1 Summary and recommendations

1.1 Summary

1.1.1 This is the Third Report of the Expert Group on Cryptosporidium in Water Supplies following those published in 1990 and 1995 under the chairmanship of the late Sir John Badenoch. Ministers decided to re-establish an Expert Group on Cryptosporidium in water supplies under the chairmanship of Professor Ian Bouchier following the outbreak of cryptosporidiosis in north west London and Hertfordshire in early spring 1997 which was associated with drinking water derived from underground strata.

1.1.2 The tasks of the Group as defined in its terms of reference were to:

- assess the lessons learned from suspected waterborne outbreaks of cryptosporidiosis;
- consider the results of research carried out since publication of the Second Report of the Group of Experts;
- consider whether there is a need for further advice on: protection of water resources, including surface and groundwaters; provision of additional water treatment; design of monitoring programmes and strategies; management of outbreaks of drinking water related illness;
- consider whether further research is appropriate; and
- report jointly to the Secretary of State for the Environment, Transport and the Regions and the Secretary of State for Health.

1.1.3 The Group addressed these requirements and came to the following important conclusions:

- Outbreaks of water related cryptosporidiosis do not just ‘happen’. There appears to be a strong correlation between outbreaks and situations where an inadequacy was identified in the treatment provided or in the operation of the treatment process, or where there was overloading of the treatment process.

- Turbidity monitoring through the water treatment process is a vital element in checking that treatment barriers are working properly. The unifying factor in all outbreak situations is the potential for peaks in turbidity to be present in the treated water leaving the works. The fact that turbidity events were not recognised in all cases could be a reflection of inadequacy in the continuity of turbidity monitoring, the interpretation of results or in the calibration and control of the equipment.
Not all groundwater is consistently of high quality. Sources affected by the possibility of intermittent rapid transmission of water from the surface are potentially at high risk of contamination by *Cryptosporidium*.

No reliance can be placed on disinfection at this time so physical barriers remain the form of treatment that will provide protection against *Cryptosporidium*. Conventional treatment is effective providing it is operated within design capacity and not bypassed.

It is not possible to recommend a health-related standard for *Cryptosporidium* in drinking water.

There is currently no cure for cryptosporidiosis. As a precautionary measure, to reduce the risk of waterborne cryptosporidiosis, immunocompromised persons should be advised to always bring to the boil all tap and bottled water used for drinking.

There are lessons to be learnt from the experience gained from handling outbreaks, in particular, the need for local working partnerships and the importance of communications, planning and rehearsals.

There is a need for more general recognition that water is not the only source of *Cryptosporidium* infection in humans. The organism can be acquired from food, milk, swimming pools, contact with farm and domestic animals and person to person transmission. Some epidemiological surveys following outbreaks have been deficient and there is a need for greater consistency in the quality of investigations.

Making human cryptosporidiosis a laboratory reportable disease in England and Wales would enable earlier identification of outbreaks and greater consistency in their reporting and recording.

There are a number of areas relating to *Cryptosporidium* that require further research including aspects of monitoring, analysis, water treatment and disinfection efficiency, transport and fate of oocysts in groundwater systems and therapy.

1.1.4 As a result of these findings the Expert Group has made a number of important recommendations with particular emphasis on advice to:

- water utilities;
- organisations and individuals concerned with the management of incidents and outbreaks; and
- those undertaking epidemiological surveys.

1.2 Recommendations

1.2.1 All of the Expert Group’s recommendations are reproduced below with short explanations where necessary. The full background is given in the main body of this Report (numbers in brackets refer to the Report paragraph).
1.2.2 The Group concluded from its examination of these incidents that outbreaks of water related cryptosporidiosis do not just ‘happen’. There appears to be a strong correlation between outbreaks and situations where an inadequacy was identified in the treatment provided or in the operation of the treatment process, or where there was overloading of the treatment process. A key factor in all situations was the potential for peaks in turbidity to have been present in the treated water leaving the works. The fact that turbidity events were not recognised in all cases could be a reflection of inadequacy in the continuity of turbidity monitoring or in the calibration and control of the equipment. Specific recommendations arising from these findings are included below under the heading Advice to Water Utilities but a general recommendation is given here.

Recommendation

1.2.3 All water utilities should review their implementation of the Badenoch recommendations (3.2.1).

1.2.4 The Group considers that there are four broad ways that a water utility could become aware of oocysts in the water supply:

- water utility detects oocysts in a sample of water;
- water utility detects a change of operational circumstance which potentially risks oocysts contaminating drinking water supplies;
- local health authority gets notification of an increase in stools containing Cryptosporidium oocysts; or
- the national disease surveillance centre is the first to detect a cluster of cases.

Arising from its consideration of these points, the Group has identified a number of recommendations to improve early recognition of potential problems, communications and reporting.

Recommendations

1.2.5 Water utilities should investigate immediately when oocysts are detected in raw water to establish if any circumstances exist to allow Cryptosporidium to enter water supplies. Investigations should include review of recent treatment plant operational data (3.3.3).

1.2.6 Water utilities should develop local liaison arrangements with the local authority and health authority for rapid appraisal of the potential health risk, particularly when oocysts are detected in final water or in distribution (3.3.4).

1.2.7 Water utilities should ensure that employees operating assets producing drinking water are aware of the types of circumstance which can potentially put water supplies at risk of Cryptosporidium contamination. Procedures should be in place to ensure rapid recognition and appraisal of risks associated with any relevant change in operational circumstance (3.3.6).

1.2.8 Water utilities should provide copies of water supply zone maps to Consultants in Disease Control or Consultants in Public Health Medicine and health authorities should make early contact with the local water utility if an outbreak of cryptosporidiosis is suspected (3.3.9).

1.2.9 Human cryptosporidiosis should be made a laboratory reportable disease in England and Wales and consideration should be given to
Groundwater as a drinking water resource and its vulnerability to contamination by Cryptosporidium (Chapter 4)

1.2.10 Wherever possible, health authorities should make postcodes of cases of human cryptosporidiosis available to water utilities to help both organisations identify as early as possible if particular water sources are involved and to allow regional trends to be assessed (3.3.12).

12.11 Groundwater provides over 30% of all water abstracted for public water supplies in England and Wales, 8% in Northern Ireland and 5% in Scotland. The possibility that an outbreak of cryptosporidiosis in March 1997 in north London was associated with a groundwater supply raised questions about Cryptosporidium as a possible groundwater contaminant. The Group concluded that not all groundwater is of consistently high quality. Water utilities should be especially vigilant for the possibility of intermittent rapid transmission of water from the surface into boreholes, wells and springs.

1.2.12 The isolation of oocysts in groundwater soon after rainfall recharge is a high risk circumstance which warrants immediate investigation. After making a risk assessment, water utilities should assess the possibility of minimising risk of contamination by reviewing catchment control options or by operational improvements to the security or integrity of the groundwater source. In rare cases the risk may be so unacceptably high that treatment installation is required. In the majority of cases, however, it will be necessary to carry out surveys and further investigations to confirm an unacceptable risk of groundwater contamination with Cryptosporidium before adopting a treatment solution. All risk assessments should be regularly reviewed, especially following any significant change in the catchment, the condition of the water supply source, or the demand on the source. The Group identified the following recommendations.

Recommendations

1.2.13 Water utilities should systematically assess and rank the potential risk of groundwater contamination by Cryptosporidium by application of a tripartite approach which assesses source, catchment and hydrogeological factors (4.8.1).

1.2.14 Continued use should be made of existing national groundwater vulnerability maps and source protection zoning schemes to assess risk of contamination with Cryptosporidium (4.8.2).

1.2.15 For Cryptosporidium risk assessment, a fourth classification ‘extreme vulnerability’ is recommended for use with vulnerability maps and zoning schemes (4.8.3).

1.2.16 In order to ensure that groundwaters continue to be protected from agricultural activity, the Ministry of Agriculture, Fisheries and Food should promote further the application of the Code of Good Agricultural Practice – Water within the farming industry (4.8.4).

1.2.17 Careful attention should be given to the operational aspects of groundwater abstraction (4.8.5).
Advice to water utilities (Chapter 5)

1.2.18 The Group concluded that ‘incidents do not just happen’. Worldwide there is an increasingly strong correlation between outbreaks and inadequacies in drinking water supply. A key element in providing appropriate treatment is the assessment of risk from Cryptosporidium.

Recommendation

1.2.19 The Group recommends that water utilities carry out an assessment of risk from Cryptosporidium for each source and put in place a procedure for updating periodically the review of the risk assessment. Water treatment requirements and monitoring systems should be reviewed against the level of risk (5.2.2).

1.2.20 Most waterborne outbreaks occurred due to deficiencies in water supply including those in which the treatment was inadequate, or the works were operated above design capacity or some part of the treatment was bypassed. As recognised in the earlier Expert Group Reports a conventional treatment works (that is coagulation aided filtration) operated in accordance with good practice, is normally an effective barrier against Cryptosporidium. The Group makes the following recommendations on water treatment.

Recommendations

1.2.21 Water treatment works should be designed to handle the typical peak turbidity and colour loadings in the source water (5.3.5).

1.2.22 Water treatment works should be operated at all times in a manner that minimises turbidity in the final water; attention should also be given to other parameters which reflect the performance of chemical coagulation, that is, coagulant metal concentration and colour (5.3.6).

1.2.23 Water treatment works should normally be operated within the design capacity and without by-passing of the solids-liquid separation processes which are responsible for removal of turbidity and coagulant solids; coagulation itself should never be by-passed or compromised (5.3.7).

1.2.24 In the event of an emergency, if it is necessary to overload or by-pass solid-liquid separation processes, a stringent monitoring regimen should be initiated to ensure that turbidity targets indicated in 1.2.32 below are not exceeded; if there is an indication that these targets will not be achieved, an immediate advice to boil notice should be issued (5.3.8).

1.2.25 For high risk sites, if minimisation of the effects of filter start up on final water quality cannot be achieved through more easily implemented changes (for example improved backwash or delayed start after backwash), modifications to the works should be made to allow the first flush to be run to waste or recycled to the works inlet (5.3.9).

1.2.26 Coagulation/flocculation processes should be checked regularly to meet changing conditions of source water quality and other environmental factors (5.3.10).

1.2.27 Only dedicated washwater mains should be used to carry the returned washwater flow (5.3.11).

1.2.28 Filters should be operated and maintained under optimum conditions with attention to the quality and depth of media and to the operation of the backwashing/air scouring system (5.3.12).
1.2.29 Treatment works staff should be trained to be aware of the potential effect on the final water quality of even very small changes in the catchment or the treatment stream (5.3.13).

1.2.30 Investigation of waterborne outbreaks has shown that often there was a significant increase in turbidity at the time that the contaminated water was estimated to have gone into supply. The Group has made the following recommendations on monitoring.

**Recommendations**

1.2.31 Water utilities should check that process monitoring systems are appropriate to the risk at each source (5.4.2).

1.2.32 For all sites at which Cryptosporidium might be a high risk, as determined by the risk assessment, monitoring should include continuous turbidity measurement on the outlet of each filter and on the final water using instruments capable of detecting changes of less than 0.1 NTU (5.4.3).

1.2.33 Water utilities should define for each of their treatment works the value and duration that constitute a significant deviation in turbidity of the final treated water irrespective of its relationship to the regulatory standard; for example it may be that at large water treatment works alarms should be set to be triggered by any increase in turbidity in the final water of greater than 50% of the normal average or suitably representative level; for small works, the increase of concern would vary and consideration should be given to the impact of the backwashing to individual filters (5.4.4).

1.2.34 Appropriate action procedures to react immediately to turbidity alarms, based on the level of risk and the history of the source/works should be in place; actions might include immediate sampling for Cryptosporidium, isolation of the filter(s) or source or, if suggested by history, the issue of advice to boil (5.4.5).

1.2.35 Good experience has been reported with the operational use of particle counters which, when used in conjunction with turbidity monitors, can provide a more sensitive indication of particle breakthrough.

**Recommendation**

1.2.36 The Group encourages the use of particle count monitors to provide additional information to that provided by turbidity measurements (5.4.7).

1.2.37 Waterborne outbreaks occur even though oocysts cannot be detected in the water. This supports the general view that the ‘contamination’ occurs for only a few hours during which time it would be complete chance that routine samples coincided with the event. Random spot sampling is, therefore, unlikely to be effective for operational monitoring.

**Recommendation**

1.2.38 Water utilities at high risk sites give consideration to either:

(i) continuous sampling for Cryptosporidium with analysis times linked to turbidity monitoring results; or

(ii) sampling triggered by turbidity events (5.4.9).
1.2.39 Generally, good local working relationships and practices involving water utilities, health authorities and local authorities are in place. However, the Group wishes to emphasise the importance of both Incident Management Teams and Outbreak Control Teams and of the role of the water utilities in ensuring that the required local advice and support is in place to respond quickly to changing operational circumstances.

**Recommendations**

1.2.40 Water utilities should review their working relationships with local health authorities and environmental health officers in the form of Incident Management Teams. Criteria should be established for identifying outbreaks and procedures put in place for activating Outbreak Control Teams (5.5.2).

1.2.41 Water utilities, in liaison with health authorities, should set out criteria for decision-making on the issue and the withdrawal of notice on advice to boil water and review these with experience (5.5.3).

1.2.42 Should there be an outbreak of cryptosporidiosis, the water utility, as a member of the Outbreak Control Team, should encourage the use of good epidemiology recommended in this Report to establish the source of the outbreak, including whether illness is associated with the drinking water supply (5.5.4).

1.2.43 Water utilities should encourage Incident Management and Outbreak Control Teams to review and rehearse regularly the response procedures to incidents and outbreaks (5.5.5).

**Advice on management of waterborne outbreaks of cryptosporidiosis (Chapter 6)**

1.2.44 Since the First Report of the Expert Group, an increased understanding of cryptosporidial infection has been gained, as too has experience in incident and outbreak investigations and management. Incident Management Teams (IMT) and Outbreak Control Teams (OCT) are seen as part of the overall arrangements by health authorities for the control of communicable disease and as such are very practical teams whose aim is the protection of public health by the prevention of infection. If an incident leads to an outbreak of illness in the community or it is expected that this will occur, the IMT will evolve into an OCT. In practice, the function and membership of both these teams is similar, to protect public health and return the situation to normal as soon as possible. The exact stage when an IMT will become an OCT will depend on each incident and local circumstances and could be early in the incident.

1.2.45 It is important to remember however that there may be conflicting interests both within and outside the teams. The detail of information necessary to reach a conclusion for medical and public health needs may fail badly as legal evidence in a criminal prosecution and the resource required to collect different levels of evidence may vary considerably. It would be expected that, as the OCT is set up at the request of a Director of Public Health, it is primarily a team with a health objective.

**Recommendation**

1.2.46 It is essential that Outbreak Control Teams are aware at the outset of the scope and purpose of their brief and that there is a clear understanding of the roles, responsibilities and standing of each member (6.1.5).

1.2.47 An incident involving the breakthrough of *Cryptosporidium* oocysts through water treatment and into distribution may not be as obvious to identify as complete malfunctions such as disinfection or plant
breakdown. This is covered in more detail in Chapter 5 on advice to water utilities. It is possible that some water treatment plants may contribute to the background level of cryptosporidiosis in a community but there are other sources such as contact with animals, swimming pools, food and milk. Usually the sources of background levels are not investigated or identified.

**Recommendation 1.2.48** To facilitate recognition of an incident involving *Cryptosporidium*, there is a need for local studies to identify background levels of cryptosporidiosis, and for local risk assessments to be conducted so that any increased incidence can be identified easily (6.2.5).

1.2.49 The need for systematic recording of events, particularly in the fast-moving early stages of an incident, should not be neglected and log-books will have an important role in the epidemiological study and in any subsequent review of lessons to be learned.

**Recommendation 1.2.50** All those involved at any stage of an incident should start a log-book immediately. This should include dates, times, key facts, summaries of telephone calls, and the actions taken by named staff (6.2.8).

1.2.51 The Group recognises that there is a need for uniformity in the wording of advice on boiling water to ensure that the water is microbiologically safe whilst avoiding confusion to consumers and potential dangers with overheating electric kettles. It is necessary only to bring the water to the boil to kill *Cryptosporidium* oocysts. Water should be allowed to cool before use.

**Recommendation 1.2.52** All notices of advice to boil water issued to consumers should make it clear that it is only necessary to bring the water to the boil and then to allow it to cool before use (6.2.21).

1.2.53 The Group emphasises the importance of liaison and team work in managing an incident or outbreak involving *Cryptosporidium* in the drinking water supply. The organisations concerned should meet regularly to discuss procedures and these should be rehearsed regularly.

**Recommendations 1.2.54** All parties likely to be involved in an IMT or OCT should establish a working dialogue and trust, preferably prior to the emergency situation, so that when a major incident occurs it will be dealt with more effectively (6.3.6).

1.2.55 All parties should regularly simulate incident and outbreak events to rehearse emergency procedures (6.3.7).

1.2.56 There is a strong argument for some members of the team being appointed on account of their experience in dealing with water borne outbreaks previously or their knowledge of water treatment and distribution.

**Recommendation 1.2.57** The Expert Group recommends that a list of national experts who can be contacted in the event of an outbreak, be compiled. Consideration should be given to how the list should be compiled but it could include epidemiologists, public health microbiologists and water engineers with experience in the investigation of waterborne outbreaks of infection. Such experts would supplement local knowledge but not replace it (6.3.11).
1.2.58 The Group recognises that the statutory powers for the investigation and control of communicable disease rests within the health authorities and the local authorities. However, it considers that OCT reports should be formally received and recommendations commented upon by the Drinking Water Inspectorate or its regulatory equivalent to ensure consistency and that any lessons learnt are communicated widely.

**Recommendation 1.2.59** OCT reports on waterborne outbreaks should be formally received and recommendations commented upon by the Drinking Water Inspectorate or its regulatory equivalents (6.3.14).

**Guidance on the epidemiological investigation of outbreaks of infection (Chapter 7)**

1.2.60 The Group recognises that high quality epidemiological information is vital to the investigation of possible outbreaks of waterborne infection associated with mains water consumption because microbiological evidence of water contamination by pathogenic organisms is often difficult to obtain and even when it is available, such evidence is rarely conclusive. Some previous epidemiological surveys have been deficient and there is a need for greater consistency in the quality of investigations. The Group commends the use of the Guidance on the Epidemiological Investigation of Outbreaks of Infection (Appendix A4 of this Report) to assist in the conduct of epidemiological studies for CCDCs/CPHMs and other members of OCTs.

**Recommendation 1.2.61** The Group recommends the Chairman and members of the Outbreak Control Team use the Guidance on the Epidemiological Investigation of Outbreaks of Infection (Appendix A4 in this Report) in all outbreaks where waterborne infection is suspected (7.3.2).

**Advice to the immunocompromised (Chapter 8)**

1.2.62 Cryptosporidiosis in immunocompromised people often results in a chronic life-threatening gastroenteritis with a high mortality. Whilst the Group recognises that the occurrence of Cryptosporidium in treated water is very rare it considers that the following recommendation will minimise the risk to immunocompromised people from drinking water.

**Recommendation 1.2.63** The Group recommends that all water, from whatever source, that might be consumed by immunocompromised persons should be brought to the boil and allowed to cool before use (8.3.7).

**Current therapeutic approaches to cryptosporidiosis (Chapter 9)**

1.2.64 No antimicrobial agent has yet proved curative for cryptosporidiosis. However, there have been a number of encouraging reports on the use of paromomycin, and albendazole and nitazoxanide which may have some clinical use in cryptosporidiosis. A number of other agents including azithromycin, have shown some limited therapeutic effect. No drug regimens are known to be effective in preventing the recurrence of cryptosporidiosis.

**Recommendation 1.2.65** The Department of Health should continue to keep work in progress under review and encourage further controlled trials of new agents as they become available (9.6.2).


1.2.66 Appendix A1 sets out those recommendations from the Second Report of the Expert Group, many of which originated in the First Report, which the current Expert Group considers to be of continuing relevance and worth emphasising. In addition the Group has added and amplified some of the recommendations where necessary and these are set out below.
**Further recommendations of the Expert Group**

1.2.67 A national database should be established to provide comprehensive information on the occurrence of oocysts in both source and treated water (A1.3.1).

1.2.68 Research work on oocysts in sewage effluents should be directed at that work associated with typing and host specificity (A1.3.2).

1.2.69 The advice on storage and disposal of animal waste should be reaffirmed and efforts increased to encourage farmers to follow Codes of good practice (A1.3.3).

1.2.70 The inactivation of Cryptosporidium oocysts should be made one specific consideration in policy and practice in the disposal of sludges to land (A1.3.4).

1.2.71 Advice on personal hygiene in handling food, in preparation of ice and bottled waters should be reviewed and promoted by the new Food Standards Agency (A1.4.2).

1.2.72 It is considered that although disinfection has some effect, its contribution at time of most need (ie barrier breakthrough) has not been proven so in public health protection terms it cannot be relied upon (A1.5.2).

1.2.73 In light of some mistaken laboratory identifications of Cryptosporidium, consideration should be given to further training of laboratory staff and electronic links with expert laboratories (A1.5.4).

**Future of the Expert Group**

1.2.74 The re-establishment of the Expert Group acknowledges the need to re-consider *Cryptosporidium* as a water supply issue in the light of experience gained in water treatment and outbreak management.

**Recommendation**

1.2.75 The Expert Group should reconvene at two yearly intervals to consider, in the light of experience, whether additional advice should be issued and identify topics where further research is needed (2.9.2).

**Recommendations for research (Chapter 11)**

1.2.76 The Group has identified the following as areas requiring further research:

For groundwater:

(i) development of operational monitoring tools to improve the detection of rapid influence of surface water sources on the quality of groundwater;

(ii) transport and fate of *Cryptosporidium* and other pathogens in groundwater systems;

(iii) application of chemical and particulate tracers to investigate the transport and attenuation of pathogens in groundwater;

(iv) mechanisms causing, and the significance of, turbidity in groundwater to establish the role of rapid influence by surface water and assessing the use of turbidity as a monitoring tool; and

(v) attenuation rates for *Cryptosporidium* in soils and unsaturated zones following application of farm wastes and sewage sludge to land (4.7.2).
For treatment and monitoring:

(vi) application of continuous monitoring for Cryptosporidium in treated waters and investigation of correlation between Cryptosporidium and operating conditions that might lead to breakthrough of the organism;

(vii) investigations into the ways laboratory analytical procedures might affect the biological properties of oocysts;

(viii) development of a standardised approach to conducting disinfection trials;

(ix) development of reliable, routine tests for oocyst viability;

(x) further studies of the application of seroprevalence studies in assessing the impact of water treatment in reducing community exposure to Cryptosporidium;

(xi) investigation of the impact of operating filters under declining rate on the removal of Cryptosporidium;

(xii) evaluation of quality changes in treated waters and development of procedures to allow operators to identify Cryptosporidium risk associated with these changes for specific treatment works;

(xiii) development of techniques to specify and assess the performance of filtration systems for oocyst removal from groundwaters; and

(xiv) further evaluation and development of the use of bacterial spores to assess treatment performance (11.7.1).