

**An outbreak of
cryptosporidiosis
linked to swimming
at the
Eastwood Pool,
Giffnock**

Final Report



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Glossary

CDSC	Communicable Disease Surveillance Centre
CEO	Chief Executive
D&V	Diarrhoea and Vomiting
Defra	Department of Environment, Food and Rural Affairs
DNA	Deoxyribonucleic acid
GCC	Glasgow City Council
EDC	East Dunbartonshire Council
EHO	Environmental Health Officer
ERC	East Renfrewshire Council
GGNHSB	Greater Glasgow NHS Board
GSS	Glasgow Scientific Services
HIV	Human Immunodeficiency Virus
HPA	Health Protection Agency
HPS	Health Protection Scotland
HSE	Health and Safety Executive
ISRM	Institute of Sports and Recreation Management
MLG	Multi-locus genotyping
NHS	National Health Service
NHSGG	NHS Greater Glasgow
NLC	North Lanarkshire Council
OCT	Outbreak Control Team
PAC	Poly aluminium chloride
PCR	Polymerase Chain Reaction
PHPU	Public Health Protection Unit
PWTAG	Pool Water Treatment Advisory Group
UC	Uniformity Coefficient
RFLP	Restriction Fragment Length Polymorphism
RIPH	Royal Institute of Public Health
SCID	Severe Combined Immune Deficiency
SEHD	Scottish Executive Health Department
SLC	South Lanarkshire Council
SPDL	Scottish Parasite Diagnostic Laboratory
SW	Scottish Water
WDC	West Dunbartonshire Council

1. Summary

Over a period of about 6 weeks from the beginning of September to the middle of October in 2003, 50 cases of illness suspected to be due to infection with a strain of the *Cryptosporidium hominis* parasite and linked to the Eastwood Pool Complex, Giffnock, were reported to Greater Glasgow NHS Board's (GGNHSB's) Public Health Protection Unit. Of these, 29 were microbiologically confirmed (24 had primary exposure to the pool and 5 had secondary exposure via contact with a primary case) and 21 were unconfirmed (all 21 had primary exposure to the pool). Their dates of onset of illness ranged from 5 August to 20 September 2003 while the dates of possible exposure to pool water of primary cases ranged from 2 August to 8 September 2003.

East Renfrewshire Council (ERC) owns and manages the pool complex. The then Community & Leisure Department and the Property & Technical Services Division within ERC were responsible for the day-to-day running and on-going maintenance of the pool, respectively.

Following voluntary closure of the pool by ERC on 9 September 2003, an Outbreak Control Team (OCT) was convened consisting of representatives from GGNHSB^a, ERC, Glasgow City Council Environmental Protection Services^b, the Scottish Parasite Diagnostic Laboratory and the Scottish Centre for Infection and Environmental Health^c.

The OCT concluded that the primary cause of the outbreak was exposure of pool users to contaminated pool water at Eastwood Pool Complex during August and early September 2003. Persistent contamination with *Cryptosporidium* was attributed by the OCT to a multi-factorial failure of the pool treatment plant system.

Direct observation by the OCT; the reports by the independent contractors commissioned by ERC to diagnose the problem with, and refurbish, the pool treatment plant; expert opinion offered by pool consultant experts in the field; and information provided by ERC officials suggested that the poor state of the filters was only one causal factor in this outbreak. The November 2000 refurbishment of the filters was found as a result of investigation into this outbreak to be seriously substandard. However, the lack of flow rate monitoring that resulted from non-calibration of existing meters was likely a contributory factor. Flow rates must be monitored in order to ensure that adequate flows are maintained to the filter from the pool and therefore that optimum flow rates are maintained as the water gravitates through the sand filter^d. In addition, in order to ensure that oocysts are retrieved from all corners of the pools, flow rates need to be adequate and therefore monitored. A related point is the fact that the input valves combined with pool inlet diffusers need to direct the water multi-directionally in order to avoid the formation of eddies that allow oocysts to accumulate in the pool. Those at the Eastwood Pool Complex were suboptimal, sending water out in long jets that created areas where pool circulation was poorer than in the remainder of the pools.

Amongst other problems, the scum drain drainage system was poorly designed, allowing water to lie in this area and the introduction of air into what must remain a closed, airless water system.

^a Now Greater Glasgow and Clyde NHS.

^b A representative from Glasgow City Council Environmental Protection Services was invited because several of the cases were residents of Glasgow City Council and because many pools in Glasgow City Council area had been refurbished by the same company that had carried out the November 2000 refurbishment on Eastwood Pool Complex.

^c Now Health Protection Scotland (HPS).

^d Optimal speeds for a sand filter of the kind used by the Eastwood Pool complex range from 10-25 m/hour (so-called medium rate filters).

Finally, the dosing of the pool with coagulant to encourage the coalescing of oocysts necessary to effect their removal by filtration, was carried out weekly rather than being linked to either swimmer usage statistics (a proxy for foreign organic material) or flow rates, as advised by Pool Water Treatment Advisory Group guidelines¹ (PWTAG) used nationally.

One possible initial source of the contamination was a family that used the pool following their return from Menorca in early August, while still convalescing from cryptosporidiosis. Nevertheless, conclusive proof of their role as causal is not available and it was the OCT's view that the persistent contamination of the pool resulting from the failure of the treatment plant described above was the most relevant causal factor in this outbreak. Any recommended solutions should therefore both address the need for pool operators, in both the private and public sectors, to optimize the quality of their operations by adhering to national guidelines, and the need for swimmers to avoid using pools and spas when they are actively ill with, or recovering from, a diarrhoeal illness. Pool operators and users should be made aware of this.

These conclusions were based on detailed epidemiological, environmental, microbiological and technical evidence available from notified cases of clinical illness and positive laboratory results from human faecal specimens, detailed questionnaire-based interviewing of cases, water sampling, physical inspection of the pool and its filters, as well as the evidence provided by the two independent contractors commissioned by ERC. It was reassuring to members of the OCT that unofficial advice obtained from various pool treatment consultant experts throughout the UK corroborated that provided by the independent contractors commissioned by ERC.

Pending the reports of these independent contractors, and for the purposes of the interim report it produced in February 2004, the OCT concluded that the filters were not fit-for-purpose as the result of an inappropriate choice and grade of filter media and a dysfunctional backwash^e system. This was on the basis of finding large amounts of filter sand on the floor of the pool, the very uneven surface of the sand medium in the filter itself and the many seashells found in the filter sand. The OCT concluded that the inadequate state of the filter had gone undetected as a result of a failure to visually inspect the vessel since the refurbishment in 2000, which was a clear breach of the PWTAG guidelines. In the interim report, the OCT also noted that pool flow monitors had not been calibrated and that, therefore, the flow of water from the pools and rain-spray area to the filters could not be monitored and hence removal of oocysts could not be assured.

In parallel to the OCT investigations, the Community & Leisure Department and the Property & Technical Services Division within ERC initiated their own investigations. This included commissioning work by independent contractors as referred to above. The Property & Technical Services Division commissioned a detailed report by Filtec Water Services Limited on the filter vessels, themselves, that was produced on 25 November 2003, and submitted to the Chair of the OCT on 3 December 2003. This report concluded that the refurbishment in 2000 had been 'substandard'. It revealed a wide range of problems with the filters, over and above that relating to the sand specification described above, which it agreed was questionable. The seashells found in the sand may have migrated upward in the filter from a poor quality gravel layer. Other problems identified were:

- long-standing wear and tear (corrosion and splitting of the filter vessel concrete),
- loss of filter media,

^e Backwash refers to the system whereby a large amount of water is allowed to flow through the filter in the reverse direction to enable it to clean the sand and gravel of debris collected during the primary filtration process. This dirty backwash water is then drained to the sewer. This backwash water can be tested for pathogens included *Cryptosporidium* oocysts.

- faulty design and condition of the 'laterals' which were deemed unserviceable,
- inappropriately large sized gravel in the base of the filter which served no purpose, and
- low backwash and air scour rates.

Following the outbreak, extensive refurbishment of the filters, and the introduction of effective flow rate monitoring, PAC dosing and scum drain drainage was carried out by another independent contractor, in addition to major renovation and general improvements to the pool area. New protocols were introduced by ERC addressing day-to-day operation and maintenance by pool operators, to inform users on safe use of the pool area and how to respond to extraordinary events (*e.g.* faecal or vomitus accidents into the pool). A leaflet was issued by ERC informing the public about the re-opening of the newly refurbished pool complex which advises users not to use the pool if they have been suffering from diarrhoea within the previous 14 days.

The OCT Chair wrote to the Chief Executive of each of the five other local authorities advised by GGNHSB including WDC, EDC, NLC, SLC, and GCC. This communication was aimed at informing them about the outbreak and its suspected cause, the need to adhere to PWTAG guidelines and, in particular, the need to inspect their pool filters if that had not been done in the past year. These local authorities were informed that the company involved in the 2000 refurbishment at the Eastwood Pool was known to have completed similar work in many other Scottish pools.

The interim report of the OCT's investigation was used by the Scottish Executive Health Department (SEHD) to inform local authorities nationally about the possibility that other swimming pool filters might also be in a sub-optimal state and might need to be inspected. The SEHD wrote to all Scottish local authorities and NHS Board Consultants in Public Health Medicine informing them of the recent problems with pool-related cryptosporidiosis outbreaks, and the need to ensure that the operation of pool treatment plants complied with PWTAG guidance. The correspondence to all local authorities across Scotland included a template letter to use when communicating with private pool operators.

In conjunction with the six local authorities it advises, GGNHSB produced a poster advising swimmers not to use pools within 14 days of suffering from infectious diarrhoea. This has been distributed to all public and private swimming pools in the GGNHSB area.

Finally, this investigation revealed the long-standing difficulties and inadequacies inherent in a weakly regulated industry where the private sector, in the form of independent swimming pool contractors and expert swimming pool consultants, interface with the statutory sector in the form of local and health authorities. The combination of non-enforceable guidelines (PWTAG) and the inevitable reliance on private companies, some of which fail to achieve minimum standards of workmanship, suggests that the risks of suboptimal pool water quality are likely to persist rather than reduce. The risks of outbreaks may also be increased if contracts for swimming pool related works are not properly specified and do not contain appropriate evaluation criteria but rather rely solely on price. NHS Board Departments of Public Health will need to ensure that they can identify and investigate each outbreak as they arise, including ensuring accessing independent technical advice.

This investigation was complicated by the conflict of interest experienced by some departments of ERC when faced with participating in an investigation of an outbreak linked to premises owned and operated by ERC. Valuable lessons have been learned locally that need to be extended nationwide if we are to move forward in this area of public health protection.

2. Introduction

During the first week of September 2003, the Public Health Protection Unit at Greater Glasgow NHS Board advised East Renfrewshire Council (ERC) Environmental Health of a number of confirmed cases of cryptosporidiosis in their area, and requested their investigation, as is normal practice. These cases were identified on the basis of confirmed laboratory results reported by Glasgow NHS microbiology laboratories which routinely test all faecal diarrhoeal specimens for the presence of the oocysts of the *Cryptosporidium* parasite.

As the number of these cases seemed higher than the normally expected level of 1-2 per week over the entire GGNHSB area, a principal EHO from East Renfrewshire Council (ERC) contacted the PHPU on 4 September 2003 to establish whether there was indeed an excess of cases associated with the East Renfrewshire area. At this stage Greater Glasgow NHS Board was not aware of any possible explanation for this trend.

Later that same day, another EHO from ERC advised GGNHSB about the possibility that two unrelated cases of cryptosporidiosis had both been swimming at the Eastwood Pools, raising for the first time, the possibility of a pool-related outbreak.

By Tuesday, 9 September, GGNHSB had information on five people with cryptosporidiosis whom EHOs had identified as having recently been swimming at the Eastwood Pool. By 3 pm that day, the pool management decided to close the pool in the interests of public safety and on the advice of a senior ERC environmental health officer, and pending further investigations. In view of this, Dr H. Irvine, Consultant in Public Health Medicine for GGNHSB determined, on the same day, that this qualified as an outbreak. An Outbreak Control Team (OCT) meeting was held on the following day, Wednesday, 10 September 2003.

Over the next five weeks, seven outbreak control team meetings were held (10th, 15th, 19th, 23rd September; 22nd October, 14th November, and 16th December).

An interim report produced by the OCT in February 2004 was shared with the Chief Executives (CEs) of ERC and GGNHSB, the Director of Public Health for GGNHSB and the Principal Medical Officer at the SEHD. In response to the interim report, the SEHD issued a letter to every local authority (with a copy to each NHS Board) informing them about the outbreak and advising them to take certain actions in respect of their private and public swimming pools (appendix 11.1 and 11.2). A letter was sent by the Chair of the OCT to the CE of ERC making some interim recommendations regarding the proposed remedial refurbishment. Finally, the Chair of the OCT wrote to the CEs and Chief Environmental Health Officers of the five other local authorities advised by GGNHSB to advise of the need to inspect any swimming pools in their jurisdiction, given the possibility that other pools in the Glasgow area might have been refurbished to a sub-standard level.

This final report includes a comprehensive description of the outbreak, its investigation, the many lessons learnt and recommendations aimed at ensuring that such swimming pool-related outbreaks are better identified, controlled and, ideally, prevented in future.

3. Background

The normal background rate for confirmed cryptosporidiosis infection in the GGNHSB area (population ~900,000) is approximately 1-2 cases per week during the non-springtime period. During the spring, lambs and calves are more likely to harbour *C. parvum* in their gut² and heavy spring-time rain showers are more likely to wash viable *C. parvum* oocysts into public water supplies. The number of reported cases in humans typically rises as a result of contact with young infected farm animals and/or consuming contaminated drinking water. Human outbreaks of significant size also arise in the GGNHSB area (*i.e.* more than 10 cases per week) in the summer or autumn, due to infection with either *C. parvum* or *C. hominis*, and are usually associated with travel abroad. During periods where swimming pool-related outbreaks are occurring abroad and pool-using British nationals return home with cryptosporidiosis infection, contamination of UK swimming pools needs to be considered as a risk factor in causing local outbreaks. Other causes of cryptosporidiosis include eating food contaminated with farm animal faeces. The historical tendency for the epidemiology of cryptosporidiosis in the UK to be bi-modal (springtime outbreaks of waterborne *C. parvum* and autumn travel-related outbreaks of *C. hominis*) is diminishing. Outbreaks of both species are now reported at any time of the year in England and Wales, perhaps reflecting better diagnosis, rising incidence of pool-related outbreaks, increasing travel abroad and improving drinking water quality (verbal communications with Dr Rachel Chalmers of the *Cryptosporidium* Reference Laboratory and Dr Gordon Nichol of HPA, Centre for Infection).

Until recently, outbreaks of cryptosporidiosis reported as being associated with swimming pools were uncommon in Scotland. A pool-related cryptosporidiosis outbreak was reported in Tayside in August 2002, and in West Lothian in 2003. In the summer of 2003, a large outbreak was reported in Majorca linked to swimming at the Alcudia Pins Hotel. Many of these cases returned to Scotland (including Glasgow) where they were recorded by the Scottish Centre for Infection and Environmental Health as being cases of infection acquired in Majorca. In the UK as a whole, reported cases of cryptosporidiosis climbed significantly throughout the summer and autumn of 2003 and links to either swimming abroad in *Cryptosporidium*-contaminated pools or in UK-based “water feature” pools were suspected in a number of small outbreaks although not consistently substantiated by epidemiological (analytical) studies^f.

Cryptosporidium is a single celled parasite of which there are 16 species in the genus. Seven of these species have caused infection in humans although five of these are much more likely to be found in immunocompromised individuals^g. *C. hominis* and *C. parvum* are the most commonly found species in humans and can cause significant clinical infection in immunocompetent individuals and severe infection in the immunocompromised.

Cryptosporidium hominis (formerly known as *C. parvum* Type 1) multiplies almost exclusively in the gut of infected human cases and carriers and is, therefore, considered to be primarily transmitted from person to person. *Cryptosporidium parvum* (formerly known as *C. parvum* Type 2) multiplies in the gut of infected mammals and therefore involves transmission from both humans and other mammals to humans. Transmission with either strain can be direct between an infected person and an immuno-susceptible contact^h, as with intimate or hand-to-hand contact. In

^f Data presented by the HPA at a Royal Institute of Public Health seminar on swimming pool and travel-related cryptosporidiosis on 2 December 2003, RIPH, London, and confirmed by verbal communication with Dr Gordon Nichol, HPA, CDSC, Colindale.

^g These include *C. meleagridis*, *C. felis*, *C. canis*, *C. suis* and *C. muris*.

^h An immuno-susceptible contact is a person who does not have sufficient prior exposure to the pathogen to mount an effective defence after coming into contact with the source case.

such person-to-person transmission, outbreaks tend to be limited in size. Alternatively, transmission can be indirect, as when a vehicle such as food or water is involved, potentially resulting in larger point-source outbreaks. Significantly-sized outbreaks involving either *C. hominis* or *C. parvum* may be caused by waterborne point sources such as when a domestic septic tank, or farm animal slurry, contaminates a water supply. Outbreaks can also be caused by contamination of swimming pool water by infected swimmers. In the latter scenario, water is supplied to the pool via the mains, becomes contaminated as a result of one or more infected swimmers and remains contaminated if the pool treatment works is unable to remove the chlorine-resistant oocysts, via filtration.

When sufficient numbersⁱ of viable and pathogenic oocysts are swallowed (constituting the infectious dose for that particular species/isolate of *Cryptosporidium*), they can result in either sub-clinical or symptomatic infection in the host. Each infectious oocyst releases four sporozoites that complete the life cycle in the same host (Figure 1). The massive increase in parasite numbers after completing numerous cycles of multiplication causes illness by damaging the lining of the small intestine. The average incubation period, which is not known with certainty, is 7 days on average, but can extend from 1-12 days.

Cryptosporidiosis is diagnosed by identifying the characteristic, spherical oocysts (4-6 microns in diameter) in a fresh faecal specimen using a light microscope and special stains. Direct and/or nested polymerase chain reaction (PCR) tests followed by restriction fragment length polymorphism (RFLP) and / or DNA sequencing can be used to further identify the species of *Cryptosporidium* associated with the illness. In many instances this is likely to be either *C. parvum* or *C. hominis* (which infect both immuno-competent^j and immunocompromised humans). Further molecular sub-typing (mini- and micro-satellite typing also known as multilocus genotyping (MLG) can be carried out as a research tool to identify sub-types of *C. parvum* and *C. hominis*, providing forensic-type evidence that can be used to link the oocysts identified in suspected causal media (food, water or environmental specimens) with outbreak faecal specimens (the equivalent of 'DNA fingerprinting').

Cryptosporidiosis is characterised by 7-21 days of unpleasant, watery diarrhoea, abdominal pain, mild fever and, less commonly, nausea and vomiting³. There is no well proven and routinely available chemotherapeutic treatment or cure although the infection is normally self-limiting in otherwise healthy, immunocompetent individuals. In the severely immunocompromised^k, cryptosporidiosis can cause intractable diarrhoea, severe extra-intestinal disease and rarely even death. For this reason, specific groups of severely immunocompromised patients are advised to boil all drinking water, at all times of the year^{1, 4}.

ⁱ The infectious dose varies widely from 10 to 1000 depending on the species and isolate of *Cryptosporidium*.

^j One is described as immuno-competent if one has a functioning immune system capable of mounting both a normal humoral and a cell-mediated response to infection.

^k Patient groups that are considered severely immunocompromised include: Patients with HIV infection who are significantly immunocompromised; individuals with specific T-cell deficiencies, such as CD40 ligand deficiency, also known as Hyper IgM Syndrome; and Children with severe combined immunodeficiency (SCID).

¹ Following a review in this country of the published literature, the Department of Health declared in 1999 that only these three high risk groups of immunocompromised patients need to routinely boil their drinking water.

4. Investigation of the outbreak

4.1 General features of the investigation

The OCT obtained much useful evidence from:

- clinical notifications and laboratory reports of confirmed infection,
- questionnaire-based interviewing of cases,
- epidemiological analyses,
- testing pool water for oocysts,
- molecular DNA testing of oocysts from human faecal specimens and oocyst-positive water specimens,
- the reports of the (private sector) independent contractors who were commissioned by ERC to investigate the pool treatment plant,
- National guidelines produced by the Pool Water Treatment Advisory Group (PWTAG) entitled *Swimming Pool Water: Treatment and Quality Standards* (Figure 2),
- Scientists from Scottish Water,
- the OCT Report of the Tayside swimming pool related outbreak of August 2002,
- (private sector) expert swimming pool consultants who investigate problems with, and who advise on the design of, pool treatment plants.

A physical inspection of the pool layout and the uncovered filters was conducted by the OCT. Various hypotheses about how the outbreak occurred in the light of the epidemiological evidence were then generated.

Shortly after the outbreak was confirmed, ERC established a working group to plan and co-ordinate its response to the outbreak, and to the subsequent investigation. This group was drawn from the then Community & Leisure Department (now the Community Services Department, the Property & Technical Services Division, Corporate Health & Safety and Environmental Health. The group was chaired by the Head of Culture & Sport. The Environmental Services Manager and Health & Safety staff played a key part in steering and monitoring the activities of this group which reported to the Council's Corporate Management Team.

This group worked in parallel with the OCT, with its main focus being to ensure that all appropriate remedial work was carried out. Minutes from the working group were forwarded to the OCT and the Environmental Services Manager acted as the link between this group and the OCT.

However, this parallel working arrangement created some complications and a degree of confusion as to accountabilities and authority for aspects of the investigation. At times, it was unclear to the OCT whether ERC was organising the technical investigation themselves or in accordance with the OCT's direction.

ERC commissioned Filtec Water Services Limited to carry out a technical assessment of the pool filter. This entailed a dig-out of the filter serving the small pool. Based upon Filtec's report, ERC compiled a specification for remedial work to the pool filters and related plant. Taking guidance from the OCT, ERC commissioned a separate contractor, Barr & Wray (Holdings) Ltd to carry out the work detailed in this specification. Filtec were retained to oversee this work and carry out a monitoring role during this contract. This was as recommended by the OCT to provide external assessment of the standards being achieved.

The progress of the remedial work was reported to the ERC working group, and through this group to the OCT .

4.2 The physical layout of the Eastwood Pool Complex

The OCT visited the pool on 22 September 2003. This involved a tour of the changing and pool areas, and the plant room, the results of which are described in the section on ‘Environmental (including technical)’ results (section 5.4).

4.3 Epidemiological/human microbiological investigation

On-going surveillance of communicable infection at the Public Health Protection Unit (PHPU) of GGNHSB is based on the receipt of clinical notifications of illness from medical practitioners and laboratory reports of confirmed infection from hospital and reference laboratories. Reports of confirmed infection are forwarded to the Departments of Environmental/Protective Services of the relevant council advised by GGNHSB on the basis of the patient's postcode. This is to enable the EHOs to interview the cases using a standard questionnaire with a view to identifying possible causal risk factors. Given that most cases of infection were interviewed by EHOs, this means that EHOs are well placed to pick out causal links between cases within their own geographic area. The data obtained by the EHO is returned to the PHPU, where the data is collated and analysed including plotting the data on an epidemic curve by onset date, if relevant.

Enhanced surveillance

Enhanced surveillance was introduced by the PHPU and the ERC Protective Services Division as a result of identifying the outbreak. This involved advising other Scottish NHS Board departments of public health and local authority Departments of Environmental Services to report new cases of diarrhoeal illness with recent links to the Eastwood Pool. Furthermore, all GGNHSB medical practitioners were informed about the outbreak and advised to look out for patients with diarrhoeal illness lasting more than 2 days, the need to organise faecal testing, as well as the need to report cases with links to the Eastwood Pool to the PHPU.

4.4 Microbiological (water testing)

On 10 September, the OCT questioned pool management staff from ERC, in a fax to ERC EHOs, about recent historical records of pool water quality.

As part of the OCTs investigation it was decided that sampling of the pool water for the presence of *Cryptosporidium* oocysts should take place. Scottish Water agreed to support the OCT on commission by offering portable Genera[®] monitors. Scottish Water had advised Tayside NHS Board during a Tayside swimming pool-related cryptosporidiosis outbreak in 2002 and had learned much about the technical aspects of such outbreaks and the role of oocyst measurements. In the absence of an alternative source of expertise, the OCT commissioned sampling from Scottish Water and a series of oocyst measurements from the Scottish Parasite Diagnostic Laboratory (SPDL), both in the pool water and backwash water.

To investigate the possibility that the water had been contaminated at source, the OCT also requested data from Scottish Water regarding the quality of mains water (coliform and oocyst counts) supplied to the Eastwood Pool.

4.5 Environmental (including technical investigation of the pool treatment plant)

On 10 September, the OCT also requested documentation, via a fax to ERC EHOs, from ERC pool management staff, regarding the following:

- Pool protocol for dealing with faecal contamination episodes.
- Recent records of the pool water microbiological monitoring.
- Detailed report on the design/specification of the existing treatment works (coagulation, filtration and disinfection).
- Reports on evidence of any cracks in the pool lining or other problems with pool integrity.
- Records of staff attending work, including teaching sessions, with illness (D&V).
- Details of the internal pipework connecting the pools with each other and their water supplies, filters and sewer drains.
- Records of flow rates, pressure differentials and other management protocols for pool water treatment.
- Pool cleaning routine.

At the first meeting of the OCT on 10 September, the Chair again requested technical information verbally, from the pool managers representing ERC who were present. This included information about the operation of the pool plant including how the pool water treatment plant should operate, the type of filter (whether single or multiple layer), the filtration rate, (in metres/hours), pressure differential at which backwashing should be initiated, *etc.* The ERC pool management staff who attended this meeting were unable to provide the required technical information, referring instead to the existence of a large collection of standard operating procedure manuals housed at the pool. As they would not necessarily have this level of technical detail and could not supply this at short notice, the pool managers agreed to bring Mr David Richmond (of Richmond Associates) to attend the second meeting of the OCT (15th September) to provide these details. Mr Richmond is a private consultant who was employed in the past to advise ERC on the original design and refurbishment of the pool complex, as he did in November 2000.

The OCT also requested data on pool usage statistics from the ERC EHOs.

4.6 Advice from private swimming pool consultants acting as expert advisers

In parallel with the investigation carried out by ERC's Property and Technical Services Division, the OCT Chair contacted PWTAG, the independent advisory body on pool water treatment and was referred to a number of private consultants who could act as expert advisers on the technical aspects of pool treatment works including sand filters. Although, they would normally receive a fee for their consultancy service, they agreed to provide advice, by phone, free of charge. The Chair of the OCT felt the need to gain technical understanding of the technology involved and obtain a 'second opinion' about what might have gone wrong with the filter.

5. Investigation results

5.1 The physical layout of the Eastwood Pool Complex

The pool complex at Eastwood is physically divided into two parts. The main pool (Figure 3) is

served by its own independent sand filtration system (consisting of two filters B & C). The other part comprises a small training pool, a splash pool, several water features (rain spray) and some small chutes into the training pool (Figures 4 and 5). The water in this group of facilities is common to all the sub-components and is served by a third independent filter (filter A).

On the day of the visit by the OCT (22 September), the pools were empty and the filters opened and drained of water. (See section 5.4 on 'Environmental (including technical) results' for a description of the filters themselves.)

ERC EHOs and Community and Leisure Department staff pointed out a number of longstanding problems at the Eastwood Pool Complex that they felt could usefully be sorted during the period of closure while the outbreak was investigated. One example included a stainless steel pool-side floor drain aimed at collecting soapy shower water to prevent it entering the pool. This gave cause for concern because of the dead space underneath it. Samples of accumulated debris were obtained from underneath the steel tray and sent to the SPDL for testing by the OCT. However, this structural fault was not suspected by the OCT to be relevant to the current outbreak.

5.2 Epidemiological/human microbiological investigation

Cases of illness continued to be reported to the GGNHSB for the rest of September and first half of October. As of 17 October 2003, there was a total of 50 cases of illness suspected to be due to *Cryptosporidium* infection linked to the Eastwood Pool Complex. Of these, 29 were microbiologically confirmed (24 had primary exposure to the pool and 5 had secondary exposure via contact with a primary case), and 21 were unconfirmed (all 21 had primary exposure to the pool).

All 45 cases with primary exposure to the pool used the small pool sub-complex during the period of suspected contamination, either exclusively or by combining their use with that of the main pool. No additional cases were identified via enhanced surveillance outwith GGNHSB.

Direct and nested PCR-RFLP testing of the confirmed human faecal specimens by SPDL revealed that all the parasitologically confirmed cases were *C. hominis*.

The epidemic curve (Figure 6) suggests that the outbreak resulted from persistent contamination in that dates of onset of illness for cases are reported spanning from 6 August to 22 September 2003. Also plotted are the dates when members of a family (Family 'A'), who were convalescing from cryptosporidiosis acquired while on holiday, used the pool. The possible dates of contamination by the convalescing Family 'A' are marked with arrows.

Family 'A'

A family (Family 'A') used the Eastwood Pool on three separate occasions during August and was considered to be a possible source of the original contamination. It was discovered that an adult female within the family tested positive for *C. hominis*. The family of two adults and two children returned from a holiday in Menorca, where they had used a hotel swimming pool, on 25 July, falling ill with diarrhoea at different times after their return to Scotland (see table 1 for dates of pool usage and onset of illness). The adult male and the two children reported using the Eastwood pool on three occasions (1st, 17th and 23rd August). However, although the convalescing adult female, who reportedly never used the Eastwood pool, tested positive for *C. hominis* parasite both during her illness in mid-August (15 August) and again more than three weeks after her symptoms resolved (12 September), her partner and the two children were negative when tested, which was

approximately one month after their symptoms resolved (11 September).

Unfortunately, the other family members failed to provide a specimen as requested at the time when they were actually suffering from diarrhea in August. The four year old child used the Eastwood pool on the day he developed diarrhoea which was within 7 days (the incubation period) of leaving Menorca. None of the other members of this family developed illness within 7 days of leaving Menorca, so it is assumed that the 4 year old child was the index case importing the infection into Scotland and then transmitting it to the two adults and 7 year old sibling (Figure 7). The convalescing adult male and 7 year old child then went on to use the pool again on the 17 and 23 of August, providing additional opportunities for contamination of the pool. However, in the absence of confirmatory laboratory evidence of *Cryptosporidium* infection in the two children and adult male, this hypothesis aimed at explaining the contamination of the pool remains speculative, particularly given their reported short duration of illness, which is generally not typical of cryptosporidiosis.

Table 1

Descriptive data characterising Family ‘A’: a possible source of the contamination.

Family member	Faecal test result and date specimen submitted	Date(s) of using the pool	Date of onset of illness	Duration of illness
36 year old female	+ for <i>C. hominis</i> (15 Aug. and 12 Sept.)	Attended the poolside for the children's lessons but never entered the pool.	6 Aug.	14 days
35 year old male	Negative (11 Sept.)	Used the pool on 17 and 23 August with the two children.	5 Aug.	3 days
4 year old child	Negative (11 Sept.)	Used the pool every day from 28 July - 1 August and then 17 and 23 August.	31 July	4 days
7 year old child	Negative (11 Sept.)	Used the pool every day from 28 July - 1 August and then 17 and 23 August.	9 Aug.	6 days

5.3 Microbiological (water testing)

Pool management staff from ERC informed the OCT that pool water samples submitted to Glasgow Scientific Services during June, July and August 2003 indicated that guidelines were being met on bacteriological water quality, based on bacterial (coliform) counts, and water clarity. Given that *Cryptosporidium* oocysts are not routinely monitored by pool operators and that these can reach levels sufficient to cause illness in the presence of acceptable standard indices of bacteriological water quality and water clarity, the latter, although reassuring, were not thought to be immediately relevant to the investigation of the cause of outbreak.

Following closure of the pool to the public on 9th September, the filtration system was allowed to continue running. After approximately 16 hours (equating to about as many filtration circulations of the small pool water), sampling of water in the small pool water and the small pool filter backwash water, was conducted using Genera[®] filters and 25 litre grab samples, respectively. Results of these samples (Table 2) revealed that there were very high counts of oocysts in the backwash water (40 oocysts per 10 litres^m) and detectable levels of oocysts in the pool water (0.194 oocysts per 10 litres). Given that the total circulation turnover time for the small pool is in the region of one hour, this pool had been left empty of bathers in the expectation that it would be successfully cleared by its filter system following 16 filtration cycles. Clearly it had not done so.

The large pool was tested on Thursday 11 September and was found to have no detectable oocysts in the pool water but the backwash water from Filter B showed high counts of oocysts (33.3 oocysts per 10 litresⁿ). This suggests that oocysts were being successfully trapped by Filter B although there is no scientific way to interpret these levels quantitatively as the equivalent of ‘maximum allowable levels’ in backwash water are unknown.

Over the next few days of repeated circulation through, and backwashing of, all the filters, the pool water on both pools became and remained negative for oocysts and the small pool backwash water gradually reduced its contents of oocysts. However, because small numbers of oocysts were still present in the small pool backwash water by the fifth day following pool closure (14 September) (after around 96 circulation turnovers and 15 backwashes) it was – indicative that something was wrong with the filter A itself.

^m This is probably an underestimate as the backwash water was ‘dirty’ according to the visual inspection by a Scottish Water scientist and only 8 litres out of the 25 litre grab sample could be used to retrieve oocysts before the retrieval sieve became blocked by organic material.

ⁿ This is again assumed to be an underestimate as only a fraction of the grab sample could be tested by Scottish Water’s technology.

Table 2: Cryptosporidium Oocyst Detections (Genera)

Site	Date Sampled	G/C No	Lab Ref	Volume (L)	%Analysed	Count	Count/10L
Small pool	10/09/2003	G3807	2251191	463		9	0.194
Backwash Small Pool(a)	10/09/2003	C6553	2251032	8		16	40
Small pool	11/09/2003	G3848	2253349	840		1	0.012
Backwash Small Pool(a)	11/09/2003	C6572	2252769	6		2	13.3
Big pool	11/09/2003	G3847	2253354	459			-ve
Backwash large Pool (b)	11/09/2003	C6570	2252747	3		2	33.3
Backwash large Pool (c)	11/09/2003	C6571	2252773	3			-ve
Small pool	12/09/2003	G3886	2255336	867			-ve
Backwash Small Pool(a)	12/09/2003	C6603	2253942	10			-ve
Big pool	12/09/2003	G3885	2255327	391			-ve
Backwash large Pool (b)	12/09/2003	C6601	2253952	17			-ve
Backwash large Pool (c)	12/09/2003	C6602	2253954	13			-ve
Small pool	13/09/2003	G3914	2256338	446			-ve
Backwash Small Pool(a)	13/09/2003	C6612	2256100	10.5	25%	1	3.81
Big pool	13/09/2003	G3913	2256339	827			-ve
Backwash large Pool (b)	13/09/2003	C6613	2256101	10			-ve
Backwash large Pool (c)	13/09/2003	C6614	2256103	11.5			-ve
Source water	13/09/2003	G3902	2256096	869			-ve
Small pool	14/09/2003	G3934	2257671	442			-ve
Backwash Small Pool(a)	14/09/2003	C6615	2257780	12	25%	1	3.33
Big pool	14/09/2003	G3933	2257668	797			-ve
Backwash large Pool (b)	14/09/2003	C6616	2257782	13			-ve
Backwash large Pool (c)	14/09/2003	C6617	2257788	14			-ve
Small pool	15/09/2003	G3956	2258514	421.8			-ve
Backwash Small Pool(a)	15/09/2003	C6635	2257791	19			-ve
Backwash Small Pool(a) start	16/09/2003			12			-ve
mid	16/09/2003			10			-ve
end	16/09/2003			12			-ve
Before filter	16/09/2003			13			-ve
Backwash large Pool (b) start	16/09/2003			19			-ve
mid	16/09/2003			15			-ve
end	16/09/2003			12			-ve
Before filter	16/09/2003			14			-ve
Backwash large Pool (c) start	16/09/2003			12			-ve
mid	16/09/2003			10			-ve
end	16/09/2003			12			-ve
Before filter	16/09/2003			13			-ve

5.4 Environmental (technical investigation of the pool treatment plant)

History of faecal episodes

Pool management staff reported that there had been no episodes of contamination at the pool, including faecal accidents, reported by pool staff. Published literature on pool-related outbreaks suggests that most outbreaks of cryptosporidiosis occur without there being any reported contamination incident.

On request, a copy of the faecal episode policy for the pool was provided to the OCT; as were statistics relating to customer usage for the 5 weeks preceding closure; basic dimensions of the pool; and a copy of the coagulant dosing schedule.

Pool usage statistics

It was established that during the period 1 August to 7 September, 17,444 people had used the pool, an average of about 500 per day. Formulae referred to in the PWTAG Guidance that are used to estimate permitted customer load, take into consideration the dimensions of the pool on the basis of preventing physical accidents due to collision and other factors. Therefore, shallow pools are allowed more people per square foot than deep pools. This does not take into consideration the risk from microbiological contamination which is greater the more shallow the pool. According to these PWTAG formula, Eastwood Pool was not in breach of the upper limit of its customer load. Nevertheless, it is worth noting that during the month of July there were more than double the number of swimmers (17,568) than accommodated during the month of November (8,276).

ERC staff confirmed that, although the customer load increased substantially during the warm summer months, particularly on 'free days'^o, the pressure differential across the filter indicating when backwashing was required had not been reached. As a result, the frequency of filter backwashing remained at about once per week both summer and winter and the coagulant dosing schedule also remained the same. PWTAG guidance on the subject suggested that backwashing should be done *at least once a week*, if not more frequently, and that inadequate frequency of backwashing allows the gelatinous flocs^p, formed after coagulation, to impair filtration by causing blockage or breakthrough at the filter.

Basic history and description of the pool treatment plant

At the first meeting of the OCT, pool management staff from ERC informed the OCT that the pool had been refurbished in November 2000 to 'national standards'. ERC pool management staff stated that the filters had not been inspected since then.

However, they also pointed out that plant operators within the council were qualified as pool plant operators. An external company approved by the Institute of Sports and Recreation Management (ISRM) had carried out this training.

ERC Property & Technical Services Division reported that they had liaised with the company who carried out the 2000 refurbishment (Thermalec[®] – Independent Contractor A) on a number of

^o A 'free day' is a day when the pool is open to the public and entry to the pool is free of charge.

^p Gelatinous flocs are formed from the coalescing of organic material and any other debris of human origin after a coagulant is rapidly mixed in the water.

“snagging issues” but had not been aware of any major problems other than the fact that small amounts of sand appeared in the main pool and accumulated on the floor of the pool. This had been checked by Thermalec[®] – Independent Contractor A, who had advised that this was builder’s sand, possibly related to cracked drains and should cease once all the sand within the system had dispersed.

Thermalec[®] (Contractor A) went into receivership on 7 September 2003, just two days before the outbreak was identified by ERC EHOs.

Another independent pool contractor was contacted by ERC in June 2003 (Contractor B) and asked to provide an independent assessment of the pool floor sand. They arrived on site on 14 August 2003 and began collecting sand from the bottom of the pool on 18 August. Their initial verbal assessment was that there could be a potential problem with the filters serving the main pool (Filters B & C) but did not report any concerns about the small pool or the filters serving it. They did not report any items of immediate concern. This independent contractor was contacted on 8 September 2003 and was asked to make arrangements to uplift the sand samples collected (which were accumulating in large quantities in a bucket in the plant room). Their investigation was not completed by the time the pool was closed (on 9 September). No written report was ever submitted by the independent contractor (B).

A sample weighing over 1 ½ kg taken from the sand that was collected in the bucket in the plant room was submitted to the Glasgow Scientific Services (GSS) laboratory for analysis, labelled as ‘pool filter sand’, although there was confusion over its origin. GSS reported that this sample was not builder’s sand and provided a list of particle sizes present in the sample, although they were unable to comment on whether this sample could be pool filter-grade sand. Interpreting the report on sand particle sizes submitted by GSS, scientific staff from Scottish Water concluded that the range of sizes of sand particles suggested that this was *not* filter grade sand, the uniformity coefficient (UC)⁹ of the sample being too high.

Mr Richmond (of Richmond Associates), a swimming pool consultant commissioned by ERC both at the time of the refurbishment in 2000 and up to the time of the outbreak, attended the second meeting of the OCT on 15th September, at the request of the pool management staff with a view to answering any technical questions from OCT members. He pointed out that he was familiar with the design of the pool treatment works as he had designed its refurbishment in November 2000 but was not involved with either the actual refurbishment contract or the ongoing operation of the pool water treatment plant. He informed the OCT that the filters at the Eastwood Pool were single layer filters operating at 25 m³/hour/m². When questioned as to how pool managers could ensure that the speed of the water flowing through the filter was maintained at 25 m³/hour/m² when there was no way of measuring the flow of water to the filter from the swimming pool, he stated that there was no need to monitor the flow rate as the entire system was designed to run at that rate and could only run at that rate. It was subsequently discovered that pumps are used to maintain an adequate flow rate of swimming pool water to the filter and that gravity is *not* used to maintain the ideal speed through the filter as the plant is a fully pumped pressurised system. The water flow rate (cubic metres per hour) to the filter is a function of the desired speed through the sand (25 m³/hour) in relation to the surface area of the filter sand (square metres, m²).

⁹ The UC or uniformity coefficient is a measure of the size range of the media in question. A lower UC is normally specified for filter media.

Physical inspection of the filters themselves

On 16 September 2003, as part of ERC's ongoing investigation, the filters were opened and thoroughly examined in the presence of ERC Environmental Health Officers, ERC Pool Managers, Scottish Water scientific officers and Mr Richmond. All present felt that the immediate appearance of the surface of the sand gave cause for concern because of the combination of a very uneven surface, and the large collection of small objects that were later confirmed as being a variety of mollusc shells.

When the OCT subsequently visited the pools on 22 September 2003, it was observed that the backwash viewing sightglass on filter C (Figure 8) was caked on the inside with dark scale. Given that the duration of backwashing (5 minutes at the Eastwood Pools) is determined by watching the colour and clarity of the backwash water, the OCT was concerned about the ability to objectively determine an adequate backwash duration. It was not felt that the repeated backwashing that had been carried out since the pool was closed could be the explanation for the scale-stained windows. With repeated backwashing of pool water in the absence of swimmers, the viewing window would be expected to become cleaner.

The members of the OCT also noticed, at this visit, that the bed of Filter A was speckled with a variety of seashells including those from scallops, periwinkles and clams, some of which were collected and measured. Several of these shells measured more than one centimetre in diameter and it was deemed that water could become trapped in the shells' cavities, providing a locus for retention of microbiological pathogens. The EHOs reported that the other two filters looked similar.

ERC arranged for samples of sand to be taken from the filter vessels and submitted for analysis to another independent contractor (Contractor 'C'). Contractor 'C' submitted the samples to another company (Consultant 'D' recommended by Scottish Water). Consultant 'D' suggested that the sand was indeed 'filter medium' but that more detailed investigation would be necessary to ascertain if this was of a suitable type and quality for a commercial pool filter.

Advice from private swimming pool consultants acting as expert advisers

Expert Adviser 'A', the first private consultant to be contacted by the OCT, was a private swimming pool consultant no longer involved with the contractual side of the business (installation and refurbishment of filters) who was also a technical adviser to PWTAG. Adviser 'A' agreed to act as an independent source of technical advice about the optimal design and function of a swimming pool filtration system. Adviser 'A' suggested that the presence of shells in the sand filter media, even small shells, would be totally inappropriate and would interfere with both the filtration and the backwash. He added that he had never seen mollusc shells in a pool filter in the thirty years he had worked in the swimming pool business. He also emphasised the need to ensure that the flow of water to all the compartments and corners of the pool complex was adequate in order to ensure that the oocysts in the pool reached the filter. He confirmed that without adequate dosing with a coagulant, the filter would be ineffective at removing oocysts. Finally, he expressed concern about the report that the surface of the sand appeared uneven, suggesting that implied a problem with the underdrains (laterals) within the filter structure.

The OCT Chair contacted another private consultant recommended by PWTAG for a 'second opinion'. Expert Adviser 'B', who was also a technical adviser to PWTAG, also provided independent technical advice about the optimal design and function of a swimming pool filtration system. Expert Adviser 'B' advised that his firm had no connections with refurbishment contractors and that their company acted solely as expert consultants designing new pool treatment works and

diagnosing problems in existing systems (what he referred to as ‘head to toe audits’).

He confirmed that most members of PWTAG would expect that it should take no more than a few hours for the most of the oocysts in a pool to be cleared by an effectively functioning filter system^r. He stated that any persistent contamination suggested that the treatment plant was not working effectively. Expert Adviser ‘B’ suggested that the high oocyst counts in the backwash water were not as worrying as the presence of significant counts of oocysts in the small pool water 16 hours after closure of the pool (10 September) and the persistent presence of oocysts two days after closure (11 September).

When provided with a summary of the existing technical data related to the Eastwood pool event, he suggested that there were at least three obvious factors to consider:

- **adequacy of the flow of water**, and therefore circulation, to each of the three interconnecting components of the small pool (two small pools and a rain spray area), to ensure adequate retrieval of the oocysts from all zones and their delivery to the filter. This would require the installation and maintenance (including calibration) of flow meters on each of three interconnecting pools and that adequate flows are maintained with the use of adequately powered, operated and maintained pumps. The same principle applies to the main pool.

According to Expert Adviser B, this tends to be neglected in that pool managers often allow these meters, if present, to fall into disuse. In fact, those at Eastwood Pool had not recently been calibrated and therefore had fallen into this category.

- **adequacy of coagulant dosing**, which, ideally, should be adjusted with the customer load. The more organic material deposited in the pool as a result of increased customer load, the more coagulant is required. Inadequate dosing would allow non-coagulated oocysts to pass through the filters.
- **the efficiency of the filter to remove oocysts** which is dependent on the design, content and operation of the filter itself.

‘B’ pointed out that ‘crowning’ of the sand (the appearance of an irregular surface with multiple peaks which suggests excessive turbulence), the accumulation of filter sand on the floor of the pool, and the presence of large objects in the filter sand (mollusc shells) all suggested that the efficiency of the filter should be questioned as the integrity was likely to be impaired. He suggested that the only way to diagnose the problem would be a complete investigation of the filter including emptying it to assess the under-drains.

‘B’ dismissed the notion that repeated backwashing (which had taken place at Eastwood Pool in response to the outbreak) would be a likely cause of the crowning, given that normal or effective backwashing tends to flatten the filter sand bed.

He agreed that the presence of shells, even small shells, would be inappropriate and would interfere with both the filtration and the backwash. He also volunteered that he had never seen mollusc shells in a pool filter in all the years he had worked in the swimming pool business. He advised that there were two main sources of pool filter grade sand in the UK (including Leighton Buzzard sand) and that they were both quarries that did not have any shells in them. He dismissed the suggestion that

^r PWTAG states that it should take no more than 6 turnovers of the pool water to clear oocysts so the total time taken depends on the turnover period.

perhaps the shells were appropriate in the coarse media layer below the sand layer and that they had migrated toward the surface during repeated backwashing. He advised that they were too large to be used for coarse media and were inappropriate in any part of a pool filter.

Finally, a third expert (Expert Adviser 'C') recommended by PWTAG was contacted. 'C' is a well respected adviser on the technical aspects of both drinking water and pool water treatment. 'C' suggested that he had never heard of mollusc shells being used in filter media as it would almost certainly interfere with the filtration process. He argued that any scientific argument for placing shells in the filter must be regarded as dubious.

'C' focused on the presence of considerable oocysts 16 hours after closure. Having published papers on mathematical modelling of oocyst retrieval, he pointed out that an optimally functioning filter should remove between 99% and 99.9% of oocysts through the *first pass* and that, therefore, the Eastwood pool should not have demonstrated a count as high as 0.194 per 10 litres in the small pool water, after 16 such passes. In his opinion, such a count after 16 passes strongly suggests that the filtration process was ineffective for the purpose.

'C' proposed at least two additional mechanisms that would compromise the efficacy of the filtration, in addition to the presence of the shells, which he regarded as the most minor of the three.

1) Coagulant dosing with poly aluminium chloride (PAC) or other agent.

'C' pointed out that at the time of refurbishment and at least annually, measurements of turbidity and/or particle size should be carried out in order to adjust the PAC dosing. Once this ideal level is found it is usually retained, until new turbidity/particle size measurements suggest it needs to be adjusted. In the meantime, the PAC dosing is adjusted from this baseline level based on the flow rates determined by the flow meters on the pool distribution system. He suggested that further adjusting the PAC dosing on the basis of customer load would theoretically be desirable, but in practical terms, difficult. He pointed out that if turbidity/particle counts had not recently been done then it was impossible to accurately 'fine-tune' the amount of coagulant currently required for optimal functioning of this particular pool filter.

2) The physical state of the filter.

The presence of sand backing into the pool combined with the uneven surface of the sand suggests the presence of blocked underdrains and/or broken nozzles within the backwash system. This would result in uneven flow rates of backwash which result in an uneven surface and inadequate fluidisation of the sand, and therefore inadequate cleansing of the sand during backwashing. Ultimately, this results in an inefficient and clogged filter medium that allows break-through of oocysts during filtration.

'C' pointed out that the advantage of Perspex viewing windows on the filters themselves enabled operators to confirm that adequate fluidisation of the sand was taking place during backwashing. This is apparently demonstrated by the apparent expansion of the sand during backwashing. It also enabled operators to assess the contours of the filter sand surface, which reveal much about turbulence and uniformity of filtration and backwashing. Finally, it enabled operators to assess whether the sand requires to be topped up without closing down the system. He pointed out that such windows need regular cleaning to be effective and that if ignored for more than one year it was inevitable that they would become opaque.

In summary, all three consultant experts recommended by PWTAG independently highlighted three main issues to consider given the findings at the Eastwood Pool:

1. The filter itself and specifically the likelihood that the underdrains were malfunctioning.
2. The level, and ability to titrate, the coagulant dosing required against customer load and/or flow rates.
3. The ability to monitor the flow within the wider pool water distribution system to ensure optimal delivery of oocysts to the filter and to inform coagulant dosing.

Filtec's findings – diagnosing the problem in the filter after digging it out

Another independent contractor (Filtec[®] Water Services Ltd - contractor 'E'), was commissioned by ERC to act as the consultant swimming pool expert charged with investigating (diagnosing) the problem with the treatment plant.

Filtec commented that the sand did not appear to be filter grade sand on the basis of visual inspection, though they awaited more definitive tests.

Air scouring tests were then conducted at this stage before the dig-out. Air scour pattern testing is important as it demonstrates how level the underdrain system is and how effective the air will be in agitating the filter bed prior to the backwash. Air scour tests are conducted by back-driving air through the sand and observing the pattern of bubbles appearing on the surface of the filter media at various levels. It is critical that the underdrain system is level to ensure that the filter operates at its maximum potential.

Filtec's initial report (dated 13 November 2003) made the point that air scour^s tests showed very poor distribution (Figure 9), on all three filters. This suggested that the air blower was undersized for the quantity of air required to scour the filter bed effectively and that the existing design and/or functioning of the 'laterals' in the base of the filter was inefficient, non-level and/or characterized by considerable blockages or breakages of the underdrains.

This was later confirmed following the dig-out when omission of air distribution holes on the topside of the laterals was observed. It was also noted that the design of the laterals was further flawed by the positioning of the drainage holes, these being diametrically opposite rather than on the underside of the lateral (as confirmed by photograph provided by Filtec and shown in Figure 16).

Arrangements were then made for Filtec to carry out a sectional dig out and check the filter underdrains and laterals under direct visual inspection. This report also referred to the dig out having revealed that the supporting concrete floor had completely failed in the vessel examined with the likelihood of failure in the remaining two filter vessels, providing an explanation for the dysfunctioning laterals. The photographs (Figures 9 to 16) were obtained from their report, with permission from Filtec.

Filtec submitted a final report to ERC dated 25 November 2003. It concluded that the refurbishment carried out in 2000 on all three pool filters was 'substandard', although filter B was deemed to be in the worst condition. Filtec agreed that the specification of the sand used was questionable and that the presence of whole and fragments of seashells suggested that the filter sand and support gravels were of poor quality. The presence of fine sand grit and small seashell fragments found between the laterals (where it would interfere with the backwash and filtration) (Figures 10, 11, and 12) as well as in both pools (large and small pool complex) also suggests inappropriate sand was used in these

^s Air scour is used before fluidising the filter with water during the backwash process to aid with the expansion and cleaning of the sand. An air scour pumps air through the sand in reverse direction of the usual filtration. The normal pattern on an air scour test should be uniform and cover the entire area of the filter.

filters. The jetting pattern (Figure 13) confirms that sand is being forced through into the gravel layers because of inappropriate flows during filtration. All three filters had lost filter media ranging from 100-200 mm, assuming the correct tonnage had been installed in 2000 (there were no records of the amounts installed). The obvious tide mark shows where the original sand level used to be (Figure 14) and suggests considerable loss of sand. They also commented on the very large, oversized gravel used in the coarse media layer which they argued served no purpose. The concrete floor in filter C was in poor condition with a deep crack running through it and deterioration was evident against the filter vessel face (Figure 15). They were not able to inspect the laterals or header in detail as it had been decided to have these removed by another company (Barr and Wray Holdings p.l.c., contractor 'F') which was ultimately commissioned to refurbish the pool filters. However, their summary of defects commented on the fact that the laterals used were of an old, flawed design that would not allow adequate air scouring and that they were unserviceable, perhaps explaining why both backwashing and air scouring was ineffective.

Filtec recommended:

- that refurbishment be carried out by a filter specialist with a proven track record,
- that a media supplier with a proven track record is contracted to provide the sand and gravel media,
- that the various depths of the media layers are recorded at the time of the new refurbishment,
- the purchase of an entirely new and modern lateral system with nozzles,
- regular checks for media loss, uneven bed, hollows, *etc.* although they did not specify how often.

They did not mention introducing filter vessel viewing windows.

Finally, they felt that the fact that water from the small pool complex (which is more likely to be heavily contaminated by children infected and symptomatic with *Cryptosporidium*) is used as a source of backwash water for its own filter (Filter A) was undesirable, given that the oocysts in the contaminated pool water would risk being trapped in the stagnant underside of the filter with repeated backwashing. However, an expert from Barr and Wray argued that the backwashing of the filter from the pool water is the only way that this can be done on a single filter system. He pointed out that oocysts will be washed into the underside of the filter on backwash but if the filter is operating correctly they will be flushed out back to the pool as the underside of the filter should not be stagnant at any point; they would not add to the burden of oocysts in, and would eventually be removed by, a functioning filter. Backwashing with fresh mains water is impractical due to the quantities and flows required.

ERC pool management staff argued that the written description they provided of the coagulant dosing regimen conformed with PWTAG guidelines. However, ERC pool management staff admitted that they did not conduct any routine audit of technical procedures relating to pool plant operation or maintenance and therefore it was impossible to be sure that pool staff were actually complying with the recommended dosing schedule. In addition, it transpired that the dosing regimen was not informed by either user statistics, time of the year or pool water flow rates (as the latter was not monitored).

The Scottish Water (SW) scientists argued that the role of alum or poly aluminium chloride (PAC) as a coagulant is critical in the treatment process aimed at removing oocysts. Chemical coagulants are required to coagulate organic material which in itself enhances the ability of the sand to act as a filter. However, in addition they are required to coagulate the oocysts (which are only 4-6 microns in diameter) to form larger particles that are more easily trapped by the sand. SW scientists argued that

in the absence of adequate coagulant dosing, even an optimal filter would allow oocysts through and therefore back into the pool water.

Barr and Wray – sorting the problem

Following the diagnosis of the problem by Filtec, ERC commissioned more than £65,000 worth of work in the form of definitive refurbishment on the pool treatment plant and related work. This was carried out in the autumn and winter of 2003/4. In response to a specific query to this effect from the Chair of the OCT, Barr and Wray produced a report⁵ ‘for and on behalf of the OCT Greater Glasgow NHS Board’ dated 17 October 2004. In it, they reported their entire involvement in the inspection work (which they shared with Filtec) and subsequent refurbishment.

The following is a summary of the section entitled “Plant Inspection” in Barr and Wray’s report⁵ and relates to the pre-dig inspection.

On initial inspection of the filters, whose access doors had been removed by ERC, Barr and Wray observed that the filter linings appeared to be breaking down with blistering and crazing of the lining being evident.

The filter media was inspected visually with samples removed for closer inspection. Within the media it was noticed that mollusc shells were evident along with black deposits of carbon-like material mixed with a number of other unidentifiable particles. This was deemed by Barr and Wray to be ‘extremely unusual in filter grade media used in swimming pool applications’. The samples sent for analysis showed a grade of 16/30 quartz media, which is the appropriate grade for a swimming pool filter. However, it was mixed with particles that could not be identified. It was clear from the considerable degree of contamination that the filter media was sub-standard and would have to be replaced.

Barr and Wray also noticed that the surfaces of the three filter beds were uneven with the leisure pool filter showing an area where the undergravel had been forced upwards mixing with the filter sand and creating a deep depression in the filter bed. They concluded from this, and the results of the air scour tests, that there was a problem with the underdrain system (laterals) and that this was supported by the quantities of filter sand that had entered both swimming pools. Taking all this into account, and without having actually seen the underdrains exposed, Barr and Wray concluded that the underdrain systems would probably have to be replaced on all three vessels.

Upon inspection of the remaining aspects of the filter plant and the pool areas, Barr and Wray also observed that there were a number of other items that gave cause for concern namely:

- The alum used to create a coagulant **was** neither linked to usage levels of the pool nor adequately continuously dosed.
- The scum channel draw-off system proved to be ineffective with little or no movement of water from this area. This would allow stagnation of contaminated water in the draw-off system, water that could re-enter the pool.
- The inlet grilles to both pools were ineffective to disperse the flow of water evenly through the pool.
- The old water balance pipes connecting both pools when it was originally one system were not sealed and capped off correctly, as were the redundant water features. This would result in dead-legs where stagnant water could accumulate.
- The flow-meters on both filter plants were defective and unable to provide the correct backwash flows required for effective washing of the filter vessels

Barr and Wray's conclusion was that all the above items contributed to the inability of the filter plant to remove the *Cryptosporidium* oocysts and this was reported (verbally) to East Renfrewshire Council along with estimates of the costs involved with the necessary remedial work.

Filtec was then commissioned to dig out the filter and prepare a report on its findings⁶ as described above before which Barr and Wray would then recommence their involvement by refurbishing the filters, as described below.

The following is an excerpt from the section entitled “Remedial Work” in the Barr and Wray’s report⁵ and this refers to the refurbishment.

The works could now get under way with the complete internals of the filter vessels being removed and the internal surfaces being shotblasted to SA2.5 standard followed by the application of an epoxy coating to the required dry film thickness.

New underdrain systems were then fitted inside each vessel complete with air scouring pipework and a securing system to keep the underdrain system level. New concrete was poured into the base of each filter to secure the underdrains and provide a sound foundation base for the filter media.

A new air blower system complete with pipework and valves was installed and prior to the filters being filled with the new media, air scour pattern tests were carried out on each vessel that proved to be very effective. The consultants (Filtec Water Services Ltd.) and representatives of East Renfrewshire Council witnessed these tests.

During the refurbishment of the filter vessels, work was proceeding with the other listed items.

- All the filtration pipework in the plant room along with pipework in the ducted areas underneath the pool surround were dismantled and flushed to remove all the residue filter media that had escaped from the vessels. The pool features were also dismantled and cleaned.
- New valves were fitted throughout the plant where existing ones showed signs of excessive wear and the interlink connections between the two systems were severed to produce two independent water treatment plants. This would also reduce the risk of any cross-contamination especially from the backwash water where both plants were connected to each other.
- New diffuser type inlet grilles were fitted to the pool inlets to improve the distribution of filter water through the pools.
- The old balance pipes were sealed with epoxy foam and new blanking plates, as were the redundant water features.
- New PAC dosing systems were installed on both pools that use peristaltic pumps to deliver the correct dose of PAC at a continuous rate. The systems installed are operator friendly and have the ability to increase or decrease the dose rate to suit the bathing load with ease.
- The main pool flow-meter was cleaned and recalibrated with a new flow-meter being fitted to the leisure pool system as this was beyond repair.

¹ This report was written on request from the OCT Chair more than one year after the outbreak and is dated 22 October 2004.

- The old scum channel draw-off systems on both pools were removed and scum saver tanks fitted. The scum saver tanks allow a free flow of water through the scum channels back to the filter plant by means of specialised control valves. The valves also protect against air being drawn into the system should the pool water level drop below the scum channel level.

The question was raised as to the efficiency of the circulating pumps on both pools. During the refurbishment works in 2000, new pumps were fitted to the leisure pool and the existing main pool pumps were refurbished by the pump manufacturer. The decision was taken not to carry out any further work on the pumps because in 'pump years' they were relatively new and tests would be carried out on them during the commissioning of the filter vessels. During the commissioning period the pumps were tested against the calibrated flow-meters and they were found to be more than capable of producing the flows required both on backwash and plant flow proving the decision not to carry out further remedial works was justified.

Upon completion of all the works the filter plants and all the associated equipment installed was commissioned and demonstrated to ERC staff. Staff training was then carried out to familiarise the staff with new equipment and the new backwash procedures.

Dye testing was then carried out on both pools to test the circulation in the pools and they proved to be very successful. Representatives of East Renfrewshire Council, including the Environmental Services Manager witnessed these tests and video recordings were made for record purposes.

Both pools were super-chlorinated to ensure they were free from any microbiological pathogens prior to hand over to ERC.

Finally the pool water in both pools was tested by Scottish Water to ensure that they were completely free from contamination with *Cryptosporidium* oocysts.

In total, the time period taken to complete the works from taking over the site to handover back to ERC took some three months.

6. Control Measures

The principle control measure applicable during this outbreak was the immediate closure of Eastwood pool. This was volunteered by ERC, following a recommendation from one of its senior Environmental Health Officers, on the basis of preliminary epidemiological evidence suggesting the involvement of the pool. The pool was therefore closed on the basis of suspicion. ERC Protective Services are to be commended for this prompt and effective action, which probably prevented many more cases of illness from developing. Later that day, it was decided by the Outbreak Control Team that was convened, that an outbreak had occurred in relation to the pool. This was confirmed over the next few weeks when the outbreak fully declared itself and case-finding revealed its full extent.

7. Discussion

7.1 The importance of preventing pool-related outbreaks of cryptosporidiosis

Swimming pool-related outbreaks of cryptosporidiosis should be preventable in a well functioning pool. Cryptosporidiosis is an unpleasant infection that tends to cause prolonged, watery diarrhoea of up to several weeks duration. Furthermore, consumers of drinking water and users of swimming pools are generally unaware of the risk of contracting cryptosporidiosis during the normal course of their life and it is the responsibility of the public health structures and systems in place to ensure that the risk of infection is kept to a minimum. Water authorities are required by law to provide water that meets EC-derived standards. However, similarly stringent requirements are absent in the regulation of swimming pools, an area of regulation that has tended to fall increasingly behind a range of other public health improvements.

7.2 The difficulties posed for pool operators

Private and Local Authority pool operators have the job of maintaining pool water quality often with limited operations and maintenance budgets, leading to a potential conflict of interest between making a profit (or breaking even in the case of local authorities) *versus* emphasizing pool water quality. Some local authorities have transferred council pools to Trusts as a means of enabling additional finance to be made available for operating pools.

The fact that the national swimming pool guidelines are not legally enforceable makes it harder for environmental health and public health professionals to demand higher standards of pool refurbishment, maintenance and operation. Some independent pool contractors may exploit the fact that this industry is weakly regulated and resources limited, creating a situation where the pool operator is under pressure to accept the lowest bid. During this investigation, the OCT heard complaints from a number of contractors expressing concern about the undercutting of quotes for refurbishment and maintenance contracts made by less conscientious contractors. In combination with more foreign holidays by pool users who use public swimming pools on their return to Britain, the result is the potential for more imported pool-related outbreaks of cryptosporidiosis.

Oocysts are the dormant, transmissible form of the protozoan parasite *Cryptosporidium*. They are very robust and survive for long periods in cold water. They are not killed by contact with chlorine-based chemicals at the concentrations found in swimming pool water. To render the water safe, in respect of *Cryptosporidium*, oocysts must be physically removed from the pool via the filtration system.

The key elements aimed at removing *Cryptosporidium* oocysts from the water in this treatment process include the:

- a) effective circulation of water within the pool, and
- b) correct use, in appropriate concentrations, of a chemical coagulant in the water, and,
- c) correct use of a well designed, constructed and maintained sand filtration system.

All three mechanisms must be maintained to ensure the control of oocyst levels in swimming pools and item c) is, itself, dependent on a wide range of disparate efforts on the part of a range of players over a prolonged period. It is, therefore, not surprising that oocysts may pose a problem even when chlorine levels are adequate and therefore bacterial counts remain within acceptable limits. A higher standard of pool water quality maintenance is required for the control of oocyst counts than for bacterial counts.

7.3 National guidance on swimming pools

For the purposes of this investigation and as advised by Scottish Water scientific officers who aided the Outbreak Control Team (OCT) in the initial stages of the investigation, the OCT referred to a national guidance document issued by the independent *Pool Water Treatment Advisory Group (PWTAG)*. This document is called “Swimming Pool Water – Treatment and Quality Standards” and was published in 1999 and reprinted in 2001¹.

Members and organisations associated with PWTAG have considerable expertise and interest in the operational, health and safety, public health or recreational aspects of swimming pools. They would like to ensure that pools are as safe for the public as is reasonable to achieve. For several years, PWTAG has argued that their guidelines should be transformed into enforceable regulations (verbal communication with Brian Guthrie, Secretary of PWTAG). This has involved approaches by PWTAG to all relevant statutory departments who have an interest in health and leisure including the Department of Health, the Department of the Environment (now Defra), the Department of Education (given links with school swimming pools) and the Department of Culture, Media and Sport. All interested parties have consistently failed to move in that direction, perhaps assuming that the existence of PWTAG guidance is sufficient and citing the lack of evidence that pool-related outbreaks are common or involve infection-related deaths.

In the absence of UK or EC-derived regulations, the OCT viewed the guidelines as helpful and informative, providing reasonable standards and a rationale for the specifications underlying those standards.

In the meantime, the British Standards Institute produced a code of practice⁷ on the management of public swimming pools that was publicly released on 2 December 2003, shortly after the outbreak. In its foreword, the BSI authors make clear that “while drinking waters and even coastal waters are subject to regulation in the UK, there is no equivalent specification for the control of swimming pool water quality”. The code of practice (so-called PAS 39) was prepared at the request, and at the expense, of PWTAG and is based on PWTAG’s 1999 guideline. It points out that the PWTAG guidelines give more comprehensive guidance than the BSI code of practice, including details on how to improve water quality in pools where conventional disinfection is inadequate. Most importantly, it makes clear that the PAS 39 code of practice is not to be regarded as a British Standard. Although the foreword ends by pointing out that compliance with the code of practice does not of itself confer immunity from legal obligations, it should be pointed out that the main problem is lack of compliance with both the BSI code of practice and the original PWTAG guideline.

7.4 Comparing basic standards advised by PWTAG with those at Eastwood Pool

The PWTAG guidance includes recommendations regarding the optimal design and operation of swimming pool treatment plant that includes quality and performance standards as follows:

- the specifications for the design and constitution of single-layer sand filters including the filter shell; the shell lining; and the recommended grade (1:2 size ratio) and depth (approximately 800 mm) of sand and coarse media underlay (200 mm) (particles of which should be no more than a few mm in size).
- the optimal range of filtration rate through the sand filter for a conventional commercial/public pool (medium rate of 10-25 metres/hour).
- the optimal backwash rate and duration in the reverse direction (in m/hr) (the backwash water flow rate must not be less than the rate necessary for fluidisation of the filter specified by the manufacturer).

- the need to have flow meters fitted in order to ensure that these flow rates are maintained.
- the need to have flow meters fitted and operating elsewhere in the pool in order to ensure that the flow and therefore circulation of pool water is adequate and also in order to regulate the amount of PAC dosing.
- the need to regularly service these flow meters.
- the need to fit pressure gauges at the top and bottom of the filters in order to be able to measure the pressure differential across the filter, the criterion by which the operators decide *when* to backwash (pressure differential reached across the sand filter).
- the need to have an automatic air eliminator and a safe, manually operated quick air release mechanism fitted to each filter.
- the *recommendation* that ‘Perspex’ viewing windows are fitted to enable visualisation of aeration and fluidisation of the sand during backwash with a view to deciding the duration of the backwash process.
- a recommendation to close down and inspect the filter media and lining *at least every twelve months*.

At Eastwood Pool, the filters differed from the above in the following ways:

Frequency of inspection of the filters

Chapter 21 on “Plant Maintenance” describes a typical maintenance schedule as an example of the ‘right approach’. It includes a list of items that should be done daily, weekly, monthly and every 6-12 months. Included in the list to be done every 6-12 months is a ‘thorough inspection of the filter’. Elsewhere in the guidance, PWTAG recommends that the filter should be closed down at least every 12 months and thoroughly inspected every 6-12 months by someone familiar with the sort of problems that can appear^u. ERC staff cited resource limitations and the fact that they felt that the level of ongoing maintenance was sufficient. Therefore, on this important point alone, it appeared that the plant and its operation deviated from the current guidance issued by PWTAG.

Effectiveness of filtration

It is expected that, in a well designed, well maintained and operated pool, successive filtration circulation cycles will, in effect, remove all oocysts. PWTAG guidelines state that 6 turnovers are required to clear oocysts, assuming an effective filtration process. ERC pool technical staff informed us that Eastwood Pool’s filtration circulation or turnover times for the large and small pool complex are approximately two hours and one hour, respectively. The inference from this is that it should take no more than 8 hours to clear the Eastwood Pool water of all oocysts once the source of oocysts has been removed. The evidence at Eastwood Pool suggests that contamination by oocysts persisted until 16 hours after closure when no possible recontamination by swimmers could occur. This suggests that the filtration process itself was mal-functioning and that oocysts were being recycled back into the pool for considerably longer even in the absence of any newly introduced organic material.

^u These internal inspections should involve looking at evidence of problems with sand quality, under-drains and corrosion. Unusual signs include fissures, uneven sand bed, mud balling, *etc.* and require investigation. Filter media may need to be topped up each year and replaced every 5-7 years. See page 75 and 125 *Swimming Pool Water: Treatment and Quality Standards* published in 1999 by PWTAG.

Effectiveness of backwash

According to the guidance, the filter itself can be “cleaned” by using a “backwash” process where pool water or fresh mains water is pumped through the filter in the reverse direction. This is preceded by an air scour where air is pumped in reverse direction to aerate and expand the sand to facilitate rinsing. The material released from the filter by this process is then discharged to the sewer. This is the key mechanism for ridding the filter of oocysts once the filter has cleared the pool water of oocysts. The fact that the backwash water had very high counts suggests that the filter sand had retained large numbers of oocysts during filtration and an unknown percentage of these were released during backwash.

However, the effectiveness, duration and frequency of backwash are all called into question.

The effectiveness of backwashing is suspect due to the evidence of the poor ‘air scour’ patterns, the crowning and dipping of the sand surface, the amount of silt in the gravel layer, and the design and state of the laterals which were deemed ‘unserviceable’.

The frequency of backwashing did not vary with user load (daily number of swimmers) between winter and summer, remaining constant throughout the year at once weekly. Furthermore, a trigger point for carrying out backwashing is the achievement of a specified pressure differential across the top and bottom of the filter. Given that there was a conspicuous shortage of sand as well as displacement of effective media by useless large bore gravel, it would be difficult to achieve a sufficient pressure differential, thereby preventing the conditions needed to trigger a backwash.

Determining the desired duration of backwashing would be made impossible by the obscured Perspex on the backwash exit pipe. It would be impossible to identify the point at which the backwash water ran clean when the viewing segment of the exit pipe was so dirty.

The sand in the filter

The long-running debate within the OCT about whether or not the sand was ‘filter-grade’ sand was never entirely settled. The report by Filtec described it as ‘of questionable specification’, because of the range of sizes and given the inappropriate presence of sea-shells. However, given that the seashells could have migrated upwards into the sand layer from a gravel layer source, it is not possible to conclude that the sand layer was not provided by an accredited provider of filter grade sand, however, none of the limited UK suppliers supply sand containing sea shells.

In addition, the loss of sand media from the filters is an important problem because it results in the gradual reduction of the depth of medium and affects its filtration efficacy. The sand loss needs to be inspected regularly and the sand topped up on a regular basis for the medium to retain its filtration efficacy. This did not appear to have happened at the Eastwood Pool.

The sand in the pool

The PWTAG guidance lists two possible causes of sand appearing at the inlet of a swimming pool^v including: incorrect backwashing (in which case the operating instructions should be referred to) and a broken nozzle or filter lateral, which again implies faulty backwashing given that the nozzle or filter laterals are employed to backwash the sand. The fact that significant quantities (several kilograms) of sand had been backing up into the large pool at the Eastwood Complex for months with no satisfactory explanation is another worrying indication that suitably qualified opinion had not been

^v See page 125 of PWTAG Guidance.

sought and that the PWTAG guideline had not been referred to.

Any assessment of the range of particle size based on samples from the pool floor is flawed because the samples must contain a representative and full range of sizes and loss of some particles is inevitable when the sand has been rescued from underwater.

Calibration of the flow monitors

The PWTAG guidelines and expert consultants recommended by PWTAG consistently made it clear that the flow rate of water both to the pool and to the filter must be monitored in order to ensure these rates remain adequate to retrieve all oocysts from the pool and to ensure optimum speeds through the filter during filtration and backwash. The lack of calibration of all flow monitors at the Eastwood Complex ensured that oocyst retrieval could not be maximized and filtration and backwash speeds could not be optimized.

Coagulant dosing

Coagulant dosing should be informed by daily monitoring of flow rates in combination with intermittent studies of turbidity and particle counts, which reflect organic load, which, in turn, is related to swimmer numbers. No studies of turbidity and particle count had been conducted in recent history. No flow rates could be accurately measured. A fixed dose of alum was used weekly and was not altered relative to pool usage. The regimen for alum dosing at Eastwood Pool prior to the outbreak did not enable the optimal coagulation of oocysts to be achieved. This was subsequently changed to regulated PAC dosing as part of the refurbishment programme carried out.

The ability to remove oocysts during an obvious faecal accident

The PWTAG guidance does report some reservations regarding the ability of pool filters to deal with, what potentially may be, the release of millions of oocysts into a pool as a result of, for example, a single incident involving visible contamination of the pool water by a bather with infectious diarrhoea into the pool. There is likely to be a period after such an episode of contamination where exposure of swimmers to oocysts is inevitable. However, a properly designed, operated and maintained pool, still in use by swimmers, is expected to be able to clear any oocysts within two days. Furthermore, there was no reported incident of contamination by visible diarrhoea at the Eastwood Pool Complex.

In conclusion, on comparison between PWTAG guidance and routine pool operation, all three essential mechanisms required to ensure effective removal of oocysts (*i.e.* an effectively functioning filter, flow rate management and coagulant dosing) were compromised at the Eastwood Pool Complex.

7.5 The clinical impact of the outbreak

An epidemiological study of community infection involving a range of gastroenteric pathogens, including cryptosporidiosis, has suggested that for every microbiologically confirmed case of cryptosporidiosis there are seven additional faecal oocyst-positive individuals in the community that are not investigated (ID2 study). In addition, it is suspected this figure could be double or more because of the fact that almost 50% of partially immune subjects with clinical cryptosporidiosis do not excrete oocysts in their faeces and would therefore avoid detection by standard diagnostic methods based on light microscopic examination of faecal specimens⁸. It should therefore be borne in mind that this outbreak was probably much larger than suggested by the number of cases reported

to the Board. Fortunately, there were no cases of immunocompromised patients developing serious complications from cryptosporidiosis associated with this outbreak. It is possible that such patients generally avoid public swimming pools.

7.6 Postulated mechanism of infection

In this outbreak, the OCT believed that *Cryptosporidium* oocysts were ingested by swimmers via contaminated water, in sufficiently high numbers to equal or exceed the infective dose for that particular isolate.

Hypotheses regarding the original source of the contamination and the attributable cause of the outbreak

A number of possible hypotheses to explain the source of the contamination and cause of the outbreak were considered by the OCT, including:

- Undetected faecal accident or accidents by an infected swimmer or cohort of infected swimmers (either symptomatic or asymptomatic) causing a point source outbreak that was prolonged because of a failure of the filtration system to remove the oocysts.
- Repeated contamination of the pool on several occasions by several different unrelated swimmers over an extended period causing a prolonged outbreak involving multiple point sources, in the face of either a functional or non-functional filtration system.
- Deliberate contamination, either on a one off or repeated basis, in the face of either a functional or non-functional filtration system.

Of these possible hypotheses, an undetected faecal accident or accidents by an infected swimmer or an infected 'family' of swimmers causing a point source outbreak that is prolonged because of a failure of the filtration system is the most likely. This conclusion is on the basis of the evidence that suggests that all of our cases were suffering from one common sub-genotype of *C. hominis*. Also, this was the same sub-genotype isolated from one member of a suspect family (Family 'A') that had recently returned from a holiday in Menorca where they regularly used a hotel pool and had used the Eastwood pool just before, and during the early phase of, the outbreak under investigation. We are hypothesizing that the prolonging of exposure and therefore the size of the outbreak was due to the fact that the functioning of the filter was inadequate, allowing viable oocysts to remain in circulation for weeks rather than hours or days.

The mother in Family 'A' could not have been a victim of the Eastwood pool-associated outbreak as she never used the Eastwood pool. However, her link with children who were ill with diarrhoea and who did use the pool early in the course of this outbreak means the family is a possible source. Her partner and two children, who did use the pool and who experienced illness of very short duration at around the time of their pool usage, tested negative for *Cryptosporidium*. The fact that they did not provide a faecal specimen when first asked (mid August) is relevant in that the delay in testing (until 11 September) may explain the negative result for the adult male and two children. Despite the negative results, the OCT's view is that it is likely that this family brought a novel strain of *Cryptosporidium hominis* from Menorca. It is possible that the four-year old son was the index case, contracting his infection from a swimming pool in Menorca, contaminated the Eastwood pool on his return to Scotland as a result of using the pool when he was still suffering from diarrhoea and infected his mother who suffered illness later on (Figure 7). However, this hypothesis remains speculative and it was accepted that the OCT is unlikely to be able to identify the original source with absolute

certainty.

Irrespective of the initial contamination source, it is still deemed more relevant that the compromised state of the filter or its operation had enabled accumulation of oocysts in the pool water and persistent contamination. This contamination lasted almost 6 weeks and for 16 hours after the pool was closed on 9 September and despite ongoing circulation of the pool water through filter A. It was deemed by the OCT that the pool filter should have been able to cope with any additional burden of oocysts, given the lack of a history of a frank faecal contamination episode associated with this (or any other) family using the pool in August and September. Furthermore, contamination of the pool by one or more individuals should only have caused exposure to other swimmers for a few hours after each visit (until the filters would have cleared the water of the oocysts). However, several cases of illness in this outbreak were not exposed until they visited the pool on 8th September shortly before closure of the pool on the 9th September. It is, therefore, more appropriate to question the ability of the filters to remove the oocysts that will, from time to time, enter the pool as a result of contamination by diarrhoeal or convalescing swimmers than to attribute the cause of the outbreak to a single convalescing family returning from abroad.

7.7 Providing Genotyping (DNA fingerprinting) evidence of causation

Recently a series of micro- and minisatellites (multi-locus genotyping - MLG) have been used to further subdivide both *C. hominis* and *C. parvum* into a large number of MLGs (more than 50). In conjunction with the University of Glasgow, the Scottish Parasite Diagnostic Laboratory (SPDL) undertook multi-locus genotyping (at nine loci) of the *Cryptosporidium* oocysts obtained from most of the confirmed human cases (both directly linked to the pool and from the mother of the suspect family) and the water specimens.

This revealed that, for the samples that amplified at all loci, all human specimens from pool users associated epidemiologically with the outbreak contained a single *C. hominis* MLG subtype, thereby providing corroborative evidence⁹ that the outbreak was indeed a point source event. The limited genetic material available from the sample provided by the mother of the suspected family was also positive for *C. hominis*, and this had the same profile, at the six loci that amplified, as the MLG subtype found in the other human cases. The smaller quantity of DNA obtained from the mother possibly explains why matching was only possible at 6 loci. From these MLG data, it can be concluded that the family was linked to the outbreak.

As in many outbreaks, it is impossible to conclusively prove that the family was the source of the oocysts in this outbreak by using the pool when ill, however the circumstantial and the limited MLG evidence supporting that hypothesis is compelling.

Unfortunately, there was inadequate genetic material present in the water samples to confirm whether the *C. hominis* in the pool water and backwash water was of the same subtype as that found in the human specimens and therefore we are unable to conclusively prove that the water was the causal medium. *Cryptosporidium* is periodically found in swimming pools at an unknown frequency and its presence during this investigation provides additional strong circumstantial evidence that this point source outbreak was pool water-borne.

7.8 East Renfrewshire Council's role in the outbreak

There are unique features associated with this outbreak which raise legitimate questions about the roles that ERC was required to fulfill. ERC's role in this outbreak can be seen in terms of three stages:

1. preceding the outbreak;
2. following the presentation of cases and including the investigation of the outbreak and its technical causes.
3. following the definitive refurbishment in January 2004.

Preceding the outbreak

The ERC's Property and Technical Services Division was responsible for commissioning a refurbishment in November 2000 which proved to be seriously substandard. ERC then failed to ensure adequate maintenance on an annual basis, allowing the filters to decline into an unacceptable state. In addition to the lack of maintenance of the filters, there was non-calibration (and therefore non-use) of flow rate monitors and coagulant dosing that was not linked to pool usage level as described above.

Following the outbreak

Only EHOs from ERC were full members of the OCT with other staff invited to attend to provide information as required. This resulted in some confusion and impairing of the functioning of the team and it is clear in hindsight that their roles should have been clearly explained to them.

EHOs at ERC were prompt in advising that the Council close the pool and the Council took immediate steps to implement this recommendation. The pool was not re-opened until the underlying cause of the outbreak had been identified and the necessary remedial action taken. This process involved digging out the filters, renovating and re-sanding them, under close supervision, and other refurbishment and maintenance issues had been completed. As explained at 4.1 above, ERC established a working group to lead and co-ordinate its response to the outbreak. This was chaired by a senior officer from Community & Leisure and included staff from other relevant services and EHOs. The Environmental Services Manager acted as a bridge between this ERC Group and the OCT

As recommended by the OCT, ERC commissioned two independent private contractors, one to investigate the problems with the treatment plant and another to refurbish the filters. ERC also took the opportunity to carry out a wide range of repairs and renovation to the pool and also carried out a range of supporting tasks to ensure a more hygienic environment in the future, both as regards the running and maintaining of the pool and its use by the public.

However, there were occasions when it was unclear to OCT members to what extent the Working Group set up by ERC was acting independently and when it was acting on advice from the OCT.

In reality, the technical investigation proved complicated due to the mechanisms adopted with ERC commissioning technical experts answerable to ERC rather than accountable directly to the OCT. Ideally, an OCT would have direct access to and a clearer role in the direction of any technical experts commissioned as a result of an outbreak. If the OCT is not able to direct a technical investigation, questions are likely to be raised about the independence of the investigation.

Following the refurbishment of January 2004

In addition to the above, ERC took the decision to examine ERC's entire swimming pool stock for any indication of potential problems and make any the subject of reports to the Council, if necessary, to try to prevent such an outbreak occurring again, as far as practical. Preventative repairs were conducted on a number of pools.

The initial investigations were carried out by a contractor recommended by Scottish Water and details of the investigation, proposed works and the remedial work carried out were provided to the OCT. The OCT Chair visited the site after the work was completed.

However, it should be noted that the remedial work was carried out on behalf of ERC and the OCT cannot therefore vouch for the diagnostic or refurbishment work.

It is noted that the Council retains the right to make decisions about the selection of contracts aimed at maintaining the treatment plant for its swimming pools, including the Eastwood Pool complex. The on-going financial pressures on both councils and private operators means that the specification of future maintenance contracts (in terms of quality and frequency of visits) may be at risk of being compromised. It is therefore essential that local authority contracts include a quality element (through the specification and/or evaluation process) in contracts which they let and private operators may well include other elements for consideration apart from price.

8. Conclusion

The original source of the *Cryptosporidium* contamination remains speculative but may have been a family that had recently returned from a holiday abroad and that was suspected to be convalescing from cryptosporidiosis. One member of this family was demonstrated to be infected with the same multi-locus genetic (MLG) type, based on a more limited number of genetic loci, as the MLG type found in the victims of the outbreak. The four year old child of this family used the pool at around the time of the suspected contamination, while suffering from diarrhoea.

However, no matter what the original source of the contamination, the primary preventable cause of the actual outbreak was a dysfunctional pool treatment plant that had been refurbished to a sub-standard level in November 2000 followed by a failure to examine and maintain the filters for almost three years.

9. Lessons learnt

Several aspects made investigation of the outbreak more difficult and challenging than necessary:

9.1 Conflict of interest: should a local authority department be allowed to investigate itself?

The outbreak was associated with a large and popular pool owned and run by a local authority. Normally the local authority has statutory responsibility, jointly with the NHS Board, for investigating such outbreaks, implying that it would be in the difficult position of investigating its own practice. This posed particular problems for the Environmental Health Officers (EHOs) who would normally take charge of the technical aspects of any investigation surrounding an outbreak. In this case, the same local authority departments that ran and maintained the pool were responsible for assessing the technical cause of the outbreak and identifying appropriate remedial work. As a result, a working group was established by ERC and a private consultant was appointed by them. ERC EHOs formed part of the working group and fed information back to the OCT, which had important repercussions for the functioning of the OCT. The OCT depends on the crucial technical input of the EHOs and the ability to obtain clinical, epidemiological and microbiological data from testing and interviewing ill cases and from water sampling. This was not an ideal situation and also placed ERC's Environmental Protection Services in a potentially difficult position. As a consequence of this complicated arrangement, the Chair of the OCT decided to obtain technical information about the treatment of pool water from outside expert sources detached from the actual investigation until early December when it received the Filtec report commissioned by the local authority. The members of the OCT had to wait three months after the outbreak declared itself, to learn any more about the filters than what they could observe directly at the visit on 22 October and what they could deduce from the expert advice obtained by telephone. The pool remained closed throughout this period.

This raises fundamental questions as to the mandate and authority of an OCT. It also raises the question as to whether a local authority responsible for running a swimming pool should investigate and sort its own problems with minimal intervention by an outside regulator or minimal input from the OCT. The local authority staff involved in pool management may not always understand or fully appreciate the need for independent validation of these aspects that an OCT can provide.

As described above, this investigation highlighted difficulties that can arise when an outbreak is linked to an establishment that is owned and run by a local authority. Given that the same local authority employs the Environmental Health Officers that are charged with joining NHS public health officials to investigate the outbreak as core members, these EHOs are vulnerable to a conflict of interest. As a result, with the agreement of the Environmental Services Manager at ERC, the Chair of the OCT wrote to the local office of the Health and Safety Executive (HSE) to bring the outbreak and the concerns the OCT had about the state and operation of the pool filters to the attention of local HSE inspectors. This enabled a third party (HSE) to be involved with the regulation of the pool operators (duty holders), under the Health and Safety at Work Act 1974. During the investigation, the OCT was informed by both the Environmental Services Manager at ERC and the Inspector of Health and Safety at the local HSE office that the local authority EHOs have no powers to take action against their own local authority in respect to investigating incidents and outbreaks linked to that council. This does not preclude EHOs from supporting NHS Designated Medical Officers in the investigation and interviewing of individual cases with illness but does mean that they are lacking the powers to investigate and take action regarding the incident involving the filtration at the pool that allowed the outbreak to occur.

In addition, the OCT became aware of the fact that the pool managers, who are also employees of

ERC, operate the pool linked to the outbreak, and are therefore also vulnerable to conflict of interest in any investigation conducted in conjunction with the NHS Board. This became apparent at the first two meetings when representatives of these departments attended.

Finally, another conflict of interest arose associated with the presence at the first three OCT meetings of the ERC media relations representative. The press representative was expected to act in the interests of ERC as pool owners and managers and yet also to provide impartial advice to the OCT. This proved to be problematic at several points in the proceedings. For example, there is a potential for considerable media interest in an outbreak like this one (Figures 17 to 19). A joint ERC-GGNHSB press release was drafted that contained ERC financial information, unavailable to the OCT, and quotes from ERC local councillors that were clearly designed to promote, and minimise adverse publicity for, the council. Statements appeared in the local and national press alluding to the cause of the outbreak and attributed to an ERC spokesperson that were not deemed accurate by the OCT and yet drew on some of the confidential health data discussed at OCT meetings (Figure 20). Specifically, these attributed the outbreak to a family returning from Menorca and failed to mention the fact that the pool treatment plant was not fit-for-purpose. This constituted clear breaches of the rules of investigating such outbreaks, namely that the discussion at all OCT meetings is confidential, and that all media communications are exclusively conducted through the press release of the OCT.

The above difficulties necessitated the Chair limiting the status of specific ERC staff, including pool management and PR staff to that of 'in attendance', which implies that they are not in a position to fundamentally influence the final report and its recommendations, *etc.* In addition, *core* meetings of the OCT (as per national guidance on the subject) were convened to steer the investigation and write the OCT report. Finally, a second press release was issued by the OCT to clarify the issue of attribution of the cause of the outbreak (24 September).

This issue should be acknowledged and more detailed guidance provided on ensuring that potential conflicts of interest are addressed.

9.2 The role of the HSE

There was a degree of confusion about the role of the Health and Safety Executive, particularly at the outset, both on the part of the local authority and on the part of the HSE itself. The SCIEH representative advised that the HSE be informed about the outbreak. In contrast, the local authority did not regard the HSE as occupying a statutory role in the immediate investigation. Initially, the HSE questioned the need for their involvement given the fact that no lives had been lost or seriously threatened by the outbreak. Subsequently, the HSE felt they had a role as an outside regulator because of inadequacies in the public health legislation. The latter does not provide any other statutory body, other than the HSE, to take a prosecution against a local authority. It is clear that current public health legislation makes it impossible for a local authority to take formal action against itself.

9.3 The need for independent expert technical advice for the OCT

None of the usual members of the OCT, nor any individual or department within the local authority, would normally be expected to possess the specialised technical expertise required to adequately investigate the technical aspects of the suspected underlying cause of this outbreak (the pool treatment plant). This meant that some department or agency would have to commission, at a cost, a thorough investigation by an outside private contractor. Ideally, the OCT should be in a position to commission such technical reports, as and when required, to support its overall investigation. In that

case, the OCT should be able to draw on funds, yet no source of such funding has been identified. For example, in this case it would be reasonable for the local authority to pay for such a report once the OCT had agreed which sub-contractor would carry out the work, given that it was confirmed that the local authority was effectively responsible for the outbreak^w. In that case, the outside contractor would be accountable to the OCT rather than, as occurred in this case, the council. The OCT would subsequently ‘own’ any reports commissioned for its investigation. In this case, ERC ‘own’ the reports produced by the independent contractors, the most relevant of which are contractors ‘E’ and ‘F’.

9.4 Guidelines versus regulations for pool treatment standards

The PWTAG guidelines proved to be very useful to the OCT as the main authoritative source of technical information for this investigation. It enabled OCT members to question ERC staff on relevant aspects of the pool treatment plant and how it is supposed to work. However, it became apparent that there is no obligation on pool operators (whether private or public) to comply with PWTAG, which are entirely guidelines, as opposed to enforceable regulations. While pool operators commonly insist that they “follow PWTAG”, evidence was presented to the OCT that suggests divergence from PWTAG guidelines is common and that the pressure to keep costs down (whether in the public or private sector) is relentless. Profitably running a swimming pool, or even breaking even, can be challenging. The dual incentives to maintain high usage statistics and keep running costs down work against public health by ensuring that swimmers are brought together in close proximity in pool water that may not have been subjected to adequate quality filtration processes. The latter are complex^x and expensive to operate and maintain. This investigation was characterised by much anecdotal opinion about the ability of reputable contractors to flourish in a very competitive market where councils and private sector operatives are still tempted to accept the lowest bid. These pressures are highly likely to be exacerbated by the lack of enforceable regulations.

^w In food-borne outbreaks related to commercial premises, recouping the cost of such technical investigations may be more problematic, particularly as the source of an outbreak may not always be identified.

^x The expertise of a mechanical or civil engineer is required to design and diagnose problems with such treatment plant.

10. Recommendations

The OCT agreed the following recommendations, based on the findings and the lessons learnt. These are grouped under the following headings: Prevention; Surveillance and case investigation; Swimming pool related outbreak investigation; Risk management and outbreak control; and Risk communication.

10.1 Prevention

Recommendation 1 aimed at the Scottish Government, UK Government and other devolved administrations

The PWTAG guidelines and expertise, as well as the knowledge of the Pool Water Treatment Advisory Group should be used to inform the creation of swimming pool and spa regulations enforceable under updated Health and Safety legislation in keeping with other European countries. Evidence from this outbreak investigation strongly suggests that a voluntary set of guidelines is not enough to ensure adequate control of pool water quality. Swimming pools should therefore be subject to an increased level of regulation, appropriate to the potential for risk and bearing in mind the large numbers of people using swimming pools, in the same way that other recreational waters currently are.

Recommendation 2 aimed at local authorities and the Health and Safety Executive

Until such time that replacement regulations are introduced, public (e.g. local authority) and private swimming pool operators should be reminded of the need to adhere to PWTAG guidelines. PWTAG guidelines consider the optimal design, including the selection of constituent materials, of swimming pool filtration plants when constructing pool treatment works. These also provide standards for the operation and maintenance of pool treatment plant to avoid parasite-related outbreaks (e.g. cryptosporidiosis and giardiasis). Finally, PWTAG guidelines suggest that swimmers should be advised not to use the pool within 14 days of diarrhoeal illness. Pool operators should take this advice seriously and pass this message on to their customers, in the interest of protecting public health and, therefore, their own interests (see ERC community newsletter in appendix 11.3 that was issued in response to the outbreak and advises pool users to abide by the 14 day rule).

Recommendation 3 aimed at pool operators, local authorities and the Health and Safety Executive

As part of their on-going maintenance arrangements, existing pool operators (of both privately and publicly owned pools) should conduct a comprehensive inspection of their pool filter(s), including inspection of the sand, and take remedial action if necessary, at least once a year. It follows that if they have not done so in the past year, they should inspect their filter(s) immediately.

Recommendation 4 aimed at NHS Greater Glasgow and Clyde and other NHS Boards

NHS Greater Glasgow and Clyde and other NHS Boards should independently endorse the advice that swimmers should be advised not to use a public swimming pool within 14 days of diarrhoeal illness, quoting the source of this advice (PWTAG). Such advice could be called and publicised as the “14 day rule”.

Recommendation 5 aimed at NHS Boards

All NHS Boards should consider organising an area-wide poster campaign for all swimming pools to promote the “14 day rule”. These posters should discourage users from using the pool within 14 days of diarrhoeal illness of infectious or unknown origin. This would be in recognition of the fact that the incidence of pool-related outbreaks could be reduced if there was greater public awareness of the need to avoid using public swimming pools when diarrhoeal or convalescing from diarrhoeal illness. This was carried out in NHS Greater Glasgow in 2004 (see appendix 11.4).

10.2 Surveillance and case investigation

Recommendation 6 aimed at local authority Departments of Environmental Health and NHS Boards

Gastro-intestinal illness investigation forms should be reviewed by the various NHS Board public health protection units across Scotland to ensure that questions include reference to the potential role of exposure to swimming pool water as a source of infection. It is important that routine investigation of all cases of gastrointestinal infection includes adequate questioning about exposure to recreational water including swimming pool water.

10.3 Risk management and outbreak control

Recommendation 7 aimed at pool operators, local authorities and the Health and Safety Executive

As soon as there are reasonable grounds, on the basis of surveillance data, to suspect a pool as a source of an outbreak, the operators should voluntarily close the pool or be asked if they would be willing to do so by the OCT or statutory agency. This enables an OCT to investigate the outbreak and its cause with less pressure than would exist if exposure to the suspected source continued and than would be brought to bear by the media. Where the epidemiological evidence is sufficiently strong, closure of a pool on suspicion alone is justifiable. This may be effected either by seeking voluntary closure of the pool or if necessary resorting to appropriate legislative measures.

10.4 Swimming Pool-related outbreak investigation

Recommendation 8 aimed at NHS Boards

The Chair of an OCT/IMT should convene their team by clarifying the roles and responsibilities of all members and those in attendance in order to ensure that those participating respect the need to adhere to protocols including the need to maintain confidentiality. Not all members of an OCT will be aware of the potential for conflicts of interest and the need for strict adherence to confidentiality when dealing with sensitive personal information. These aspects need to be emphasised at the outset and reiterated subsequently.

Recommendation 9 aimed at NHS Boards and the Public Health and Wellbeing Directorate of the Scottish Government.

The Chair of an OCT/IMT should consider setting up a Technical sub-group in complex situations such as a swimming pool incident, where there is a need to obtain very specialised technical or scientific advice to assist the OCT/IMT determine the cause of the incident and to identify the best risk management strategy to prevent a recurrence. This sub-group should act as a focus for investigating technical issues which require specialist support not available from members of the OCT/IMT. Members of the sub-group could include outside experts or commissioned consultants who would not then need to be members of the actual OCT/IMT itself. This sub-group could be chaired by an appropriate member of the OCT or by someone else co-opted specifically for the task.

Recommendation 10 aimed at the Public Health and Wellbeing Directorate of the Scottish Government.

Any future review of the management of incidents and outbreaks should address, in more detail, the critical issue of conflict of interest as it relates to public bodies linked to outbreaks they would normally be expected to investigate. In particular, given the key role of Environmental Health Officers on OCTs as core members, and the fact that they remain in an ideal position to investigate sites in their own area, this new legislation should empower local authority EHOs to investigate outbreaks linked to premises owned and operated by their employer and/or give powers to authorise an EHO from another authority to lead the investigation. Regulation by a third party (such as the Health and Safety Executive for example) becomes even more essential in this case and the mechanism and degree of such regulation requires clarification in law. Such regulation by an outside party must provide for the possibility of referral to the Procurator Fiscal, otherwise the performance of statutory bodies could be expected to fall below acceptable standard.

Recommendation 11 aimed at NHS Boards

Future OCT Chairs should be reminded, via normal professional networks (e.g. CPD training events) of the need to recognise the potential for conflict of interest when convening OCTs, and to take appropriate action at the earliest opportunity. The overall success of an investigation strongly depends on the cooperative functioning of a cohesive team and conflict of interest is the most significant threat to team-working. Appropriate action includes informing the DPH and CEO of the lead NHS Board and may also include limiting the status of members; contacting the chief executive of the organisation with the conflict of interest to clarify the role and powers of the representative officers; obtaining additional expertise from outwith the team to supplement that provided by those with the conflict of interest; informing any relevant outside regulators (e.g. HSE, SEPA, Drinking Water Quality Regulation Team, etc.) and inviting the latter to attend the OCT as non-core members.

Recommendation 12 aimed at NHS Boards

As soon as it is determined that an outbreak is swimming pool-related, the OCT should be able to commission a complete 'head to toe audit' from a reputable, independent pool contractor. The investigation of a swimming pool related outbreak is likely to be of a highly specialized and technical nature, beyond the realms of knowledge routinely possessed by either health board or local authority staff, including the local authority staff charged with maintaining and running the pool. This means that expert and impartial advice is required regardless of who leads the investigation. By

leading an impartial investigation of the outbreak and combining this with a commissioned diagnosis of the technical reasons for contamination, the OCT is in the best position to get to the bottom of the outbreak and ensure it doesn't happen again, while retaining the confidence of the public. This division of labour, and the related accountability, should be made clear to all members at the outset.

Recommendation 13 aimed at NHS Boards and local authority Departments of Environmental Health

If a pool is suspected as the source for an outbreak of gastro-intestinal illnesses, the pool water and backwash water should be tested using the best available technology (Genera[®] at the time of writing), whether or not the pool is closed to the public. Given that *C. hominis* oocysts were found in the pool water and the backwash water, this provided strong supporting evidence of a pool-related outbreak. Persistent presence of oocysts after several days following closure, provides conclusive evidence of filtration failure.

10.5 Risk communication

Recommendation 14 aimed at NHS Boards and local authorities

Any press releases or guidance relating to an ongoing outbreak investigation should be cleared with the OCT first. This is especially true where a public body that provides a public service is potentially or directly involved in the causation of an outbreak and that body is required to make public comment or guidance. It is critical that the press releases of the public body are consistent with those issued by the OCT and that they are approved by the OCT.

Recommendation 15 aimed at NHS Boards and other multi-agency partners

The communications and public relations staff of all national and local agencies with which GGNHSB liaises should be reminded that lead responsibility for communication from OCTs during outbreak investigation lies with GGNHSB and not with the individual agencies. The communications strategy of GGNHSB should be reviewed and disseminated to interested counterparts by the Director of Communications of GGNHSB. During this outbreak, evidence emerged that suggested that the communications strategy for GGNHSB had not been cascaded to PR staff in ERC.

Figure 1: An electron microscopic view of sporozoites leaving an oocyst embedded in the lining of the small intestine.



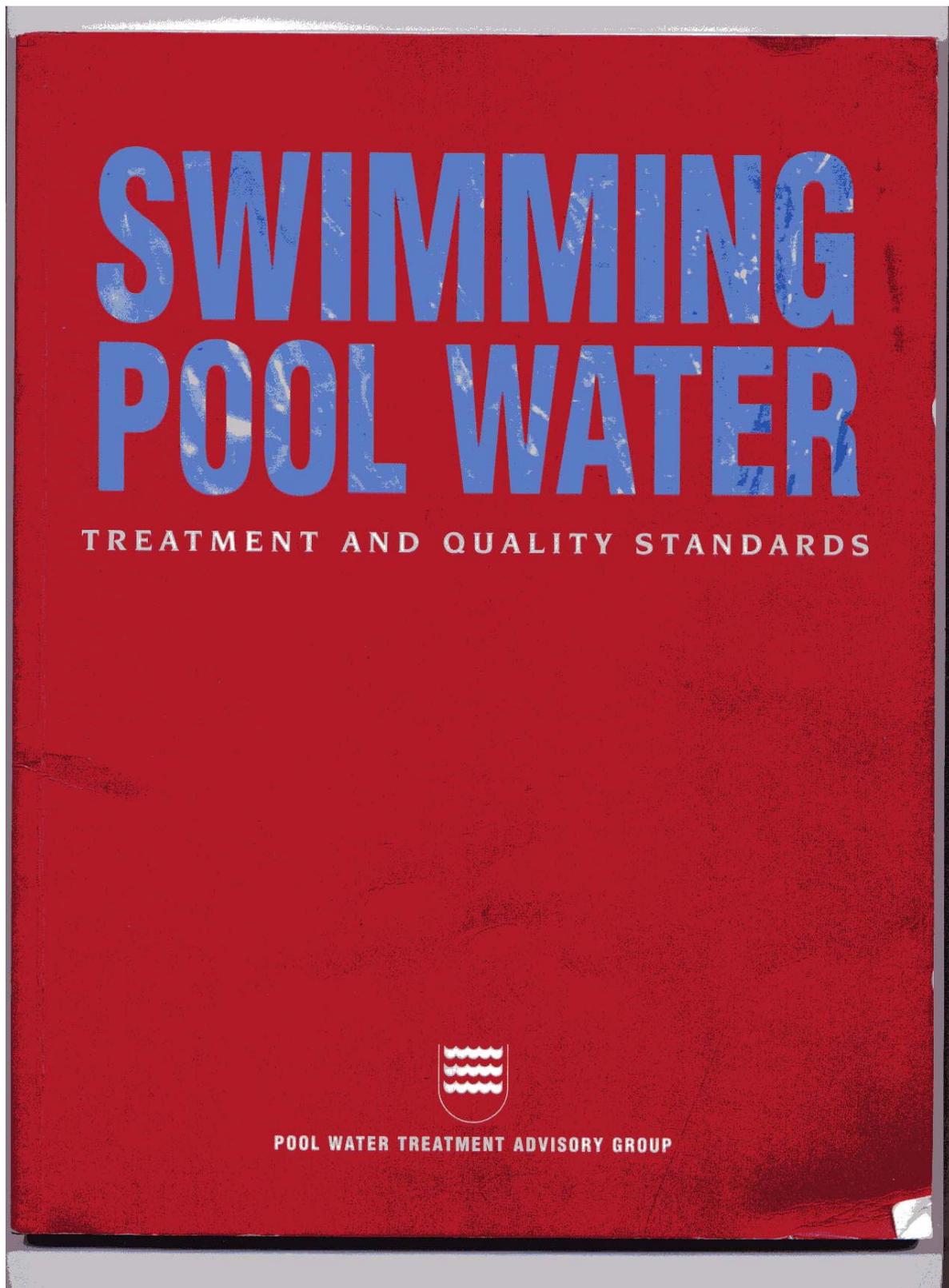


Figure 2: The cover of the PWTAG standards that provide useful guidance, but are not compulsory.



Figure 3: Eastwood Pool demonstrating the shallow end of the large pool, in the foreground, and a glimpse of the small pool and rain water area and slides, in the background.



Figure 4: A view of the small pool complex from the far end demonstrating how shallow the water is and yet how it might attract a large number of users.

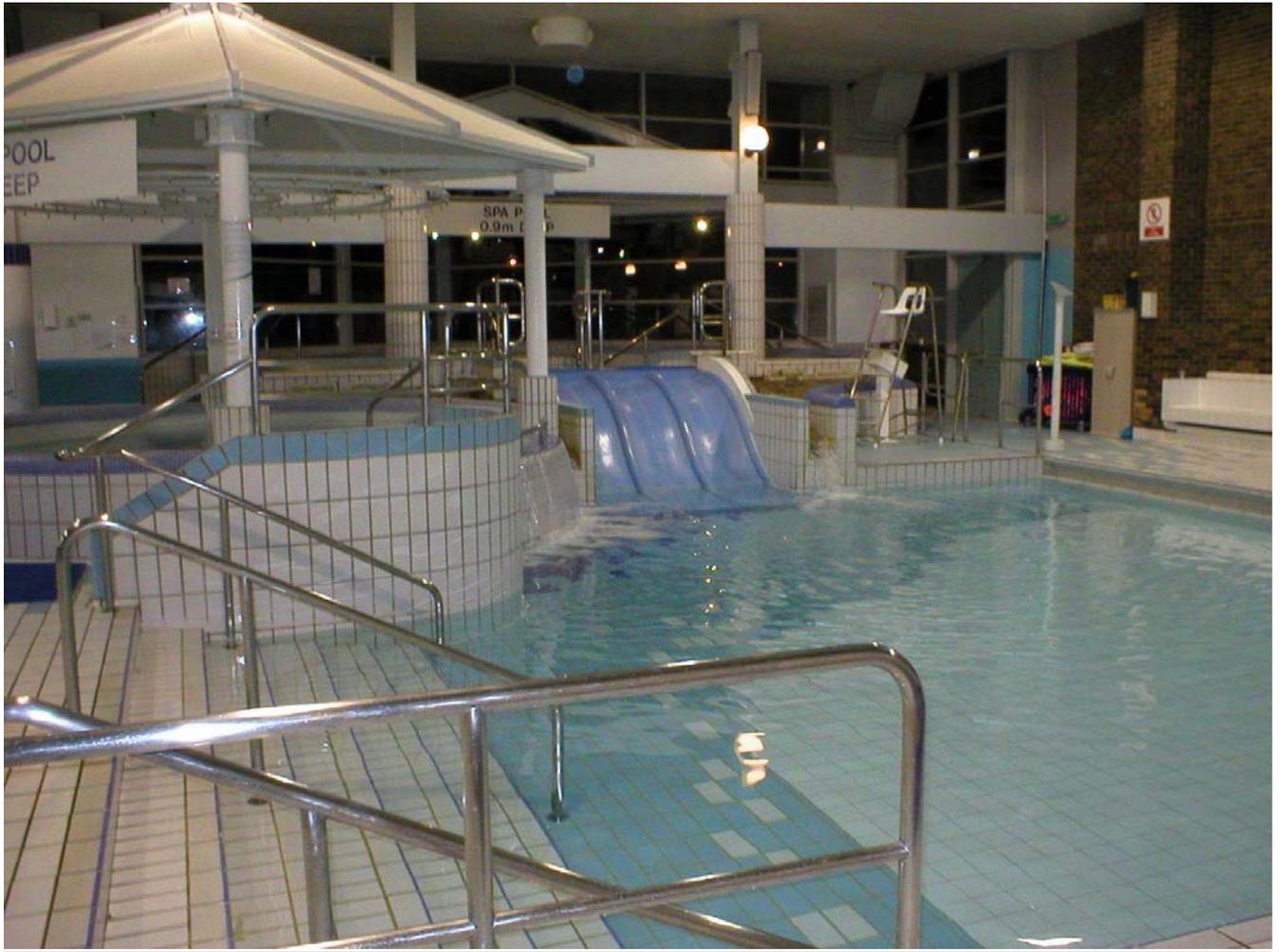
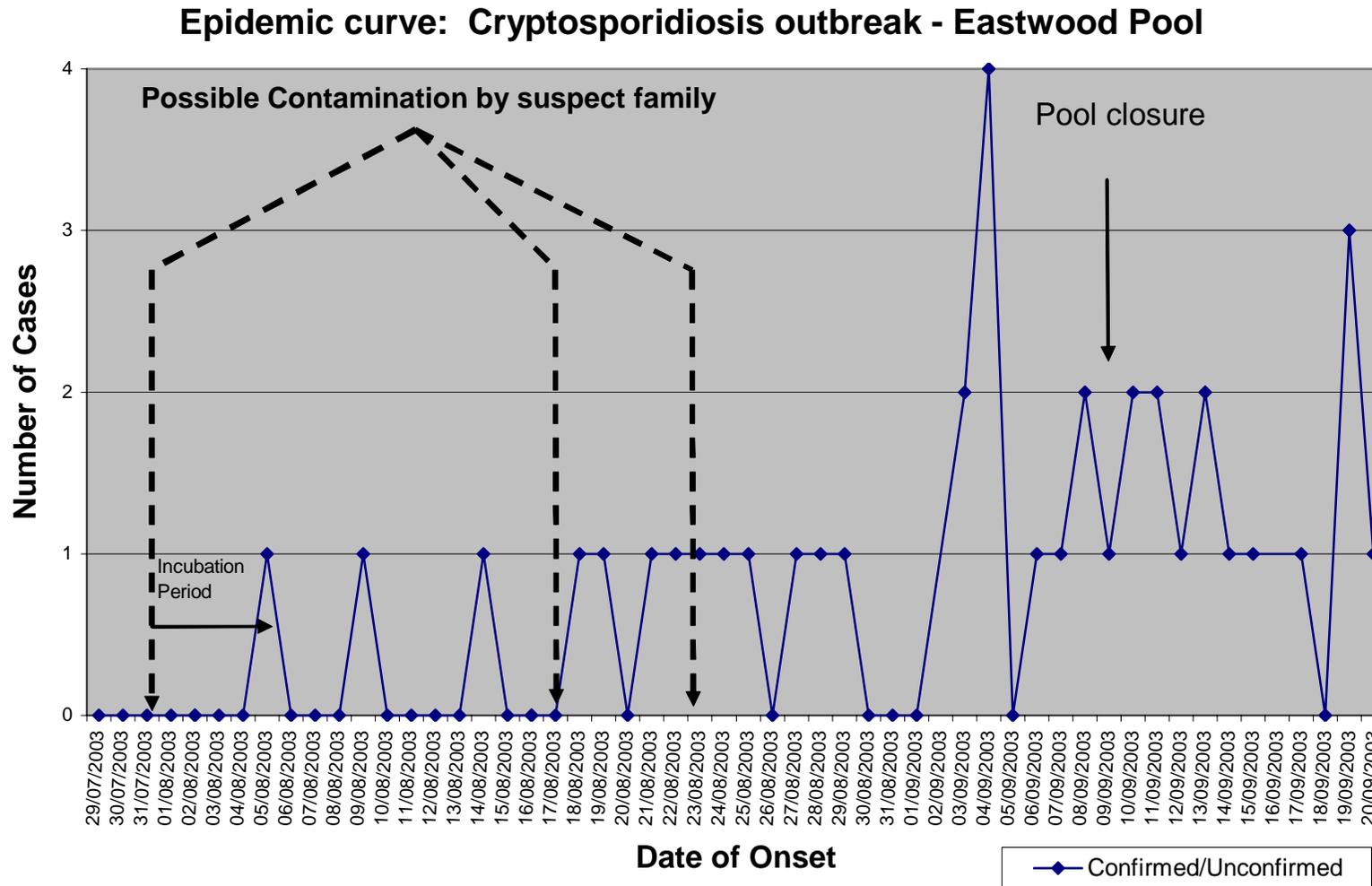


Figure 5: A better view of the small pool whose water is connected to the supplies for all the other features in the small pool complex but is entirely separate from the large pool system.

Figure 6: Epidemic curve



Holiday
(Menorca)
for
suspect
Family

Figure 7: Relevant dates for the family 'A'

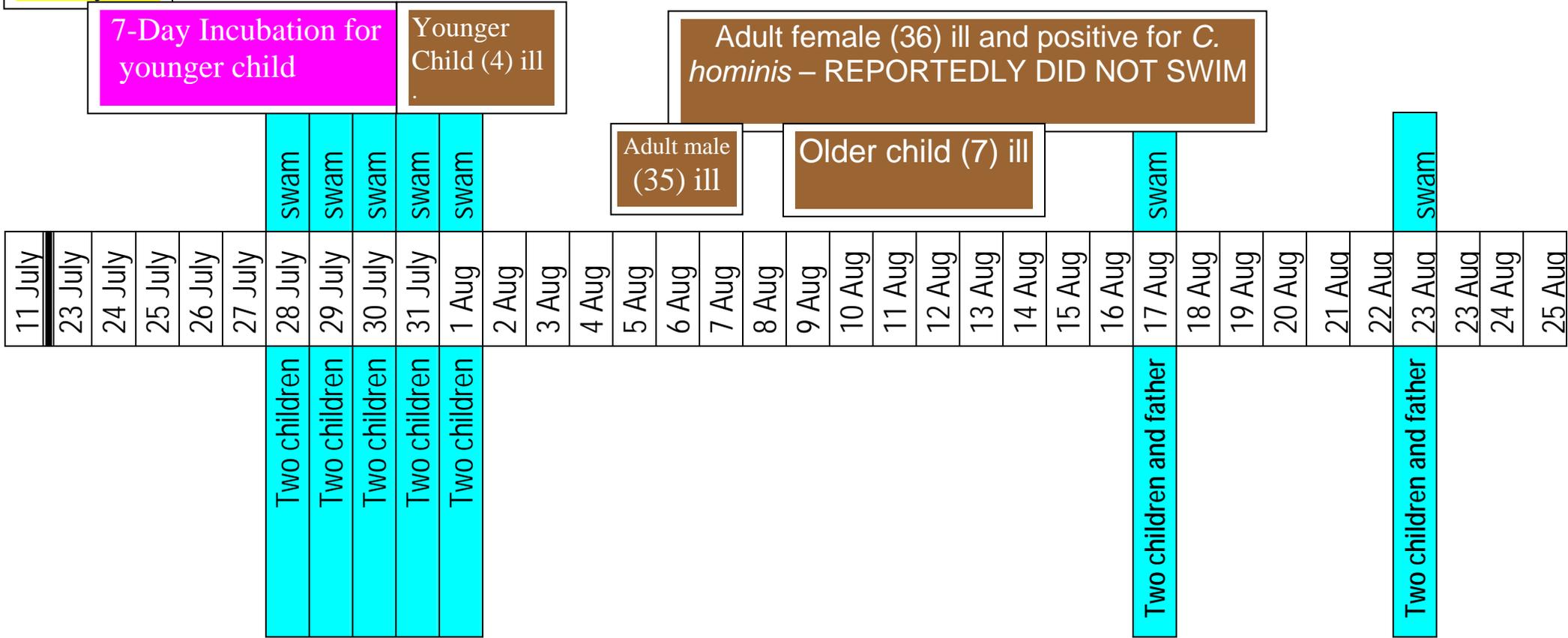




Figure 8: Filter C, one of two filters processing the water of the large pool.



Figure 9: Filter C, Air scour pattern very poor



Figure 10: Filter A, Sand migration through mid size gravel



Figure 11: Filter A, Large amount of fine sand, silt and seashell fragments between laterals.



Figure 12: Filter B, Seashell fragments in gravel



Figure 13: Filter B, jetting through gravel and sand migration



Figure 14: Filter C, Small gravel removed, tide mark evident



Figure 15: Filter C, Deterioration of concrete against filter container face



Figure 16: Filter A, Close up of silt etc between laterals, NB Stagnant water

Fears after pool closes

by Laura Coventry

SWIMMERS who use Eastwood Pool have been advised to seek medical attention if they are worried following its closure after a health scare.

The pool in Eastwood Park was closed to the public "as a precautionary measure" on Tuesday afternoon after being linked to five confirmed cases of cryptosporidiosis.

As **The Extra** went to press, the total has risen to six adults and children in East Renfrewshire have now contracted the bug.

But as the council's environmental officers and public health officials attempt to establish the source of the infection locals are in a state of fear.

One regular user of the baths from Giffnock was surprised at the shock revelation having only swam in the pool on the eve before closure.

She told **The Extra**: "I was there on Monday night and I feel fine, but it is quite scary to think that something as serious has happened so close to home.

"Eastwood is a very busy pool, especially during the summers, and on Monday night it was packed."

A spokesman from Greater Glasgow Health Board urged



Don't go with the flow: Eastwood pool is closed while the source of cryptosporidium is sought.

locals not to panic but to seek medical attention if they are concerned.

He allayed their fears by saying: "Because of the incubation period of 2-12 days, the chances are the source has probably gone now, but that is what the meetings are trying to establish.

"If anyone is concerned about their children they should go to their GP."

Yesterday, an outbreak control team met and decided that it would remain closed

until the root of the problem has been identified.

A spokesman from East Renfrewshire Council said: "It has still not been confirmed that Eastwood pool is definitely linked, as we are still carrying out tests on water samples.

"It will be closed at least until tomorrow which is when we expect test results to come through.

"A lot of health officials from Greater Glasgow Health Board and specialists from

Scottish Water are involved. Once we have the results they will be interpreted by the specialists."

Cryptosporidium is a parasitic intestinal infection and can be contracted by coming into contact with human or animal faeces, the main symptoms is diarrhoea.

Investigations are ongoing and East Renfrewshire Council, the health board and Scottish Water will reconvene tomorrow.

● *This is the latest scare surrounding the pool: earlier this year a glass panel fell injuring two boys, this also happened in 2002, and in March the pool was evacuated after a small fire.*

DESPITE appearances, more than 250 people attended the Newlands South Church



Figure 17: The first newspaper article when the story broke.

POOL CLOSED FOR A MONTH

£50k to get rid of bug

COUNCIL chiefs will spend £50,000 cleaning up a bug-hit swimming pool.

Eastwood Pool will be closed for a month while environmental health bosses carry out a full inspection and overhaul of the filtration system.

Last week, 14 people were struck down by a potentially deadly cryptosporidiosis, which is linked to the popular bath. Community Services chief Allan Steele said: "We are sure that the pools are safe before we reopen them."

"Most of all, we want to ensure that our many and loyal swimmers that everything has been done to eliminate the bug. "We apologise for any inconvenience caused by the longer term closure, but are sure that our pool users will agree that this investment is worthwhile."

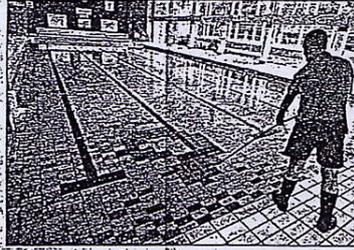
Bug hits another 7 swimmers

By Gordon Thomson

THE number of swimmers at a swimming pool struck down by a stomach bug has doubled to 14.

The news comes as it was revealed the pool at the centre of a health scare is to stay closed for at least four weeks. Council chiefs have ordered specialist workers to disinfect every part of the pool and filtration system at Eastwood Leisure Centre in Giffnock.

The move comes despite samples showing that the water in the main pool and three smaller ones are clear of any traces of the cryptosporidium bug which causes vomiting, diarrhoea and stomach cramps. Fourteen people, most



EVE
TIMES
25/9/03

OUT OF ACTION: the pools at Eastwood will stay closed for another four weeks

children, have now fallen victim to the bug. One youngster needed hospital treatment. An NHS Greater Glasgow spokeswoman said: "We can confirm another seven cases have been

identified. Investigations are continuing." Officials at East Renfrewshire Council, which closed the pool two weeks ago, have decided on a £50,000 clean-up.

Every pool will be drained, disinfected and cleaned while the filtration system is tripped down and disinfected. The work is expected to get under way next week. A spokesman said:

Experts say many would not have reported crypto illness.

Bug outbreak may have hit 350 swimmers

By Jonathan Paisley and Graeme Murray

HEALTH chiefs fear more than 350 people may have been infected by a cryptosporidium out-



Evening Times 25/9/03

"We'll keep the pools closed for another four to six weeks for a complete overhaul of the filtration system."

"We want to reassure ourselves and the public that crypto is out of the system." A bug-infected youngster is thought to have been responsible for the outbreak after having an accident in the children's pool.

The local authority will now launch a public education programme including a warning not to go swimming less than two weeks after suffering diarrhoea. The health scare has also forced council chiefs to introduce a temporary ban on swimming lessons for youngsters.

have been hit by bug testing routinely for the bug cause I understand it's not possible. Health chiefs at NHS Greater Glasgow have been searching for new cases of the illness linked to the pool, but insist the pool was closed as soon as the outbreak was identified. Council bosses at East Renfrewshire Council, meanwhile, have ordered an £85,000 clean up at the pool, which will remain closed for six weeks. Tests revealed the bug had infected the drainage system at the main pool and two smaller ones. Hygiene procedures at all five pools in East Renfrewshire are being reviewed following the break.

Pool shut after five struck by killer bug

RECORD 10/9/03

A SWIMMING pool was forced to close yesterday over fears it was infested with a potentially deadly stomach bug.

Five swimmers fell ill after taking a dip at the Eastwood Leisure Centre, near Glasgow.

Now council officers are testing to see if the pool is infested with the cryptosporidium bug. The five victims have been confirmed as having the bug, which causes diarrhoea, stomach cramps and fever and can be fatal to babies, the old and the sick.

Two more people are suspected of having caught it. An outbreak of the bug - a parasite which can be passed on through human or animal faeces - means 160,000 Glasgow residents had to boil their water last summer. It was believed to have been caused by sheep droppings in the supply.

The leisure centre's 25-metre pool, along with a smaller kids' pool, is used by about 500 people daily. The swimming pools were shut at 3pm yesterday. All other facilities remain open.

East Renfrewshire Council and health bosses said the pools had been closed as "a precautionary measure".

A health spokesman said the five infected swimmers were all recovering at home. Council officials say they aim to have the pool open by Friday.

7th case of bug in pool

RECORD 16/9/03

A SWIMMING pool was linked to a seventh case of a killer stomach bug last night.

Eastwood Pool, near Glasgow, has been closed to the public since last week after several users fell ill with cryptosporidiosis.

East Renfrewshire Council and NHS Greater Glasgow issued a joint statement yesterday saying tests found high levels of the bug in the water and the pool filter.

They added: "Another case has been linked to the pool and it remains closed for investigations to continue."

The 25-metre pool and smaller kids' pool are used by about 500 people daily.

The bug causes diarrhoea, stomach cramps and fever and can be fatal to babies and the old.

RECORD 25/9/03

Number of water bug cases rises

THE number of people who contracted the cryptosporidium bug after visiting a swimming pool has risen to 18. All the cases have been linked to the pool at Eastwood leisure centre, Eastwood, East Renfrewshire.

RECORD 20/9/03

Pool bug cases rise

FOUR more swimmers have caught a potentially deadly stomach bug from a swimming pool.

A total of 18 people have contracted cryptosporidium from Eastwood Leisure Centre, near Glasgow.

An ineffective filtration system at the pool, used by 500 people a day, has been blamed for allowing levels of the bug to build up.

Water bug closes swimming pool

A PUBLIC swimming pool was closed by health officials yesterday following an outbreak of the cryptosporidium bug. Eastwood Pool in East Renfrewshire was shut by the local authority and NHS Greater Glasgow after five visitors to the pool caught the bug.

Pool bug strikes six

HEALTH chiefs yesterday confirmed a sixth case of the cryptosporidium bug linked to Eastwood Leisure Centre pool in East Renfrewshire.

The pool was shut on Tuesday after five people with the bug said they had recently swum there. Investigations into the source of the infection are continuing. The pool remains closed.

Symptoms include diarrhoea, abdominal cramps, headaches, nausea, vomiting and fever.

Figure 18: A collection of further newspaper articles, the publicity probably reflecting the fact that Eastwood Pool was a large and popular pool in an up-market part of Greater Glasgow.

Health bosses raise alarm after swimmers treated for sickness virus



HEALTH SCARE: Eastwood Leisure Centre pool has been closed due to contamination fears

Pictures: Lewis Segal

Bug scare shuts pool as five children fall ill

By Jonathan Paisley

A PUBLIC swimming pool was at the centre of a major health scare today after five young swimmers contracted the cryptosporidium bug.

Eastwood Leisure Centre's pool in Giffnock has been shut down amid fears it has been contaminated.

Health bosses raised the alarm after five children contracted cryptosporidiosis.

One needed hospital treatment after falling ill with the bug, which causes severe sickness, diarrhoea and stomach cramps and can be fatal in severe cases.

Up to 500 people use the pool each day and health bosses fear more cases will be confirmed over the next few days.

The pool was shut at 3.30pm yesterday after health chiefs traced the source of the bug.

But some parents were angry children were allowed to use the pool until then.

One mother said: "You would have to be worried if your kids had been in there. Why it wasn't shut and people warned earlier I don't know."

Outbreak control experts from East Renfrewshire Council, which operates the pool, and NHS Greater



TURNED AWAY: John LaCombre couldn't have swim lesson

Glasgow will carry out further tests on the water today and the pool will remain closed until at least Friday.

If the water tests positive for the bug, the pool will be shut for weeks as its drainage system will have to be sterilised.

Young children were still

using the pool as late as mid-afternoon yesterday but swimming lessons for around 130 schoolchildren had to be cancelled last night.

The closure is the latest problem to hit the pool.

In April two 12-year-old boys were injured when a panel

shattered, sending shards of glass down into the pool.

A virtually identical incident occurred last year.

And in March this year 100 people were evacuated after a light fitting went on fire.

Figures show more than 19,000 swimmers used the pool during August alone.

Bridie LaCombre, 35, from Clarkston, turned up at the pool last night with her six-year-old son John.

She said: "He had a swimming lesson but the staff have just told us what happened."

"They normally ring if a session is cancelled but this was clearly a last-minute thing."

A council spokesman said: "We took immediate action as soon as we were notified of the link."

"The tests will be carried out today and we hope to know the results on Friday."

A spokesman for NHS Greater Glasgow said: "The five cases were not serious and the patients are recovering. One was treated in hospital and the others by their GPs."

Last month four-year-old John Rowan, of Cambuslang, was one of 15 British holiday-makers to be diagnosed with cryptosporidiosis after using a contaminated swimming pool at a resort in Majorca.

Jonathan.paisley@
eveningtimes.co.uk

Figure 19: More newspaper coverage.

Crypto pool stays closed

by Laura Coventry

EASTWOOD Pool remains closed after tests concluded it is the "most likely" source of the cryptosporidiosis outbreak.

High levels of the dormant form of cryptosporidium were found by specialists in the water and filter of the pool

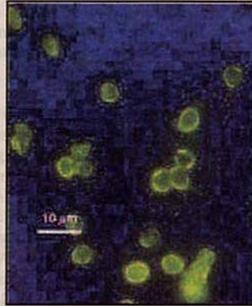
since its closure last Tuesday.

A spokesman from Greater Glasgow Health Board also said there was a further incidence of the disease: "Another case of confirmed Cryptosporidiosis has been found to have had a link to Eastwood Pool.

"This brings the total number of confirmed cases linked to the pool to seven."

A further three suspected cases, out of 19,000 swimmers last month, are being investigated.

Last week, the pool at the recreation centre in Eastwood Park was closed to the public as a "precautionary measure" after it was suspected of being



High levels of cryptosporidium were found to be present in Eastwood Pool.

linked to the bug, which infects the small intestine. Sufferers contract cryptosporidiosis by ingesting water which has

come into contact with human or animal faeces.

This week, fears became a reality.

A spokesman from East Renfrewshire Council — which operates the leisure centre — said: "So far tests on the small pool have been positive, but negative for the big pool.

"We need absolute negatives for three days running in both pools and our filtration system until we can reopen it."

"The pool is not the source. We suspect the water may have been polluted by a youngster who may have contracted the dormant form in a pool abroad.

He added: "We are being advised by a Scottish Water

consultant who was involved in a similar incident at Perth Pool and are doing everything we can to find out when the pool will be safe."

If swimmers have symptoms of cryptosporidiosis (diarrhoea, vomiting and stomach cramps) they are advised to "take no chances" and consult GPs as soon as possible.

Meanwhile, the contaminated pool remains closed for the foreseeable future as investigations continue.

It may have to be drained and its filtration system sterilised.

This, and other possibilities, will be discussed tomorrow (Friday), as the outbreak control team reconvenes to review the situation.

Figure 20: A newspaper clipping, claiming to quote an ERC spokesperson, that implies that the pool has been vindicated and a family exclusively implicated, suggesting that a breach of confidentiality for individuals attending the Outbreak Control Team meetings impacted on media representation of the event.

11. Appendices

- 11.1. Letter from SEHD civil servant to Chief Environmental Health Officers (EHOs) in Scotland warning them about the event and the need to check the pool filters over which they have some jurisdiction. It refers to an attached draft letter that could be used by EHOs to communicate with private pool operators.**
- 11.2. Letter from SEHD civil servant to Consultants in Public Health Medicine in Scotland warning them about the event and the need to be vigilant in the surveillance of swimming-pool related outbreaks.**
- 11.3. ERC newsletter announcing the opening of the refurbished Eastwood Pool including a reference to the '14 day rule'.**
- 11.4. The colourful poster designed to discourage pool and spa use by those who might be convalescing from gastrointestinal infection.**

Appendix 11.1

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Health Department
Public Health Division

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<http://www.scotland.gov.uk>

Letter to Chief Officers of Environmental Health

Your ref:

Our ref:

15 March 2004

Dear Colleague

CRYPTOSPORIDIOSIS OUTBREAKS LINKED TO SWIMMING POOLS

As you will be aware there have recently been several outbreaks of swimming-pool related cryptosporidiosis. These have occurred in various parts of Scotland and also in Majorca where large outbreak last summer was linked to swimming at the Alcudia Pool. With this in mind, I write to bring to your attention, a concern that some swimming pools in Scotland may be vulnerable to persistent contamination with the *Cryptosporidium* parasite.

Last summer and autumn saw confirmed cases of cryptosporidiosis in the UK reach an unprecedented high. A contributory factor may be that holiday makers returning to the UK following holidays abroad, and having contracted the infection, go on to contaminate their local swimming pool.

It is not, of course, possible to entirely prevent those carrying the *Cryptosporidium* oocyst from using Scottish pools. However, there are a number of measures which might be taken to reduce the chance of this, e.g. use of posters located in pool premises prohibiting diarrhoeal or convalescing¹ swimmers from using the pool. In addition, any incidents involving faecal contamination require to be recognised and dealt with by pool staff conversant with the appropriate measures to take.

It is critical that those operating swimming pools understand and adhere to existing guidelines² aimed at minimising the risk from any cryptosporidium that might be introduced into the pool.

The investigation of a cryptosporidiosis outbreak linked to a swimming pool in Scotland in Autumn 2003, pointed strongly to the state and operation of the pool filter being sub-optimal. Pool Water Treatment Advisory Group³ (PWTAG) guidelines² state that a filter should be closed down at least every 12 months and fully inspected every 6-12 months. The pool filters in question had apparently not been examined since the facility was refurbished in November 2000. Secondly, the presence of mollusc shells in the filter media was deemed inappropriate, likely to interfere with filtration and backwashing and, importantly, called into question the origin of the sand and whether it was indeed filter sand. Thirdly, on removal of the sand from one filter there was evidence to suggest that the supporting concrete floor of the filter had failed. This compromised the ability of the underdrains and nozzles to provide an even backwash flow. Finally, there were a number of other breaches of PWTAG guidelines that could account for persistently raised oocyst counts in the pool water and the outbreak during the months of August and September, 2003. The evidence strongly indicated a filtration system unable to cope effectively with *Cryptosporidium* oocysts.

The report of the outbreak control team is currently in draft form although final publication is anticipated shortly. However, as a precautionary measure it seems appropriate at this stage to offer advice based on what are likely to be

its principal findings.

My purpose in writing is thus to recommend to councils that they take steps to assure themselves that swimming pools over which they exercise jurisdiction (both public and privately owned) are adhering to PWTAG guidelines. All pool operators should begin by inspecting their pool filter(s) if this has not been done in the past year or following a refurbishment. The company which refurbished the Scottish pool where problems arose went into receivership in September 2003 but, prior to this, had refurbished or installed a number of swimming pool filters in Scotland. The fact that unsatisfactory work may have been carried out elsewhere cannot be discounted and other pools may experience similar problems.

The attached draft letter has been prepared which you may wish to use as a template when writing to privately owned pool operators.

Please feel free to contact me, should you wish to discuss the matter further.

Yours sincerely

George Morris

PROFESSOR GEORGE MORRIS
Scientific Policy Adviser
Scottish Executive Health Department

¹The PWTAG guideline suggests that individuals who have been suffering from infectious diarrhoea (of any cause) should not use public swimming pools for 14 days after their last diarrhoeal stool.

² The PWTAG guidelines are entitled *Swimming Pool Water – Treatment and Quality Standards* and were published as a soft cover book in 1999 (ISBN 0 951 7007 66) and updated on their website in 2001.

³ Pool Water Treatment Advisory Group (PWTAG) is a multi-disciplinary, multi-agency NGO that is sponsored by the Department of Health and that contains members from a number of agencies including private swimming pool consultants and the Health Protection Agency.

Appendix 11.2

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Health Department
Public Health Division

St Andrew's House
Regent Road
Edinburgh EH1 3DG

Letter to Consultants in Public Health Medicine

Telephone: 0131-244 3238
Fax: 0131-244 2030
George.morris@scotland.gsi.gov.uk
<http://www.scotland.gov.uk>

Your ref:
Our ref:

15 March 2004

Dear Colleague

CRYPTOSPORIDIOSIS OUTBREAKS LINKED TO SWIMMING POOLS

I attach for your information, a letter with enclosures which has been sent to Heads of the Environmental Health service in your area.

The letter recommends certain actions which are regarded as important to reduce risks of swimming pool related cryptosporidiosis. The decision to communicate this advice has been prompted by a recent outbreak linked to a swimming pool in Scotland.

Should you wish to discuss any aspect of this please do not hesitate to get in touch.

Yours sincerely

George Morris

PROFESSOR GEORGE MORRIS
Scientific Policy Adviser
Scottish Executive Health Department

Appendix 11.3



A message from Councillor Allan Steele



Welcome back to your local pool.

We're back in business after five months of hard work to ensure that everything is in tip-top condition.

Since we decided to close the pool in September, we've invested £137,000 in it.

The filters have had all of their 45 tonnes of sand replaced. The glass is back in the viewing gallery, plant has been overhauled, facilities improved, and everything has been given an early spring clean and thoroughly tested.

We believe that keeping the pool shut for longer than we had originally intended, to ensure that it

returns to use in sparkling condition, has been worth it, and we're sure you will agree.

I would like to thank you for your patience while we were closed and promise that we will do all we can to ensure that you enjoy your swims at Eastwood Pool, whether you are a returning customer, enjoying swimming lessons, or a new bather.

A handwritten signature in black ink that reads 'Allan C. Steele'.

Councillor Allan Steele JP
Convener
Community services

A special welcome from our staff



All of our staff are delighted to welcome you back to Eastwood Pool.

They've missed you during the closure and they've been working hard to make sure that everything is A1 for your return.

To them the sight of an empty pool is not what their job's all about. And it gets them down.

They're at their happiest when the pool's busy with plenty of swimmers.

Now they're looking forward to working with and for you to make sure that whether you're swimming, having swimming lessons, or just watching your children enjoying the pool, then they're there to make sure your visit is as enjoyable and safe as it possibly can be.

And their special message to you?

"Welcome back. We're delighted to see you!"

Public relations material issued by ERC to announce the reopening of a refurbished Eastwood Pool in January 2004.



Help us keep it clean

You'll see new notices in cubicles and around the pool.

Staff have worked hard to ensure that the pool and changing village are kept as clean as possible.

And the notices in the cubicles ask you to tell a member of staff immediately if you think that anything's needing cleaned.

Please do let them know at once and they'll be happy to help you.

You can also play your part in helping keep the pool water clean by keeping two simple rules.

These are:

- Always shower before you use the pool
- Do not under any circumstances swim in the pool if you have had diarrhoea within the last 14 days

Further information and advice

If you need assistance, further information or advice, please contact any member of staff or phone Eastwood Pool on

0141 577 4956

The back page of the newsletter describing the refurbishment and the appeal to users to play their part in keeping the pool free of contamination (the "14 day rule").

HAD THE TROTS IN THE PAST FORTNIGHT?



THEN DON'T USE THE POOL!

If you have had infectious or unexplained diarrhoea in the last 14 days, it is possible you could spread the germs that caused it by using a swimming pool or spa pool too soon. The Pool Water Treatment Advisory Group recommends that people don't use pools for 14 days after suffering diarrhoea."

NHS Greater Glasgow endorses this advice in the interests of public health.

For further information, consult a member of pool staff, your GP or NHS Greater Glasgow (0141 201 4917).



The poster distributed throughout Greater Glasgow pools after the outbreak in a campaign aimed at discouraging pool use in those convalescing from gastrointestinal infection.

12. Membership of the OCT

Core and full membership

Dr Helene Irvine, Consultant in Public Health Medicine, **GGNHSB** - Chairman
Mrs Anne Higgins, Environmental Services Manager, **ERC**
Mr Bill Arthur, Principal Environmental Health Officer, **ERC**
Mr Jim Blair, Manager, Public Health Unit, Environmental Protective Services, **GCC**
Professor Huw Smith, Parasitologist, **SPDL** (Scottish Parasite Diagnostic Laboratory)
Mrs Monica Maguire, Public Health Nurse, **GGNHSB**
Dawn Nelson, Communications Manager, **GGNHSB**
Dr Colin Ramsay, Consultant Epidemiologist, **SCIEH**
Mr Paul Hampton, Senior Scientist, **Scottish Water**
Mr Ejaz Rasool, Senior Scientist, **Scottish Water**
Mr Fraser Reid, Senior Scientist, **Scottish Water**
Linda Collins, Minute taker, **GGNHSB**
Tracey Curtis, Minute taker, **GGNHSB**

In attendance

Mr Paul Martin, Recreation Officer, **ERC**
Mr Ian Smith, DSO Leisure Manager, **ERC**
Mr Hugh Dougherty, Public Relations Manager, **ERC**
Mr David Richmond, Consultant adviser to ERC, **Richmond and Associates, Water Treatment Consultants.**

13. References

¹ Pool Water Treatment Advisory Group (1999). *Swimming Pool Water: Treatment and Quality Standards*. Micropress Printers Limited. www.pwtag.org.

² Department of the Environment, Trade and the Regions and Department of Health (1998). *Cryptosporidium in water supplies: Third Report of the Group of Experts. 'The Bouchier Report'*. London:HMSO.

³ American Public Health Association. *Control of Communicable Diseases Manual*. 18th edition. Editor: D.L. Heyman 2004.

⁴ Department of Health. 1999. *CMO's Update*.

⁵ Barr and Wray Limited. Eastwood Recreation Centre Outbreak of Cryptosporidiosis: Report on the Plant Inspection and Remedial Works Associated with the Water Filtration and Treatment Plant. October 2004. www.barrandwray.com.

⁶ East Renfrewshire Council Property and Technical Services. Eastwood Leisure Centre Report on Filter Vessels: A report prepared by Filtec Water Services. ERC, November 2003.

⁷ British Standards Institute. Management of public swimming pools – Water treatment systems, water treatment plant and heating and ventilation systems – Code of Practice. PAS 39:2003, 2 December 2003.

⁸ Chappell CL, Okhuysen PC, Sterling CR, Wang C, Jakubowski W, Dupont HL. Infectivity of *Cryptosporidium parvum* in healthy adults with pre-existing anti-*C. parvum* serum immunoglobulin G. *Am J Trop Med Hyg*. 1999 Jan;60(1):157-64.

⁹ Scottish Parasite Diagnostic Laboratory. Laboratory Report of the findings of the molecular identification of the *Cryptosporidium* found in faecal and water specimens provided by district general hospital laboratories and public health investigators following an outbreak linked to the Eastwood swimming pool, September 2003.