Ofwat) and through mergers and acquisitions where permitted by the competition authorities. Additionally, competition for non-domestic customers was introduced through the Water Act 2003. In broad terms these changes initially saw the acquisition by investors of small water companies, and their subsequent amalgamation in a process that has brought in a wide range of investors in water services, including foreign pension funds and asset management companies, many of which own or have stakes in water companies or their holding companies. By way of example, Affinity Water originates from three small water companies: Colne Valley, Rickmansworth and Lee Valley. These local companies merged in 1994 to form Three Valleys Water plc, which then merged in 2000 with another company, North Surrey Water (itself formed in 1973 from the merger of four smaller companies). A French water company created Three Valleys Water and, as a consequence, the English water company was rebranded Veolia Water in 2009. In 2012, the company was sold to a consortium of investors and became known as Affinity Water. Since Veolia Water also own other

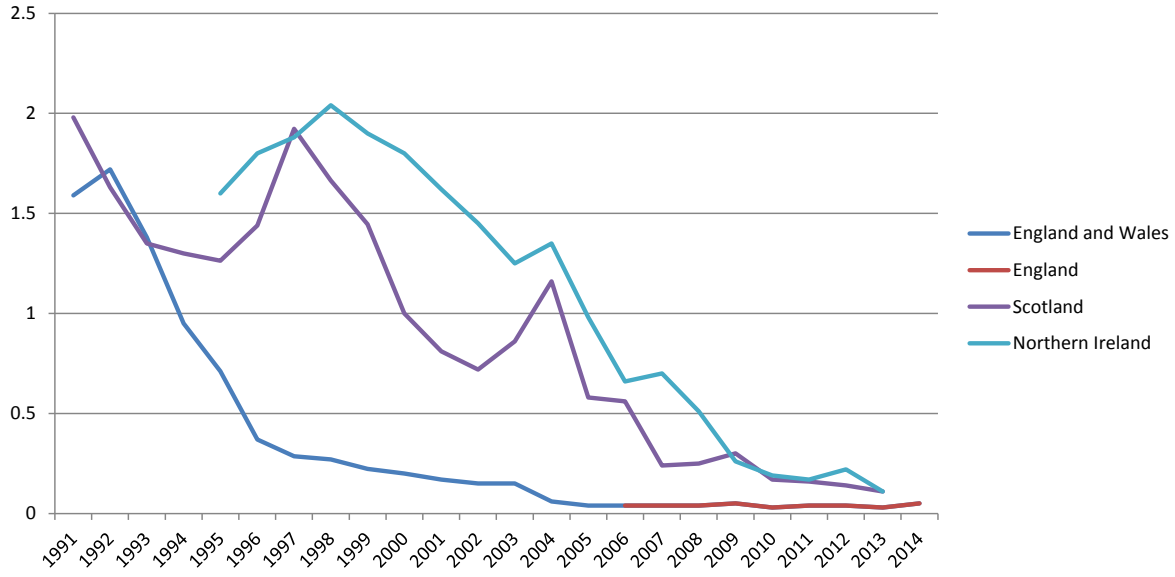
companies, such as the former Tendring Hundred Water company, this is now also part of Affinity Water's operational area.

A number of the companies, both past and present, operate assets and provide cross border supplies where water resources arising in one country are used to provide water supplies to consumers in another. In 1990, just one company, the Wrexham and East Denbighshire Water Company, operated solely within Wales, whereas three companies (Chester Waterworks Company, Severn Trent Water and Dŵr Cymru Welsh Water) operated in both England and Wales. Today the Wrexham and East Denbighshire Water Company and the Chester Waterworks Company have been merged into a single company (Dee Valley Water) which, like Severn Trent Water and Dŵr Cymru Welsh Water, serve consumers in both England and Wales.

How good is drinking water at the tap in 2014 compared to 1990?

In 2014 the water companies in England carried out 3,853,350 tests, for which there is a numerical standard that must be complied with, either at the consumer's tap or the point where water leaves a treatment works, treated water storage reservoir or tower. Only a tiny fraction (0.04%) of these tests failed to meet the standards in 2014 and this compares very favourably to the situation when the regulatory regime was first introduced 25 years ago as illustrated in Figure 3.

Figure 3: Percentage of tests failing in zones 1991–2014



In 1990, the industry in England and Wales carried out a total of 3,296,400 tests on samples collected from premises located in 2,536 water quality zones and from 1,814 works and 4,924 service reservoirs. In total, 32,427

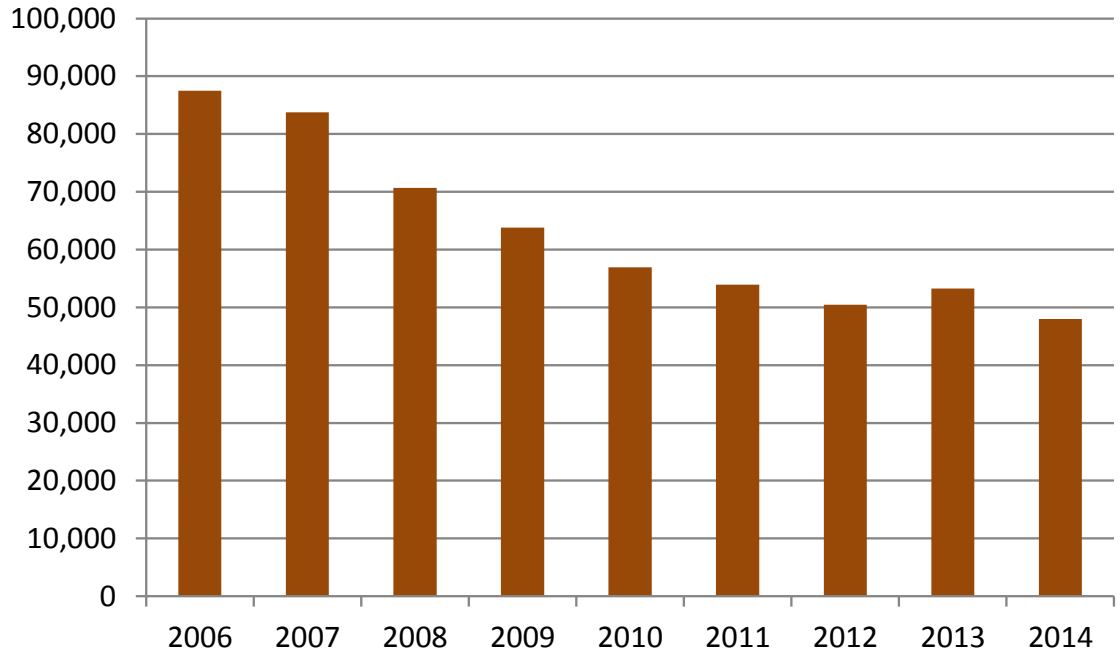
failed to comply with one of the standards and compliance with standards at the start of the regulatory regime was therefore 99.00%. When considering the need for enforcement the first Chief Inspector's Report, describing the data from 1990, identified a number of key issues to be addressed as follows:

Lead: in 1990, out of approximately 68,000 tests 3.1% (2,121) failed to meet the standard of the time (50µg/l). Full compliance was achieved in 1,943 out of the 2,536 zones. In the remaining 593 zones the failures were recognised as being due to lead supply pipes connecting premises to the water company main or plumbing inside the premises installed prior to lead being banned in the 1970s. The new regulations required companies to identify zones at risk and introduce water treatment. In 1990, a total of 35 companies entered into legally-binding programmes to carry out surveys to assess the risk. The first annual report, showed that 562 zones had been identified as being at risk with 713 zones not at risk. Since that time the standard for lead has been tightened and now stands at 10µg/l. Investment in risk assessment, water treatment and opportunistic removal of lead supply pipes and plumbing over 25 years has reduced substantially the number of sample failures. In 2014, there were just 84 failures at the tighter standard (10µg/l) with 70 of these being confirmed as due to customer owned pipes and plumbing in older housing.

Discoloured water: when iron and manganese deposits accumulate in the distribution network they can give rise to consumer complaints when there is a change in flow or pressure. In 1990, 2,226 (3%) out of 73,635 tests failed the standard for iron (200µg/l). These failures occurred in 751 (29.6%) water supply zones and the companies estimated that 65,958km of old, unlined cast iron mains needed cleaning, lining or replacement in 2,358 zones. Additionally, there were 708 (1.2%) tests that failed the standard for manganese (50µg/l) out of a total of 61,226 tests impacting on 245 (9.7%) water supply zones. In the first Asset Management Plan period (1990–1995) the companies were required to renovate the highest risk mains (14,100km) in 1,146 zones. These long-term strategic distribution system programmes of work continued for a further 10 to 20 years, alongside other investment in water treatment necessary to remove naturally occurring iron and manganese in raw water sources. Driven by the Inspectorate's assessment of compliance data and discolouration events, including prosecutions where water was sufficiently discoloured as to cause consumers to reject it as unfit for human consumption, there are now fewer failures in part due to 90 separate schemes addressing manganese and iron at works. Since completion of the strategic investment programmes in 2010, iron failures occur on average 122 times per year. The same trend is evident for manganese where the number of failures now average 25 per year. In 2014, there were just 120 iron failures and 27 manganese failures, many (59) were due to a short-term, local network event dealt with by flushing. Importantly

the consumer benefits of these improvements can be seen from the decline in consumer reports of 'dirty tap water' from 87,517 to 47,986 a year between 2006 and 2014.

Figure 4: Consumer contacts to water companies reporting dirty water



Hydrogen ion (pH): in 1990, eight companies reported 995 (2.5%) failures of the pH standard out of around 41,000 tests. In most cases this was due to the leaching of lime from cement mortar-lined mains. As a consequence of long-term strategic investment to improve the distribution network this problem has been largely eradicated, with pH exceedances reported at the low average rate of 9 a year since 2004. Additionally, as a consequence of improved water treatment, there are now far fewer failures due to acid water (pH <6.5), a problem related to the nature of the upland surface water sources in Wales and the North West of England. In 2014, there were only six such failures, all of which occurred in the Northern region.

Nitrate: in 1990, the number of water sources impacted adversely by nitrates was 192 (11%) and water leaving treatment works 94 (5%) exhibited values above the standard of 50 mg/l. Together these works supplied a population of around 5.3 million people living or working in 209 water supply zones. The nitrate issue, related mainly to agricultural practices, had been growing in England during the 1980s (for example, an additional 38 works were identified as being newly affected between 1989 to 1990), however, the companies had taken early action to change or blend sources so that water leaving all but three of these works met the nitrate standard. Despite changes in agricultural practice driven by environmental legislation, there is

no quick way to reverse the impact on groundwater and nitrate has continued to impact drinking water sources over the past 25 years and blending or treatment is likely to be needed at 29 works in the near future.

Trihalomethanes (THMs): These substances may be formed when water is disinfected with chlorine if the process is not tightly controlled. In 1990, this was sometimes the case as evidenced by the results of tests which showed that out of a total of 18,000 there were 987 (5.3%) which failed to meet the standard for Total Trihalomethanes (100µg/l) and 83 water supply zones exhibited a rolling three-monthly average above 100µg/l. As a consequence of enforcement by the Inspectorate, 24 water companies were required to invest in enhanced water treatment and control. Since completion of these programmes of work, failures of the standard have become rare (average of just four failures a year since 2010). In 2014, there were no failures of the THM standard.

Water quality at treatment works

Treatment works vary considerably in size, but all are sampled regularly in proportion to the volume of water supplied.

Over the past 25 years the number and size of works operated by the companies in England and Wales has changed markedly. In 1990, there were 1,817 works and this has declined to 1,243. The majority of the 574 works no longer in use were abandoned in the first three AMP periods (1990–2005) with, on average, 36 works being decommissioned each year. During the same period the volume of water entering supply has increased (from 16,592 to 17,836Ml/d) and a comparison of figures shows the main change in water supply arrangements across the industry has been the closure of many small treatment works. This trend of increased output from fewer works has come about through greater knowledge of source water quality and expansion of the distribution network enabling rationalisation of assets and greater connectivity. For example, in 2014, there were 119 inter-company transfers of treated or raw water.

All water entering supply must be free from harmful micro-organisms and companies are required to demonstrate that disinfection is effective at all times. Disinfection may be achieved by physical methods (typically UV irradiation or membrane filtration) or by the application of oxidising chemicals (such as ozone or chlorine). Treated water leaving a works is tested regularly for the indicator organisms, coliforms and *E.coli*. In 1990, treatment works compliance for *E.coli* was only 99.86% (with 283 failures recorded at 174 different treatment works). In 2007, the law was changed to make it an offence if a water company failed to adequately design, maintain and operate effective treatment including disinfection. This strengthening of

the safety rules has driven up operating standards so that in 2014, compliance was very high at 99.99% with only three failures for *E.coli* at three different treatment works.

Cryptosporidium is a microscopic parasite that can cause water-borne illness. If human sewage or animal faeces containing the parasite enter a raw water source then this parasite, which is very resistant to traditional methods of water treatment, may gain access to drinking water and pose a serious risk to consumers' health. This risk was first widely recognised as a result of a large outbreak in Oxford and Swindon in 1989[1]. There were other smaller water-related outbreaks in the early 1990s, the most notable being in Torbay, South Devon, in 1992 and 1995, along with others in the North West of England and Yorkshire. To address this serious risk to health, the Government accepted the recommendations of an independent expert group[2] and the law was changed in 1999 to require water companies to identify all works at risk by monitoring for the parasite and improving water treatment. Following a further outbreak in North Wales in 2005, the law was further tightened by introducing a turbidity standard at works of 1NTU. In 2014, testing of raw water for *Cryptosporidium* verified a potential risk at 149 out of a total of 376 abstraction points serving 127 treatment works operated by 16 water companies. Despite good compliance with the turbidity standard of 1NTU (99.98% in 2014) there have been two further small water-related outbreaks of human cryptosporidiosis (Northamptonshire 2008 and Bournemouth 2013) due to site-specific failures in maintenance and operational knowledge. This demonstrates the need for continuous risk assessment and a rigorous application of knowledge about this particularly hazard.

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[1] *Cryptosporidium* in Water Supplies. Report of the Group of Experts. Chairman: Sir John Badenoch. July 1990. Department of Health/Department of the Environment.

[2] *Cryptosporidium* in Water Supplies. Third Report of the Group of Experts. Chairman: Professor Ian Bouchier November 1998. Department of the Environment, Transport and the Regions & Department of Health.

Water quality in distribution systems

The distribution system comprises the network of pipes delivering water to homes and businesses, as well as water towers and service reservoirs. In 2014, the distribution network in England comprised a total of 3,947 reservoirs and more than 316,000km of water mains, all of which must be operated and maintained in a hygienic manner that ensures water quality does not deteriorate.

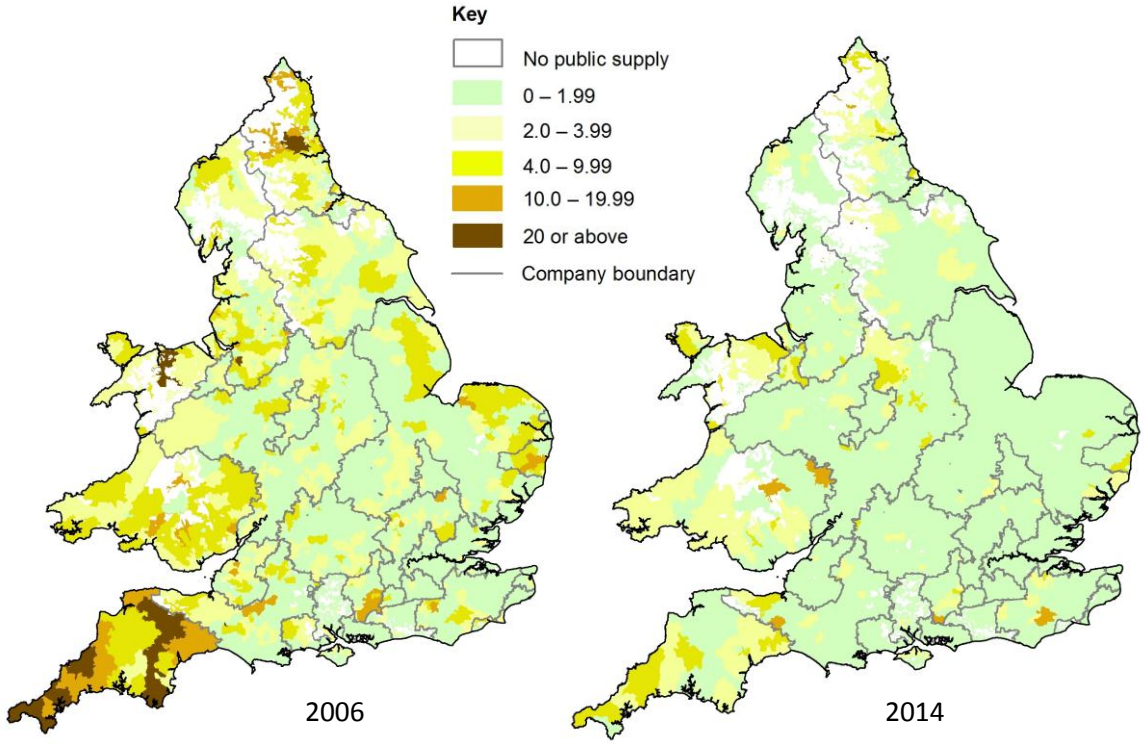
Water companies must sample each reservoir and tower weekly, and test for *E.coli* and coliform bacteria. The coliform standard is for no more than 5% of samples in a year to contain coliforms at any reservoir, however, the cause of each failure must be investigated and action taken to repair any defects identified with the integrity of these structures. In 2014, just 10 samples contained *E.coli* and no storage points failed to meet the standard with 126 failures requiring investigation. This compares favourably to the situation in 1990 when there were 509 *E.coli* failures and coliforms were detected at 371 reservoirs across England and Wales. This improvement in the microbiological quality of stored treated water has been brought about through improved maintenance, for example, over the 25-year period 11% (494) of the reservoirs in use in 1990 have been decommissioned because they were assessed as no longer fit for purpose or were no longer required.

Water companies must maintain their network of water mains so that they remain clean and hygienic, and take action whenever a consumer reports that water at the tap is not clear and bright in appearance, and free from any objectionable taste and odour. The number of discolouration contacts from consumers is important evidence used to plan programmes of mains cleaning, rehabilitation or replacement, and to measure that these are effective, In 2014, the industry average number of discolouration contacts from consumers in England was 0.76 per 1,000 population, down from 1.5 per 1,000 population a decade ago.

The progress in addressing discolouration and the associated reduction in consumer contacts since 2006 is shown in Figure 5.

Discolouration contacts have historically been a problem in the north and south-west of England. This is still broadly the case today with the northern region accounting for 34% of all discolouration contacts contrasting with London and the South East receiving only 13% of the industry total.

Figure 5: Discolouration contacts to companies 2006 and 2014



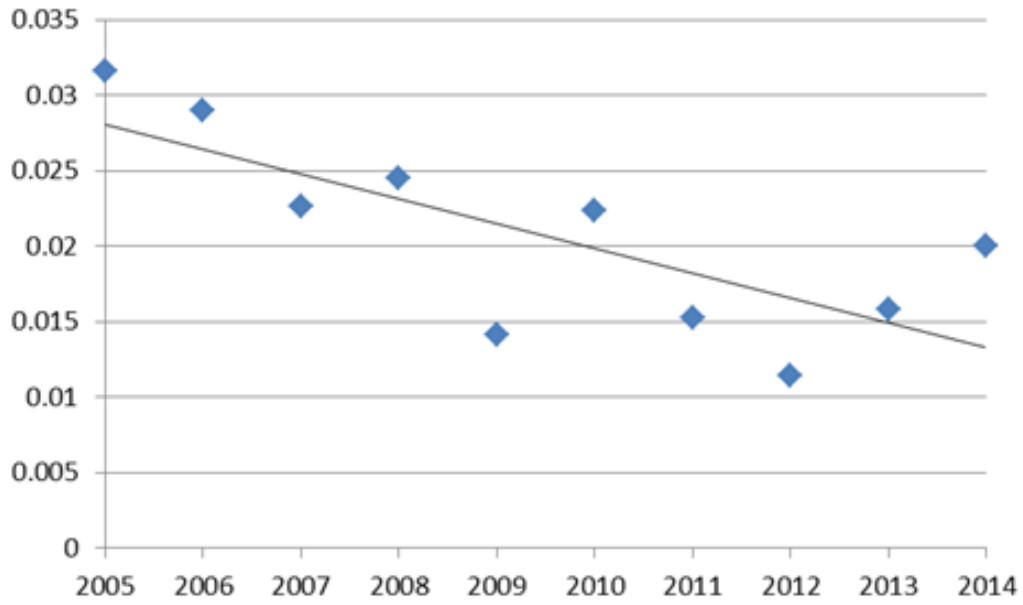
Water quality at consumers' taps

The point of compliance is where water is drawn off from taps by consumers and, since 2004, testing has taken place daily at randomly selected consumer taps for 51 parameters that have numerical standards. Sampling frequencies are determined by the size of the population in the water supply zone. In 2014, nearly all (99.95%) of these consumer tap samples met all the standards.

Poor tap hygiene or inappropriate plumbing arrangements are the most common causes of microbiological failures in a consumer's tap sample. Following an investigation to rule out a wider problem in the distribution network, companies give advice to householders about how to maintain water quality in the home[3]. In England in 2014, only 31 out of a total of 150,248 samples contained faecal indicator organisms (*E.coli* and Enterococci) compared to 60 1 out of a total of 146,760 in 2004. Figure 6 illustrates the overall downward trend in failures for these two parameters across England and Wales since 2005.

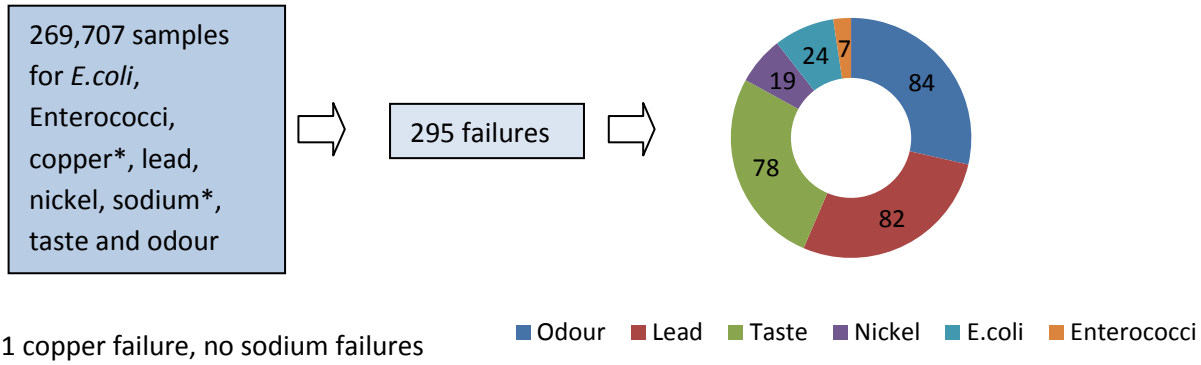
[3] Leaflet is available at http://www.water.org.uk/news-water-uk/looking-after-water-your-home

Figure 6: Percentage failure rate of *E.coli* and Enterococci tap water samples 2005–2014



Plumbing arrangements and fittings also contribute to failures of chemical standards and result in objectionable tastes and odours. In 2014, a total of 119,459 tests at English consumers' taps exhibited failures for lead, copper, nickel, sodium, taste and odour. Figure 7 illustrates the relative frequency of failures most commonly attributed to household plumbing.

Figure 7: Illustration of failures predominantly caused by household plumbing in 2014

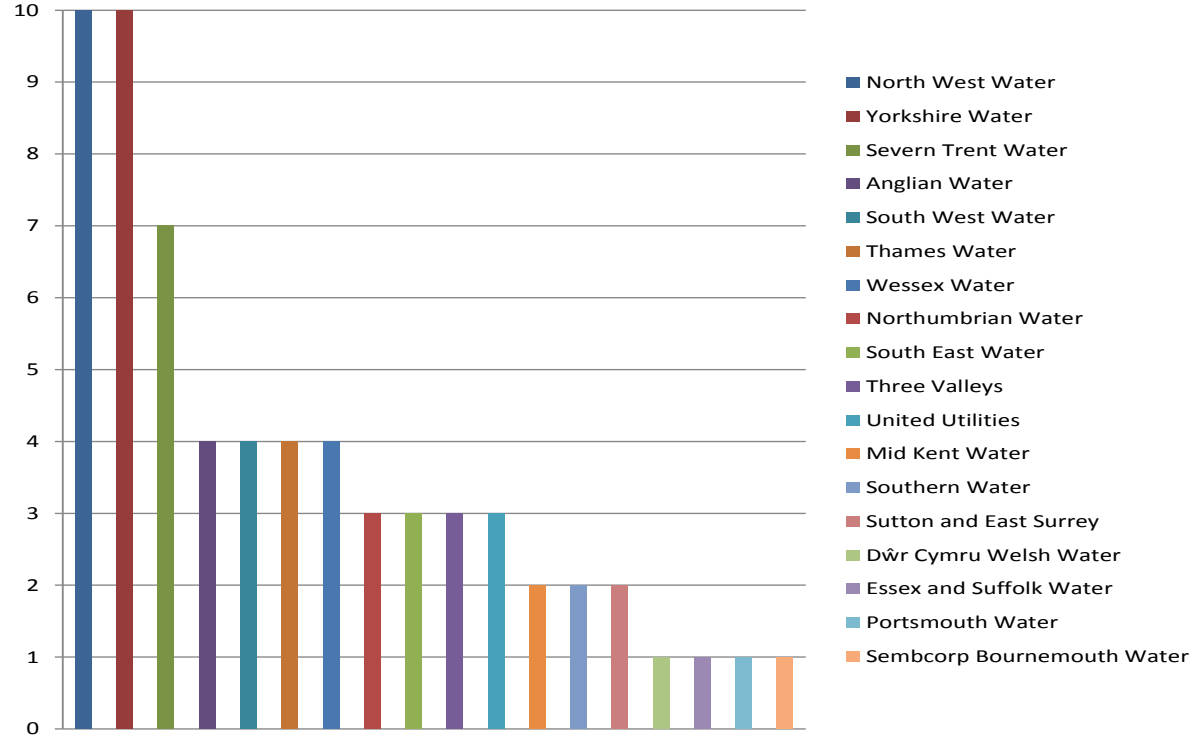


*1 copper failure, no sodium failures

Events and incidents

Very occasionally things happen that may have an adverse effect on water quality or cause consumers concern therefore companies are required by law to tell the Inspectorate about all these events. In England in 2014, there were 488 such events and 220 were risk assessed as being significant or serious requiring an independent investigation by a drinking water inspector. Companies are required to act on recommendations made by the inspector to prevent a recurrence. Legally enforceable Notices may be put in place to ensure that a supply is improved. Exceptionally, where there is evidence that an offence was committed, the company may be prosecuted in court. Since its formation the Inspectorate has successfully brought 75 cases (65 in England and 10 in Wales) across the industry, the first being in 1995 (following an event in 1993). The majority of prosecutions occurred during the first 15 years of the current regulatory regime and improvements made by the industry since mean that the Inspectorate has only found it necessary in the public interest to bring seven investigations to court since 2010. The prosecution record of the Inspectorate is shown in the chart below. In nearly all cases the company pleaded guilty and in some cases the Inspectorate dispensed a caution, rather than prosecute[4] in court. Since 1990, the Inspectorate has cautioned 11 different companies on 24 separate occasions.

Figure 8: Number of prosecutions in England 1990–2014



[4] The Inspectorate's Enforcement Policy is available at http://dwi.defra.gov.uk/about/enforcement-pol/dwi-enforcement.pdf

In 2014, there were just 12 serious events and most were short-lived. These events involved a range of issues including treatment failure (2), microbiological contamination or identification of *Cryptosporidium* in a supply (4), chemical contamination (3), issue of boil water advice (1) and wide scale flooding (2).

Technical audit

An important part of the work of inspectors is auditing the assets, procedures, data and operational processes of water companies. This enables inspectors to hear about any technical issues first hand from operational and scientific staff and gather evidence independently to ensure planned improvements are being made in an appropriate and timely way.

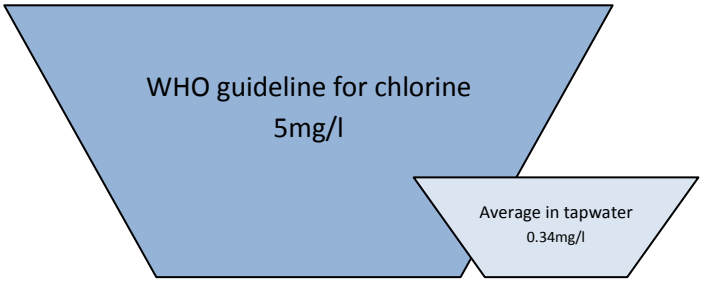
The Inspectorate operates a risk-based approach to technical audit whereby a wide range of technical and other information about the companies is brought together and analysed to identify where a site visit is likely to add the greatest benefit in terms of reducing risk to water quality through advice, recommendations or enforcement. In 2014, DWI carried out 419 technical audits of which 31 were deemed unsatisfactory.

Table 9: Audits completed by DWI

Audit topic	Audit numbers for companies supplying English consumers	Audit numbers for companies supplying Welsh consumers
Water treatment works	25	-
Treated water storage points	15	-
Bulk transfer agreements	7	1
Sampling rounds	7	3
Consumer complaints	36	-
Issuing of statutory notices	94	14
Reviews of schemes	108	21
Changes of solution	6	1
Closures of schemes	59	9
Receipts of risk assessments	62	-

Consumer contacts

Overall in 2014 across England, there were 87,920 consumer contacts relating to water quality equating to a contact rate of 1.6 per 1,000 population. Over the decade there has been a 38% reduction in the number of contacts of all types. In relation to consumer contacts about an objectionable taste and odour, in 2014 these were relatively few (21,881 in total equating to a contact rate of 0.4 per 1,000 population) and most related to chlorine. A small number of consumers object in principle to the use of trace levels of chlorine to secure the hygienic condition of the distribution network, and a few are particularly sensitive, causing them to detect and report minor variations in the chlorine residual concentration in tap water. In 2014, the number of such reports by consumers was relatively low (0.2 per 1,000 population).



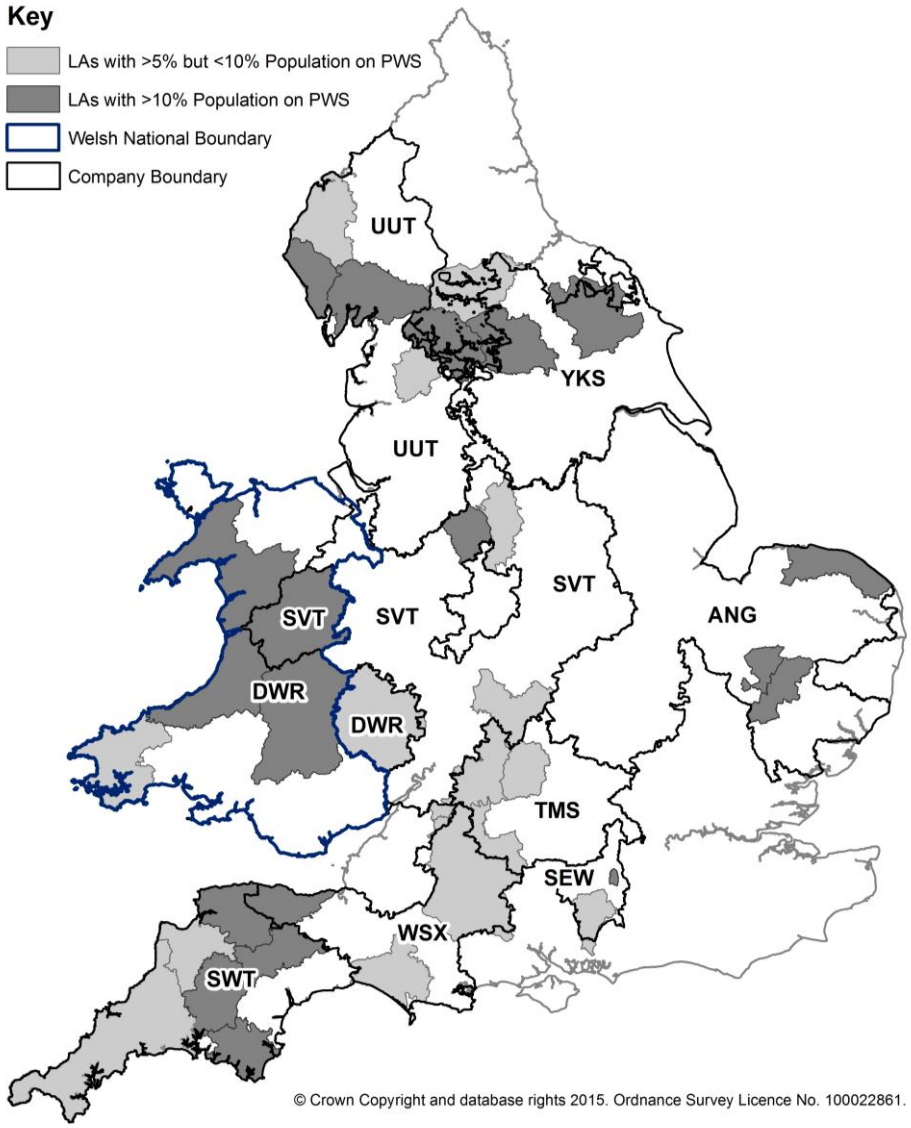
In England the level of residual chlorine at the consumer's tap is typically very low (average 0.34mg/l), and close to one-fifteenth of the health-related guide value of 5mg/l. As a result of challenges by inspectors, there are virtually no occasions when water leaving a treatment works or service reservoir contains a residual chlorine value above 2mg/l (seven in 2014) and companies have taken steps over the last decade to keep residual levels stable and as low as possible.

Very occasionally, consumers attribute ill-health symptoms to the water supply. These situations are rare (0.05 per 1,000 population on average over the last decade) and they are investigated promptly in collaboration with health professionals. Most are found to be unrelated to the water supply, instead they are triggered by personal or wider social perceptions. Exceptionally a problem is found with the maintenance of plumbing by landlords or public building owners, or an illegal cross connection is found in the local neighbourhood. Since 2004, companies have used their powers of enforcement to investigate and remedy 19 such events across the industry caused by illegal connections, often done by people who use or operate their own private water supply.

Private water supplies

Private water supplies are drinking water supplies that are not provided by a water company and are, instead, the responsibility of the owners and users. Local authorities under the supervision of the Inspectorate regulate the quality and sufficiency of these supplies. Overall around 1% of the resident population of England do not have access to a public mains water supply, but for some communities the dependency on a private supply is far greater. For example, in 18 local authority areas this figure is over 10% of the resident population. (See Figure 10). Additionally a significant number of visitors (1.4 million) visitors and tourists will consume water from private supplies at some time during the year.

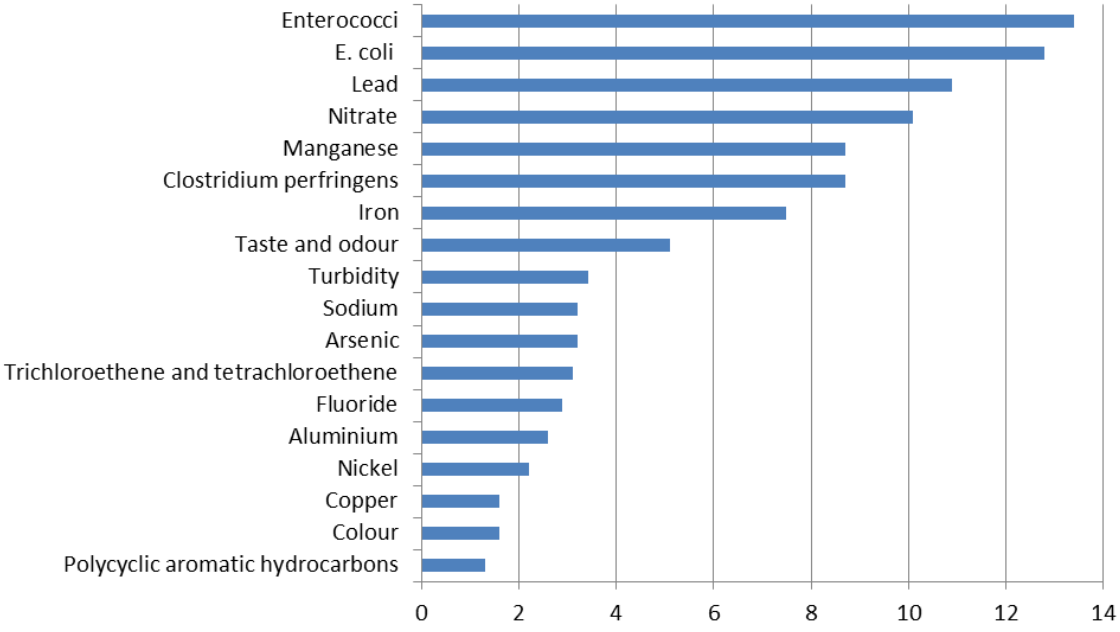
Figure 10: Local authorities with greater than 5% or greater than 10% of the resident population dependant on a private water supply



The sources of private supplies are many and varied, and a surprisingly large number of householders and businesses depend on them for their water supply for drinking, cooking, food preparation and showering or bathing or washing of hands. In 2014, there were 37,717 private supplies known about in England and 5,840 of these either served 50 or more people (used more than $10m^3$ of water a day) or were used in a commercial or public activity. However, the majority serve just a single domestic property (25,231) or a small number of households on a shared basis (6,474).

Environmental Health professionals in local authorities must risk assess and sample these supplies. In England in 2014, 69% of the supplies used to provide a service to the public had a completed risk assessment, with 143 local authorities reporting that they had risk assessed all such supplies in their area. A total of 8,054 tests on samples collected from these supplies in 2014 showed that 7.8% did not meet the essential safety standard for *E.coli*. The smaller shared domestic supplies, which are sampled less often, exhibited a failure rate for *E.coli* of 23%. Figure 11 illustrates the percentage of failures for tests from private supplies where there are greater than 1% of tests failing.

Figure 11: Percentage* failure rate for private water supplies



*Parameters included where greater than 1% of tests fail

The finding of *E.coli* in a private water supply demonstrates that faecal matter from birds, animals or humans is gaining access to the water supply and there is a high risk of the supply being associated directly with illness. In these circumstances, the owners and the users of the supply are given immediate advice to boil the water before use until the supply has been improved to make it safe. The risk assessment may identify that suitable

treatment is in place, but it is not being correctly operated or maintained and the remedy is therefore straightforward. However, in many cases the water source is not adequately protected, there is no treatment in place and the owner and users do not understand the risks or what they should be doing to keep their supply safe. In these instances, the local authority must require the supply to be improved. Over the last five years, local authorities have identified such situations (and required improvements to be made) on 1,454 occasions.

This evidence about the contamination of many small private supplies is compelling and its open publication by the Inspectorate strengthens considerably the case for regulatory intervention to mitigate this public health risk.

Drinking Water Inspectorate | Nobel House, 17 Smith Square | London | SW1P 3JR | Tel: 0300 068 6400

www.dwi.gov.uk