Drinking Water Quality Regulator for Scotland

DRINKING WATER QUALITY REGULATOR FOR SCOTLAND

Drinking Water Quality in Scotland 2017 Public Water Supply

SAFEGUARDING YOUR DRINKING WATER QUALITY

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FOREWORD

This is the sixteenth report from the Drinking Water Quality Regulator for Scotland (DWQR). The report provides a summary of the quality of Scotland's public water supplies for 2017. My report also describes our work during the calendar year 2017 in scrutinising the quality of drinking water provided by Scottish Water.

Compliance with the standards set out in legislation and in the EU Drinking Water Directive in 2017 was 99.91%, demonstrating the continuing high quality of drinking water that consumers in Scotland receive. This is the same as reported for 2016 and 2015. In my view, there are still opportunities to improve performance, for microbiological parameters at water treatment works and service reservoirs, reduction in the formation of disinfection by-products, reducing metals which cause discolouration and minimising the amount of lead in drinking water supplies.

The numbers of consumers who have contacted Scottish Water because they are concerned about the quality of their drinking water continues to decrease, with 9,239 contacts recorded in 2017, this is half the number recorded in 2012.

During 2017 the number of samples failing from service reservoirs increased. On three occasions it was necessary for Scottish Water to advise consumers to boil their water as a precaution until the problem could be investigated and remedial action taken. The reasons for more than half of these failures was found to be the condition of the reservoir and Scottish Water has now increased the amount of money it spends on maintaining these assets.

I was disappointed during 2017 that Scottish Water were late in completing investment projects at four water treatment works for which they had given Scottish Ministers Statutory Undertakings to complete. Of the four delayed projects, three are now complete, with the fourth project, a new treatment works which will supply Oban, expected to be complete this Summer.

Very high levels of compliance with standards is something that I expect Scottish Water to safeguard and improve upon, through diligent operation, maintenance and investment in their water supply systems.

Sue Petch
Drinking Water Quality Regulator for Scotland

EXECUTIVE SUMMARY

In Scotland the public water supply is provided by Scottish Water. All other supplies, owned and managed by individuals, are known as private water supplies. The Drinking Water Quality Regulator for Scotland (DWQR) regulates the quality of water supplied by Scottish Water, ensuring that drinking water supplies meet the requirements of The Public Water Supplies (Scotland) Regulations 2014 ("the Regulations").

Some key facts about the public water supply in Scotland for 2017 are shown below:

Scottish Water supplied **1.8** billion litres of drinking water per day

from **238** water treatment works

through **47,000** km of water mains

99.91% satisfactory samples from consumers' taps

Scottish Water takes and analyses its own samples to demonstrate that the water supplied complies with regulatory requirements. In 2017, 305,459 tests were undertaken on samples collected across drinking water assets, mostly from consumers' taps. This sampling and analysis is independently accredited, and is consistent with water industry practice in the rest of the UK.

The DWQR assesses Scottish Water's monitoring programme and results. These are discussed in Section 1 of this report. We also inspect a range of Scottish Water activities and assets that could affect quality and investigate any water quality incidents that are reported. Information on our audit and investigative work is given in Sections 2 and 3 of this report. During 2017 we conducted the following activities in fulfilment of our scrutiny function:

Investigated **32** drinking water quality incidents	Assessed Scottish Water's sampling and monitoring programme of **305,459** samples	Evaluated **808** water quality event notifications
Responded to **124** consumer contacts	Carried out **19** technical inspections of assets and activities	Reviewed risk assessments and improvement plans for **238** supplies

1 DRINKING WATER QUALITY 2017

Water Treatment Works

Scottish Water has 238 water treatment works (WTW) that treat water to ensure it is safe to drink and complies with the standards set out in the Regulations. Treatment works in Scotland range from large supplies serving whole cities to very small works that supply small communities consisting of a few properties. Regardless of size, Scottish Water is expected to ensure that its water treatment works are capable of treating the range of raw water quality which may be found in source waters.

The majority of regulatory analysis takes place on samples collected from consumers' taps, but some important sampling also takes place on water as it leaves each treatment works. The number of samples which need to be collected each year varies depending on the volume of water supplied by the treatment works.

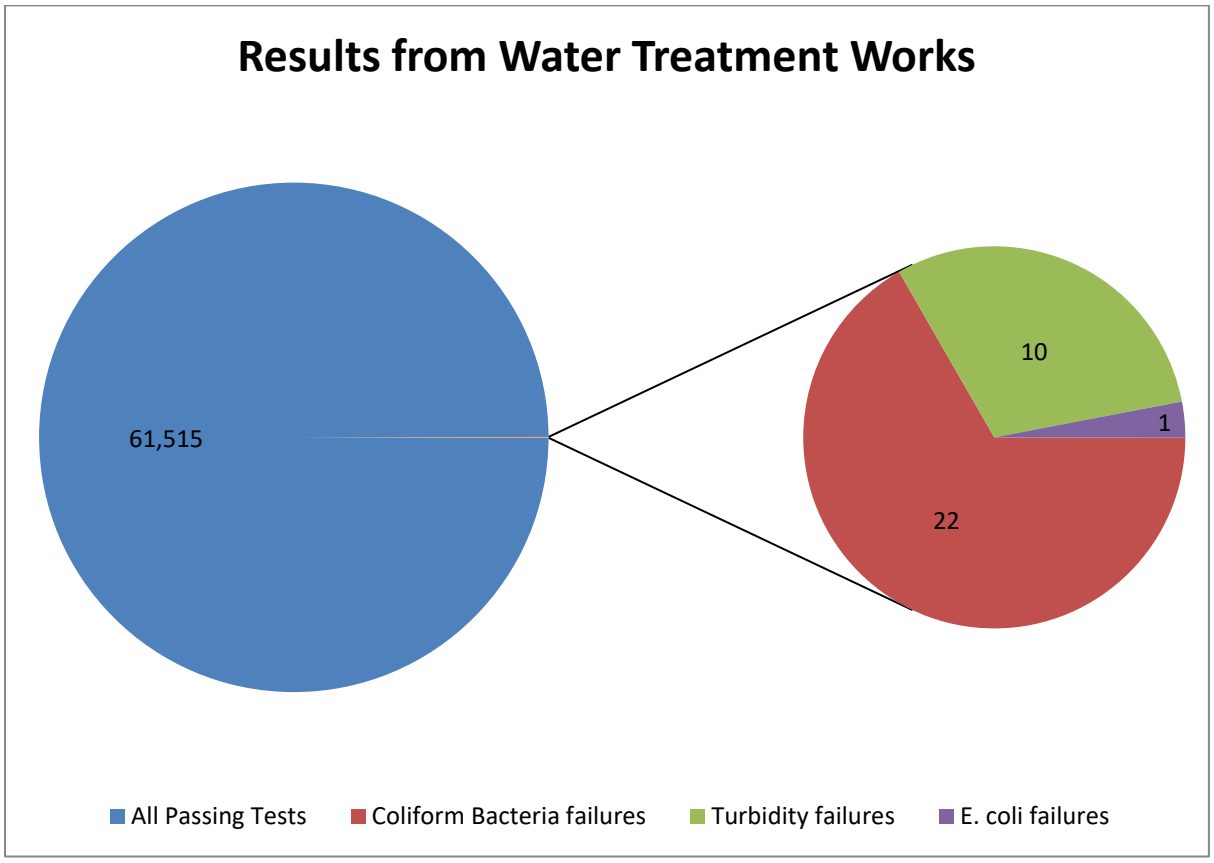

Figure 1 Proportion of treatment works sample failures

Over 60,000 tests were undertaken on samples collected at treatment works. Of these, thirty three failed to meet the required standard. A summary of all the tests carried out on water supplied from treatment works is given in Table 2 of the Performance Tables.

Microbiological Quality at Treatment Works

Coliforms and *E. coli* are two parameters measured in water leaving treatment works in order to verify that disinfection has been successful. All failures must be fully investigated by Scottish Water and reported to DWQR, the local NHS board and local authority.

When investigating sample failures at treatment works, Scottish Water consider a number of factors, such as changes in the quality of the incoming raw water; issues or unexpected changes in the treatment process; the circumstances of sampling, including the condition of the sample line and sample tap; and evidence from samples taken downstream in the distribution system. They should also consider taking additional samples, including between stages of the treatment process, to establish whether there is a genuine problem and where this might be. Data from on-line monitoring can also yield very useful information on quality around the time of the failure. Scottish Water routinely carries out root cause analysis of investigations of sample failures and this is beneficial in understanding and resolving the causes underlying many failures.

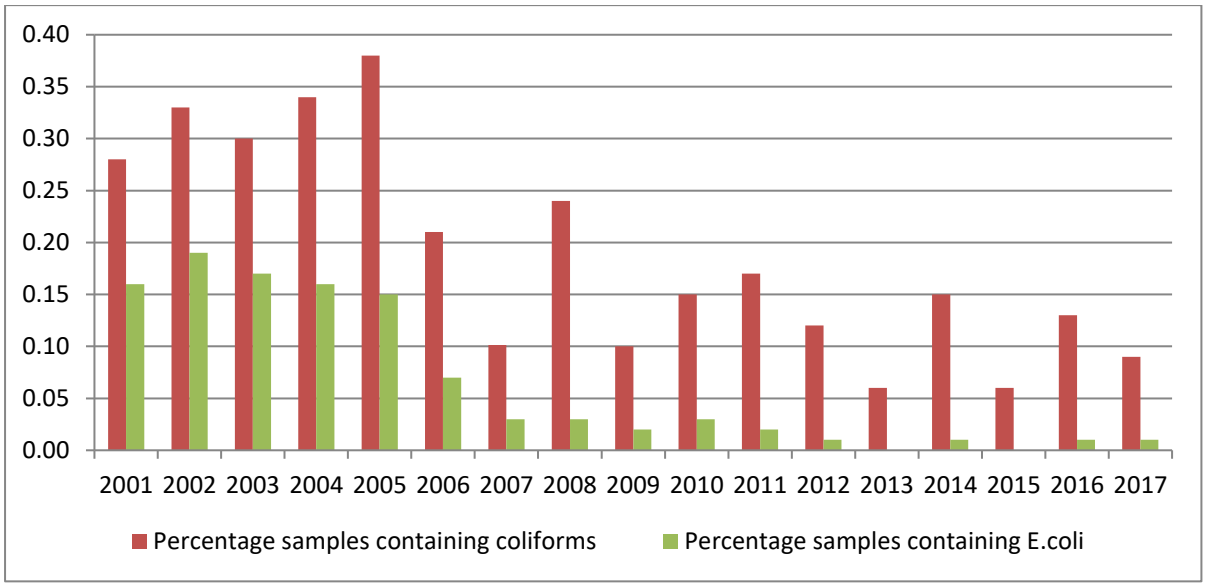

Figure 2 Year on Year Microbiological Failures at Water Treatment Works

Microbiological compliance, as shown in **Figure 2**, has improved over the years (summary data is given in Table 3 in the Performance Tables). There were twenty two detections of coliforms at treatment works, representing an improvement on 2016's performance but more than this were reported in 2015. One sample contained *E. coli*, compared with two

detections in 2016. Scottish Water has committed significant resource into improving this performance and has a number of water quality improvement initiatives under way which include asset capability assessments; the development of a bacterial barrier assessment tool; and extensive investigation using flow cytometry. Site specific disinfection plans, created at the request of DWQR, have highlighted some issues with the capability of the disinfection process at certain sites, and Scottish Water will need to take action to address these if it is to secure a consistent improvement in microbiological performance.

Two treatment works recorded more than one microbiological failure in 2017.

Fetlar, a treatment works in the North of Shetland recorded two samples containing coliforms in quick succession during the Summer. These were both attributed to a non-standard sample tap, which has since been replaced. No further failures have occurred since then.

Lomond Hills WTW, a supply in mid-Fife, also had two failing samples during the year, although these were six months apart. No conclusive cause was attributed to either of these and there has been no recurrence.

A single *E. coli* failure occurred at Lintrathen WTW, which supplies parts of Angus and Tayside. Scottish Water were unable to determine a cause for the failure.

Chemical Quality at Treatment Works

Water is tested for two chemical parameters, nitrite and turbidity, in samples taken from treatment works. Nitrite is a compound of nitrogen that can occur in supplies where ammonia is added to chlorine in a process called chloramination. This process needs to be tightly managed, and the presence of nitrite in significant quantities can indicate that it is not controlled as it should be. There were no failures of the nitrite standard in water leaving treatment works in 2017.

Lamellas for filter washwater recovery

Turbidity is a measure of the extent to which particulate matter in the water scatters light – effectively how cloudy the water appears. Turbid waters cannot be properly disinfected, hence a treatment standard of 1.0 nephelometric turbidity units (NTU) has been set in the Regulations. In 2017 there were ten exceedances of the standard for turbidity at nine treatment works. Summary data is shown in Table 4 in the Performance Tables.

Cryptosporidium at Treatment Works

Cryptosporidium is a microscopic protozoan parasite that can live in the gut of humans and other animals. *Cryptosporidium* oocysts can enter a water supply if faecal material is washed into the source (raw) water and oocysts are not removed by the treatment process. *Cryptosporidium* is not killed by chlorine and requires the water treatment process to be well optimised and monitored in order to ensure that it is physically removed. Scottish Water tests water supplies for *Cryptosporidium* in order to verify that these processes are effective. Ultra-violet (UV) light can be effective at inactivating oocysts, and Scottish Water uses this process at a small number of sites where physical removal of oocysts by the original treatment process is not achieved consistently in all cases.

The number of detections of *Cryptosporidium* reported in final water samples was forty nine of which five were subject to UV treatment and inactivated. This number of detections is almost half that of the previous year, and a very significant reduction on historic levels (summary data is given in Table 5 of the Performance Tables). Ten of these detections occurred at Turriff WTW in central Aberdeenshire, which has shown a significant increase on previous years. The performance of the filters at this plant is of concern and refurbishment is underway. DWQR will be seeking a firm completion date from Scottish Water for this refurbishment. As an interim measure, Scottish Water has recently installed UV treatment to ensure inactivation of any oocysts present.

Filter refurbishment

Bonnycraig WTW, which serves Peebles in the Scottish Borders, recorded eight *Cryptosporidium* detections, again, due to inadequacies in filter performance. The filters are being refurbished, and the works has recently installed UV treatment, ensuring oocysts are inactivated.

Service Reservoirs

Service reservoirs are located at points in the distribution system to store water, for hydraulic reasons and to meet the demand for water from consumers through the day. If these service reservoirs are not maintained they can be prone to inward leakage from contaminated surface water. This needs to be controlled through inspection and maintenance.

DWQR inspects a selection of structures each year in order to ensure that they are being maintained and operated in a manner that minimises risk of contamination of the water.

Coliforms and *E. coli* samples are taken regularly from service reservoirs to verify that disinfection is effective within the distribution system and to identify any instances where the water may have become contaminated. All *E. coli* and coliform failures must be fully investigated by Scottish Water and reported to DWQR, the local NHS board and local authority.

Summary results for service reservoirs in 2017 (Tables 6 & 7 in the Performance Tables) show that there was an increase in bacteriological sample failures compared to those in 2016. DWQR has significant concerns about the condition of many of these assets and Scottish Water has committed to increasing the levels of maintenance. **Figure 3** shows comparative annual performance since 2007.

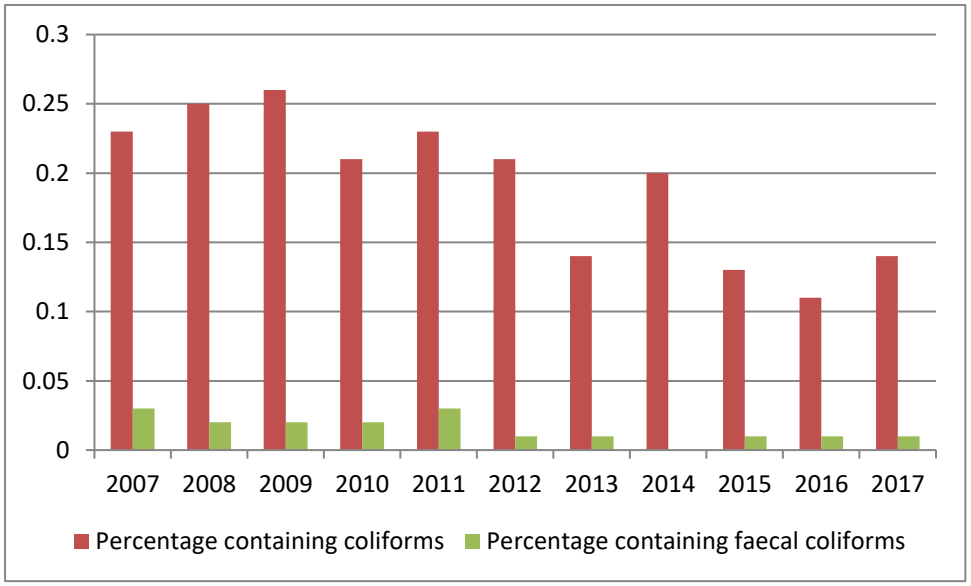

Figure 3 Year on Year Microbiological Failures at Service Reservoirs

The Regulations require that no sample from service reservoirs should contain *E. coli* and at least 95% of samples do not contain coliforms. Five samples contained *E. coli*, the details for which are detailed in the following paragraphs. Sixty eight samples contained coliforms, compared with fifty three in 2016 (two service reservoirs failed to meet the 95% requirement) and:

Failures for *E. coli* and coliforms at Lossiemouth were attributed to the poor condition of the service reservoir and gulls nesting on the roof. In response, the reservoir was bypassed and remains out of service.

At Tolsta in Lewis an *E. coli* failure resulted in a 'boil water' notice and bottled water being issued to consumers. The service reservoir was bypassed and, as it was found to be in poor condition, remains out of service. This was assessed by DWQR as an incident and a full report can be found on the DWQR website.

A failure in early January 2017 at Mellon Charles in Caithness was attributed to sampling conditions.

The investigation into a failure at Portnahaven, Islay, found the service reservoir to be in poor condition and evidence of livestock accessing to the roof of the service reservoir due to a broken gate. The site has been secured and repairs to the service reservoir are complete.

No cause could be determined for the *E. coli* failure at Inschfield service reservoir at Insch, Aberdeenshire, which was in a good state of repair with adequate chlorine levels.

All service reservoirs, except two, met the regulatory requirement that 95% of samples should not contain coliforms. These failures were at Lossiemouth, where two out of twenty nine samples contained coliforms and one contained *E. coli* (detailed above) and Fyvie Gallowslack, south of Turriff, where two out of thirty seven samples contained coliforms. This asset also had coliform failures in 2014 and 2016. It was assessed as being in poor condition and has been removed from service.

We declared an incident in the Craigie zone after another faecal indicator bacteria (Clostridium perfringens) was found in a sample taken from a service reservoir at Colpy which was found to be in poor condition. A 'boil water' notice was issued to consumers and water was supplemented using tankers until the service reservoir could be permanently bypassed.

Six service reservoirs have had three or more coliform failures in the last five years, including in 2017. In addition to Fyvie Gallowslack (detailed above), these are:

Torphins Cockardie, near Banchory (2015, 2016 & 2017), attributed to poor asset condition - including vegetation growing through the gravel roof - which has been repaired.

Ellon Low Level in Ellon has had failures in four of the five previous years (2013, 2014, 2016 & 2017). This service reservoir is at the end of a long distribution system and this is considered by Scottish Water to be a contributory factor due to water age and risk of biological re-growth. Further investigation is required to understand and resolve the issue.

Newmachar Westside at Blackbraes east of Inverurie (2014, 2016 & 2017): no overall cause was determined for these failures, but the temperature of the water is suspected to be the issue. Further investigation is required to understand and resolve the issue.

Failures at Maunderlea near Turriff (2014, 2015 & 2017) were attributed to the sample tap and line which have been replaced.
Despite recent cleaning of the service reservoir at Portknockie near Buckie, failures have continued (2015, 2016 & 2017). Holes were noted in the structure which have now been sealed.

The monitoring requirement at service reservoirs is for weekly samples to be taken when they are in service and a 'live' part of the water supply route. There were shortfalls in the numbers of required samples taken from a number of service reservoirs. DWQR is satisfied that this is due to the reservoir being withdrawn from supply for a period of time for inspection, cleaning, repair or frozen sample points.

Water Quality at Consumers' Taps

Scottish Water's supply area is divided into 286 water supply zones. Most sampling to assess regulatory compliance takes place at consumers' taps, and testing takes place for seventy parameters. Sampling frequencies are determined by the size of the population in the water supply zone.

In 2017, 141,097 tests were carried out on samples taken at consumers' taps. Of these, 133 failed to meet the standard set out in the Regulations. This means that 99.91% of tests carried out at consumers' taps complied with the standards. The equivalent figures for 2016 were 131 failing samples and 99.91% compliance, demonstrating a similar performance. Sixty nine supply zones failed to meet one or more of the standards, which is an improved position on 2016's figure of eighty five.

Table 1 Summary of Failing Tests at Consumer Tap Samples During 2017

Parameter	Total No. of Tests	No. Failed Tests	No. Zones with Failures	% Compliance
Coliform Bacteria	14,037	34	23	99.76
E. coli	14,037	2	2	99.99
Clostridium perfringens	5,013	1	1	99.98
Iron	5,007	31	25	99.38
Lead (10)	1,479	14	13	99.05
Manganese	5,008	11	9	99.78
Hydrogen ion (pH)	5,039	6	5	99.88
Aluminium	5,008	5	5	99.90
Nitrite	2,404	10	5	99.58
Total Trihalomethanes	1,581	7	4	99.56
All other individual pesticides	10,869	4	3	99.96
Turbidity	5,039	2	2	99.96
Taste	5,040	1	1	99.98
Odour	5,039	2	2	99.96
Ammonium	5,041	1	1	99.96
Copper	1,479	1	1	99.93
Nickel	1,479	1	1	99.93
SCOTLAND	**141,097**	**133**	**69**	**99.91**

Table 1 above shows only the parameters which had a failing test result recorded in samples taken from randomly selected consumers' taps. The number of samples taken for each

parameter that Scottish Water is required to test for is shown in Table 8 of the Performance Table report.

Compliance for a number of key parameters is discussed in more detail below.

Coliform Bacteria

Coliform bacteria or 'Total Coliforms' represent the group of bacteria of which *E. coli* is one species. They are common in the environment and do not necessarily indicate faecal contamination. They should not be present in the water supply as they are readily deactivated by chlorine, which is added in controlled amounts to all of Scottish Water's supplies.

Coliforms were detected in thirty four samples in 2017, which is marginally better than the thirty seven recorded the previous year. There does not appear to be a geographical pattern to the exceedances, with fifteen of the failures occurring singly in different supply zones. Three zones recorded three failures, and five recorded two failures.

When these failures occur, Scottish Water takes further samples from the premises and also from neighbours' taps to determine if there is a local property issue or a wider supply system concern. A significant proportion of failures, however, are found to be caused by hygiene issues at the kitchen tap. Scottish Water notifies the consumer of the findings and provides the appropriate advice in each case.

Scottish Water has demonstrated that reductions in the numbers of failures in the public supply system are possible by such means as thorough treatment of water; diligent maintenance of storage points and distribution systems to ensure their integrity and cleanliness; and careful management of residual chlorine and water age. The importance of maintaining these measures to avoid there being contributory factors from treatment, trunk mains and storage points in the distribution system and management of interventions in the supply network, cannot be understated.

E.coli

E. coli is an extremely important parameter because it is an indicator of faecal contamination and the microbiological safety of the water. The detection of *E. coli* in a water sample may be an indication that the supply in that area has become contaminated or it may simply relate to the tap from which the sample was taken. Scottish Water must investigate each failure thoroughly to try to determine the cause and respond appropriately.

Compliance for this parameter is relatively stable with only a few failures occurring each year. Two samples failed singly in separate zones in 2017. One was attributed to the poor condition of a private storage tank and the other to the condition of the kitchen tap.

Clostridium perfringens

Clostridium perfringens is a secondary indicator of faecal pollution. Clostridial spores can survive in water much longer than organisms of the coliform group and can resist disinfection. Their presence in disinfected waters may indicate deficiencies in treatment. If they are found in distribution systems and at consumers' taps, they can be an indicator of some historic contamination having occurred.

One failure of this standard occurred in 2017, the cause of which could not be determined.

Iron

Iron occurs naturally in some water supplies but should be predominantly removed by the treatment process. It is used as an alternative flocculant to aluminium at a few treatment works in Scotland. The most common cause of failures of the iron standard at consumers' taps is corroding cast iron water mains which can cause sediment to build up in distribution systems. High concentrations of iron can cause discoloured water supplies, greatly inconveniencing consumers.

Scottish Water has a large programme of renovation and cleaning of the water mains that cause the most significant water quality issues. This is reducing the numbers of consumer complaints about discoloured water.

Compliance with the iron standard has improved over the years but 2017 saw a poorer performance compared to the previous year with thirty one samples failing in twenty five supply zones. There were six zones where two failures occurred and the remainder were single failures.

Manganese

Manganese occurs naturally in some raw waters, especially in the west of Scotland. If it is not removed effectively by the treatment process it can accumulate as fine black sediment in distribution system pipework and cause severely discoloured water supplies and great inconvenience for consumers. Overall compliance continued to improve in 2017, but has further to go. Even a relatively low concentration of manganese in the final water of a treatment works can accumulate in pipes and cause problems in distribution pipework.

Two water supply zones recorded two failures in 2017, Corsehouse in the south west and Turret B in Perthshire. These failures were attributed to disturbance of deposits in the water mains following Scottish Water interventions in the distribution system. This emphasises the need for effective controls over access to the network for maintenance and repair works.

New filters have been constructed at Muirdykes water treatment works to enable manganese removal and these were introduced to the process stream during the spring of 2017. The quality of water from this works has improved as a result and the associated supply zones no longer feature in the report of manganese failing zones.

Lead

In Scotland, lead does not occur naturally in significant concentrations in our water supplies. The problem arises when drinking water comes into contact with lead supply pipes; lead tanks; lead solder joints on copper pipes; or inferior quality brass fittings and taps, particularly for longer periods (for example overnight / weekends / holiday periods). This can result in high lead levels in the drinking water supply.

We have established a project to review the policy in relation to the reduction of exposure to lead in drinking water. The project aims to raise awareness with consumers of the concerns regarding lead in drinking water and to promote the removal of lead service pipes and plumbing.

Although the majority of lead piping is privately owned and therefore outside Scottish Water's direct control, the company does have a responsibility under the Regulations to minimise the risk from dissolved lead. Over the past three years there were fifteen in 2015, thirteen in 2016, and in fourteen in 2017, failures of the lead standard. All but two of those fourteen occurred singly in separate zones. Two failures were recorded in Dumfries in the Larchfield supply zone. In all cases, there was lead within the domestic plumbing system. In four cases, Scottish Water also needed to replace its own communication pipes as a result of the failing samples. Scottish Water also notified the householders of the health risks of lead and that they should seek to replace their own customer-side pipework.

Scottish Water is required to treat water supplied to zones where there is a demonstrable risk of failure of the lead standard. This is achieved by adding small amounts of orthophosphoric acid to the supply and optimising the dosing to provide a coating to lead pipes, thereby reducing the plumbosolvency – the ability of the lead to dissolve from the pipes and contaminate the water. Of the fourteen failures, four occurred in zones with this treatment in place. Nine zones were considered to be at low risk of failure and Scottish Water must keep these under review.

Total Trihalomethanes (THM)

THM are a group of disinfection by-products that can form when organic substances combine with chlorine used to disinfect the water. As Scotland's upland waters are naturally rich in these organic compounds, management of THM formation presents Scottish Water with a challenge. Scottish Water has devoted much effort to reducing the formation of THM in its water supplies and has made significant improvements. In 2017, seven failures occurred within four zones whereas in 2016, eight failures occurred in separate zones.

In addition to meeting the standard for total THMs, Scottish Water is also required to minimise the production of all disinfection by-products. **Figure 4** shows the number of zones affected at different levels of THM within the standard. It illustrates that whilst there is a continuing reduction in failures, there is an increasing number of zones with Total THMs at

50% of the standard. This indicates there is still a significant challenge to minimise the formation of disinfection by-products.

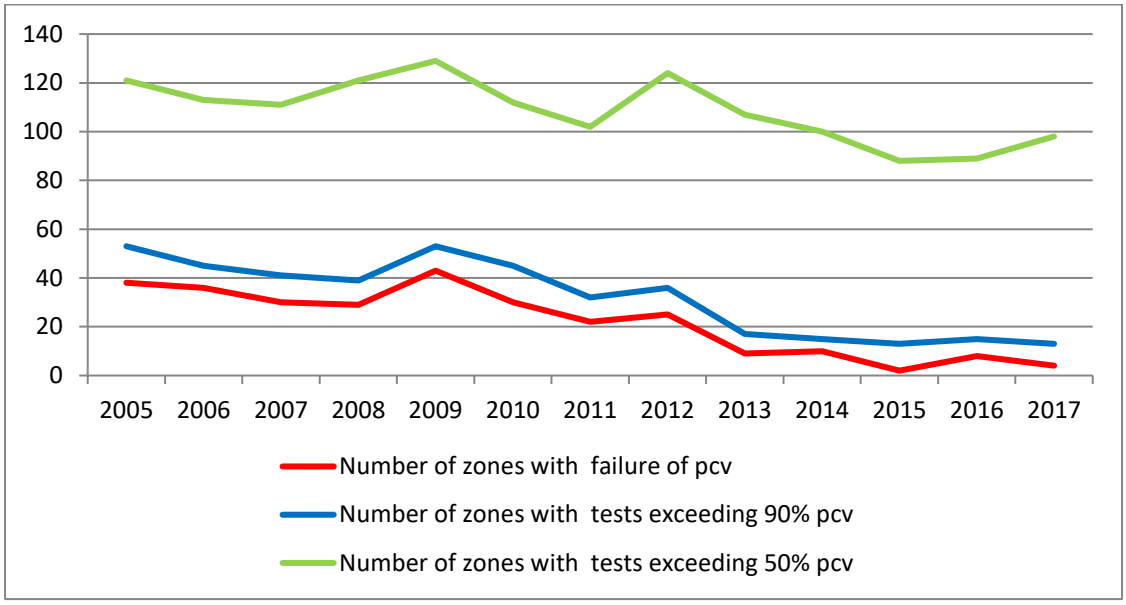

Figure 4 **THM Performance 2005 - 2017**

Two of the failures of the THM standard this year were caused by treatment control issues at Penwhapple and South Moorhouse treatment works. South Moorhouse, also records a further sample where THMs are within 10% of the PCV (prescribed concentration or value).

In all, there are nine zones with measurements of THM values in the band of 90 – 100µg/l indicating they are perhaps at risk of exceeding the standard. Two of the zones failing, or at highest risk of failing, have had improvement works carried out in 2017. These include the completion of a full new treatment works at Whalsay and, a replacement of membranes at Unst. Five of the zones, Tullich, South Moorhouse and three supplied from Bradan WTW, will benefit from improvements scheduled to be completed in 2018. Over the next three years, Scottish Water has planned improvements to be completed at Burncrooks WTW which will improve supplies in a further two of the failing or highest risk of failing zones. Scottish Water plan to undertake studies on another three of the failing or high risk zones to inform potential investment in the next investment period from 2021.

THMs analysis

It is essential that Scottish Water maintains robust and optimised treatment processes to minimise the formation of disinfection by-products.

Nitrite

Nitrite forms when nitrifying bacteria react with the ammonia that is added to chlorine in a process known as chloramination. If the process is not tightly controlled and nitrifying bacteria are allowed to persist in the distribution system due to high water residence times, failures of this parameter can result.

In 2017 there were ten failures of this parameter which is a poorer performance than in 2016. One supply zone, Spynie in Moray, accounted for four of those failures and at Pateshill in West Lothian three failures were recorded. The others occurred singly in different zones. In the case of the Spynie failures, these occurred in the Elgin/Forres area and they are attributed to the age of the water. Contributing factors of the location within the distribution system and the condition of water mains supplying the area have also been identified. In the Pateshill zone, the failures were localised to the Broxburn area with similar factors identified. DWQR has stressed to Scottish Water the importance of careful management of chloraminated supplies to minimise the potential for nitrification. Scottish Water has put in place mitigation plans for 2018, and is also carrying out studies in three of the zones which will inform them of future investment needs.

Nickel

Nickel is a compound that occurs in the environment only at very low levels. It is used for many different applications but mainly in the production of stainless steel and other metal products. Its presence in drinking water generally arises from contact with plumbing fittings, such as nickel or chromium-plated taps or certain types of kettles.

A single failure occurred in 2017 which was attributed to the type of tap or plumbing fittings used in the domestic distribution network inside the property that was sampled.

Taste and Odour

Failures of the standard for both taste and odour occurred on Housay in the Shetland Isles. An odour only failure was recorded at Tarbet in the Belmore supply zone. In both cases, Scottish Water was unable to identify a cause as further samples did not exhibit the same characteristics.

Turbidity

Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through it, making it appear cloudy. The standard is primarily an aesthetic one, but high turbidities need to be investigated, especially in water leaving the treatment works, as they could indicate a problem with the treatment process and may mean that the effectiveness of disinfection has been compromised. Failures can occur at consumers' taps

for a number of reasons, but the most common cause is the disturbance of sediment in corroding iron water mains.

Two turbidity failures occurred in separate zones in 2017. This includes one in the Daer Camps B zone at Cambuslang for which no clear cause could be determined and the other in the Turret B zone in Perthshire which also failed the iron, manganese and aluminium standards. This sample failure was attributed to a sudden change in flows caused by Scottish Water's operations on the distribution system, creating a disturbance of deposits within the mains. In both cases, flushing of the supply restored water quality.

Hydrogen Ion (pH)

The pH of a substance is the measure of how many hydrogen ions it contains, with large numbers of hydrogen ions making it more acidic. Most waters in Scotland are naturally soft and acidic and therefore have a low pH. Such water can be corrosive to metals used in plumbing, therefore Scottish Water needs to correct this to bring the pH into the required range. Alkaline water with high pH values can sometimes occur where water is in prolonged contact with some water mains containing cement. Waters with a very high pH can have a taste that some consumers find unpleasant.

Compliance for pH was considerably poorer in 2017 than in the previous year with six failures occurring in five zones. A single failure occurred in 2016 for this parameter. This year Greenock zone recorded two failures which were attributed to problems with the control of sodium hydroxide dosing pumps at the water treatment works. The two samples were taken some four weeks apart illustrating this was a more prolonged issue. Control of final pH in this supply system was subject to an investigation by DWQR. The other failures occurred singly in separate zones and were attributed to the water mains and residence time or turnover of the water. Flushing of the supply restored water quality in these cases.

Aluminium

Aluminium can be naturally occurring in water. It is also used as a flocculant in some water treatment processes and, if these are not operating efficiently, it can enter the water supply system via this route.

There were five aluminium failures in five separate zones in 2017 compared to one failure in 2016. These were attributed to disturbance of pipeline deposits and flushing of the supply restored water quality.

Ammonium

Ammonium in drinking water is not of immediate health relevance. It can however compromise disinfection efficiency, result in nitrite formation in distribution systems and cause taste and odour problems. Ammonium is used at some water treatment works where

chloramination is used for disinfection. Scottish Water is expected to control chloramination very carefully, and fully address any concerns that consumers may have.

A single failure of the standard occurred in the Auchneel zone and this was attributed to a problem with the dosing pump at the treatment works.

Radon

Radon is an odourless, colourless, radioactive gas that occurs naturally. It is released from certain rocks and the risk of occurrence varies according to geology. Although direct ingestion of radon in water is harmless, prolonged exposure to radon in air by inhalation has been linked to an increased risk of lung cancer. It is likely that any radon dissolved in water will readily gas off upon exposure to atmospheric pressure, adding to the total radon contact of the air.

The Private and Public Water Supplies (Miscellaneous Amendments) (Scotland) Regulations 2015 were introduced on 28 November 2015. Their purpose is to limit the contribution that radon in drinking water makes to the total concentration of airborne radon. There is therefore no PCV (Prescribed Concentration or Value) for Radon in water supplies but an action level has been set: where a sample exceeds 100 Bq/l, Scottish Water must undertake further investigation to identify the source of the high radon value. There was one sample which exceeded this trigger value in the Oykel Bridge zone for which Scottish Water undertook the required investigations. An improvement scheme is to be carried out at Oykel Bridge WTW by March 2021. Subsequent sampling showed the supply to be satisfactory and it continues to be subject to normal monitoring.

Consumer Contacts

When a consumer calls Scottish Water regarding the quality of their water supply, the contact is recorded and classified according to the nature of the issue.

Scottish Water received 9,239 consumer contacts relating to water quality in 2017, equating to a contact rate of 18.5 per 10,000 population. This is the lowest rate of contact experienced and is half the number recorded in 2012. The reduction in consumer calls about discolouration largely accounted for the overall improvement on last year's 10,659 contacts, although the number of calls about taste and odour tempered the performance.

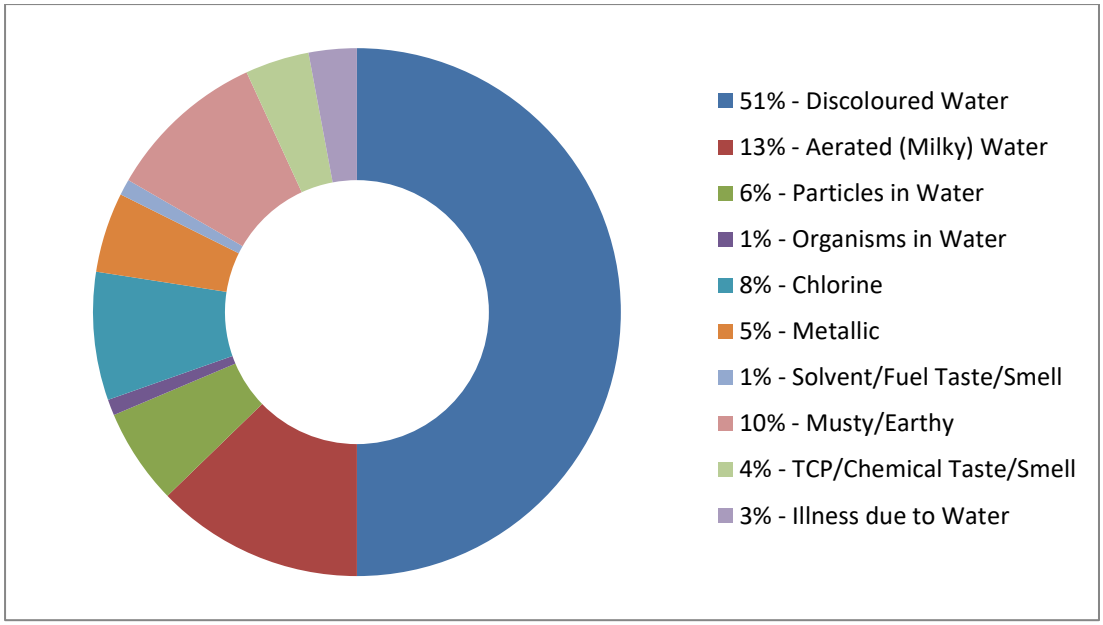

Figure 5 Breakdown of Consumer Contacts by Type

Figure 5 shows 64% of calls were received in response to discoloured water and aerated (or milky) water. These two categories not only reflect problems with the condition of the water supply network but they also highlight problems caused by operational activity where flow changes within the water mains are caused by the operation of valves or by burst mains. The diagram also shows a significant proportion (over 28%) of contacts relating to the taste or smell of the water supply causing concern to consumers.

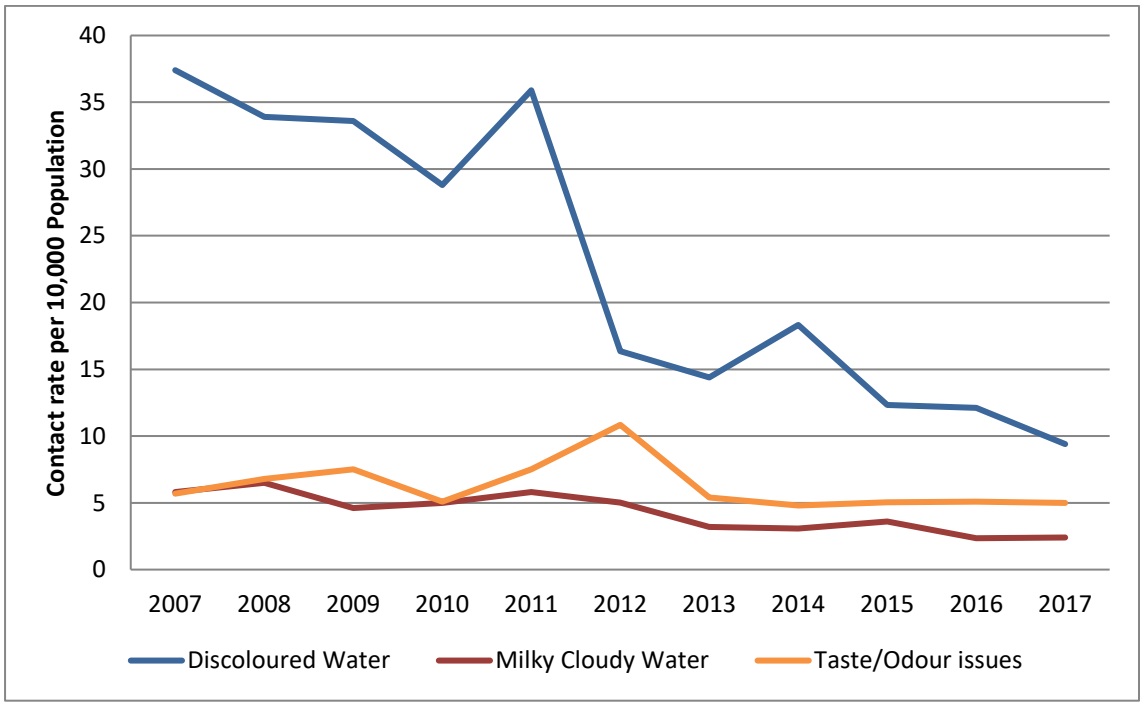

Figure 6 Trend in Key Contact Categories

Whilst it is acknowledged that the proportions of categories will shift as the overall numbers change, **Figure 6** further illustrates the point in terms of the trends in key contact types. The downward trend has continued this year through the reduction in discolouration complaints. It is a matter of concern, however, that Scottish Water has not been able to make progress with reducing taste and odour contacts as these have continued to demonstrate a consistent level over the past five years.

Unusually this year, the majority of taste and odour complaints are not of chlorine but are of an earthy or musty nature. Over 36% of all taste and odour complaints described an earthy/musty character, equivalent to 1.8 per 10,000 complaints. This was driven primarily by a water quality incident in August, affecting the supply to consumers in the Falkirk area which is supplied from Carron Valley treatment works. Geosmin, a substance usually associated with algal blooms, was found in the impounding reservoir water. It is not harmful to health but can cause an unpleasant earthy musty odour. This persisted for some weeks until Scottish Water were able to install temporary treatment to remove the geosmin.

Chlorine complaints accounted for 30% of all taste and odour contacts and these equate to 1.5 per 10,000 consumers. These equal the lowest ever level of contacts for chlorine which was recorded in 2015. Other taste and odour complaints tend to be episodic, driven by a particular event.

Both the geosmin issue in August and the significant negative change in chlorine complaints in 2017 are perhaps illustrative of the impact of separate water quality events on the overall numbers rather than the general reflection of pipeline condition and resulting contacts concerning discoloured water that has historically been the case. It is important, however, that Scottish Water continues to review the disinfection plans and chlorine residuals in water supply systems to ensure these are appropriate and to identify opportunities to reduce the amount of chlorine being added whilst not compromising microbiological safety.

The overall contact rate for all categories of consumer contacts in 2017 was 18.5 per 10,000. In geographic terms, the areas where most issues were raised by consumers are shown in **Figure 7**. There are seven zones where more than 200 contacts were received. This has reduced from eight zones in 2016 and the chart shows the supply zones ranked by contact rate.

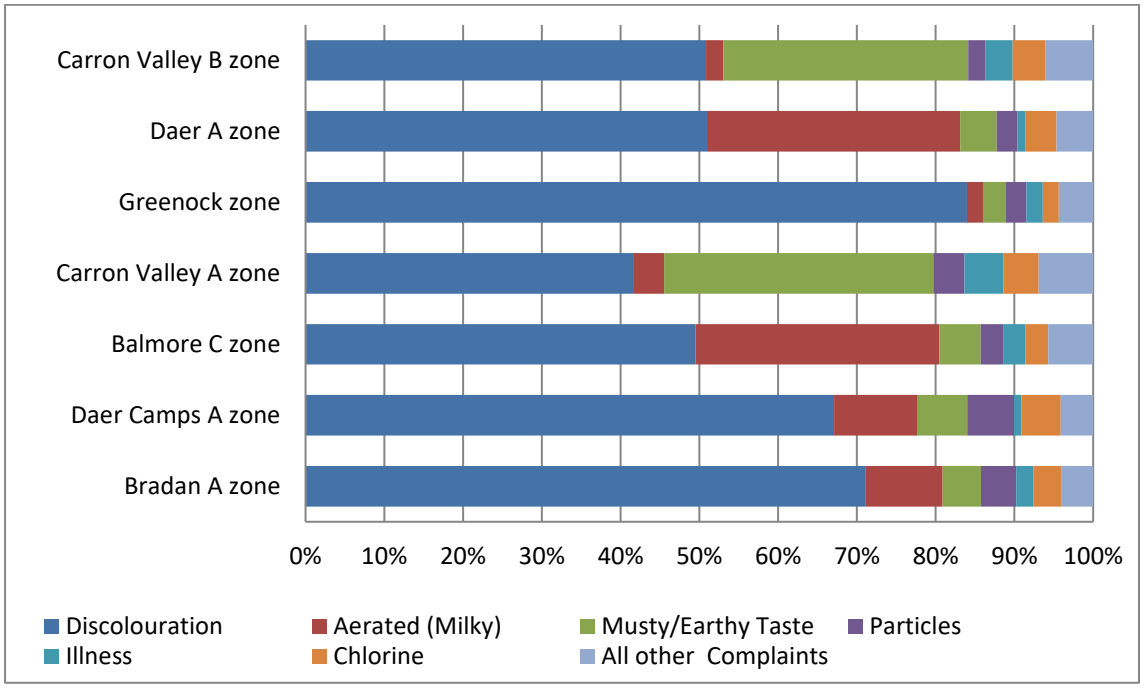

Figure 7 Water Supply Zones With Most Water Quality Complaints

The picture this year is not dominated by discolouration as has been the case in previous years.. It illustrates clearly that the issues of concern to consumers in the Carron Valley A and B zones was taste, and in the Daer A and Balmore C zones, of aerated water. The aerated water was confirmed to be the consequence of burst mains and planned mains diversion works. This illustrates the impact of separate water quality events on the overall numbers of contacts rather than the general reflection of pipeline condition or treatment works performance that has historically been the case.

Although there have been significant improvements made in reducing discolouration, the issue remains a consistent concern in some parts. Discolouration complaints in the Greenock zone are substantially related to the condition of iron pipe and deposits within the distribution system being disturbed by changing flows. New filters have been constructed at Muirdykes water treatment works to enable manganese removal and these were introduced to the process stream in the spring of 2017, considerably improving the quality of water received in this area. It is expected that the associated improvements within the network system and continuing mains rehabilitation work will see a consequential reduction in consumer complaints during 2018. Overall, Scottish Water continues to work through its cleanliness index project to better understand those areas with greatest risk of discolouration and the mitigation actions that can be implemented to reduce consumer concerns.

Consumer Contacts to DWQR

Scottish Water has a responsibility to investigate water quality complaints and supply issues. The DWQR guides consumers to report any concerns to Scottish Water in the first instance to enable their investigation and resolution. Where consumers are dissatisfied with Scottish Water's response and have pursued and completed a formal complaint with Scottish Water, the DWQR can carry out an investigation of the issues.

Table 2 Consumer Contacts Received by DWQR

Contact Category	Number of Contacts				
	2017	2016	2015	2014	2013
Appearance					
Discoloured Water	4	12	3	6	6
Aerated (Milky) Water	0	2	0	1	2
Particles in Water	2	1	0	1	2
Organisms in Water	1	0	0	1	0
Taste and Odour					
Chlorine	5	4	2	9	5
Metallic	0	0	1	0	2
Solvent/Fuel Taste/Smell	0	0	1	0	0
Musty/Earthy	1	2	0	0	2
TCP/Chemical Taste/Smell	0	0	0	0	1
Other contact about Water Quality					
Illness due to Water	5	4	2	2	2
Other Contact	7	4	6	3	10
Total Public Water Supply Water Quality contacts	**25**	**29**	**15**	**23**	**32**
Public water supply issues & requests for information	35	21	8	23	27
Private water supply issues	59	29	23	16	12
General Enquiries to DWQR	5	36	32	37	21
Total Consumer Contacts to DWQR	**124**	**115**	**78**	**99**	**92**

We carried out formal investigations of two complaints against Scottish Water in 2017. One concerning the pH of the water and illness and, the other, of black particles, taste, odour and illness.

Case 1 - The consumer had contacted Scottish Water on several occasions regarding the quality of water and attributing the high pH of the water to skin irritation. The complaint was investigated and a water sample was taken. The water was shown to comply with regulatory parameters and a full written explanation of the sample results was provided. The consumer was dissatisfied with the content of the letter and with subsequent investigation and discussions with Scottish Water scientific and public health staff. Scottish Water's final response failed, in the consumer's eyes, to fully address the issues.

In consideration of the complaint against Scottish Water, and the concerns raised by the consumer regarding the pH of the water supply, we consulted scientific literature on skin irritation and drinking water, extensive local water quality data, World Health Organisation guidelines, and discussed the matter with the NHS Consultant in Public Health Medicine.

We found Scottish Water's response to the complaint to be within an appropriate timescale and well considered, with the views of the consumer taken seriously and the issues raised fully investigated. The information provided was clearly explained and all data was accurate and pertinent.

We are satisfied that Scottish Water has fully responded to the concerns of the consumer and that the public water supply meets the required standard and is safe to drink, use and bathe in.

Case 2 - The consumer expressed concerns about the drinking water supply which, they believed, was causing household members to suffer illness. These included a bleach-like taste and stale smell to the water as well as the presence of black particles. The consumer had previously contacted Scottish Water on a number of occasions to complain about the quality of the water supply, reporting an unpleasant taste and odour and of causing illness. Scottish Water had carried out investigations and taken samples with all samples showing the water to be compliant with regulations.

In August, the consumer again contacted Scottish Water to complain that the water supply had an unpleasant taste and odour and was still causing illness. At this time, Scottish Water was receiving a significant number of taste and odour contacts due to the presence of geosmin, an algal breakdown product, in the reservoir supplying Carron Valley Water Treatment Works. Although not harmful to health, geosmin can produce unpleasant earthy taste and odour. Scottish Water sampled the supply and a neighbouring supply and all were found to comply with regulatory parameters. Scottish Water provided the consumer with explanations of the sample results and assurances that nothing had been detected in the water that could cause illness and that the water was safe to use and drink. Scottish Water further explained to the consumer that the taste and odour issues being experienced may have been due to the presence of geosmin and provided reassurance that this substance, while unpleasant tasting, is not harmful to health. As part of the investigations of the complaint, a byelaws inspection highlighted a number of conditions present within the property which could pose a risk to the quality of the water supply and the owner was advised of the necessary improvements. We consider that Scottish Water has responded fully to the concerns of the consumer and have taken all reasonable and necessary steps to investigate the water quality complaints. However, the consumer's complaint was partially upheld because Scottish Water had not responded to the fluctuating levels of chlorine in the supply from the service reservoir.

The full determinations are published on the DWQR website www.dwqr.scot.

2 WATER QUALITY EVENTS AND INCIDENTS

Scottish Water is required to tell the DWQR about all events that have affected or could affect water quality or cause concern to consumers. This includes all regulatory sample failures; operational sample failures that are significant or unexpected; any failure of a treatment process; significant numbers of consumer contacts; and issues which attract significant media interest.

Each event is reviewed and classified into one of five categories: not significant, minor, significant, serious or major. Those events categorised into one of the latter three categories are classed as incidents requiring further detailed investigation by DWQR. Where further information is required a full report may be requested from Scottish Water. It should be noted that where a full report is not requested, this does not suggest in any way that the incident is less serious.

Incidents are fully investigated by DWQR staff, a written assessment is produced, and recommendations are made where appropriate. A short summary of the incident assessment is published on the DWQR website. For the most serious incidents, enforcement action or even prosecution may be considered.

In 2017, 808 events were reported to DWQR, the majority of which were not significant. This is a slight deterioration from 2016, when 798 events were reported. Thirty two of these events were classified by DWQR as incidents, a disappointing increase from twenty six in 2016. **Table 3** shows the numbers of events and the Scottish Water operating areas where they occurred. A summary of incidents is available on our website www.dwqr.scot.

Table 3 Event Classification 2017

	Not significant	Minor	Significant	Serious	Major
East	190	33	5	3	1
North	94	25	9	0	0
South	163	27	3	2	0
West	221	23	7	2	0
Total	**668**	**108**	**24**	**7**	**1**

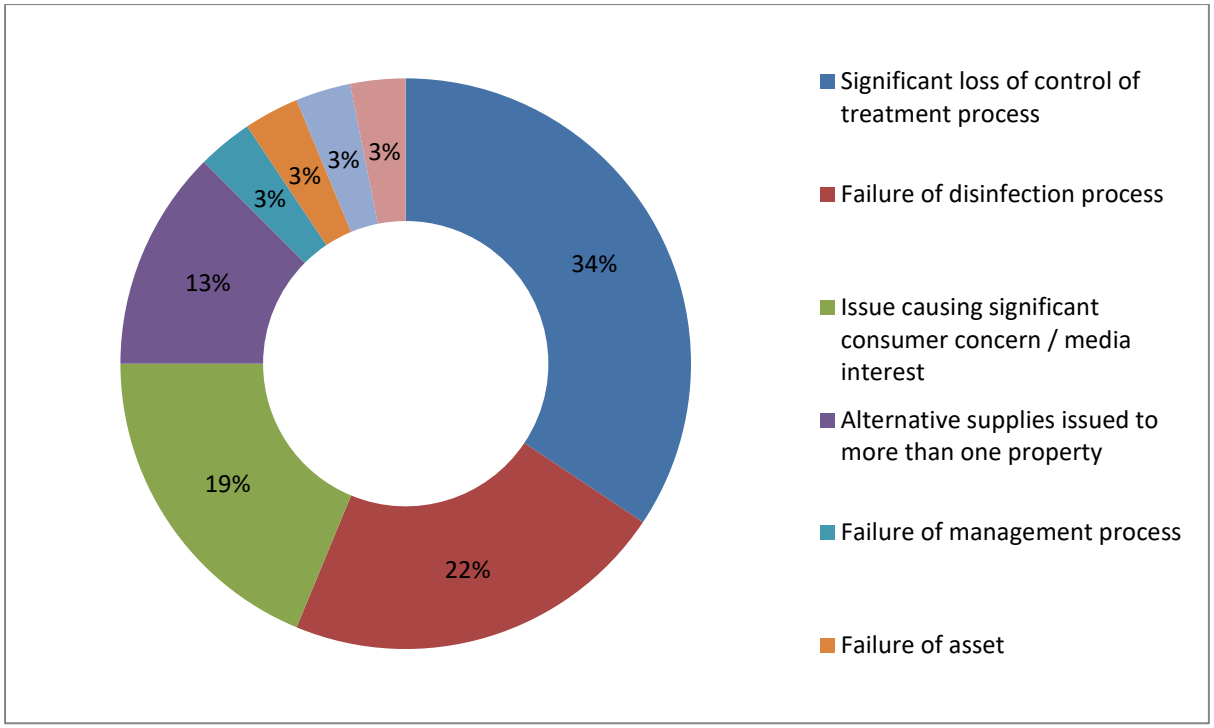

Figure 8 Reasons for Determination of an Incident

The majority of incidents were caused by a failure of or loss of control of a critical treatment process. There was a reduction in the proportion of incidents caused by this, down to 34% of incidents from 58% in 2016. Around one in five incidents were caused by disinfection failures in 2017, a similar number to the previous year. Thirteen percent of incidents were declared because alternative supplies, such as tankered water, had to be provided to consumers. Several incidents are worth highlighting as they present significant learning points for Scottish Water and these are discussed in more detail below.

Whalsay Regulatory Supply Zone – restrictions on water use – June 2017

A new reverse osmosis (RO) membrane filtration plant for Whalsay in Shetland was brought into service at the end of May 2017 to better remove precursors for trihalomethanes, replacing the old coagulation and filtration processes. Scottish Water was alerted to issues with the supply a week later, when two consumer contacts within the Whalsay water supply zone were received, describing taste and odour concerns. Analysis of the supply showed unacceptably high pH and aluminium concentrations. An Incident Management Team was set up and, following discussions with the Consultant in Public Health Medicine, a decision was taken to impose a "Don't drink, Don't cook" restriction on the supply affecting 140 consumers. Arrangements were put in place to provide bottled water to distribution points in communities and to vulnerable consumers.

The RO membrane stage was required at this site to remove THM precursors, but this process also removes other dissolved substances, making the water chemically aggressive, and subsequent re-mineralisation is required to ensure a balanced, chemically stable water supply. The omission of an adequate remineralisation stage caused large fluctuations in the

pH of the supply, along with the re-solubilisation of aluminium deposits in the water main, which will have accumulated over the life of the old treatment works. This created a high concentration of aluminium in the water supplied to consumers, and the aggressive nature of the water also put consumers at risk of high concentrations of plumbing metals, including lead.

At its peak, a sample taken in the northern extremity of the system showed an aluminium level of 1368µg/l. The standard for aluminium in Regulations is 200µg/l. Over the course of the incident, several operational actions were taken to try to resolve the issues at the works, but ultimately the reverse osmosis stage was isolated, allowing recovery to take place. Restrictions on use were put in place for 120 properties for two days and the remaining 20 properties for a further day. Once a new carbon dioxide dosing system was installed at the works, a balanced, less aggressive treated water was achieved and the water supply complied with regulatory standards.

RO membrane at Whalsay WTW

It is clear from DWQR's investigation of the incident that there were significant failures in Scottish Water's governance of design of the new works processes; their process for the appointment of appropriately qualified contractors; commissioning procedures; water quality testing of the new production stream; a basic lack of understanding of water chemistry and the impact of the new treated water on the wider water distribution system and consumers' pipes. Additionally, information provided to DWQR shows that consumer contacts describing different taste and odour concerns were received two days prior to the contacts initiating the field response to the incident. Given the short passage of time from the introduction of the new supply, DWQR considers this should have alerted Scottish Water more quickly to there being possible negative consequences of the change-over, suggesting that the commissioning of the plant was not being sufficiently controlled and monitored. DWQR found the water analysis performed during commissioning to be wholly inadequate to monitor the treatment process and enable a fully informed decision to be taken on acceptance of the new treatment plant. Furthermore those involved in the acceptance process failed to appreciate the importance of proper commissioning which was, in part due to a lack of scientific input. In terms of managing the incident, the measures deployed to address consumer concerns and the actions taken to carry out remedial works, DWQR is satisfied that these were carried out effectively.

Kyle of Lochalsh WTW – pH failure – February 2017

In late January 2017, a valve was commissioned to replace the existing ageing valve which controlled the pH blend through the remineralisation (remin) vessel at Kyle of Lochalsh

WTW. A high final water turbidity alarm was later triggered, due to low levels of remineralisation media being carried forward from the remin tank to the clear water tank. Scottish Water topped up media, but the treated water pH became very difficult to control, resulting in the supply having a high pH. Over the next few days the valve failed to control the pH, so pH was manually controlled until a full valve control exercise could be implemented. After a series of adjustments and investigations, the blend valve was eventually optimised in mid-February.

Investigations showed that the replacement valve was not commissioned properly; the control changes required by the valve were not fully taken into account, and the media used in the remin vessel was not being topped up regularly. This led to the remin tank functioning with very little active media during the commissioning of the new valve, giving an incomplete picture of the control changes the valve would need to function effectively. Additionally, the remin tank is undersized by 50-60%, making pH control difficult due to the high flow rate through the remin tank, significantly higher than the flow recommended for the media.

The pH after the remin tank is set to be 9.5, the upper maximum allowable pH standard, due to subsequent monosodium phosphate (MSP) dosing for plumbosolvency control, which lowers pH. There is therefore no margin for error if there is an issue with the dosing control of either pH controlling chemicals or MSP. It is noted that Kyle of Lochalsh WTW is one of five sites in Scotland which has not optimised plumbosolvency control. The online final water pH probe was faulty, so incorrect readings were being used throughout the incident to monitor pH, and there was a general lack of pH monitoring at the site. There was inadequate sampling and analysis of water from consumers' taps which gives no confidence that wholesome water was supplied to consumers.

Scottish Water reacted appropriately to the high turbidity alarm, and considerable resources were put into maintaining the pH within the required limits during the incident and working to resolve the considerable issues pertaining to the incident. However, the issue of commissioning the valve with a low media content could have been easily avoided. Problems were experienced at Aultbea WTW in October 2015, partly as a result of leaving too long a gap between topping up media in the remin tank, and it is disappointing that lessons highlighted by that incident had not been learned.

Carron Valley WTW – elevated consumer contacts – August 2017

Scottish Water became aware of an elevated number of consumer contacts from Falkirk and the surrounding area about taste and odour in August 2017. Sampling showed the presence of geosmin in the supply, a naturally occurring compound which is associated with algae and can be detected at very low levels by consumers of the supply. Following trials, a temporary powdered activated carbon (PAC) plant was sourced from another of Scottish Water's treatment works and installed at Carron Valley WTW. Analysis of the supply and consumer contacts showed that treated water geosmin levels subsequently reduced. There were 377

water quality contacts between 1 August and 13 October from consumers to Scottish Water as a result of this incident.

In response to the high number of consumer contacts generated from this incident, DWQR staff visited Carron Valley WTW in September 2017 to discuss the ongoing incident and progress with PAC dosing. The level of attention being given to the issues was reassuring.

While a significant proportion of consumers would not consume the supply because of its taste and odour, Scottish Water was able to demonstrate through appropriate analysis of the supply that it was not a risk to health and acted decisively in dealing with the incident once staff were aware of it. Deficiencies in the method of collating consumer contact data meant Scottish Water staff were slow in responding to this incident, but once they were aware, operational staff acted in a systematic, well co-ordinated manner. Comprehensive sampling across the water supply system was carried out, and logical and thorough operational actions were based on the analytical results. Alternative supplies were made available.

Scottish Water identified six actions and DWQR identified a further four, to minimise the risk of recurrence. These mainly focussed on the monitoring of the supply to better understand algal growth and the formation of algal by-products, and also on ensuring that the PAC plant was suitably set up for any further algal blooms on the raw water.

Penwhirn WTW – process failure followed by non-compliant water supplied on re-start – December 2017

In mid December 2017, Scottish Water's operational staff were advised that telemetry contact had been lost with Penwhirn WTW near Glenluce in Dumfries and Galloway. Attendance on site was delayed as the standby operator had been called out to an alarm at another water treatment works. When the operator arrived on site, over five hours later, it was found that the works was without power and the treatment process had shut down. The operator did, however, notice some water passing through the works without being treated. Issues with the PLC unit, which controls the treatment were discovered, which prevented a rapid re-starting of the treatment process. Following restart of the treatment works, twelve complaints were received from consumers. The only parameter that failed in the water tests undertaken by Scottish Water during the incident was colour, which is largely of aesthetic significance. However, the presence of highly coloured water is strongly suggestive that trihalomethane precursor compounds may have been present during the disinfection process, potentially leading to large concentrations of these disinfection by-products. It is unacceptable that Scottish Water does not appear to have analysed for these compounds during the time of greatest risk.

Scottish Water attributes the root cause of the incident to the failure of the battery operated UPS system to properly shutdown the treatment works when the power failed. Although there was a standby generator which should have taken over from the mains supply (and is tested regularly), on this occasion the fault with the PLC prevented this from happening. The battery in the UPS system only had sufficient charge to partially close the inlet valve to the

works, which enabled some untreated water to continue to flow. Scottish Water estimate this to have been a very small amount, although there is nothing other than visual evidence to back this up.

Upon restart, the water flowing through the treatment process was of poor quality due to the disruption to the process. This was initially noticed by consumers, although the situation improved once the process stabilised.

It appears that there had previously been little understanding of the battery requirements of the UPS system. These were last changed six years ago, despite there being a scheduled maintenance task every two years. This has now been changed to an annual replacement.

Operational staff were aware that the water supplied initially on start-up was not of acceptable quality, but felt that they had little choice due to low levels of water within the tanks in the supply area. The poorer quality was due to the disturbance of the treatment process rather than the effect of the untreated water flowing through the works, although it appears that little in the way of risk assessment of the impact of supplying non-compliant water was undertaken at the time. From trend information about the water quality through the treatment process DWQR considers that, had Scottish Water waited even a short period of time before returning the works to supply, the improvement in water quality would have been significant. It is acknowledged that staff were no doubt under considerable pressure, but their decision making process was hampered by a lack of water quality monitors at the site, with those present being set to an inappropriate scale. This is something Scottish Water has identified and is committed to addressing.

Shapinsay Service Reservoir – restrictions on water use – September 2017

A sample taken from Shapinsay SR, Orkney, in September 2017 failed microbiological standards with three coliforms and one *E. coli* present. On receipt of the laboratory report, additional samples were taken from the service reservoir the following day. However, following discussions with the Consultant in Public Health Medicine (CPHM), a decision was taken to issue a "Do Not Drink, Do Not Cook" notice and bottled water was shipped to Shapinsay for distribution to all consumers. An Incident Management Team was formed to co-ordinate and agree actions and roles during the incident. As a precaution, a decision was also taken to isolate the service reservoir from the water network to supply directly from the mainland and restrictions on water use notices were delivered to consumers. All five additional samples taken following the initial failure met microbiological standards and it was agreed to lift the restriction on use. "End of restriction" notices were provided to all consumers. The service reservoir was refilled and put back into supply the following day, following confirmation that the samples that were taken prior to the service reservoir being isolated were clear.

Scottish Water's investigation has failed to identify conclusively the root cause of the sample failure but has identified two issues: the handling and storage of sample bottles and the possibility of sample contamination; and the integrity of the service reservoir itself.

Its investigation of the service reservoir identified a number of concerns with the tank structure that may cause contamination of the supply. Reference to rainfall records highlights heavy rain in the locality in the days prior to the sample being taken. DWQR staff visited the site following the incident, carrying out an audit of the service reservoir and made a number of observations on integrity issues which were of sufficient concern to expect priority attention by Scottish Water.

DWQR audit of Shapinsay SR

Scottish Water took the necessary steps to identify the probable source of the contaminated water and limit its onward transmission to consumers. Sampling carried out provided confidence around the severity of the contamination. The necessary contacts were made with the Consultant in Public Health Medicine allowing appropriate protective measures to be put in place. DWQR's investigations have, however, highlighted concerns that the incident response did not fully adhere to the Scottish Waterborne Hazard Plan (SWHP) agreed by all key agencies and stakeholders. Evidence gathered indicates that communications with Orkney Islands Council environmental health officers were not carried out and that these were expected to be cascaded by the NHS Trust. The establishment of effective communications with all health stakeholders is a fundamental requirement for successful management of water quality incidents allowing a clear understanding of the issues being presented and actions required to be taken. It is Scottish Water's responsibility to ensure that effective communication takes place. In this case, comments received from health stakeholders indicate there was confusion around communications; on the formation of an Incident Management Team; actions for vulnerable groups in the community; and the degree of severity of the restriction on use notice issued. The importance of inclusivity of stakeholders was demonstrated by the proliferation of confused comments and misinformation on social media platforms by islanders, pre-empting the establishment of the Incident Management Team and official actions. It is essential that Scottish Water works to ensure there is a full and clear understanding of roles and responsibilities in the SWHP in order that control of incidents is maintained.

Craigie Regulation Supply Zone - restrictions on water use – January 2017

Following a number of consumer contacts of discoloured water from the Culsalmond, Insch area on the evening of 31 December 2016 and related flushing of the water mains, a water sample taken four days later on 4 January failed microbiological standards when it was shown to contain *Clostridium perfringens*. After further flushing and sampling in response to the failure, resamples continued to show *Clostridium* at consumers' taps. In discussions with the Consultant in Public Health Medicine thirteen days after the initial detection, on 13 January, a decision was taken to issue a "Boil Water" notice to homes and businesses. Colpy Service Reservoir, which supplies the area, was isolated from the system two days later

on 15 January after a sample taken there also failed, and a temporary tanker was located to maintain supplies in the distribution system. Inspection within the service reservoir found ingress of external surface water into the tank from roof faults and this was thought to be the cause of contamination and discolouration. Continuing sampling at consumers' taps and of the tankered water supplies showed all microbiological standards to be met from the time the tanker was put in place and the boil water notice was lifted after it had been in place for six days.

Although Scottish Water responded appropriately to the discolouration complaints, DWQR considers that any indicator of contamination requires urgent investigation, and in this case there was an unacceptable delay in carrying out follow-up sampling. Whilst sampling led to identification of ingress at the service reservoir as being the source of the microbiological contamination, DWQR was not satisfied that the ingress of water into the service reservoir was also the root cause of the discoloured water problem. We did not consider that this had been adequately explored by sampling to draw this conclusion.

This incident highlighted a series of errors within Scottish Water's procedures for repairing and recommissioning service reservoirs following cleaning. A fault in the integrity of the service reservoir at a roof beam joint embedded in the service reservoir wall had been permitted to persist unrepaired, providing a point of ingress during times of wet weather. This had endured, improperly repaired, through two previous cleaning operations. An amended procedure to require joint inspection between engineering contractors, cleaning contractor and Scottish Water staff, to witness flood testing of service reservoir roofs prior to reinstatement of the service reservoir in the supply system, has been identified as an action from this incident by Scottish Water. DWQR considers it imperative that there should be systems in place to provide confidence that remedial works carried out are effective. DWQR also considers the length of time between the initial identification of an ingress problem with this reservoir in 2013 and subsequent repairs being completed in 2015 is too long. It is not acceptable that consumers were placed at risk for this period of time. Scottish Water have significantly increased the investment available for service reservoir maintenance to ensure that there is no backlog of maintenance and that repairs are made in a timely manner.

3 AUDIT AND INSPECTION

An important part of DWQR's scrutiny role is to audit and inspect activities undertaken by Scottish Water. DWQR may choose to inspect any aspect of Scottish Water's activities that could affect water quality. Inspections commonly undertaken include water treatment works, storage points, distribution system activities, response to consumer water quality issues and analytical services. Auditing takes place against the requirements of the Regulations, as well as water industry best practice. DWQR also audits the completion of investment projects. Typically site visits will be undertaken prior to DWQR signing off the larger water treatment works projects and DWQR will audit a selection of Scottish Water's self-certification projects.

The inspection process provides a number of benefits:

- It enables DWQR to verify that Scottish Water is complying with regulatory requirements at sites across Scotland
- It allows DWQR to see new initiatives and areas of best practice
- It is an opportunity for DWQR staff to meet site-based Scottish Water staff and discuss water quality issues with them
- It raises awareness of DWQR and the regulations amongst Scottish Water staff
- It enables verification of the delivery of investment work
- It enables DWQR to build an awareness of common trends, risks or deficiencies across Scotland and use these to inform future policy and guidance.

We select sites for inspection using a risk based process that takes into account sample failures and water quality events and incidents. DWQR may also choose to inspect sites randomly or directly following incidents. Other types of inspection may be undertaken in response to a particular issue or concern. In the past, DWQR has inspected the procurement of services affecting water quality and actions to complete DWQR recommendations.

DWQR uses standardised inspection templates to ensure consistency between inspectors, and the audit process is subject to an ISO accredited procedure. DWQR also participates in benchmarking audits with other regulators in the UK and beyond in order to drive consistency and to spread best practice.

Where issues are noted during an inspection, these are recorded as recommendations that are tracked and followed up. If common themes are identified, these are progressed centrally with senior Scottish Water staff. Elements of best practice are also highlighted when these are observed. Scottish Water always has an opportunity to comment on draft inspection reports and co-operates fully during the technical inspection process.

Once an inspection report has been finalised, the completed report is sent to Scottish Water and a summary placed on the DWQR website.

Water Treatment Works Inspections

In 2017, DWQR completed thirteen inspections of water treatment works. These are listed in **Table 4**. Scottish Water staff operated their plants with a high degree of professionalism and many examples of best practice were noted. As the inspections were risk or incident triggered, particular attention was paid to the deficiency that had triggered the audit, whether this was asset based or procedural.

The greatest number of recommendations were for monitoring, especially the ability to effectively monitor and control water quality throughout the treatment process and going into distribution.

Most sites visited were maintained and operated to a high standard, but notable issues that DWQR identified included:

- Insufficient signage around sampling points and monitors;
- Deficiencies in raw and treated water quality monitoring, both on-line monitoring and manual sampling. This was not only to give confirmation of water quality, but also to inform treatment process operation;
- Process control issues and the need for the development of procedures for responding to process alarms;
- The need to update and review procedures and water safety plans.

Table 4 Water Treatment Works Audited during 2017

Location	Date	Reason for Audit	No. of Recommendations
Blairlinnans (W. Dunbartonshire)	January	Risk based	6
Tullich (Oban)	March	Risk based	3
Bayhead (North Uist)	May	Risk based	4
Stoneybridge (South Uist)	May	Risk based	1
South Moorhouse (Newton Mearns)	June	Risk based	13
Hopes (E. Lothian)	August	Risk based	3
Kirbister (Orkney)	October	Risk based	1
North Hoy (Orkney)	October	Risk based	1
Newmore (Invergordon)	November	Risk based	10
Savalbeg (Lairg)	November	Risk based	8
Milngavie	November	Risk based	0
Kyle of Lochalsh	November	Incidents	3
Amlaird (Kilmarnock)	December	Incident	10

Stoneybridge WTW, South Uist

In addition to full site audits, DWQR also undertakes site visits in relation to water quality events and incident investigations and to follow up on remedial works recommended by DWQR following previous incidents. The sites visited are listed in **Table 5.**

Table 5 Sites Visited in Conjunction with Incident Investigations during 2017

Location	Date
South Moorhouse (Newton Mearns)	March
Ardreonaig WTW	July
Whalsay WTW (Shetland)	July
Chalkieside SR (Pathhead)	August
Carron Valley WTW (Falkirk)	September
Kyle of Lochalsh WTW	November

Benchmarking

DWQR retains close contact with the other water quality regulators in the UK and Europe to share best practice. During 2017 DWQR invited the Drinking Water Inspectorate of Northern Ireland to attend an audit; and we undertook an audit of Guernsey Water. These afforded excellent benchmarking opportunities: both to ensure DWQR's operations team are auditing to a high standard; and to benchmark Scottish Water's operations and procedures against other water providers.

Storage and Distribution

We undertook three audits of storage reservoirs in 2017.

Our recommendations included preventing ingress of contamination, security and record keeping.

Table 6 Distribution System Audits 2017

Location	Date	Reason for Audit	No. of Recommendations
Clachan SR (North Uist)	May 2017	Risk based	0
Graemsay SR (Orkney)	October 2017	Risk based	3
Shapinsay SR (Orkney)	October 2017	Risk based	4

Services

Scottish Water has two UKAS accredited laboratories which undertake all sample examination and analysis for Scottish Water and private contractors. Both of these sites were audited during 2017.

DWQR also audited Scottish Water's customer complaints procedure during 2017, where individual recorded calls were scrutinised to ensure that water quality complaints are dealt with correctly and efficiently. Five recommendations were made following the audit. These included the need to record contacts accurately and in good time; make sure complaints are addressed fully; and that sample results are issued quickly.

Table 7 Audit of Services

Location	Date	No. of Recommendations
Scrutiny of Customer Complaints	March 2017	5
Juniper House Laboratory (Edinburgh)	December 2017	3
Henderson Drive Laboratory (Inverness)	December 2017	3

Investment

Scottish Water has been directed by Scottish Ministers to achieve a number of different objectives to improve and protect drinking water quality. DWQR has a role to monitor progress with delivery of these outputs through the Outputs Monitoring Group (OMG) and

also signs off those outputs associated with water treatment works improvements from the 2010 – 2015 period, a small number of which remain outstanding.

Scottish Water was due to complete investment at Muirdykes, Amlaird, Bradan and Tullich water treatment works during 2017 and had given Undertakings to Scottish Ministers for these schemes which all had a completion deadline. The reasons for delay are varied, but include issues with the supply chain, technical installation problems and numerous commissioning issues. The delays at three of these sites were going to extend into several months so DWQR issued

Enforcement Notices. The exception was the new manganese removal process at Muirdykes which was successfully brought into supply a few weeks later than originally planned.

Construction of the new WTW at Tullich

Scottish Water entered a new investment period from 1 April 2015 which will run until 31 March 2021. This includes a number of outputs for improving and protecting drinking water. Scottish Water self-certifies completion of these and DWQR audits a selected number. A small number of outputs were due to be delivered during 2017 as most projects are at option selection stage or still under construction.

DWQR undertook a number of sites visits and audits during the year, either to review progress or for the purposes of assessing the project's readiness for the output completion to be signed off.

A number of site visits were undertaken during 2017 and these are detailed in **Table 8**.

Table 8 Investment site visits undertaken during 2017

Location	Solution	Reason for Site Visit
Tullich (Oban)	New treatment works	Project delay
Gorbals PS (Glasgow)	New installation (Amlaird project)	Project delay
Invercannie (Banchory)	Treatment upgrade	Investment proposal independent review

ANNEX A INFORMATION LETTERS ISSUED DURING 2017

There were no information letters issued to Scottish Water during 2017.

Copies of all Information letters are available to view on the DWQR website:

www.dwqr.scot

ANNEX B CURRENT UNDERTAKINGS AND ENFORCEMENT NOTICES

Where water supplies do not comply with the required water quality standard, there are a number of mechanisms available to DWQR to ensure that the necessary steps are taken to achieve compliance. These are set out in DWQR's Enforcement Policy, which is published on the DWQR website. www.dwqr.scot

Undertakings

In general, the DWQR will seek to secure compliance with legislation through co-operation, discussion and offering advice. This process of co-operation and discussion may result in Scottish Water giving a legally binding Undertaking to Scottish Ministers, under the provision of Section 76E of the Water (Scotland) Act 1980, setting out the steps that Scottish Water will take to secure compliance with the legislation. Such Undertakings provide a visible commitment from Scottish Water that the necessary improvement will be made.

In 2017, there were five on-going Undertakings:

Muirdykes water treatment works and supply zones – Manganese.

(The agreed delivery date for this undertaking was not met)

Amlaird water treatment works and supply zones – THMs

(The agreed delivery date for this undertaking was not met and an Enforcement Notice was issued)

Bradan water treatment works and supply zones – THMs

(The agreed delivery date for this undertaking was not met and an Enforcement Notice was issued)

Tullich water treatment works – *Cryptosporidium*
(The agreed delivery date for this undertaking was not met and an Enforcement Notice was issued)

Tullich water treatment works – THMs

(The agreed delivery date for this undertaking was not met and an Enforcement Notice was issued)

Enforcement Notices

When DWQR has evidence that Scottish Water has contravened a drinking water quality duty and the contravention is likely to recur *and* Scottish Water does not appear willing to take timely steps to rectify the situation, DWQR may serve an Enforcement Notice on Scottish

Water under Section 10 of the Water Industry (Scotland) Act 2002. Such an Enforcement Notice must set out specific actions to be taken by Scottish Water within specified timescales. Failure to complete such actions by the due date is a criminal offence under Section 12 (5) of the Act.

In 2017, there were four active Enforcement Notices:

Invercannie water treatment works - *Cryptosporidium*

Amlaird water treatment works and supply zones – THMs

Bradan water treatment works – THMs

Tullich water treatment works – THMs and *Cryptosporidium*

ANNEX C STATISTICAL METHODS USED IN THE REPORT

Water Quality Compliance Data for Local Authority Areas

In order to present drinking water quality data by local authority area, it has been necessary to report data for the group of supply zones within that area. Water supply zone boundaries do not fit local authority boundaries exactly, so the data for any supply zone which falls wholly or partly into the local authority area has been included.

This approach means that data from some supply zones is included twice or more in the Local Authority Area tables. For example, the same data for Glencorse A supply zone is included in the sections for East Lothian, Midlothian and City of Edinburgh.

Zonal Compliance

Zonal compliance is simply the percentage of samples meeting the PCV (Prescribed Concentration or Value) for that parameter.

Mean Zonal Compliance

Mean zonal compliance (MZC) for an area is built up from zonal compliance figures for individual parameters in individual supply zones. This is a helpful tool when considering water quality at national, regional and local level as it provides a simple means of summarising drinking water compliance and comparing year on year performance. It is this measure which is used as the overall measure of drinking water quality by Drinking Water Inspectorate (DWI) for companies in England and Wales and it allows us to compare national performance. It uses only the thirty nine parameters that are listed in Schedule 1 of The Public Water Supplies (Scotland) Regulations 2014 for which there is a numerical value.

All parameters are weighted equally in the calculation but the sheer number of pesticide determinands has the potential to skew the MZC calculation by placing undue weight on pesticide analysis. For that reason, results for the individual pesticides not specifically mentioned in Schedule 1 of the Regulations have been pooled to produce a single "All Pesticides" parameter. The large number of different pesticides analysed every year is determined using a risk assessment process to define specific sampling requirements in each supply zone.

MZC can be quite variable year on year as it can deteriorate significantly should a parameter fail in a very small zone sampled only once per year – effectively giving 0% compliance for that zone. This is a particular issue in Scotland, as some of the water supply zones are very small, serving populations in single figures. Regulatory sample frequencies are based on population, hence sampling for certain parameters in these zones is infrequent, with perhaps only two samples being taken for each parameter per year. If one of these samples fails, this will adversely affect MZC to a much greater extent than a sample failure in a large supply.

For this reason the measure of overall water quality compliance at consumers' taps is also calculated and used to report year on year comparative performance.

Overall Quality Compliance

The Overall Quality Compliance for Scotland as measured at consumers' taps is simply the number of samples taken which met the required standards for parameters which have a numeric value in the Regulations.

Distribution Maintenance Index

The Distribution Maintenance Index (DMI) is the same as the Operational Performance Index (TIM) used in previous DWQR reports. It is used to reflect the performance of the distribution system for a zone or collection of zones, and is simply the arithmetic mean of the MZCs for turbidity, manganese and iron for the zone.

Worked Examples

Zonal Compliance

The zonal compliance for iron for a notional supply zone, Zone 1, is calculated as follows:

	No. samples taken for iron	No. samples failing	Zonal Compliance (Iron)
Zone 1	52	2	96.15

Mean Zonal Compliance

In order to calculate the MZC for iron for a group of ten zones which include Zone 1, the arithmetic mean of all the zonal compliances for iron is taken.

Zone 1	96.15
Zone 2	98.6
Zone 3	100
Zone 4	100
Zone 5	100
Zone 6	100
Zone 7	100
Zone 8	100
Zone 9	100
Zone 10	100
MZC	99.48

ANNEX D ABBREVIATIONS USED IN THE REPORT

Bq/l	Becquerels per litre
CWT	Clear Water Tank
DMI	Distribution Maintenance Index
DWI	Drinking Water Inspectorate for England and Wales
DWQR	Drinking Water Quality Regulator for Scotland
ISO	International Standards Organisation
mg/l	milligrammes per litre
MSP	Monosodium Phosphate
MZC	Mean Zonal Compliance
NHS	National Health Service
NTU	Nephelometric Turbidity Unit
OMG	Outputs Monitoring Group
PAC	Powdered Activated Carbon
PCV	Prescribed Concentration or Value
PLC	Programmable Logic Controller
PS	Pumping Station
RO	Reverse Osmosis
SWHP	Scottish Waterborne Hazard Plan
SR	Service Reservoir
THM	Trihalomethanes
TIM	Operational Performance Index
µg/l	microgrammes per litre
UKAS	United Kingdom Accreditation Service
UPS	Uninterruptable Power Supply
UV	Ultraviolet Light
WTW	Water Treatment Works

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