Case study 7 – An outbreak of *Escherichia coli* 0157 infection amongst users of a private water supply when staying in holiday accommodation

This case study relates to the circumstances surrounding illness suffered by members of three independent family groups holidaying at two cottages served by a private supply in summer 2015. The problem was identified by epidemiological surveillance. The index case was a seven-year-old male member of a family group of 22 individuals that had been staying together in one of the cottages. The boy was admitted to hospital triggering notification of Public Health England (PHE) on 7 August. A further four individuals in this family group who were found to be symptomatic, included two other children aged seven and nine-years-old. The various members of this family group had dispersed home across the country with some returning further afield to Canada. On 10 August, PHE was notified of another child with a confirmed *E.coli O157* infection by Public Health Scotland. This child was a member of a different family group of 14 individuals that had stayed at the other cottage on the same private supply. At least one further member of this family group was symptomatic. On 13 August, PHE became aware of a further case of *E.coli O157* infection in a member of a third family group of 16 individuals that had holidayed at this other cottage.

In total the outbreak comprised 22 symptomatic cases of diarrhoea and vomiting amongst the 52 individuals making up these three family groups (42% attack rate). Fourteen of these cases were laboratory confirmed infections with the same strain of *E.coli O157* (phage type 21/28, gene VT2). Five of the cases were hospitalised at some point during their illness. Both adults and children, and both females (13) and males (9) were affected. The epidemiological curve based on self-reported first symptom onset dates indicated a point source of infection arising just prior to 31 July, with the peak of infection occurring on 4 August. Three cases with later onset dates of 8 and 9 August were probably due to secondary person-to-person spread among these household groups.

Outbreak control

Tap water samples collected on 7 August for faecal indicator tests gave satisfactory results, however, as the indicator test for *E.coli* is not capable of detecting *E.coli O157*, subsequent tap samples were collected on 11 August for pathogen testing by PHE and these proved to be positive for the outbreak strain of *E.coli O157* (phage type 21/28, gene VT2).

Action to prevent further exposure to the private water supply was agreed by the outbreak control team and put in place by the local authority in the form of a Regulation 18 private water supply Notice on 13 August. The Notice prohibited use of the water for drinking, cooking, food preparation and personal washing (hand, bath, shower). Essentially the use of the water supply was restricted at this stage to just toilet flushing with bottled water provided for all other purposes.

After some immediate improvements to the supply further tap samples collected on two consecutive days (18 and 19 August) tested negative for *E.coli O157* and in the absence of any new reported cases, this Notice was revoked and replaced on 27 August with a new Regulation 18 Notice, allowing water to be used for personal washing as well as toilet flushing but requiring water to be boiled before use for drinking and food preparation. This second Notice was required because a sample collected on 18 August had demonstrated the presence of *E.coli O157* in the spring source confirming that contamination of the source had taken place and longer term risk mitigation measures needed to be investigated by the local authority. Source monitoring showed that *E.coli*

O157 remained detectable in the source water for longer than one month (a positive sample collected on 2 September was followed by negative samples collected on 16 and 30 September).

The water supply

The private supply spring source is located in a wooded area of grazing pasture on hillside above the premises (see Figure 12).

Figure 12: Situation of the source

Water is piped from the source holding tank to five storage tanks located at one of the three premises situated adjacent to one another in a valley with land abutting a small river. The water is then piped into the treatment room where it goes into another pre-treatment holding tank, before passing through a pre-filter and a UV disinfection unit.

Figure 13: Holding tank

Figure 14: Storage tanks

Figure 15: Internal untreated water holding tank

Figure 16: UV treatment

The local authority had carried out a risk assessment of this private water supply in 2012 using the original risk assessment methodology. This risk assessment carried out by the local authority did not flag up any need for the supply to be improved because, while the source was located in grazing pasture, the livestock in question were sheep and there was fencing to keep these sheep away from the spring, the water was disinfected with UV prior to use, and there was a maintenance contract in place for annual servicing of this equipment. The original risk assessment did not require the whole supply (source to tap) to be considered and hence fell short of a comprehensive water safety plan approach. In addition the previous risk assessment methodology did not consider hazards associated with the management and operation of a supply and the implications on the risk to health of users.

Immediately following the putting in place of the first restriction Notice, the owner of the supply who lived in one of the three premises called in the maintenance engineer. The engineer's visit revealed that the disinfection system was operating but it was undersized. The equipment was designed to treat a flow of 9 litre/min whereas demand from the three premises when fully occupied was of the order of 45 litre/min. The Inspectorate's risk assessment tool guides local authorities to consider, where treatment is already in place, whether it is adequate to treat the current volume of water which is being used – i.e. at normal and peak flow periods. The engineer identified the need for a larger disinfection unit sized to treat 60 litre/min. In addition, the pre-treatment in place was a filter of nominal 250 micron size. Such a filter acts only as a coarse screen to remove larger particles, not to achieve the required 1NTU prior to disinfection. To adequately pre-treat water for UV disinfection of spring water the pre-treatment should include a second finer filter of five micron or less and this should be preceded by a 20 micron filter. Coarse screens should be located at the source tank. These issues were addressed immediately by the installation of new equipment which consisted of a 60 litre/min UV unit preceded by two cartridge filters, the first being five micron and the second being one micron nominal pore size.

The equipment was also fitted with a 'fail safe auto cut off' device to prevent forward flow of water that may not have been disinfected in the event of a power failure. Following these works the pipe network was chlorinated and flushed through. A six monthly maintenance contract was set up with the water treatment engineer and a comprehensive water safety plan was put in place.

A review of the historic local authority private supply records revealed that annual samples had been collected from a tap in one of the premises in March 2012, April 2013 and August 2014. While the sample in 2013 (and another in 2010) had given satisfactory results, Enterococci (1 per 100ml) had been reported in the 2012 sample and the 2014 sample contained coliforms (40 per 100ml and *E.coli* 30 per 100ml). Routine water indicator tests do not detect the pathogen *E.coli O157*, however, a positive result for faecal organisms (>1 per 100ml) indicates ingress of animal or human faecal matter and therefore a heightened risk of pathogens being present. In a treated water sample, a positive result also indicates that any disinfection equipment in place may not be functioning effectively. The positive sample result obtained in 2014 had been followed up by the local authority advising the supply owner to arrange for the treatment equipment to be serviced. The next sample collected on 7 August 2015 as part of the local authority regulatory compliance monitoring programme gave a satisfactory result for the parameters tested. If the previous positive result had been followed up differently with an investigation based on the methodology in the Inspectorate's risk assessment tool, the defects with this supply (changes in the catchment, undersized equipment

and inadequate active management) could have been identified earlier enabling action to be taken that may have prevented the outbreak from occurring.

As part of the outbreak investigation the local authority applied the Inspectorate's risk assessment tool and consulted with the Environment Agency. This revealed that the underlying bedrock in the spring location is fissured limestone. The general area has some drift cover of clay but this was absent in the immediate vicinity of the spring. These natural features make the source vulnerable to fast surface water in-flows creating a direct route for surface contaminants to enter the spring source. It was also found that a significant change had occurred in the catchment. A new tenant farmer had commenced grazing of the pasture by cattle, not sheep. During times of inclement weather, including heavy rainfall in late July, the cattle had taken to sheltering in the woodland where the spring was located. The cattle had damaged the fencing and had been defecating in the immediate proximity of the source. Historic maintenance of the supply had not included inspection and cleaning out of the spring water holding tank and the tank was not fitted with either an inlet or outlet sediment trap.

Figure 17: Fence pushed down by livestock

Maintenance of the supply had been limited to annual servicing of the UV disinfection equipment and there were no records of other essential active management activities such as regular visual inspections of the source and its immediate catchment, the condition of the tanks or the day-to-day functionality of the UV lamp and filter.

Based on the updated risk information, the local authority was able to work with the owner of the supply and the tenant farmer to identify changes in land use and supply management that would mitigate the identified risks and enable the boil water notice to be lifted. On 12 November, the tenant farmer agreed to install a wider perimeter fence preventing cattle from entering a 6,000 square metre area around the spring source. In addition a voluntary agreement was made to limit the grazing density in the wider area to no greater than one cow per acre. The local authority also required the supply owner to put in place a water safety plan with active management procedures and record keeping before lifting the boil water restriction notice. Although not required by the local

authority, since the outbreak, the owner of one of the holiday cottages has decided to connect the premises to the local mains water supply.

Learning points

The outbreak occurred through a combination of several factors. Recent rainfall mobilized animal excrement increasing the likelihood of pathogens entering the spring through surface inflows; tall vegetation around the source attracted the animals to shelter from rain in the area proximal to the source; the land use had changed from grazing of sheep to cattle increasing the likelihood of *E.coli O157* being present. The premises served by the water supply were fully occupied and water demand was five times higher than intended for the disinfection system design.

This case study provides compelling evidence of the need for private water supplies to be actively managed with the design and maintenance regime being informed by a comprehensive risk assessment that is kept under continuous review and updated in light of changed circumstances. Where it is identified that the manager or owner of a supply is not in direct control of activities in the catchment of a spring source then the local authority is advised to require a water safety plan to be put in place that provides confidence that the grazing of cattle in proximity to the source is restricted. The risk assessment should document all relevant persons as defined in Section 80(7) of the Water Industry Act and everyone, including the owner and manager of land where the source is situated, should contribute to and be directly involved in the development of the water safety plan. Such a plan should involve the keeping of records by the supply owner or manager of regular visual checks that land use agreements regarding livestock and the use of chemicals or fertilizer are in place and being adhered to.

Catchment measures alone are insufficient to safeguard a spring supply. There should be multiple barriers in place. Over and beyond catchment measures, as a minimum, there should be coarse screens on the raw water holding tank inflow and outflow that are regularly inspected and kept clean, combined with a treatment system sized to function effectively at times of maximum demand. The risk assessment should critically evaluate the maximum daily water use in the context of the maximum design capacity of the treatment equipment. All disinfection systems should include pre-treatment comprising two filters in series with the second being no greater in nominal size than five microns. There should be records kept by the owner to demonstrate that the condition and functionality of the screens, filters and disinfection system are checked no less often than weekly. Such records should also contain details of the action taken when checks indicated the need, as well changes made to the system to accommodate a change in use along with the details of any annual service or maintenance contract.

This case study, like many published by the Inspectorate since 2010, also demonstrates the need for private supply owners and local authorities to have access to better water engineering advice. The functionality of all forms of equipment for water treatment depends critically on the design comfortably being able to meet the maximum demand on the system. There must be safeguards in place also to ensure that rapid changes in source water quality do not result in water with a turbidity of >1 NTU being presented for disinfection. At present there is no means by which private supply owners or local authorities can be assured about the equipment and services on offer, although many local authorities keep lists of reliable treatment installers.

Through the publication of this case study, local authorities are reminded of the need to notify the Inspectorate at the earliest opportunity when there is a case of *E.coli O157* infection in a person resident in their area under investigation as to the exposure source. In such circumstances it is important to explore the individual's recent travel history for any potential exposure to a private water supply at a location elsewhere and the national private water supply record held by the Inspectorate enables ready access to information and knowledge that can enhance epidemiological surveillance in relation to *E.coli O157* and support the response of any outbreak control team formed.

An important part of this outbreak investigation, beyond the putting in place of appropriate short and long-term risk mitigation measures, was the need also to establish the spring as the source of the pathogen and the likely duration of the contamination event. Little is known about the survival of *E.coli O157* in raw water sources and their catchments so there was a need to monitor the raw water over time. This raw water monitoring highlighted that such contamination events may not be short lived since *E.coli O157* persisted in this spring source for several weeks after confirmation of the contamination event. This investigation revealed a lack of water laboratory capacity to test water samples for *E.coli O157*, which in turn highlighted a need for the Inspectorate to review with the water industry its capacity to better understand through monitoring the prevalence of this pathogen in raw waters going forward. Specific to private supplies, local authorities need ready access to a testing service for *E.coli O157* in order to verify regulatory risk assessments of vulnerable spring sources.