Water contamination events in UK drinking-water supply systems

John Gray

ABSTRACT

Water supply companies in the UK have a duty under prime UK legislation to notify the Drinking Water Inspectorate of events affecting or potentially affecting the quality of drinking-water supplies. Under the same legislation, the Inspectorate has a duty to investigate each event. After assessing all of the information available, including companies' reports, the Inspectorate advises on the way in which the event was handled and whether any statutory requirements were contravened. If appropriate, a prosecution of the water company may be initiated. Copies of the assessment are sent to the water company, relevant local and health authorities, Ofwat (the economic regulator), the regional Consumer Council for Water and any other interested parties, including consumers who request it. Generic guidance may be issued to the industry on matters of wider concern.

This paper considers the role of the Inspectorate, the powers available to it and reporting arrangements. An overview is presented of events that occurred between 1990 and 2005 and common features are identified. Causes of different types of event are discussed. The importance of well-established contacts between the various interested parties involved in protecting public health is emphasised through discussion of example incidents.

Key words | chemical contamination, consumers, drinking water, incidents, microbiological contamination

John Gray
Drinking Water Inspectorate, Room M08,
55 Whitehall, London SW1A 2EY,
UK
E-mail: *johngray587@btopenworld.com*

INTRODUCTION

Duties and structure of the drinking water inspectorate

The Drinking Water Inspectorate (DWI) was established on 2 January 1990 following privatisation of the water industry. Initially it was (to a limited extent) staffed by former members of the Department of the Environment supplemented by others recruited from, among others, the water industry itself. The DWI now operates within the Department for Environment, Food and Rural Affairs (Defra) and has a staff of 37, of which 30 are technically professionally qualified in water-related sciences or IT. The Operations group, responsible for the delivery of the technical audit and inspection functions as well as incident investigations, includes some three Principal Inspectors, each supported by three Inspectors. Each company is allocated to an Inspector who has responsibility for routine day-to-day matters including receiving incident notifications, assessing compliance data, handling of consumer complaints, and contact with local and health authorities in the companies' areas of supply. Principal Inspectors are responsible for oversight of regional issues, including contacts with regional Consumer Councils for Water. Thus there is local contact as well as regional oversight.

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Regulatory role of inspectorate

The Water Act 2003 (section 57) (HMSO 2003) provides for the appointment of the Chief Inspector of Drinking Water

and amends the Water Industry Act 1991 (HMSO 1991) to allow for the appointment of Inspectors. The Drinking Water Inspectorate acts for and on behalf of the Secretary of State and the National Assembly for Wales to ensure that water companies in England and Wales meet their regulatory obligations in terms of drinking water quality. In this capacity the Drinking Water Inspectorate has a technical audit role for public water supplies, with powers of enforcement and prosecution.

Drinking water standards

Standards relating to the quality of drinking-water supplies are contained in the Water Supply (Water Quality) Regulations 2000 (2001 in Wales) (HMSO 2000). Standards are linked to the World Health Organisation guideline values for drinking-water quality which are intended to protect public health as well as ensuring that water supplies are aesthetically acceptable to consumers. Under the EC Directive, standards will be subject to revision in the light of new knowledge. Compared with previous regulations (HMSO 1989*a*), the 2000 Regulations contain some new and revised standards but others, that are no longer appropriate, have been withdrawn.

INCIDENTS

Reporting of water quality incidents

Under Section 68 of the Water Industry Act 1991, water companies have a duty to supply wholesome water for domestic and food production purposes. However, events occasionally occur that might impact on the quality or sufficiency of the water supplied. Water companies are required to notify such events to the Drinking Water Inspectorate under the terms set out in the Water Undertakers (Information) Direction 2004 (DWI 2004). This duty is enforceable under Section 202 of the Act.

The relevant section of the current Information Direction requires water companies to notify the Inspectorate of:

- the occurrence of any event which, by reason of its effect or likely effect on the quality or sufficiency of water supplied by it, gives rise or is likely to give rise to a significant risk to the health of the persons to whom the water is supplied. This will include any event notified by a water undertaker to a local or health authority under regulation 30(5) of the Water Supply (Water Quality) Regulations 1989.
- any other matter relating to the supply of water which:
  - in the opinion of the undertaker is of national significance; or
  - has attracted or, in the opinion of the undertaker, is likely to attract significant local or national publicity; or
  - has caused or, in the opinion of the undertaker, is likely to cause significant concern to persons to whom the water is supplied.
- any reports of disease in the community which it appears might possibly be associated with a water supply.

These criteria apply only to public water supplies. The responsibility for monitoring private water supplies rests with Local Authorities.

The wording of the current Information Direction, and its predecessor Directions, deliberately leaves the decision on what should be notified to the water companies. This is because an event that appears significant to a small company could appear to be less so to a larger company. Furthermore the trigger for consumer complaints may be very different between a rural area and a highly populated inner city area. Given these perceived anomalies, the Inspectorate has, over the years, issued guidance in the form of Information Letters to the industry on the type of events that it considers should be notified. The most recent guidance was given in 1999 and included a long list of the sort of events that should be notified, with the caveat that this was not definitive. The same Information Letter (13/99) (DWI 1999) also provided guidance on the investigation process carried out by the Inspectorate.

Incident investigation

Although all events are reportable, not all events are incidents. DWI considers an incident to be:

- a non-trivial or unexpected breach of Part II of the Water Supply (Water Quality) Regulations 200, as amended; or
- a breach of Part IV of the 1989 Regulations; or

- an unusual deterioration in water quality; or
- a significant risk to the health of consumers; or
- a significant number of consumers perceive adverse water quality changes; or
- significant local or national media interest on a water quality issue that could result in consumer concern.

Most incidents are relatively minor happenings but all are assessed thoroughly and may result in recommendations to the company concerned on the actions needed to minimise the risk of future failures. Where the lessons to be learnt might benefit other companies, generic guidance may be issued to the industry. Consideration is given to whether during the incident the company contravened any of the wholesomeness standards set out in the Water Supply (Water Quality) Regulations 2000. The DWI also considers whether the company contravened any other enforceable regulatory duty. If contraventions occurred, the Inspectorate then considers whether or not the breaches were trivial or likely to recur and whether enforcement action under Section 18 of the Water Industry Act 1991 is required.

The assessment also takes into account the actions taken by the company to protect consumers and whether the company followed the advice given in *Guidance on Safeguarding the Quality of Public Water Supplies* (HMSO 1989*b*) and whether it followed industry best practice.

Depending on the circumstances, the DWI may have to consider whether water unfit for human consumption was supplied during the incident. If there is sufficient evidence to show that water unfit for human consumption was supplied, that the company did not exercise all due diligence to prevent the incident from occurring and if it is in the public interest, then prosecution under Section 70 of the Water Industry Act may be considered.

Numbers of water-related chemical incidents reported to the DWI

Between 1990 and 2001 there was a steady year-on-year increase in the number of notifications received from water companies (see Table 1 and Figure 1). This was attributed to the industry becoming more familiar with the process and the type of events that should be notified. In recent years some 60–70% of notifications have been classified as non-incidents. Occasionally the DWI is made aware of a water quality problem by a third party, for example, a health authority may inform DWI of an increase in the number of reported cases of cryptosporidiosis at the same time as informing the water company.

Table 2 and Figure 2 show the number of notifications received between 1995 and 2005. They show the number of notifications that were classified as incidents and the number of cases taken forward for prosecution.

Table 3 identifies at which part of the water supply chain the incident occurred, broadly classified as treatment works, service reservoir or in the distribution system. In earlier years, many of the incidents related to bacteriological failures or problems at water treatment works. In later years the proportion of incidents occurring within the distribution system has increased and includes

Table 1 | Type of incident by year

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Microbiological	33	21	24	26	28	42	47	35	14	24	28	42	27	27	23	26
Disinfection failure	5	7	10	8	15	12	12	8	8	11	9	3	7	7	6	0
Chemical pcv exceedence	21	6	6	5	12	20	11	39	81	105	86	63	55	45	51	35
Aesthetic parameter	3	1	4	2	9	0	0	8	15	8	8	12	9	10	2	5
Potential or alleged contamination	2	1	4	7	3	0	0	0	0	0	0	0	0	0	1	1
Hydrocarbons/oil	1	4	2	2	2	0	0	0	0	0	0	0	0	0	0	0
Cryptosporidium	1	1	9	2	0	3	6	9	1	6	6	2	0	2	1	1
Loss of supply	5	0	1	0	3	0	0	0	0	0	0	0	0	0	2	4
Other	1	2	0	1	2	6	0	4	8	4	6	16	13	8	4	11
Total	72	43	60	53	74	83	76	103	127	168	143	138	111	99	90	83

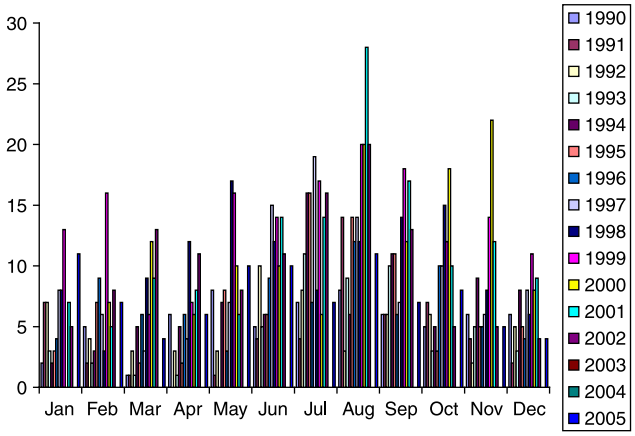

Figure 1 | Monthly distribution of incidents.

microbiological contamination as well as discoloured water incidents. The numbers reflect the increased activity occurring within the systems to carry out remedial work on what are often Victorian water mains in need of remediation.

A peak occurred in 1999 which was attributed to the condition of the distribution systems and the associated remediation work being carried out. The Inspectorate considered that many of these incidents were avoidable since work planning was, in many instances, less than perfect. Since then the number of discoloured water incidents has gradually decreased as companies have responded with improved planning and better operational management.

Table 2 | Number of notifications, prosecutions and cautions by year

Year	Notifications	Incidents	Prosecutions and cautions
1995	157	83	3
1996	176	76	3
1997	197	95	16
1998	300	120	17
1999	388	166	10
2000	429	139	4
2001	459	138	0
2002	398	130	1
2003	353	99	1
2004	304	89	2
2005	391	92	2

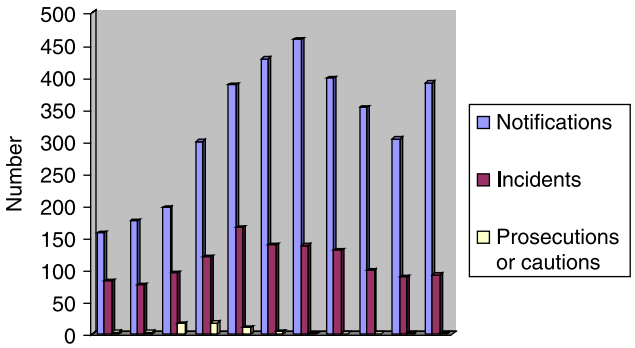

Figure 2 | Number of notifications, incidents, prosecutions and cautions by year.

EXAMPLE INCIDENTS

On day 1, a consumer reported a taste in the water supply. Three adjacent properties were affected and were supplied with bottled water. Consumers were advised not to use the water. The water company sampled on day 2 and confirmed the presence of organic chemicals including 2-(methylthio)benzothiazole, dimethyl butanedioic acid and bromohexanol at concentrations up to 0.5 μg/l. Unidentified hydrocarbons at concentrations up to 10 μg/l were also detected. All three properties had been recently connected to a new medium-density polyethylene main. The main was flushed and water quality returned to normal. The company sought toxicological advice but advice was only available for related compounds, not for the specific compounds identified.

The Inspectorate concluded that analytical support was good. However, advice related to health risks and toxicology was limited in that no specific toxicological information was available for the specific compounds in question with data only available on related compounds.

On day 1 a consumer reported a petrol-like taste in the water supply. The water company flushed the main and apparently resolved the problem. On day 14, the same consumer again reported a petrol/rubber-cement taste in the water supply. The company sampled the affected property, an adjacent property and a hydrant on day 18. Analytical results were not available until day 29, which confirmed that the value for odour exceeded the standard. On day 32, a neighbour reported a benzene-like taste in the water supply. The company flushed the main the same day, believing the problem to be associated with

Table 3 | Location of incidents by year

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Water treatment works	28	20	23	17	31	32	26	25	17	27	23	6	8	10	26	32
Service reservoirs	14	8	7	6	8	8	8	14	2	7	7	0	5	2	5	6
Distribution system	21	22	30	29	33	37	42	60	100	120	104	116	85	79	58	46
Others	–	–	–	–	–	6	–	3	5	12	5	16	14	8	0	2
Total	73	50	60	52	72	83	76	102	124	166	139	138	112	99	89	86

'a build-up of iron in the mains'. The presence of dissolved hydrocarbons up to a concentration of 31 μg/l was confirmed on day 36. The local authority and health authority were advised and the latter sought toxicological advice. Bottled water was supplied to consumers in the seven properties affected. Investigations by the company revealed no obvious source of the contamination. The company decided to replace the MDPE communication pipe and, during excavations, discovered a layer of bituminous material some 0.5 m thick close to one of the affected properties just under pavement level. This had an odour similar to that found in the consumers' supply and was subsequently shown to contain toluene, kerosene and diesel hydrocarbons.

The Inspectorate considered that there were unacceptable delays in providing analytical support and advice related to health risks and toxicology. There were also significant delays in establishing interagency assistance and communications between relevant bodies.

On day 1 the manager at a water treatment works was informed that concentrations of isoproturon had been detected by on-line organic monitoring equipment at concentrations up to 4.3 μg/l in the raw water source supplying the treatment works. Isoproturon was found in the treated water at concentrations up to 1.3 μg/l. Dosing of powdered activated carbon was immediately increased. Samples taken from the associated service reservoirs and some consumers' properties on days 1, 2 and 3 contained up to 1.5 μg/l isoproturon, in excess of the standard but less than the WHO guideline value. The company notified the local authority, health authority and the Environment Agency on day 2.

The Inspectorate considered that analytical support was good but that there were some delays in the communications between relevant bodies.

On what was to become day 1, an unknown quantity of chlorpyriphos was discharged into a river, 6 km upstream of the abstraction point supplying a water company's water treatment works. Invertebrate deaths occurred in the river on day 6. The company was informed on day 8, when it arranged for the analysis for chlorpyriphos of the previous day's sample and arranged for further samples of the raw water to be taken. A sample of raw water taken on day 10 contained 0.325 μg/l chlorpyriphos, although none was found in the treated water leaving the works. No samples were taken of treated water in the supply. The local authority, health authority and the DWI were informed on day 12.

The Inspectorate considered that analytical support was unacceptably delayed and that there were also significant delays in interagency assistance and communications between relevant bodies.

Prior to the coming into force of the Water Supply (Water Quality) Regulations 2000, the water company started monitoring in May 2000 its sources for compliance with the new standards, including bromate. It identified one groundwater source with a concentration of >100 μg/l bromate, which it confirmed by subsequent sampling. The source was isolated from the supply and discussions initiated with the health authority, the local authorities, the DWI and the Environment Agency. Samples were taken from private supplies and other water sources. It was concluded that the contamination arose from a previous industrial site. Monitoring of the plume continues but remediation has not yet been initiated. The company continues to manage the loss of an important and significant source of water.

The Inspectorate considered that analytical support, assessment of health risks, provision of toxicological advice, interagency assistance and communications between relevant bodies were good. Other examples have

been presented and discussed at two conferences, the proceedings of which have been published (Gray & Thompson 2004; Thompson & Gray 2006).

CONCLUSION AND RECOMMENDATIONS

Over recent years many incidents of chemical and microbiological contamination of drinking water have been reported in England and Wales. Few have resulted in significant adverse health effects. However, experience in responding to these events has shown that, to provide effective support to the public and consumers, close links between public health organisations, water companies, the regulators and other related bodies are essential. This paper has identified some of the common features required of the different disciplines of medical toxicology, public health and drinking-water quality regulation.

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