CREH

CENTRE FOR RESEARCH INTO ENVIRONMENT AND HEALTH

Report on the Incidence of *Cryptosporidium* in Private Water Supplies

A Report to the Drinking Water Inspectorate

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February 2001

Final Report

REPORT ON THE INCIDENCE OF *CRYPTOSPORIDIUM*

IN PRIVATE WATER SUPPLIES

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For

THE DRINKING WATER INSPECTORATE IN

RESPECT OF CONTRACT REFERENCE DWI/70/2/129

February 2001

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1. ACKNOWLEDGEMENTS

CREH *Analytical* Limited wishes to thank the following people without whose help this project would not have been possible.

The Drinking Water Inspectorate for providing the funding for the project and for Dr David Drury for help and advice both before and during the project. Dr Catherine Benton for help and guidance for the Scottish sites, Dr Lorna Fewtrell, Mr Alan Godfree, Mr Huw Morgan, Dr Gary O'Neill, Dr Colin Ramsey, Mr David Sartory, Dr Mark Wyer, Dr Peter Wyn-Jones who formed the project management group and Mr David Clapham of Bradford Environmental Health for helping with site selection. We would also like to thank Mr Randall Scott of the Department of the Environment, Northern Ireland.

Our thanks go to Carol Francis, Diane Corscadden, Lenka Rushby and Hannah Boynton for laboratory help at CREH *Analytical*, Robert Walker, Andrea Miller, Cathy Jardine, Deborah Boam, Sheila Murdoch, Caroline Davidson, Ken Punter and Scott Lambie at West of Scotland Water, Alan Williams, Andy Keen, Sharon Butler and Alex Lawson at PHLS Swansea, Doug Wilson, Claire Newbury-Barlow, Shirley Turner and Marlyn Ford from Somerset Scientific Services.

Our thanks also go to the sampling groups at each site. These include Mr Peter Weegram at Richmondshire Environmental Health, Tony Keates at Melmerby, Jason Mayhew, Roy Stevens, Ron Chittenden, Sam Taylor, Keith James, Kristian James, Joseph Palmer, Thomas Price, Andy Pritchard, Phil Govier, Huw Morgan, Carl Hobbs, Simon Clark and Jenni Aazem at Swansea Environmental Health, Roy Hunter, Eleanor Campbell, Stephen Eccles and Allan Harron at West of Scotland Water and Sharon McQuillan, Trevor Steward, Pauline Herbison and Amber Holmes at Antrim Borough Council, Antrim.

We would also like to thank the owners of the sites for permission to use the sites for the sampling programme. In particular we would like to mention Mr T. Keates, Mr C. Colhoun, Mr Reinsford-Hanney, Mr McMyn, Mr A. F. Richards and Mr P. Davies for kind permission for the use of their water supplies in this survey.

Finally our thanks go to the Public Health Laboratories at Colindale and Sheffield, and in particular Dr Gordon Nichols and Dr Jennifer Frost for typing the *Campylobacter* and Dr Peter Chapman for typing the *E. coli* O157:H7.

2. EXECUTIVE SUMMARY

Seven private waters sites within the United Kingdom were identified as suitable for monitoring. Two of the sites were in Wales, two in Scotland, two in England and one in Northern Ireland. Each site was monitored daily for six weeks on two occasions. The first occasion was in May and June of 2000 and the second was in October and November of 2000.

Samples were taken daily in each period for coliforms, *Escherichia coli*, enterococci, presumptive *Clostridium perfringens* and *Campylobacter*. Additional samples were taken for *E. coli* O157:H7 where water quality data suggested it might be present. A *Cryptosporidium* monitoring cabinet was installed at each site. Daily samples of 1000 litres were taken and processed for *Cryptosporidium* and *Giardia*. Five local laboratories were used to process bacteriological samples and parasitology samples were processed at one laboratory.

Samples were taken at each site for chemistry during the second phase. Additional samples were also taken at four sites for raw water analysis. Samples were taken at two sites for viruses. The findings of the virology samples will be the subject of a second report.

Site 1 was located in the South West of England. The bacteriological quality of the water was excellent. None of the samples taken during phase 1 failed bacteriologically. One parasite sample contained one *Cryptosporidium* oocyst and one sample contained one *Giardia* in phase 1. All phase 2 samples were negative. A filter left in the sampling equipment over the summer months contained one *Giardia* cyst. The volume sampled was in excess of 117,000 litres.

Site 2 was located in Scotland. Sixty five percent of the bacteriological samples failed for coliforms and *E. coli* during phase 1, 25.5% for enterococci and 51% for clostridia. During phase 2, 47% of samples failed for coliforms and *E.* coli, 14.3% failed for enterococci and 16.6% failed for clostridia. None of the samples contained *Campylobacter* and *E. coli* O157. Seventy five percent of samples contained *Cryptosporidium* and 60% contained *Giardia* in phase 1 and 50% of samples contained *Cryptosporidium* and 42.5% contained *Giardia* in phase 2.

Site 3 was in South Wales. None of the bacteriological samples failed in phase 1 and only one sample contained clostridium in phase 2. One sample was positive for *Cryptosporidium* and one for *Giardia* in phase 1. In contrast, 56.6% of the parasitology samples taken in phase 2 were positive for *Cryptosporidium* and 50% for *Giardia.*

Site 4 was in Northern Ireland. Two samples (4.8%) contained coliforms in phase 1. Seven percent of the phase 2 samples contained enterococci and 76.6% contained clostridia. Parasites were absent from all the samples taken in phase 1 but 2.4% of samples in phase 2 were positive for *Cryptosporidium* and 12.1% were positive for *Giardia.*

Site 5 was in Scotland. Ninety three percent of the phase 1 samples contained coliforms, 90.6% contained *E. coli,* 51.2% contained enterococci and 9.3% contained

clostridia. In phase 2, coliforms and *E. coli* were present in all the samples, enterococci in 69.7% and clostridia in 14%. Two samples were positive for *Campylobacter* in phase 1 and two samples in phase 2. *Escherichia coli* O157 was not detected. For *Cryptosporidium,* 33.3% of the samples were positive for phase 1 and 15.4% positive for *Giardia.* In phase 2, 56% of samples were positive for *Cryptosporidium* and 65.9% were positive for *Giardia.*

Site 6 was in South Wales. Only one sample was positive for coliforms in phase 1 and all the parasitology samples were negative. In contrast, 92.8% of samples were positive for coliforms in phase 2, 64.3% were positive for *E. coli*, 38% for enterococci and 54.8% for clostridia. Ten percent of the samples were positive for *Cryptosporidium* in phase 2 and 29% for *Giardia.*

Site 7 was located in Yorkshire. Here, 83.3% of samples were positive for coliforms in phase 1, 71.4% for *E. coli,* 47.6% for enterococci and 90.5% for clostridia. *Campylobacter* was isolated from 6 samples in phase 1 and *E. coli* O157:H7 was detected in one sample. This isolate was subsequently shown to be toxigenic. In phase 2, 27.3% of samples were positive for coliforms, 26.1% contained *E. coli*, 6.8% contained enterococci and 61.4% contained clostridia. One further sample contained *Arcobacter butzleri.* For parasitology, 52.2% of samples contained *Cryptosporidium,* and 57.7% of samples contained *Giardia* in phase 1 and 91% of samples contained *Cryptosporidium* and 84.4% of samples contained *Giardia*. Filtration and electro-chlorination was introduced between phase 1 and phase 2 at this site.

A brief literature review recognises that the majority of waterborne outbreaks are caused by *Campylobacter, E. coli* O157:H7, and *Cryptosporidium*. Outbreaks have occurred after heavy rainfall. Association with animal contamination such as carcasses, slurry and direct faecal contamination are amongst the main risk factors.

During both phase 1 and phase 2 there were periods of heavy rainfall. Phase 2 ended as the serious flood problems began in the United Kingdom. Water quality was affected at four of the sites during heavy rainfall. This is reflected in a dramatic increase in indicators, particularly coliforms and *E. coli* and mirrored by the presence of *Campylobacter* and increased concentrations of parasites. At site 2, indicator and parasite concentrations are higher in phase 1 than phase 2 whilst the reverse is true for sites 3, 5, 6 and 7.

At sites 4 and 7, in phase 2, where disinfection was installed, clostridia were the best indicators of faecal contamination. In the absence of disinfection, coliforms and *E. coli* were the best indicators. At site 5, clostridia were of no value in assessing faecal contamination as they were absent from samples in both phase 1 and phase 2.

Extreme hydrological events can result in raw water containing high levels of micro-organisms and turbidity. It is clear from the survey at site 7 that treatment and disinfection may not be adequate to protect water quality during extreme weather conditions. It is also clear that treated water quality is most likely to be compromised during these events. Low frequency sampling programmes will not detect such dramatic changes in water quality unless sampling is targeted at heavy rainfall events.

Sites which have proper sanitary surveys and a well protected and treated water supply have no microbiological problems. Sites in rural areas where there is no control over source water quality, water treatment is absent and there is low frequency monitoring, will have periods of high microbiological contamination.

A novel small-scale retrospective examination of laboratory confirmed cases of *Campylobacter, Cryptosporidium* and *Giardia* infections in relation to living at a location served by a private supply suggests that there may be an elevation of campylobacteriosis and cryptosporidiosis in this group in comparison to the total population. A prospective epidemiological study is suggested as the only way to adequately characterise the likely burden of disease relating to private supplies.

3. OBJECTIVES OF THE RESEARCH

CREH *Analytical* were asked to identify a number of private water supply sites across England, Wales, Scotland and Northern Ireland. The sites were chosen to reflect different water types, with or without water treatment. The sites were to be tested in two phases. Phase 1 was required to represent spring weather conditions and phase 2 to reflect late summer weather conditions. Both phases were required to last for six weeks with daily monitoring for coliforms, *E. coli*, enterococci, clostridia and *Campylobacter*. Samples for *E. coli* 0157:H7 were taken and analysed if the bacteriological quality of the supply was poor and indicated that it might be present. *Cryptosporidium* and *Giardia* were also included and these were monitored continuously during each phase. This was done using Regulatory monitoring cabinets located at each site. Local Environmental Health Officers were asked to undertake sampling and the transport of samples to laboratories. Local laboratories were contracted to perform the bacteriological analysis and samples for *Cryptosporidium* and *Giardia* were posted back to CREH *Analytical*. Sample cabinets were manufactured and installed by Hydraulics Modelling Limited. Genera Filta-Max™ filters were used for the parasite sampling. Filters were pressure tested to greater than 5 bar for 16 minutes before being posted to site. Evidence bags were used for the transport of samples. Data collected from the sample sites included sample volume, sample headloss, sample time and weather conditions. Some of this data has been included in Section 8.

Each site was surveyed by a visit prior to the installation of the sampling cabinets. The site reports are given in Section 4.

4. SELECTED SITES FOR THE PROJECT

4.1 Supply Descriptions

The water supplies in the programme are located in England, Scotland, Wales and Northern Ireland. Supplies have been chosen to maximise the range of supply types covered by this monitoring programme. There is a combination of treated and untreated supplies, supplies from springs, open streams, resurgent streams from karst groundwater systems, and boreholes. The sources supply a diverse range of consumers including a large holiday camp, 2 caravan parks, a small rural hamlet with a dairy farm, a hospital, a five star hotel and a second farm. The supplies are grouped on the basis of their location. There are two supplies in both Wales and Scotland; the supplies in each of these countries are near to each other and, thus, have similar logistical arrangements for sampling. The English supplies are at opposite ends of the country, Somerset and North Yorkshire, respectively. There is one supply in Northern Ireland.

The identity of each site location has been hidden in accordance with the wishes of the site owners.

4.1.1 Site 1

Site 1 is a large holiday resort on the North West Somerset coast of the Bristol Channel. The resort is placed amongst beautiful countryside, the Quantock Hills are to the east, Dunster Castle is to the south and the attractive sea-side town of Minehead itself is to the West. Recent works have been carried-out to improve the sea defences and import sand to improve the beach at Minehead. The resort has also made major investments employing the builders of the Millenium Dome to create an all-weather resource for guests and, hence, extend the working season. Site 1 has the capacity for 10,000 sleeping guests, and additional 2000 day visitors, and facilities to cater for 3000 diners at one sitting. The provision of adequate potable water is, therefore, of vital importance to the business. The resort water supply is pumped from 6 boreholes on site. The resort was established in the late nineteen-forties and was previously a military establishment. The boreholes and original supply system may date back to that period. The surrounding area is a combination of drained marshland set to crops or grazed mainly by sheep. Wild fowl such as Canada Geese are present in large numbers around the site. The water has high electrical conductivity (around 700μS) and nitrate concentration (22 mg/1). The high conductivity is not surprisingly given the proximity to the Bristol Channel and the nitrate concentration reflects the use of inorganic fertilisers in a wetland area. Wastewater from the site is pumped east to Wessex Water's Minehead waste water treatment works.

Typical water consumption on the site is 2Ml/d. Water is pumped from the boreholes to a covered holding reservoir prior to treatment. A solution of 14/15% sodium hypochlorite is injected into the distribution pipework. Since there is no contact tank disinfection takes place within the distribution pipework. The water treatment facility and boreholes are located at the south-

east margin of the site adjacent to drained farmland. The facility is restricted access with a screened perimeter fence. The pumps are housed in a small concrete garage and the chlorination equipment is in a brick hut next to this. There is a sampling point 15 metres down the line from the injection point. This was seen as an ideal secure location with ample room and power for a *Cryptosporidium* monitoring unit. The operating pressure of the system is 3 Bar.

Routine sampling detected a coliform failure in August 1999. An *E. coli* count of 3 cfu/100ml was repeated once in follow-up sampling. This prompted a full inquiry and upgrade of the treatment system.

4.1.2 Site 2

Site 2 is an estate in Scotland running a holiday park with 211 static caravans. The estate is situated on the shores of Fleet Bay leading out in to the Solway Firth. The site uses from 10 to 50 cubic metres of water a day, and up to 70 during peak holiday periods. The water supply is stream-fed with the catchment in lightly grazed upland moor above the estate. The water is taken-off above the more intensely grazed farmland and piped to a filter bed and holding tank. The filters are two grades of gravel. The tank holds approximately 75 cubic metres. The system is cleaned down and treated with hypochlorite bleach every two years. A supplementary borehole supply capable of delivering 50 cubic metres a day is located near the tank and filter house. This additional supply might be used during turbid runoff events in the stream or following prolonged dry spells when the stream flow is inadequate. The owner has been requested to record periods when the borehole supply is used. The borehole supply is switched in to the filter bed line in place of the stream supply.

The system includes UV treatment. Water arriving from the holding tank at 4 Bar passes through the UV tubes and on into the distribution system. The *Cryptosporidium* monitoring unit was installed in the building used for UV treatment. There was a 240 volt supply and adequate points for connection in to the water supply. Water from the monitoring unit was run to waste. The site provides sheltered and secure housing and is located in a quiet part of the estate.

The geology at site 2 is Llandovery sedimentary mudstones.

4.1.3 Site 3

Site 3 comprises an exclusive five star hotel and restaurant located near the centre of the Gower Peninsula. The hotel has 2 overnighting owners plus sleeping accommodation for 16 and further capacity to serve up to 60 guests in the restaurant. The hotel water supply is gravity fed from a private reservoir. The reservoir catchment is open scrub heathland with sheep and pony grazing (see Figure 4.7).

The water is treated by Penstar UV units followed by sand filtration and iron and manganese removal. There are two units, the first is housed in the owners' accommodation and was not suitable for the programme due to a lack of space.

The main unit is housed externally in a small wooden box in the courtyard to the rear of the hotel adjacent to and on the right hand side of the central wall. The supply feeds directly into the kitchens. There was adequate space to the left of the wooden box for wall mounting of the monitoring unit at ground level. A spare power point was available within the box. The location was sheltered, the hotel was in a remote rural area and the exclusive nature of the enterprise and presence of staff suggested that the unit was secure. The suggested installation required cutting in to the outgoing supply pipe where it lead off to the kitchen. The unit was fitted in-line to minimise waste. This gave a limitation in that the unit did not run for 24 hours but did sample the water that is used by the hotel. The owners have no data on the pressure of the supply or of their consumption rate.

The treatment system was fitted at the insistence of the Swansea Environmental Health Water Pollution Division following repeated faecal coliform counts in excess of 10 cfu/100ml. The treatment system has not produced a failure since this time. New filter units are fitted every 6 months.

The geology of the area is old Devonian sandstone which offers good water filtration.

4.1.4 Site 4

Site 4 is a psychiatric hospital with approximately 300 patients and 100 staff. The hospital water supply is gravity fed from an open reservoir on higher ground in the countryside (Figure 4.8). The reservoir water is derived mainly from underground springs but there is also the possibility of surface water gaining access. The surrounding fields are grassland with cattle and sheep grazing. There is also the possibility of some surface water getting into the reservoir. The reservoir is home to a small number of swans, mallards and coots.

The water is treated by sand filtration in a small brick building followed by chlorination and holding in a covered reservoir. The two sand filters are washed daily. There was ample room and power in the building for a *Cryptosporidium* monitoring unit, a ready supply of filtered non-chlorinated water and a power supply. The unit was contained within a locked building and therefore secure. There was no facility for sampling the chlorinated water other than dipping a well connected to the outside reservoir. The treated water was sampled at the hospital.

On one occasion when chlorination was reduced because of excessive trihalomethanes in the water, coliforms and faecal coliforms were found in the treated water. The water is reasonably clean and no problems were anticipated with Genera filters blocking.

4.1.5 Site 5

Site 5 is a farm in Scotland with two houses, two farm cottages and 3 caravans. The dairy herd was sold before the project started and the farm now rears mainly sheep. The water supply is spring fed in fields above the farm. The water is filtered by percolation through the soil and into field drains that feed a 6 cubic metre holding tank. There is no active treatment on this supply. Although the field drains were fenced off (Figure 4.11), animals could still gain access. Some algal growth was noted in the field drains and where they passed under a main road, there was no cover. The field surrounding the spring is grazed by sheep until late April, when the animals are removed and the sward allowed to grow for silage. Current water usage is around 4-5 cubic metres per day.

There was a suitable sampling point in the milk-house. The tap used for the wash-down hose was connected into the monitoring unit. Waste from the monitoring unit was fed back into the large black HDPE tank in the top corner of the building. There was electrical power and the site provided sheltered and secure housing and was located in a quiet rural area. There was no data on the pressure of the supply.

4.1.6 Site 6

Site 6 is a caravan park and is a popular holiday base for exploring the Gower Peninsula. The park has no permanent caravan residents but has 200 static units and pitches for a further 120 touring caravans. The park water supply is pumped from a borehole on site. The borehole was sunk in 1998. The surrounding area is grassland with cattle and sheep grazing, as well as open heathland with sheep grazing. All waste water from the site is drained to a treatment plant on-site at the lower end of the site.

The water is treated by ozonation followed by sand filtration and iron and manganese removal. The equipment is housed in a small concrete garage. The treated water is held in two plastic tanks. There was ample room and power in the building for a *Cryptosporidium* monitoring unit. The unit was contained within the concrete building and therefore secure. There was a sample tap located between the treatment plant and holding tanks, to the left of the entrance. The monitoring unit was located beneath the power box on the far wall of the building. Post-filtration water was drained to the holding tanks. The system delivers water to site at 7-8 Bar and can deliver up to 2000 1/sec.

The disinfection system has been found to function erratically. This is due to the plastic ozone-delivery nozzle which suffers from rapid erosion. No positive faecal coliform counts have been recorded, however, the bacteria counts (cfu/ml at 22°C) have frequently been in excess of 50 and are always greater in the holding tanks than in immediate post-treatment water. Due to these teething problems, the system had not yet been used to supply the site. A full overhaul was carried out mid-March and the system was up and running for the sampling periods. The geology here is old Devonian sandstone.

4.1.7 Site 7

Site 7 is a small hamlet of 24 properties in North Yorkshire. There are two large dairy herds, approximately 5 bed and breakfast establishments. The village water supply is gravity fed from a resurgent underground stream from a karst groundwater system. The natural amphitheatre above the resurgence contains the old village rubbish tip and houses an extensive rabbit warren. The wider catchment also contains a number of swallow holes and shake holes (Figure 4.19). The immediate area is grazed by rabbits and there is faecal matter scattered around the area. The wider catchment is upland moorland with grouse butts and is subject to heather burning. The landfill has been found to be free of methane gas production.

The water supply currently holds a boiling notice issued by Richmondshire Environmentanl Health following an occurrence of *Campylobacter* at one of the dairy farms. The supply is currently untreated and will remain so throughout the initial sampling period. By the second sampling period treatment by electro-chlorination using common salt will have been installed. The location therefore offers the interesting potential for a before and after investigation. Siting of the *Cryptosporidium* monitor unit has been arranged at the Old Moor Inn, now a private dwelling, where the owner Tony Keats, a retired microbiologist has agreed to the installation of equipment. This will be an outdoor location in a quiet rural location where security is not an issue. The unit will be within the property's grounds. The location is against a wall in the right-hand corner of the yard, connecting in to a drinking trough pipe. A 25m cable with 6m protector was necessary to reach the supply in one of the owners outbuildings.

During the sampling period in phase 1, there was a period of prolonged heavy rain which caused substantial flooding in the area (Figures 4.22 – 4.24). These photographs were taken at the peak of the flooding by Tony Keats and we have his permission to reproduce them here.

Figures Illustrating the Sites

Figure 4.1 Site 2: borehole supply at site 2.

Figure 4.2 Site 2: filter bed and holding tanks in secure building.

Figure 4.3 Site 2: pipework.

Figure 4.4 Site 3: well.

Figure 4.5 Site 3: land around the well head.

Figure 4.6 Site 3: the moorland surrounding the well head.

Figure 4.7 Site 3: wider view of the site showing grazing animals.

Figure 4.8 Site 4: upland area and reservoir.

Figure 4.9 Site 4: surrounding countryside.

Figure 4.10 Site 5: farm supply.

Figure 4.11 Site 5: showing fenced field drains.

Figure 4.12 Site 5: showing uncovered drains close to a main road.

Figure 4.13 Site 6: caravan park.

Figure 4.14 Site 6: bore hole at the rear of main reception.

Figure 4.15 Site 6: wider location.

Figure 4.16 Site 6: proximity of grazing animals.

Figure 4.17 Site 7: small rural hamlet.

Figure 4.18 Site 7: upland location site of resurgence.

Figure 4.19 Site 7: upland collecting grounds shallow lake and grazing animals.

Figure 4.20 Site 7: collecting pipe.

Figure 4.21 Site 7: distribution pipes.

Figure 4.22 Site 7: following heavy rainfall 04 June 2000.

Figure 4.23 Site 7 following heavy rainfall 04 June 2000.

Figure 4.24 Site 7 following heavy rainfall 04 June 2000.

5. LABORATORIES PARTICIPATING IN THE PROJECT

Five laboratories took part in the project. These were local to the sample sites to ensure that samples were analysed within six hours of taking. Each laboratory was supplied with the microbiological methods (Appendix C) and sufficient sterile sample bottles (Aurora Scientific) for the project. *Cryptosporidium* filters were pressure tested by CREH *Analytical* and then supplied to the laboratories and the used filters were returned by post. Each laboratory was asked to be in an external quality assurance scheme during the project and to undertake daily quality control during the sampling period.

5.1 CREH *Analytical*

Bacteriological samples from site 7 were transported daily to CREH *Analytical*. The laboratory was established in January of 1999 at Hoyland House by John Watkins (Technical Director) and Carol Francis (Senior Microbiologist). The laboratory has DWI approval for the Regulatory analysis of *Cryptosporidium* from drinking water supplies. It also runs a quality system based on that of the United Kingdom Accreditation Service (UKAS). The laboratory used 'lenticules' for daily control of the indicator analysis and Cultiloops (Oxoid) as the internal quality control for *Campylobacter*. The Laboratory External Analytical Proficiency Scheme (LEAP) was used as the external microbiological quality assurance and *Cryptosporidium* analysis.

5.2 Somerset Scientific Services

No data provided.

5.3 West of Scotland Water Laboratory

Bacteriological samples were transported to West of Scotland Water on a daily basis from both Scottish sites. The Laboratory was established in July 1994, with three staff members, Robert Walker, Andrea Miller and Jayne Wilson. In 1996 the laboratory became integrated with Strathclyde Water/Sewage laboratories. First accredited by UKAS in 1997 for routine indicator organisms, this has been maintained since. The laboratory has participated in the Public Health Laboratory Service EQA Routine Indicators Scheme since 1994 and Microcheck since 1995.

5.4 Carmarthen Public Health Laboratory

The laboratory was established in 1949, and now employs a staff of seventeen. Accredited by C.P.A since 1995 for clinical microbiology testing, the laboratory is also UKAS accredited for a wide range of water and food microbiology. Bacteriological samples from site 3 and site 6 were transported to the laboratory on a daily basis. The laboratory participates in the Public Health Laboratory Service EQA Routine Indicators Scheme.

5.5 Beechwood Laboratories

Beechwood Laboratories was established in April 1984 and was founded by Dr Alan Gardner, formally Chief Technical Officer of the Ulster Curers Association. The laboratories became one of the first independent laboratories in Northern Ireland and was granted UKAS accreditation in 1996 for a wide range of water and food microbiology. Bacteriological samples from site 4 were transported to the laboratory on a daily basis.

6. INSTALLATION OF SAMPLING EQUIPMENT

Site surveys (See Section 4) were conducted once the project was awarded to CREH *Analytical*. This was to establish the location for the installation of the *Cryptosporidium* monitoring cabinets and to ensure that a suitable supply of water and power was available. The cabinets were made by Hydraulics Modelling Limited to a design similar to that used for the Regulatory monitoring of drinking waters. Site survey data was passed to Hydraulics Modelling who undertook the programme of installation as outlined below:-

10:00	Wednesday	19.4.00	Site 3.
11:00	Wednesday	19.4.00	Site 6.
14:00	Thursday	20.4.00	Site 7.
14:00	Friday	21.4.00	Assessment visit en-route ferry.
15:30	Friday	21.4.00	Assessment visit en-route ferry.
10:00	Saturday	22.4.00	Site 4.
10:30	Sunday	23.4.00	Site 2.
14:30	Sunday	23.4.00	Site 5.
11:30	Friday	28.4.00	Site 1.

Samplers were also given the timetable and trained in the recording of data and the changing of *Cryptosporidium* filters during the installation period.

7. SAMPLING SCHEDULE AND SPECIFIC RESPONSIBILITIES

Sampling was due to commence on 01 April 2000, however, due to delays, the first start date for sampling was 08 May 2000 and sampling finished on 25 June 2000. The second sampling period was delayed with the agreement of the DWI until it was felt that heavy autumnal rainfall was imminent. This was done to avoid six weeks of dry weather from 01 August 2000. The second sampling period started 17 September and finished on the 05 November 2000. The end of the second sampling period corresponded with a period of prolonged and heavy rainfall that culminated in the widespread flooding during the second and third weeks of November.

The specific responsibilities and day-to-day logistics for each site over the two sampling periods are summarised below.

7.1 England

Site 1: Sampling and filter changes at site 1 were undertaken by the site engineer. Samples were taken at 09:00am every day and stored in a cool-box prior to collection at 09:30am by the Securicor Omega courier service. The courier delivered the samples for analysis and filters for posting to the Taunton laboratory. Filter cartridges were posted on Mondays to Fridays to the CREH laboratory in Leeds. Weekend filters were stored at the laboratory in Taunton at 4°C.

Site 7: Samples at Site 7 were taken by Peter Weegram of Richmondshire Environmental Health, or his deputy at 09:00am every day. Weekend samples were taken by Tony Keates. Securicor Omega couriers collected the samples and filter cartridges every day and delivered them to the CREH laboratory in Leeds.

7.2 Scotland

Samples from both the Site 2 and Site 5 were taken by the staff of West of Scotland Water (WoSW), co-ordinated by their chief sampler Roy Hunter. Samples were taken at 09:00am and 10:00am every day and driven back to the laboratory with the filters. WoSW sent filters on Mondays to Fridays to the CREH laboratory in Leeds. Weekend filters were stored at the laboratory at 4°C.

7.3 Wales

Samples from both Site 3 and Site 6 were taken by Sam Taylor at 09:00am and 10:00am every day and driven by her to Carmarthen Public Health Laboratory for analysis. Sam Taylor sent filters on Mondays to Fridays to the CREH laboratory in Leeds. Weekend filter storage was arranged by Sam Taylor.

7.4 Northern Ireland

Samples from Site 4 were taken by Sharon McQuillan at 09:00am every day and driven by her to Beechwood Laboratories for analysis. Filters were posted

on Mondays to Fridays to the CREH laboratory in Leeds. Weekend filters were stored at 4°C.

General notes: Cool-boxes were provided for courier transfers at Melmerby and Minehead. Weekend filters were stored at 4°C and posted to CREH at the beginning of the next working week. Samplers recorded dates, times, flow volumes, pressures and antecedent weather conditions for their site each day on the log-sheets provided.

All sampling personnel were familiar with aseptic sampling procedures as set out in Report 71 except for Jason Mayhew. Mr Mayhew received training from a member of CREH staff reinforced by Geoff O'Brian of West Somerset District Council. Tony Keats is a trained and time-served microbiologist. He received additional training from Peter Weegram for weekend samples. Samplers were provided with short-form instructions, these included contact addresses. Sample record sheets, address labels and bottle labels were also provided.

A full report on the site surveys was produced by Jeremy Wilkinson of CREH. The report included a full list of names and contact numbers. Jeremy Wilkinson also produced sample bottle labels.

For phase 2, each sample site was asked to take a 100ml sample of the treated water for chemical analysis. This was posted from each site with the *Cryptosporidium* filter. The samples were stored at 2-8°C and collected at regular intervals by Professor Adrian McDonald of the University of Leeds, Department of Geography. The samples were analysed at the University of Leeds, Earth and Environment Faculty laboratories. The laboratories operate normal quality control procedures incorporating standards, blanks and appropriate sample replication and duplicates. The majority of the phase 2 samples for chemical analysis were collected specifically for that purpose, thus much reducing the spurious phosphate results which were associated with the pre-dosed bottles used to maintain sterility as samples for phase 1 used residual waters not required for microbiological analysis.

Following the pilot analysis of private supply chemistry in phase 1 of the study, it was recognised that an opportunity existed to add considerable value to the project through the comprehensive chemical analysis of the full sample set in phase 2. This analysis would allow the exploration of possible relationships between the microbiology and the more readily analysed and automated chemistry.

Samples were also taken for virology at two sites. These samples are being analysed by Dr Peter Wyn-Jones at the University of Sunderland. Given the time taken to complete this analysis, the data generated will be the subject of a separate report.

8. DISCUSSION

Private water supplies provide approximately 1% of the population with drinking water in the United Kingdom. They are controlled under the Private Water Supply Regulations, 1991, which were made under the Water Industry Act 1991. Local authorities were required to identify all private water supplies within their area and to classify them. Classification is based on whether the water is used for domestic purposes (Category 1) or for commercial purposes such as food and drink manufacturers or properties with regularly changing populations, e.g., hospitals (Category 2). Further classification is based on the population served or the daily volume of the supply. Category 1 supplies have six classes designated A to F and category 2 supplies have five classes designated 1 to 5.

Water quality is assessed in accordance with the Drinking Water Supply Regulations which are taken from the EC Drinking Water Directive. There have been a number of studies which have examined the microbiological quality of private waters. Humphries and Cruikshank (1985), in a small-scale study in Devon, examined 55 rural supplies for total and faecal coliforms and total viable count at 22^{o}C and 37^{o}C**.** The sources included streams and surface waters, boreholes, wells and springs. Only 9 sources were found to be within EC recommended limits on all occasions. The failure for faecal coliforms was 62%. The authors suggest that yearly sampling was inadequate.

In a more recent study, Fewtrell and Kay, (1996), examined 91 private water supplies in 10 local authority areas at a frequency of twice per week. The period of sampling extended to 6 weeks and 1100 samples were taken and analysed for coliforms, faecal coliforms and enterococci. Almost 50% of the supplies failed to meet the standard on at least one occasion, with total coliforms the most common reason for failure (15%) followed by enterococci (12.7%) and faecal coliforms (9%).

Clapham (1997) undertook an intensive monitoring programme of 15 private water supplies in North Yorkshire. Tests were conducted for coliforms, *E. coli*, enterococci, clostridia, *Cryptosporidium* and *Giardia*. The survey found evidence of faecal contamination in 98.6% of the samples tested. Nine of the 15 supplies were found to contain *Cryptosporidium* and eight of the nine supplies were positive for *Giardia*. In a more recent study, Rutter *et al*., (2000) also examined private water supplies and found a similar picture. A total of 6551 samples from 2911 supplied were examined as part of the Public Health Laboratory Service routine analysis of private water supply samples over a two year period. Total coliforms, including *E. coli* were detected in 27% of samples from 42% of supplies on at least one occasion. The percentage of samples positive for *E. coli* was highest in summer and autumn and lowest in winter.

The survey by Clapham, (1997) was conducted on the basis that the supplies were identified in the first instance as having poor bacteriological quality and were sampled during or immediately after heavy rainfall. In this particular study, there is no conclusion about the effect of rainfall. Other studies have demonstrated an association between *Cryptosporidium* and rainfall. Petrie *et al.,* (1994), examined the bacteriological and chemical quality of four springs over 12 months. The bacteriological quality was found to be influenced by rainfall with counts increasing

after heavy rain and all the sites being free of faecal contamination during dry periods. A 'lag' time was also noted between rainfall and appearance of contamination in some springs. Watkins *et al.,* (1995) found that numbers of *Cryptosporidium* in an upland raw water catchment increased significantly during heavy rain and decreased again rapidly after rain. The same catchment water supply system had been involved in an outbreak in 1992, affecting 125 people (Atherton, *et al.,* 1995). In this case, snow fall followed by rain and a rapid thaw was thought to have been responsible for introducing oocysts into the raw water. In addition, slurry at a cattle feeding station was found to contain 350,000 oocysts per litre. In a more recent survey, Shepherd (2000) examined the microbiological quality of three private water sites over a two year period. Samples were taken weekly during the study with more intensive monitoring during periods of heavy rainfall. Whilst the supplies were satisfactory for the majority of the investigation period, dramatic changes in water quality were noted during heavy rainfall events. These changes resulted in large numbers of coliforms, *E. coli*, enterococci and clostridia being present in the water. In addition, *Campylobacter* was isolated from water samples at all three sites studied and *Salmonella* from one site.

Between 1937 and 1986, 13 outbreaks of waterborne infections from private water supplies were recognised (Galbraith *et al.,* 1987) with over 1900 cases of disease. The most commonly reported outbreaks are associated with *Campylobacter* with 9 reported outbreaks affecting over 700 people between 1981 and 1994 (Fewtrell, *et al*., 1996). Spring supplies and association with grazing animals are commonly quoted sources. In a review of waterborne outbreaks in England and Wales between 1992-1995, Furtado, *et al*., (1998) reviewed nine outbreaks associated with private supplies. Five of these were due to *Campylobacter*, two to *Cryptosporidium*, one was an outbreak where there were combined infections and in one the source was unknown. An outbreak of *Campylobacter* was described in a private school (Palmer, *et al*., 1983) affecting 234 pupils and 34 staff. Water was supplied from a borehole and stored in an uncovered tank in a tower. Contamination of the stored water by birds is thought to have been the cause of the outbreak.

A number or waterborne outbreaks have been attributed to private water supplies. Between 1983 and 1997, seven outbreaks of cryptosporidiosis were identified in the UK (UK WIRL, 1998). A combined *Cryptosporidium* and *Campylobacter* outbreak occurred in a private water supply in Northumberland (Duke, *et al*., 1996). Forty three overseas students were affected and two had combined infections. The water system obtained its supply from several local springs in the area. High *E. coli* counts were obtained from water supplying the building but no indicators were isolated from the springs. An investigation found three dead lambs in a collecting chamber for the supply. Pasture surrounding the storage and collecting chambers had been sprayed with slurry five days prior to the outbreak. This was followed by unusually heavy rainfall.

Iaacson *et al*., 1993, describe a large outbreak of haemorrhagic colitis in South Africa and Swaziland caused by *E. coli* O157:H7. Thousands of people were affected. The source was surface water contaminated with cattle carcases and faeces. The outbreak followed heavy rainfall after a prolonged drought. A mixed outbreak of *Campylobacter* and *E. coli* O157:H7 occurred in Grampian in 1990 affecting four people (Dev *et al*., 1991). The outbreak happened during a long, hot summer when

the water supply became inadequate and was augmented from two additional reservoirs that had been out of use. One of these reservoirs was fed from a field drain and this was thought to be contaminated with cattle slurry. Water supplied to the house of one patient was found to be heavily contaminated with *E. coli*. An outbreak of *E. coli* O157:H7 occurred in Japan in 1990 infecting 174 children in a nursery. A wide range of symptoms were seen including involvement of the central nervous system. Two children died. The drinking water was supplied from a well in the school. The organism was isolated from both the well and the drinking water.

An outbreak of giardiasis occurred in the Worcester area in April of 1992 affecting 28 people (Constantine *et al*., 1995). All the cases lived in a small village of 200 inhabitants. The source water was a shallow spring. There was anecdotal evidence that spring water flow increased after heavy rainfall. In addition, animals were allowed to graze in the field where the spring arose. Damaged cysts were also isolated from a consumers tap filter. There was no water treatment at the time of the incident.

The present survey was conducted on seven sites within the United Kingdom. Each site was tested for coliforms, *E. coli*, enterococci, presumptive *Cl. perfringens*, *Campylobacter*, *Cryptosporidium* and *Giardia*. Where microbiological evidence suggested that water quality was poor, samples were tested for *E. coli* O157:H7. There is considerable advantage in testing on a routine basis in that changes in water quality due to severe hydrological events are captured. This type of picture will be missed when samples are taken on an intermittent basis. Phase 2 was extended by at least 2 days in an attempt to cover the severe rainfall and flooding which occurred during the beginning of November 2000.

Samples were taken for water chemistry in addition to bacteriology. The results are presented in Appendix A. Samples were also taken of the raw water at four sites, site 1, site 3, site 6 and site 7. These were analysed for faecal indicators only.

8.1 Site 1

A total of 86 bacteriological samples were taken at site 1. Forty two of these samples were taken during phase 1 of the project and 44 during phase 2. None of the samples failed bacteriologically for faecal indicators or *Campylobacter*. A total of 72 parasitology samples were taken, 38 samples in phase 1 and 44 in phase 2. One of the phase 1 samples (2.6%) was positive for *Cryptosporidium* and one sample (2.6%) for *Giardia*. Only one empty *Cryptosporidium* oocyst was identified and two empty *Giardia* cysts. Only one sample (2.3%) failed for *Giardia* in phase 2. A Genera Filta-Max was left in the sample cabinet during the summer period. The sample volume amounted to 117,547 litres. The filter had to be dismantled and dissected with a sterile scalpel before being washed.

8.2 Site 2

A total of 85 bacteriological samples were taken at site 2. Forty three of these samples were taken during phase 1 and 42 during phase 2. Twenty eight (65%) of the samples failed bacteriologically for coliforms and *E. coli* during

phase 1. Eleven samples (25.5%) failed for enterococci and 22 samples (51%) failed for presumptive *Cl. perfringens*. *Escherichia coli* was present on each occasion that coliforms were isolated. At this particular site, *Cl. perfringens* was a better indicator than enterococci. An increase in indicators was observed between 17 – 20 May reflected in a similar increase in clostridia but not in enterococci. In phase 2, twenty samples (47.6%) were positive for coliforms and *E. coli* and, as with phase 1, all positive samples contained both indicators. Six samples (14.3%) were positive for enterococci and seven samples (16.6%) were positive for clostridia. An incident between 26 – 29 October gave a dramatic rise in indicators. This was related to continued heavy rainfall as reported by samplers who made observations on weather conditions during the survey. All the samples were negative for *Campylobacter*. Two samples tested for *E. coli* O157 were negative during phase 1 and two samples tested during phase 2 were also negative.

A total of 40 samples were taken for parasite analysis during phase 1, 30 (75%) were positive for *Cryptosporidium* and 24 (60%) were positive for *Giardia*. The increase in faecal indicators occurring between 17 – 20 May correlated with a significant increase in *Cryptosporidium* and *Giardia.* There was a significant increase in *Cryptosporidium* from 17 – 23 June and this does not correlate with any increase in faecal indicators, or with an increase in *Giardia*. The majority of the parasites observed during phase 1 were empty, in that internal contents could not be demonstrated by either DAPI staining or DIC. This would suggest that in this location, the parasites had been in the environment for some time. Forty parasite samples were taken during phase 2 and 20 (50%) were positive for *Cryptosporidium* and 17 (42.5%) were positive for *Giardia*. Increases in parasites occurred from 24 October to the end of the survey on 06 November. In part, this relates to an increase in indicators as noted above but the increase in parasite levels starts much earlier and lasts longer than the increase in indicators. The increase in *Cryptosporidium* at the end of October has a much higher percentage of parasites which have internal contents stained with DAPI. The greater proportion of the *Giardia* cysts observed are DAPI negative. This would suggest that *Giardia* cysts are poor survivors in the environment.

8.3 Site 3

A total of 85 samples were taken for bacteriological analysis. Forty three samples were taken in phase 1 and none of these samples were positive for faecal indicators. A further 42 samples were taken during phase 2 and only one sample (2.4%) was positive for clostridia. Sixty seven samples were taken for parasites. Thirty seven of these were taken during phase 1 and one sample (2.7%) was positive for *Cryptosporidium* and one sample (2.7%) was positive for *Giardia*. Thirty samples were taken during phase 2 and 17 samples (56.6%) were positive for *Cryptosporidium* and 15 samples (50%) were positive for *Giardia*. The majority of the positive samples in phase 2 occurred during the last two weeks of sampling although levels were only low. An increased level of *Giardia* was noted during 22 – 26 October. These are not related to any increase in indicators. The majority of the parasites here were also empty.

8.4 Site 4

Eighty four samples were taken at site 4. Forty one samples were taken during phase 1. Two samples (4.8%) were positive for coliforms only and one sample (2.4%) positive for clostridia. It is possible in these circumstances that the two positive samples were tap failures. Forty three samples were taken during phase 2 and of these, none were positive for coliforms and *E. coli*, three samples (7%) were positive for enterococci and 33 samples (76.7%) were positive for clostridia. These results suggest that there has been a contamination incident at the beginning of phase 2. The coliforms, *E. coli* and enterococci have been controlled by disinfection, but the clostridia have survived treatment and are present in the treated water is significant numbers. This perhaps indicates the merits of using all four indicators on private water supplies where the raw water source might be susceptible to contamination and where disinfection is used as part of the treatment regime..

Eighty samples were taken for parasitology. During phase 1, all 39 samples were negative for both parasites. Forty one samples were taken during phase 2. One sample (2.4%) was positive for *Cryptosporidium* and 5 samples (12.1%) were positive for *Giardia*. The incidence of positive samples, although low, occurred during the time when the clostridia count was high. This observation would reinforce the point that where disinfection is used, the absence of coliforms in contamination incidents does not preclude the absence of parasites.

8.5 Site 5

Eighty six samples were taken for bacteriological examination. Forty three samples were taken in phase 1 and of these 40 samples (93%) were positive for coliforms, 39 samples (90.6%) were positive for *E. coli*, 22 samples (51.2%) were positive for enterococci and 4 samples (9.3%) were positive for clostridia. *Campylobacter* was detected on 2 occasions, on 04 June and 10 June. On the second occasion, a count of 10 organisms per litre was obtained. Two isolates of *Campylobacter* were obtained from 10 June by subculture and these were found to be different biotypes. *Escherichia coli* O157 was not detected during phase 1 although 2 samples were taken specifically to test for the presence on the organism. A heavy contamination event occurred on 17 May giving a dramatic rise in the levels of coliforms and *E. coli*. A similar rise is present for enterococci but the contamination is not demonstrated by an increase in clostridia. A second increase occurred on 04 June, again demonstrated by an increase in three indicators but not in clostridia. The level of bacterial contamination following the first incident remains high during the remainder of phase 1 compared to levels before the incident.

Forty three samples were taken in phase 2. All the samples (100%) were positive for coliforms and *E. coli* during phase 2. Thirty samples (69.7%) were positive for enterococci and only 6 samples (14%) were positive for clostridia. *Campylobacter* was present in two samples on 28 September and 03 October but *E. coli* O157 was not present. General bacterial contamination remained high at this site during phase 2. This contamination, as in phase 1,

was not reflected in high clostridia counts. There is high contamination at the start of phase 2 and peaks can be seen on 05 October, 07 October, and between 23 – 25 October.

Eighty samples from this site were taken for parasites. Of 39 samples taken in phase 1, 13 samples (33.3%) were positive for *Cryptosporidium* and 6 samples (15.4%) were positive for *Giardia*. Of 41 samples taken in phase 2, 23 samples (56%) were positive for *Cryptosporidium* and 27 samples (65.9%) were positive for *Giardia.* A peak of *Cryptosporidium* occurred on 17 May and this correlates with the increase in bacterial contamination. There is, however no corresponding peak for *Giardia*. *Cryptosporidium* is present for only a short period and disappears quickly. This type of pulse contamination has been seen before (Watkins *et al*., 1995). A small increase is noted on 10 June and this correlates with an increase in bacterial contamination together with the presence of *Campylobacter*. For the second occasion, no *Giardia* is present.

Giardia is much more prevalent in the autumn phase. The reason for this is unclear. A bacterial contamination event is mirrored by an increase in both parasites on 28 September when *Campylobacter* was present but not on 03 October when *Campylobacter* was also present and there is no evidence of an increase in bacterial contamination. The heavy bacterial contamination on 23 – 25 October correlates with an increase in *Giardia* but not in *Cryptosporidium.* As with earlier observations, nuclear material could not be demonstrated in the majority of the *Giardia* cysts. This would suggest that they are non-viable and poor environmental survivors.

8.6 Site 6

Eighty three samples were taken from site 6 in the survey. Of 41 samples taken during phase 1, only one sample (2.4%) was positive for coliforms. There is a very different picture for phase 2. Forty two samples were taken in this phase. Thirty nine samples (92.8%) were positive for coliforms, 27 samples (64.3%) were positive for *E. coli*, 16 samples (38%) were positive for enterococci and 23 samples (54.8%) were positive for clostridia. We cannot be sure what has caused this dramatic change in water quality. Either there has been a change in water source, the source has become badly contaminated or treatment has completely failed. There were no parasites present in phase 1 but there are parasites in phase 2. There are two startling contamination events in phase 2. The first occurs between 09 – 11 October and correlates with increases in all the indicators. The second occurred between 29 October and the end of sampling on 04 November. Unlike the first peak, the second is prolonged. *Campylobacter* was not detected at site 6 during phase 1 or phase 2.

A total of 69 samples were taken for parasites. None of 38 samples were positive during phase 1. Of 31 samples taken in phase 2, 3 samples (10%) were positive for *Cryptosporidium* and 9 samples (29%) were positive for *Giardia*. Increases in levels occurred at the same time as the bacterial contamination above. The majority of the parasites detected during this phase

were DAPI negative suggesting that they had been in the environment for some time.

8.7 Site 7

Eighty six bacteriology samples were taken from site 7. Of 42 samples taken during phase 1, 35 samples (83.3%) were positive for coliforms, 30 samples (71.4%) were positive for *E. coli*, 20 samples (47.6%) were positive for enterococci and 38 samples (90.5%) were positive for clostridia. A contamination event occurred on 19 – 20 May, identified by all the indicators. A second contamination incident occurred on 29 May and *Campylobacter* was present on three successive occasions during this period. A contamination event occurred on 04 June again identified by all the indicators. *Campylobacter* was isolated at this point and *E. coli* O157:H7 was isolated from a sample taken at the same time. This isolate was subsequently shown to be toxigenic. This last contamination incident followed exceptionally heavy rainfall. The degree of rain and the state of the site can be seen in Figures 4.22 to 4.24.

Forty four samples were taken in phase 2. Of these, 12 samples (27.3%) were positive for coliforms, 11 samples (26.1%) were positive for *E. coli*, 3 samples (6.8%) were positive for enterococci and 27 samples (61.4%) were positive for clostridia. Between phase 1 and phase 2 filtration and electro-chlorination was introduced to the site. This had a significant impact on the bacteriological failures with coliforms, *E. coli* and enterococci being reduced. The clostridia, however remain high both in incidence and numbers, as might be expected. Two contamination events may be identified from the data. The first is between 20 – 21 September when *Campylobacter* was also isolated and the second is on 08 October. Both these events occurred whilst treatment was functioning. It is clear from the data that the treatment regime may be effective during normal weather conditions, but adverse conditions cause contamination to break through.

Eighty five samples were taken for parasitology. Of forty samples taken during phase 1, 21 samples (52.2%) were positive for *Cryptosporidium* and 23 samples (57.7%) were positive for *Giardia*. Of 45 samples taken in phase 2, 41 samples (91%) were positive for *Cryptosporidium* and 38 samples (84.4%) were positive for *Giardia*. There is an increase in both parasites on 28 May and a large increase on 04 June corresponding to heavy rainfall. The levels of *Cryptosporidium* breach water quality regulations. There are high levels of both parasites during the first part of phase 2. With treatment in place, only clostridia correctly identifies these large numbers. High levels on 08 October reflect the bacterial contamination and high levels on 21 October are reflected only by the clostridia. There are very high counts towards the end of the project which is the wet spell that caused the intense and widespread flooding in the vale of York. As with site 5, the *Giardia* levels are significantly higher than the *Cryptosporidium* levels in the phase 2 period. It should also be noted from the phase 2 data that, for the latter part, pellet volumes for the parasite samples increased. This is reflected in the raw water quality as a result of the extensive and prolonged rainfall which occurred at the end of phase 2.

The results of these recoveries are presented in Table 8.1. Counts of faecal indicators and parasites have been plotted to demonstrate dramatic increases, in particular, in numbers at sites 2, 5 and 7 (Figures 8.1 – 8.12). The figures have been plotted on the basis of total parasite count because sample volumes were not always available. Samplers were asked to make notes of the weather at the time of sampling and this information has been recorded either on the sample log sheets or on the evidence bags used to deliver the samples to CREH *Analytical*. Although information was not always available, Table 8.2 highlights some of the contamination events together with the comments made by the samplers at the time of sampling. Although we do not have rainfall data, this is the best indication of prevailing weather conditions. In eight of the 11 events where there is an increase in indicators, this is related to rainfall. In many instances there is a corresponding rise in parasites. Heavy rainfall in surface waters introduces large numbers of indicators and pathogens which are derived directly from surface faecal contamination. Sanitary surveys, as suggested by Clapham, (1997), should make this risk obvious. Where disinfection is installed, the increase in microbial load may be such as to overwhelm the treatment facility and allow the introduction of *Campylobacter* and large numbers of parasites into the treated water. In situations such as this, low frequency monitoring will not detect contamination events. Where a supply is suspect or there has been a history of an outbreak, monitoring during severe weather conditions is advisable. These conditions include not only heavy rain but also snow fall followed by snow melt. An outbreak of *Cryptosporidium* in West Yorkshire followed such conditions.

The survey would suggest that where there is no treatment, analysis for coliforms and *E. coli* would be adequate for the detection of faecal contamination. Sites which have disinfection should also include analysis for enterococci and *Cl. perfringens*. *Clostridium perfringens*, in particular, is useful for detecting contamination where disinfection may have killed the other indicators. Monitoring for *Campylobacter*, *Cryptosporidium* and *Giardia* is expensive. The detection of large numbers of faecal indicators should automatically warrant a boil order notice until such time as corrective action can take place. Surface faecal material which can gain access into the raw water, can introduce any of the parasites sought in this survey, and perhaps others in addition.

Table 8.1 Percentage positive samples for each site during phase 1 and phase 2.

Site	Phase	Coliforms	*E. coli*	Enterococci	Clostridia	*Cryptosporidium*	*Giardia*
Site 1	1	0	0	0	0	2.6	2.6
Site 1	2	0	0	0	0	0	2.3
Site 2	1	65.0	65.0	25.5	51.0	75.0	60.0
Site 2	2	47.0	47.0	14.3	16.6	50.0	42.5
Site 3	1	0	0	0	0	2.7	2.7
Site 3	2	0	0	0	2.4	56.6	50.0
Site 4	1	4.8	0	0	2.4	0	0
Site 4	2	0	0	7.0	76.6	2.4	12.1
Site 5	1	93.0	90.6	51.2	9.3	33.3	15.4
Site 5	2	100	100	69.7	14.0	56.0	65.9
Site 6	1	2.4	0	0	0	0	0
Site 6	2	92.8	64.3	38.0	54.8	10.0	29.0
Site 7	1	83.3	71.4	47.6	90.5	52.2	57.7
Site 7	2	27.3	26.1	6.8	61.4	91.0	84.4

Figures 8.1 – 8.12 showing the distribution of microbiological contamination at sites 2, 5 and 7 during phase 1 and phase 2

Figure 8.1 Distribution of positive bacteriological samples for site 2, phase 1

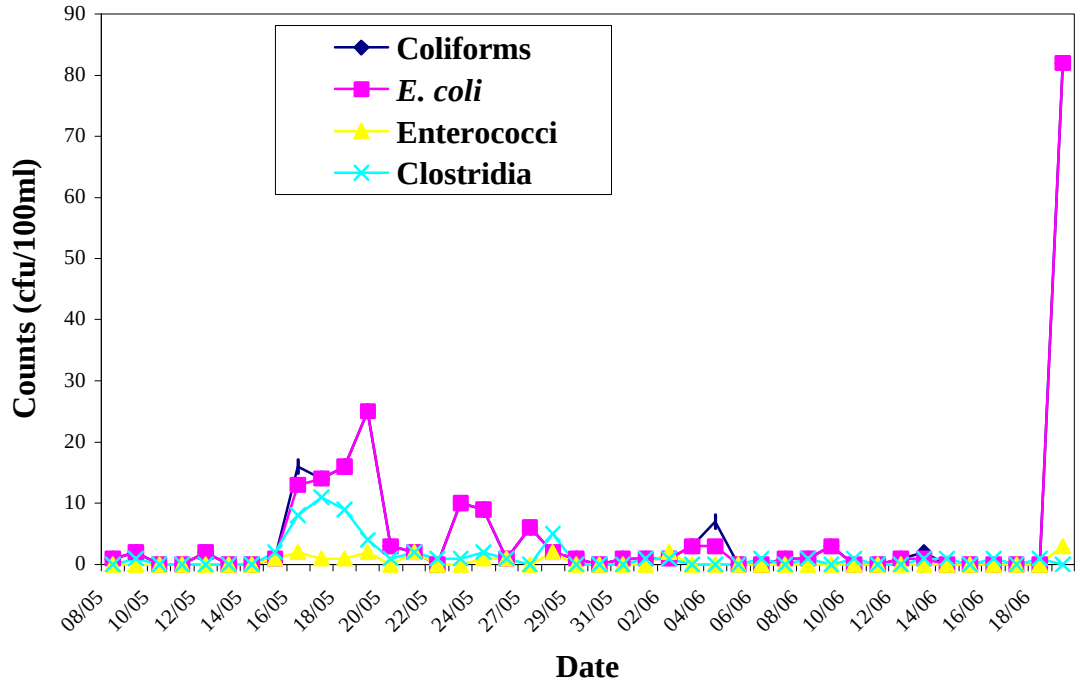

Figure 8.2 Distribution of positive parasitology samples for site 2, phase 1

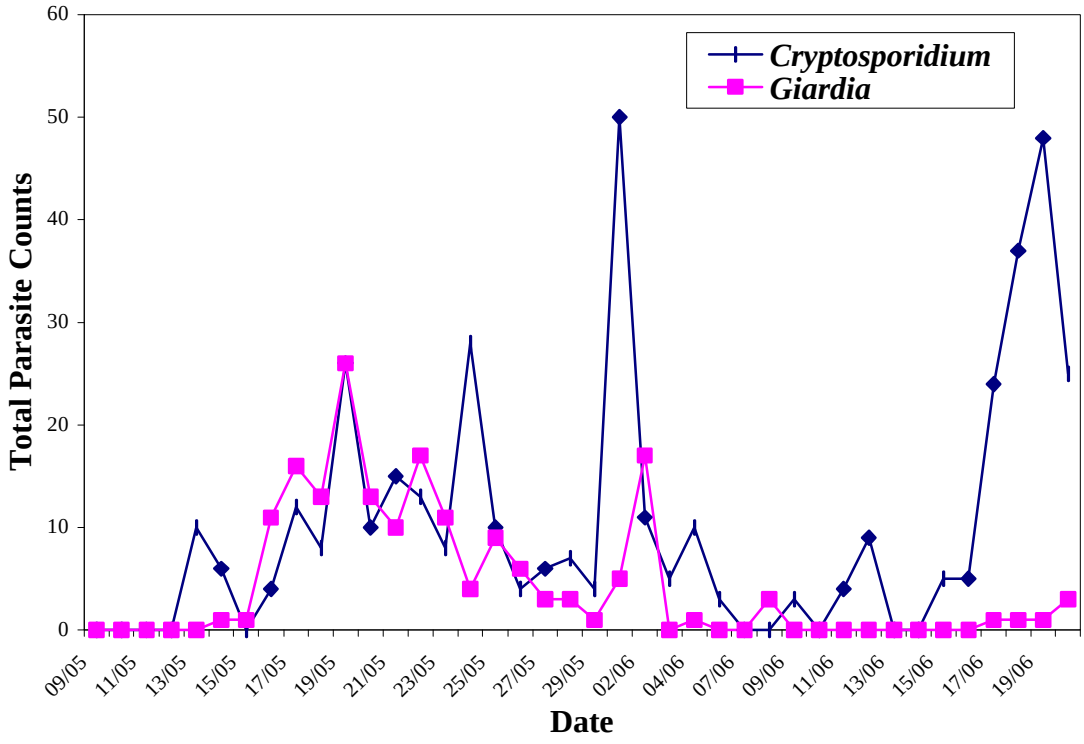

Figure 8.3 Distribution of positive bacteriology samples for site 2, phase 2

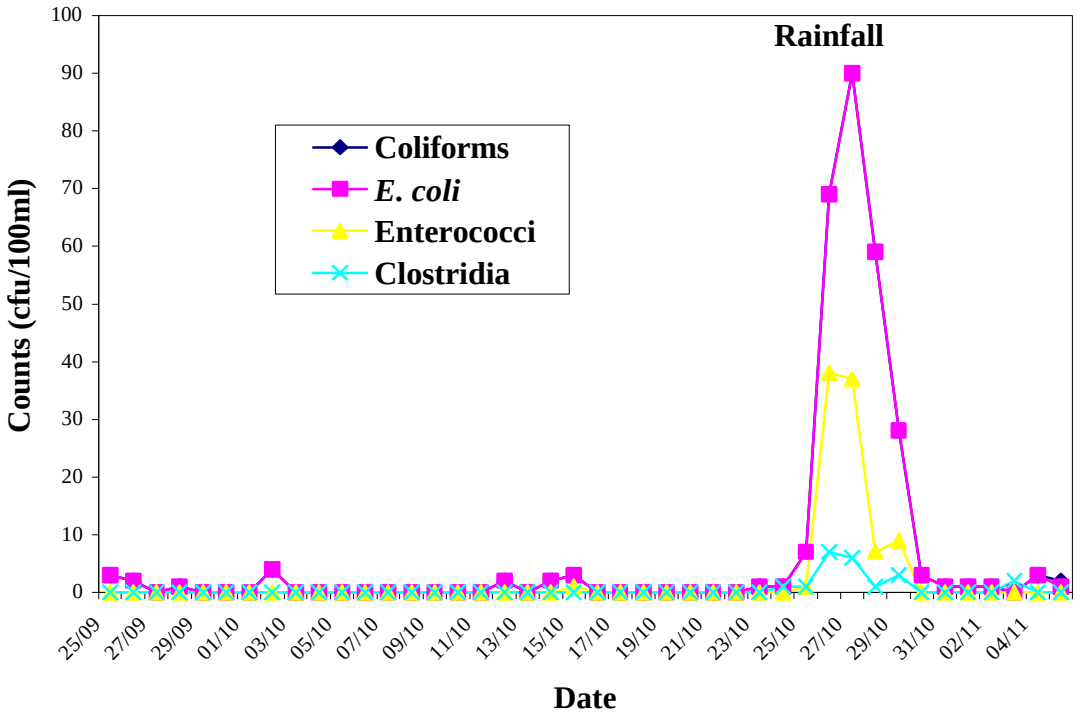

Figure 8.4 Distribution of positive parasitology samples for site 2, phase 2

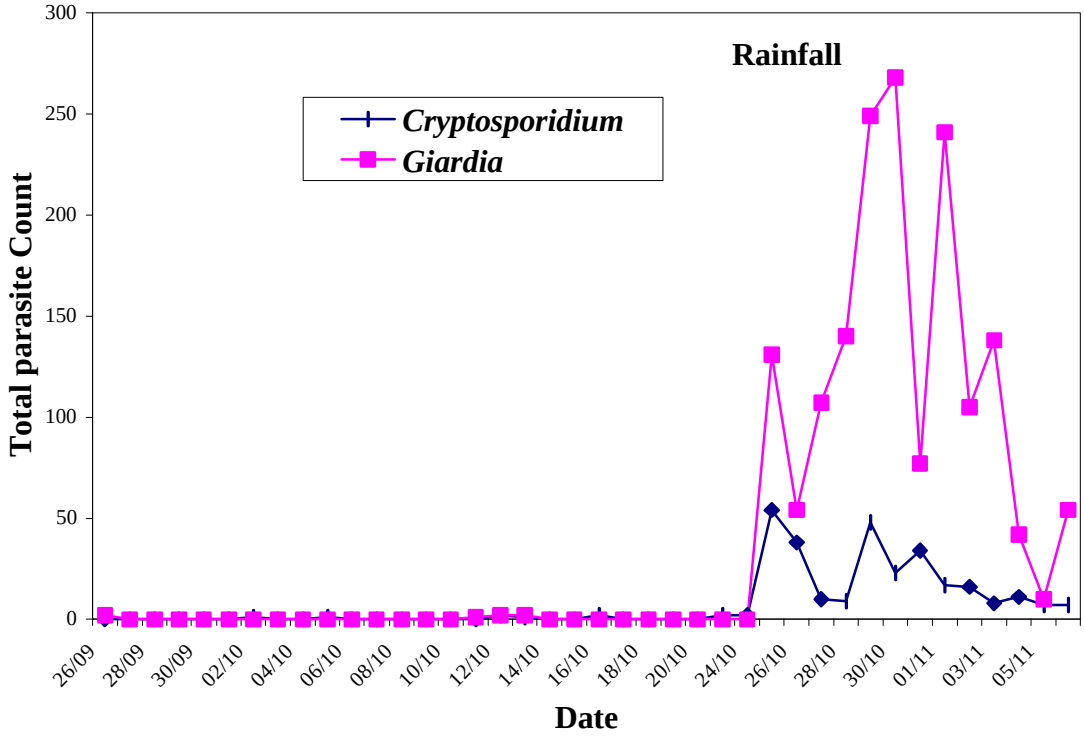

Figure 8.5 Distribution of positive bacteriology samples for site 5, phase 1

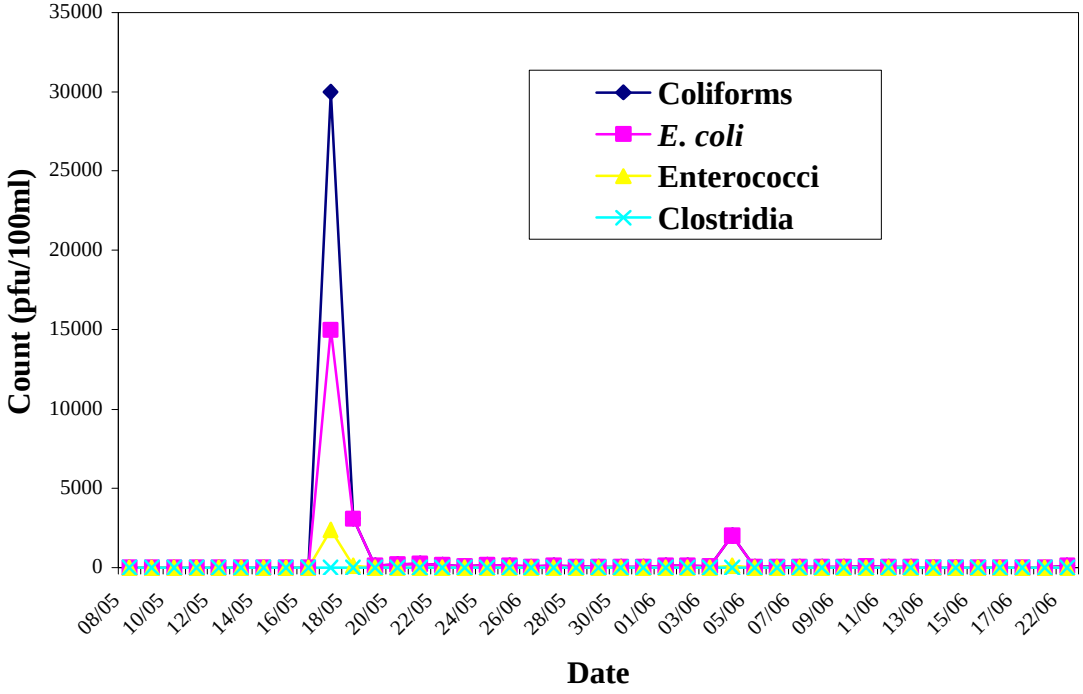

Figure 8.6 Distribution of positive parasitology samples for site 5, phase 1

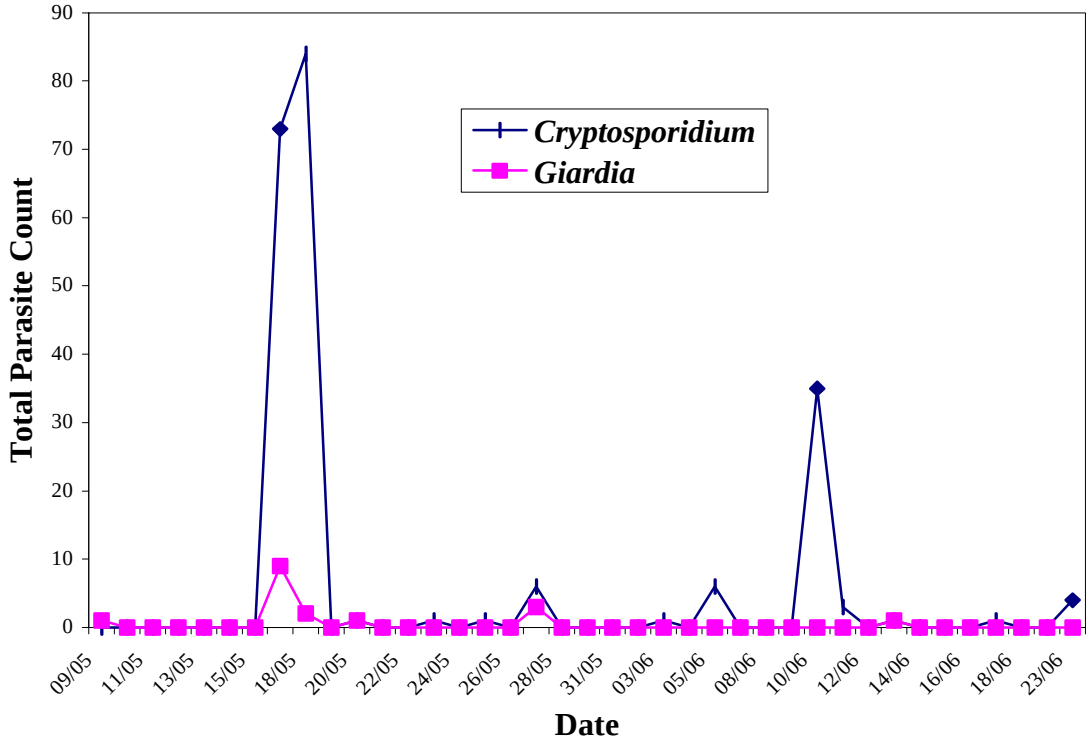

Figure 8.7 Distribution of positive bacteriology samples for site 5, phase 2

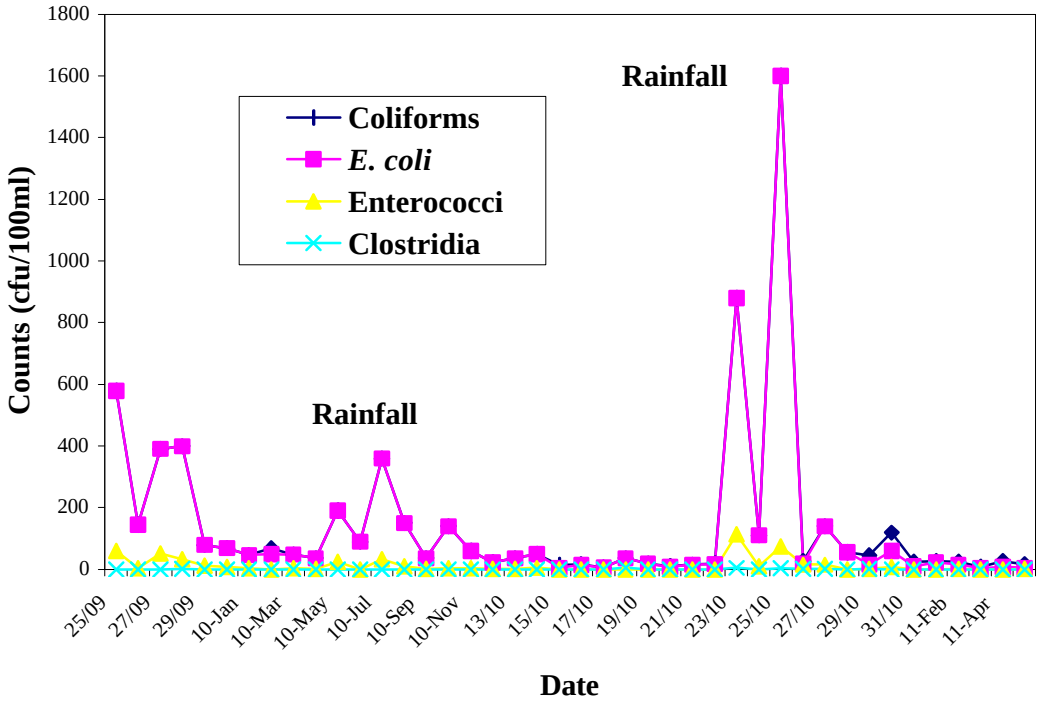

Figure 8.8 Distribution of positive parasitology samples from site 5, phase 2

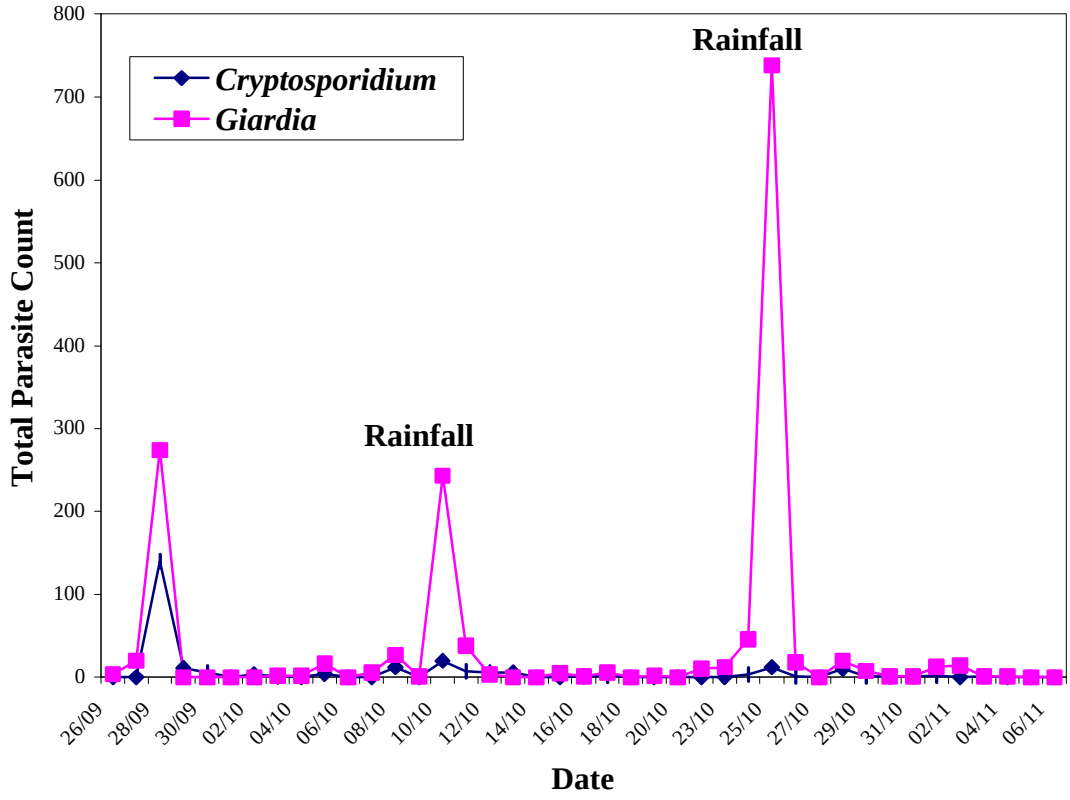

Figure 8.9 Distribution of positive bacteriology samples from site 7, phase 1

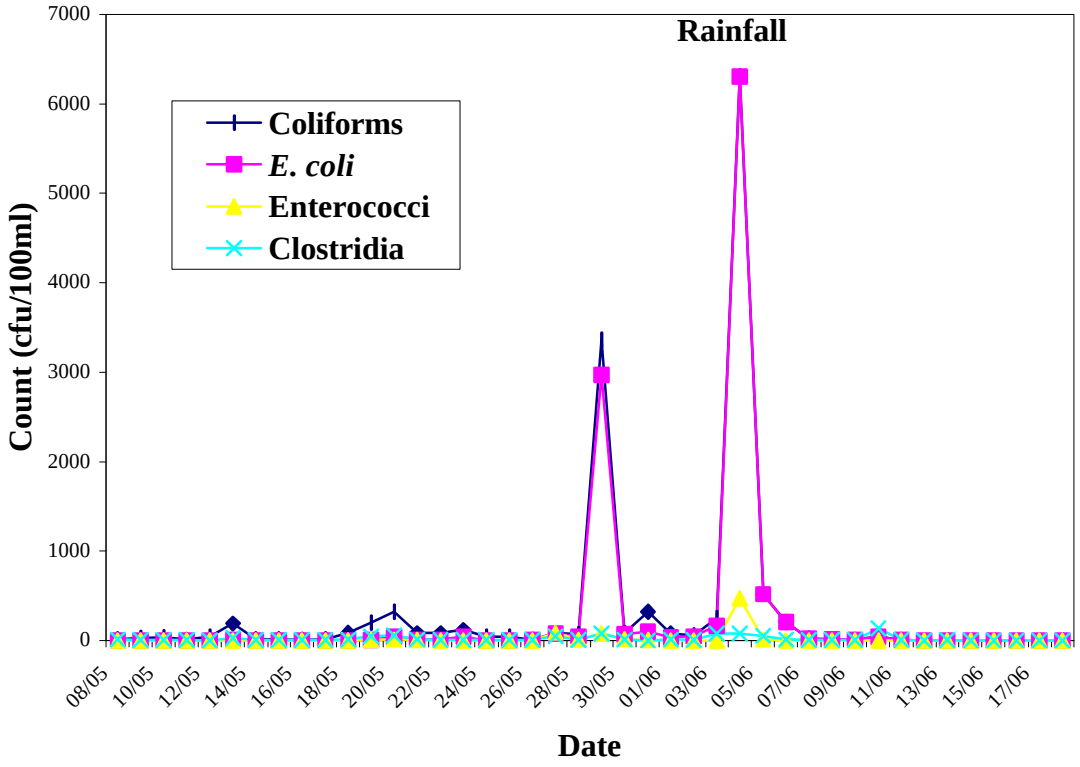

Figure 8.10 Distribution of positive parasitology samples from site 7, phase 1

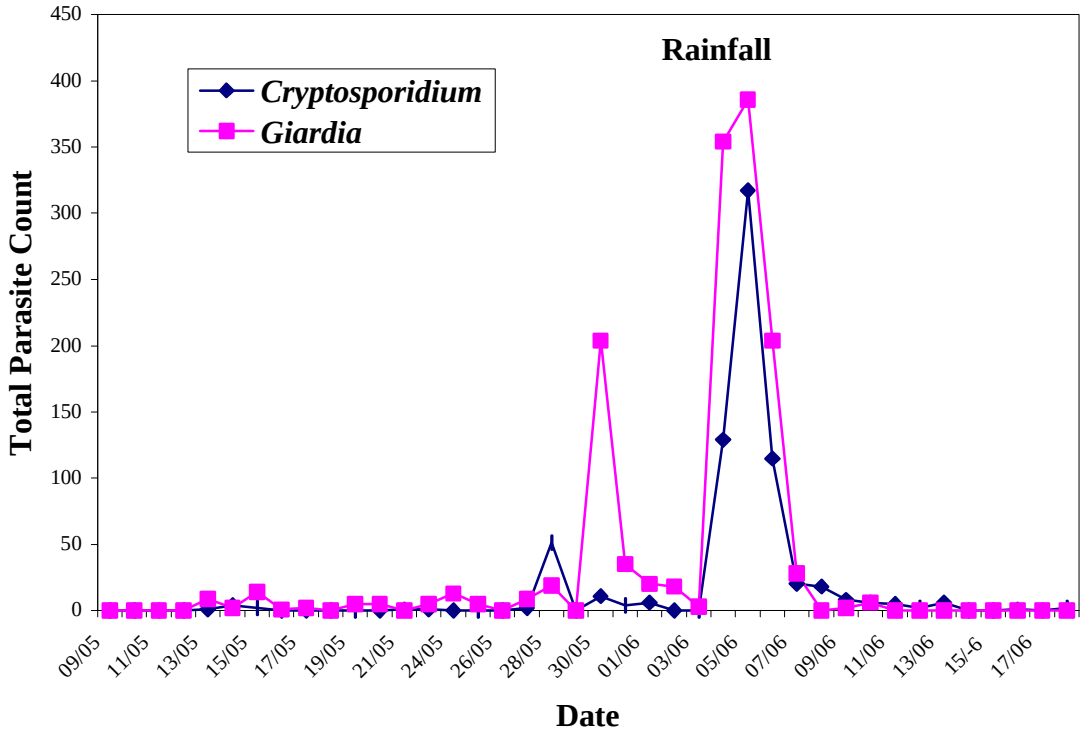

Figure 8.11 Distribution of positive bacteriology samples from site 7, phase 2

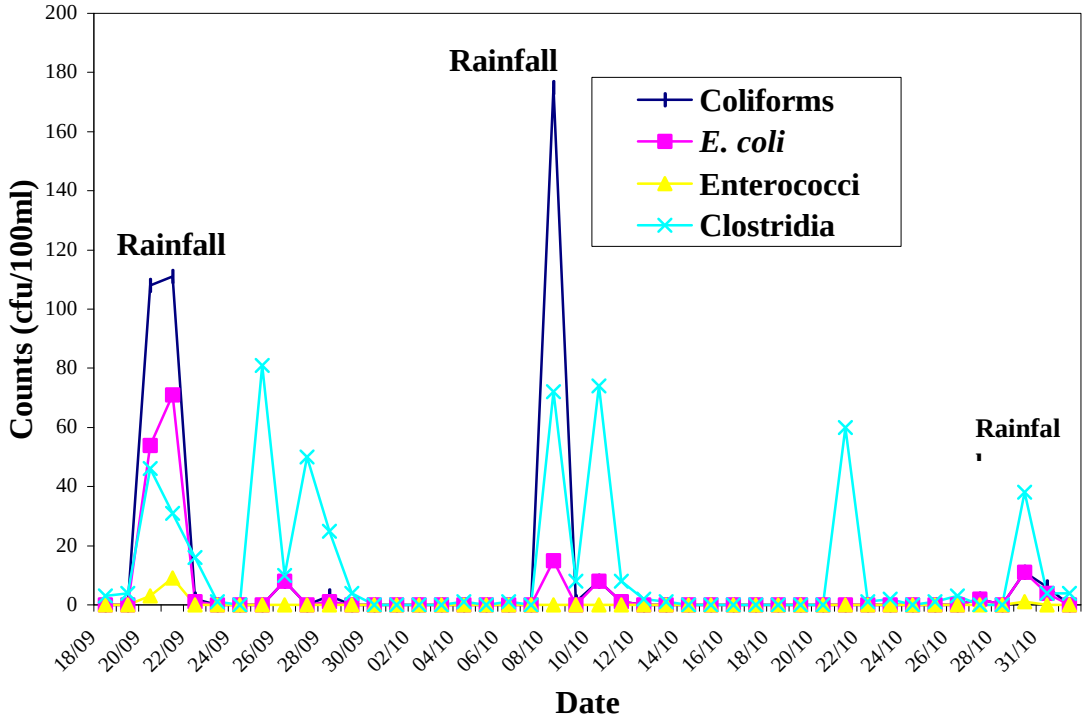

Figure 8.12 Distribution of positive parasitology samples from site 7, phase 2

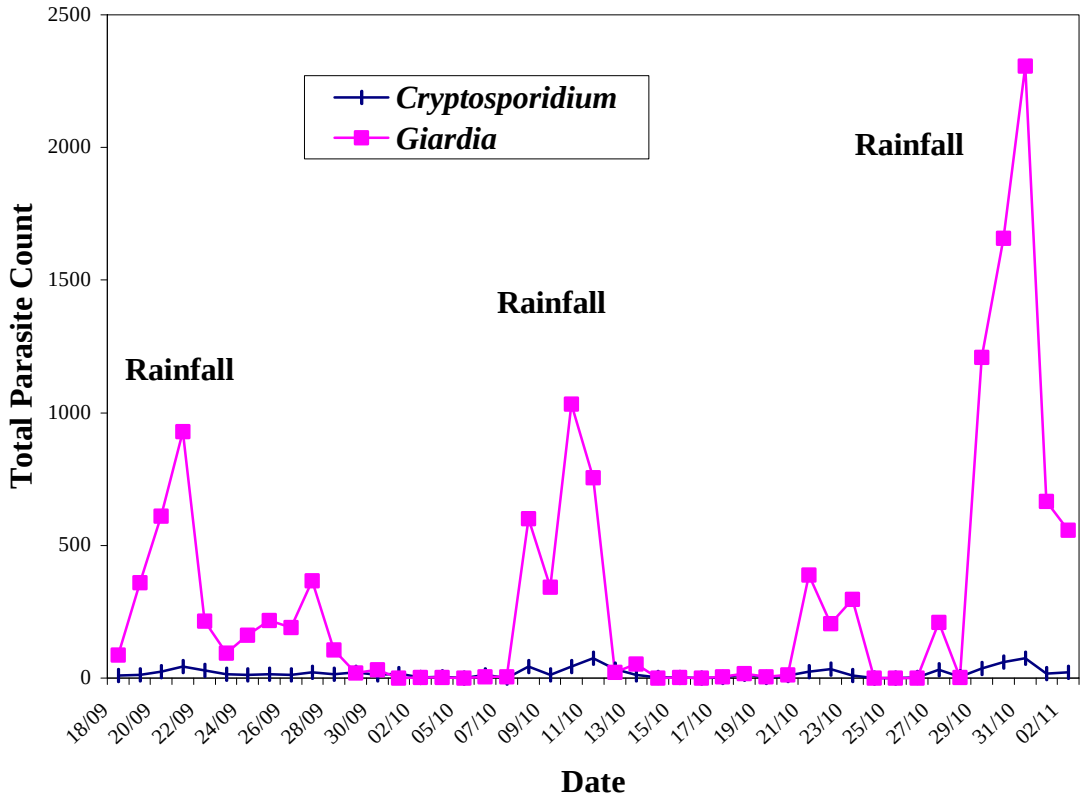

Table 8.2 Observations made by samplers on prevailing weather conditions in relation to contamination events

Location	Date	Samplers Comments
Site 2	17.05.00	Sunny intervals
Site 2	18.05.00	Sunny intervals
Site 2	19.05.00	Sunny intervals
Site 2	26.10.00	Showers
Site 2	27.10.00	Heavy rain
Site 2	28.10.00	Heavy rain
Site 2	29.10.00	Heavy rain
Site 5	04.06.00	Light rain
Site 5	05.06.00	Light rain
Site 5	06.10.00	Heavy rain
Site 5	07.10.00	Showers
Site 5	08.10.00	Heavy rain
Site 5	23.10.00	Showers
Site 5	24.10.00	Sunny intervals
Site 5	25.10.00	Overcast
Site 6	09.10.00	Heavy rain/light rain
Site 6	10.10.00	Heavy rain/showers
Site 7	24.05.00	Light rain
Site 7	03.06.00	Heavy rain
Site 7	04.06.00	24 Hours of heavy rain
Site 7	05.06.00	Heavy rain
Site 7	20.09.00	Heavy rain/overcast
Site 7	21.09.00	Showers
Site 7	28.10.00	Heavy rain/sunny intervals
Site 7	29.10.00	Heavy rain/sunny intervals
Site 7	30.10.00	Heavy rain
Site 7	31.10.00	Light rain/sunny intervals
Site 7	01.11.00	Heavy rain

Much of the literature would suggest that large private supplies which are monitored regularly, have good quality water sources with correctly applied and carefully monitored treatment, will provide good quality drinking water. Borehole sources, in particular, provide satisfactory supplies. Site 1 is a typical example. The majority of the private supplies are, however, surface waters. Thirty three percent of supplies are

springs, 16.1% are boreholes and 14.3% are wells. Ninety eight percent of supplies fall into class E and F within category 1 and 90% fall into class 4 and 5 within Category 2 (Shepherd, 2000). These supplies have a minimum sampling frequency that is often not associated with weather conditions. The supplies at site 5 and 7 are examples here. Water quality seldom meets microbiological standards and during periods of heavy rain, become contaminated with faecal indicators and pathogens. *Cryptosporidium, Giardia, Campylobacter* and *E. coli* O157:H7 were all isolated from site 7. It is hoped that this survey has supplied a better understanding of the quality of these private supplies through intensive monitoring. It highlights in particular the effect of rainfall and the need for careful monitoring even after treatment has been installed. Collecting data on the microbiological quality of water before treatment is installed would be a useful exercise. This would, perhaps, ensure that the treatment was effective, particularly during periods of heavy rainfall.

Coliforms and *E. coli* are the best indicators of problems associated with faecal contamination and rainfall. Site 5 has very low levels of clostridia even during a severe contamination event. The introduction of electro-chlorination at site 7 reduces the levels of bacterial indicators with the exception of clostridia. The additional use of clostridia at this site for assessing water quality is advisable. Similarly, a contamination event at site 4 during phase 2 is demonstrated by the presence of clostridia alone. A full picture of water quality is best obtained by using all four bacterial indicators or at least *E. coli,* enterococci and clostridia.

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APPENDIX A

Appendix A.1 Chemistry Results, Phase 1

Site No.	Time	Meter Reading	Date	Turbidity (NTU) ±5%	pH ±5%	Conductivity (uS/cm) ±5%	Suspended Solids (mg/l)	Manganese (mg/l) ±5%	Calcium (mg/l) ±5%	Potassium (mg/l) ±5%	Magnesium (mg/l) ±5%
7	7.55	31864.1	6.6.00	6.8	7.46	280	8.80	0.002	27.88	0.61	4.00
7	7.55	33528.4	9.6.00	4.3	7.64	317	6.67	0.002	36.38	0.64	4.86
7	7.55	33619.65	10.6.00	31.0	7.75	329	133.85	<0.002	35.17	0.59	4.97
7	8.10	33680.1	11.6.00	4.5	7.78	356	10.20	0.002	40.27	0.66	5.43
7	7.55	34965.8	12.6.00	5.6	7.73	355	2.56	0.003	41.03	0.75	5.66
7	7.50	35236.4	13.6.00	5.9	7.38	377	12.63	0.003	44.74	0.79	6.14
7	8.05	35604.5	14.6.00	8.9	7.74	398	20.10	0.004	47.14	0.72	6.49
7	8.05	36330.4	15.6.00	4.1	7.69	395	12.50	0.004	46.02	0.68	6.36
7	7.50	37213.4	16.6.00	4.6	7.70	394	6.12	0.003	47.03	0.73	6.66
7	7.50	38482.9	17.6.00	10.0	7.65	403	15.10	0.007	46.61	0.71	6.55
7	8.05	39148.9	18.6.00	15.0	7.70	394	39.69	0.008	48.28	0.73	6.72

Site No.	Time	Meter Reading	Date	Fluoride (mg/l) ±5%	Chloride (mg/l) ±5%	Nitrate (mg/l) ±5%	Phosphate (mg/l) ±5%	Sulphate (mg/l) ±5%
7	7.55	31864.1	6.6.00	<0.25	15.98	2.04	22.90	32.35
7	7.55	33528.4	9.6.00	<0.25	21.82	2.68	19.57	22.61
7	7.55	33619.65	10.6.00	<0.25	22.13	3.78	19.08	20.47
7	8.10	33680.1	11.6.00	<0.25	25.38	3.09	21.88	23.21
7	7.55	34965.8	12.6.00	<0.25	22.57	2.73	20.19	23.13
7	7.50	35236.4	13.6.00	<0.25	26.42	2.76	21.52	27.44
7	8.05	35604.5	14.6.00	<0.25	26.86	2.52	23.19	24.02
7	8.05	36330.4	15.6.00	<0.25	26.05	2.45	25.34	24.09
7	7.50	37213.4	16.6.00	<0.25	26.70	2.12	22.62	23.25
7	7.50	38482.9	17.6.00	<0.25	28.27	2.39	21.41	23.61
7	8.05	39148.9	18.6.00	<0.25	26.87	2.46	18.03	23.20

Calcium, magnesium, sodium, potassium and manganese - Thermo Jarrell Ash Atomscan Advantage ICP-OES
Anions - Dionex DX-500 HPLC-IC
pH - Denver Instrument Company Model 220 pH meter
Conductivity - Hanna HI-9033 conductivity meter
Suspended solids - gravimetric analysis
Turbidity - HACH model 2100A turbidimeter

Appendix A.2 Microbiology Results, Phase 1

SITE 1

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
08.05.00	0	0	0	0	Not Detected	NT		
09.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
10.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
11.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
12.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
13.05.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
14.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
15.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
16.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
17.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
19.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
20.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
21.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
22.05.00	0	0	0	0	Not Detected	NT	<0.0002	<0.0002
23.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
24.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
25.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
26.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
27.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
28.05.00	0	0	0	0	Not Detected	NT	0.0008	0.0016

SITE 1

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
29.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
30.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
31.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
01.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
02.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
03.06.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
04.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
05.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
06.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
07.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
08.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
09.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
10.06.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
11.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
12.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
13.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
14.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
15.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
16.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
17.06.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
18.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008

SITE 2

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
08.05.00	1	1	0	0	Not Detected	NT		
09.05.00	2	2	0	1	Not Detected	NT	<0.0007	<0.0007
10.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
11.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
12.05.00	2	2	0	0	Not Detected	NT	<0.0007	<0.0007
13.05.00	2	2	0	0	Not Detected	NT	0.0075	<0.0008
14.05.00	0	0	0	0	Not Detected	NT	0.0044	0.0007
15.05.00	0	0	0	0	Not Detected	NT	<0.0007	0.0007
16.05.00	1	1	1	2	Not Detected	NT	0.0030	0.0083
17.05.00	16	13	2	8	Not Detected	NT	0.0074	0.0098
18.05.00	14	14	1	11	Not Detected	0	0.0073	0.0119
19.05.00	16	16	1	9	Not Detected	NT	0.0172	0.0172
20.05.00	25	25	2	4	Not Detected	NT	0.0078	0.0102
21.05.00	3	3	0	1	Not Detected	NT	0.0112	0.0075
22.05.00	2	2	2	2	Not Detected	NT	0.0100	0.0130
23.05.00	0	0	0	1	Not Detected	NT	0.0060	0.0083
24.05.00	10	10	0	1	Not Detected	NT	0.0208	0.0030
25.05.00	9	9	1	2	Not Detected	NT	0.0088	0.0079
26.05.00	1	1	1	1	Not Detected	NT	0.0034	0.0041
27.05.00	6	6	0	0	Not Detected	NT	0.0050	0.0025
28.05.00	2	2	2	5	Not Detected	NT	0.0050	0.0022

SITE 2

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
29.05.00	1	1	0	0	Not Detected	NT	0.0031	0.0008
30.05.00	0	0	0	0	Not Detected	NT	No Sample	
31.06.00	1	1	0	0	Not Detected	NT	0.0212	0.0021
01.06.00	1	1	0	1	Not Detected	NT	No Sample	
02.06.00	1	1	2	1	Not Detected	NT	0.0034	0.0053
03.06.00	3	3	0	0	Not Detected	NT	0.0043	<0.0009
04.06.00	7	3	0	0	Not Detected	NT	0.0072	0.0007
05.06.00	0	0	0	0	Not Detected	NT	0.0019	<0.0006
06.06.00	0	0	0	1	Not Detected	NT	No Sample	
07.06.00	1	1	0	0	Not Detected	0	<0.0004	<0.0004
08.06.00	1	1	0	1	Not Detected	NT	<0.0008	0.0025
09.06.00	3	3	0	0	Not Detected	NT	0.0022	<0.0007
10.06.00	0	0	0	1	Not Detected	NT	<0.0008	<0.0008
11.06.00	0	0	0	0	Not Detected	NT	0.0033	<0.0008
12.06.00	1	1	0	0	Not Detected	NT	0.0056	<0.0006
13.06.00	2	1	0	1	Not Detected	NT	<0.0007	<0.0007
14.06.00	0	0	0	1	Not Detected	NT	<0.0007	<0.0007
15.06.00	0	0	0	0	Not Detected	NT	0.0043	<0.0009
16.06.00	0	0	0	1	Not Detected	NT	0.0037	<0.0007
17.06.00	0	0	0	0	Not Detected	NT	0.0213	0.0009
18.06.00	0	0	0	1	Not Detected	NT	0.0278	0.0008
19.06.00				No Sample			0.0319	0.0007
22.06.00	82	82	3	0	Not Detected	NT		
23.06.00							0.0167	0.0020

SITE 3

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
15.05.00	0	0	0	0	Not Detected	NT		
16.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
17.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
19.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
20.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
21.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
22.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
23.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
24.05.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
25.05.00	0	0	0	0	Not Detected	NT	<0.0167	<0.0167
26.05.00	0	0	0	0	Not Detected	NT	<0.0769	<0.0769
27.05.00	0	0	0	0	Not Detected	NT	<0.0105	<0.0105
28.05.00	0	0	0	0	Not Detected	NT	<0.0167	<0.0167
29.05.00	0	0	0	0	Not Detected	NT	<0.0151	<0.0151
30.05.00	0	0	0	0	Not Detected	NT	<0.0161	<0.0161
31.05.00	0	0	0	0	Not Detected	NT	<0.0035	<0.0035
01.06.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
02.06.00	0	0	0	0	Not Detected	NT	0.0038	0.0019
03.06.00	0	0	0	0	Not Detected	NT	<0.0050	<0.0050
04.06.00	0	0	0	0	Not Detected	NT	<0.0033	<0.0033

SITE 3

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
05.06.00	0	0	0	0	Not Detected	NT	<0.0031	<0.0031
06.06.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
07.06.00	0	0	0	0	Not Detected	NT	<0.0019	<0.0019
08.06.00	0	0	0	0	Not Detected	NT	<0.0028	<0.0028
09.06.00	0	0	0	0	Not Detected	NT	<0.0047	<0.0047
10.06.00	0	0	0	0	Not Detected	NT	<0.0047	<0.0047
11.06.00	0	0	0	0	Not Detected	NT	<0.0034	<0.0034
12.06.00	0	0	0	0	Not Detected	NT	<0.0028	<0.0028
13.06.00	0	0	0	0	Not Detected	NT	<0.0037	<0.0037
14.06.00	0	0	0	0	Not Detected	NT	<0.0035	<0.0035
15.06.00	0	0	0	0	Not Detected	NT	<0.0040	<0.0040
16.06.00	0	0	0	0	Not Detected	NT	<0.0035	<0.0035
17.06.00	0	0	0	0	Not Detected	NT	<0.0034	<0.0034
18.06.00	0	0	0	0	Not Detected	NT	<0.0031	<0.0031
19.06.00	0	0	0	0	Not Detected	NT	<0.0022	<0.0022
20.06.00	0	0	0	0	Not Detected	NT	<0,0028	<0.0028
21.06.00	0	0	0	0	Not Detected	NT	<0.0048	<0.0048
22.06.00	0	0	0	0	Not Detected	NT	<0.0048	<0.0048
23.06.00	0	0	0	0	Not Detected	NT	No Data	No Data
24.06.00	0	0	0	0	Not Detected	NT	<0.0040	<0.0040
25.06.00	0	0	0	0	Not Detected	NT	<0.0028	<0.0028
26.06.00	0	0	0	0	Not Detected	NT	<0.0029	<0.0029

SITE 4

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
08.05.00	0	0	0	0	Not Detected	NT		
09.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
10.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
11.05.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
12.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
13.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
14.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
15.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
16.05.00	0	0	0	0	Not Detected	NT	<0.0005	<0.0005
17.05.00	0	0	0	0	Not Detected	NT	<0.0011	<0.0011
18.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
19.05.00	0	0	0	0	Not Detected	NT	<0.0028	<0.0028
20.05.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
21.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
22.05.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
23.05.00	1	0	0	0	Not Detected	NT	No Sample	No Sample
24.05.00	0	0	0	0	Not Detected	NT	<0.0019	<0.0019
25.05.00	0	0	0	0	Not Detected	NT	<0.0006	<0.0006
26.05.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
27.05.00	0	0	0	0	Not Detected	NT	<0.0029	<0.0029
28.05.00	0	0	0	0	Not Detected	NT	<0.0006	<0.0006

SITE 4

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
29.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
30.05.00	0	0	0	0	Not Detected	NT	<0.0012	<0.0012
31.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
01.06.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
02.06.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
03.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
04.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
05.06.00	0	0	0	1	Not Detected	NT	<0.0009	<0.0009
06.06.00	0	0	0	0	Not Detected	NT	<0.0011	<0.0011
07.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
08.06.00	0	0	0	0	Not Detected	NT	<0.0013	<0.0013
09.06.00	0	0	0	0	Not Detected	NT	<0.0011	<0.0011
10.06.00	0	0	0	0	Not Detected	NT	<0.0012	<0.0012
11.06.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
12.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
13.06.00	0	0	0	0	Not Detected	NT	<0.0012	<0.0012
14.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
15.06.00	0	0	0	0	Not Detected	NT	<0.0011	<0.0011
16.06.00	0	0	0	0	Not Detected	NT	<0.0018	<0.0018
17.06.00	10	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.06.00							<0.0009	<0.0009

SITE 5

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
08.05.00	1	1	0	0	Not Detected	NT		
09.05.00	3	3	1	0	Not Detected	NT	<0.0008	0.0008
10.05.00	1	0	0	0	Not Detected	NT	<0.0008	<0.0008
11.05.00	1	1	0	0	Not Detected	NT	<0.0008	<0.0008
12.05.00	3	3	0	0	Not Detected	NT	<0.0008	<0.0008
13.05.00	9	1	0	0	Not Detected	NT	<0.0008	<0.0008
14.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
15.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
16.05.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
17.05.00	30,000	15,000	2,400	3	Not Detected	NT	0.0283	0.0035
18.05.00	3,100	3,100	125	1	Not Detected	0	No Volume	No Volume
19.05.00	147	147	7	0	Not Detected	NT	No Volume	No Volume
20.05.00	200	200	10	0	Not Detected	NT	0.0010	0.0010
21.05.00	240	240	3	0	Not Detected	NT	<0.0008	<0.0008
22.05.00	160	160	3	0	Not Detected	NT	<0.0007	<0.0007
23.05.00	110	110	1	0	Not Detected	NT	0.0009	<0.0009
24.05.00	160	160	2	0	Not Detected	NT	<0.0007	<0.0007
25.05.00	150	150	0	0	Not Detected	NT	0.0008	<0.0008
26.05.00	61	61	2	0	Not Detected	NT	<0.0008	<0.0008
27.05.00	130	130	0	0	Not Detected	NT	<0.0008	<0.0008
28.05.00	59	59	0	0	Not Detected	NT	<0.0008	<0.0008

SITE 5

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
29.05.00	49	49	0	0	Not Detected	NT	<0.0008	<0.0008
30.05.00	38	38	0	0	Not Detected	NT	No Sample	No Sample
31.05.00	36	36	0	0	Not Detected	NT	<0.0003	<0.0003
01.06.00	150	150	3	0	Not Detected	NT	No Sample	No Sample
02.06.00	150	150	4	0	Not Detected	NT	<0.0004	<0.0004
03.06.00	90	90	2	0	Not Detected	NT	0.0008	<0.0008
04.06.00	2020	2020	135	0	Present	NT	<0.0007	<0.0007
05.06.00	39	39	1	0	Not Detected	NT	0.0049	<0.0008
06.06.00	74	74	1	0	Not Detected	NT	No Sample	No Sample
07.06.00	19	19	1	0	Not Detected	0	<0.0009	<0.0009
08.06.00	20	20	1	0	Not Detected	NT	<0.0007	<0.0007
09.06.00	23	23	0	0	Not Detected	NT	<0.0010	<0.0010
10.06.00	110	110	9	0	Present	NT	0.0269	<0.0008
11.06.00	25	25	0	0	Not Detected	NT	0.0024	<0.0008
12.06.00	23	23	0	0	Not Detected	NT	<0.0008	<0.0008
13.06.00	9	9	1	0	Not Detected	NT	0.0008	0.0008
14.06.00	4	4	0	0	Not Detected	NT	<0.0014	<0.0014
15.06.00	10	10	1	0	Not Detected	NT	<0.0008	<0.0008
16.06.00	5	5	0	0	Not Detected	NT	<0.0007	<0.0007
17.06.00	10	10	0	0	Not Detected	NT	0.0008	<0.0008
18.06.00	7	6	0	0	Not Detected	NT	<0.0015	<0.0015
19.06.00							<0.0006	<0.0006
22.06.00	140	140	5	0	Not Detected	NT		
23.06.00							0.0028	<0.0007

SITE 6

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
15.05.00	0	0	0	0	Not Detected	NT		
16.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
17.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
18.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
19.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
20.05.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
21.05.00	0	0	0	0	Not Detected	NT	No Data	No Data
22.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
23.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
24.05.00	0	0	0	0	Not Detected	NT	<0.0013	<0.0013
25.05.00	0	0	0	0	Not Detected	NT	<0.0005	<0.0005
26.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
27.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
28.05.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
29.05.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
30.05.00			No Sample				<0.0008	<0.0008
31.05.00	4	0	0	0	Not Detected	NT	<0.0014	<0.0014
01.06.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
02.06.00	0	0	0	0	Not Detected	NT	<0.0010	<0.0010
03.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
04.06.00	0	0	0	0	Not Detected	NT	<0.0016	<0.0016

SITE 6

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
05.06.00	0	0	0	0	Not detected	NT	<0.0005	<0.0005
06.06.00	0	0	0	0	Not Detected	NT	No Sample	No Sample
07.06.00	0	0	0	0	Not Detected	NT	<0.0004	<0/0004
08.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
09.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
10.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
11.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
12.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
13.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
14.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
15.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
16.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
17.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
19.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
20.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
21.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
22.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
23.06.00	0	0	0	0	Not Detected	NT	No Volume	No Volume
24.06.00	0	0	0	0	Not Detected	NT	<0.0011	<0.0011
25.06.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
26.06.00							<0.0012	<0.0012

SITE 7

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
08.05.00	17	0	0	9	Not Detected	NT		
09.05.00	31	0	1	6	Not Detected	NT	<0.0025	<0.0025
10.05.00	35	1	0	6	Not Detected	NT	<0.0008	<0.0008
11.05.00	11	0	0	4	Not Detected	NT	<0.0008	<0.0008
12.05.00	43	0	0	1	Not Detected	NT	<0.0007	<0.0007
13.05.00	190	4	0	27	Not Detected	NT	0.0023	0.0068
14.05.00	18	1	0	5	Not Detected	NT	0.0016	0.0109
15.05.00	17	1	1	7	Not Detected	NT	0.0016	0.0016
16.05.00	7	0	0	6	Not Detected	NT	<0.0007	0.0007
17.05.00	15	1	1	4	Not Detected	NT	<0.0007	0.0015
18.05.00	91	1	0	10	Not Detected	NT	<0.0008	<0.0008
19.05.00	200	7	3	47	Not Detected	NT	<0.0008	0.0039
20.05.00	324	44	11	60	Not Detected	NT	<0.0008	0.0040
21.05.00	85	9	5	10	Not Detected	NT	0.0008	<0.0008
22.05.00	86	13	1	3	Not Detected	NT	0.0009	0.0043
23.05.00	120	40	2	3	Not Detected	NT	No Sample	No Sample
24.05.00	41	1	1	6	Not Detected	NT	<0.0008	0.0101
25.05.00	41	1	1	7	Not Detected	NT	<0.0008	0.0039
26.05.00	6	6	0	4	Not Detected	NT	<0.0008	<0.0008
27.05.00	83	77	92	46	Present	NT	0.0016	0.0074
28.05.00	71	47	13	4	Present	NT	0.1113	0.0414

SITE 7

Date	Coliforms No. /100ml	*Escherichia coli* No. /100ml	Enterococci No. /100ml	Clostridia No. /100ml	Campylobacter Pres/abs	*E. coli* O157	*Cryptosporidium* No. /l	*Giardia* No. /l
29.05.00	3,360	2,970	78	75	Present	NT	<0.0008	<0.0008
30.05.00	90	70	15	12	Present	NT	0.0141	0.2586
31.05.00	320	104	6	1	Present	0	0.0030	0.0267
01.06.00	75	37	2	10	Not Detected	NT	0.0057	0.0190
02.06.00	61	46	0	6	Not Detected	NT	<0.0010	0.0178
03.06.00	250	167	0	78	Not Detected	NT	<0.0010	0.0029
04.06.00	6,300	6,300	470	77	Present	+	0.1617	0.4436
05.06.00	517	517	10	54	Not Detected	NT	2.8480	3.4460
06.06.00	210	210	1	13	Not Detected	NT	0.2010	0.3566
07.06.00	22	22	0	3	Not Detected	NT	0.0238	0.0333
08.06.00	15	15	0	6	Not Detected	NT	0.0283	<0.0016
09.06.00	9	9	1	4	Not Detected	NT	0.0430	0.0108
10.06.00	40	40	0	140	Not Detected	NT	0.0659	0.0110
11.06.00	7	5	0	4	Not Detected	NT	0.0820	<0.0164
12.06.00	0	0	0	0	Not Detected	NT	0.0016	<0.0008
13.06.00	0	0	0	3	Not Detected	NT	0.0222	<0.0037
14.06.00	0	0	0	2	Not Detected	NT	<0.0027	<0.0027
15.06.00	0	0	0	0	Not Detected	NT	0.0014	<0.0014
16.06.00	0	0	0	0	Not Detected	NT	0.0011	<0.0011
17.06.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.06.00	0	0	0	1	Not Detected	NT	0.0003	<0.0015

SITE 1

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
09.05.00			No Vol	<0.5	0	0	0	0
10.05.00			*No Vol*	<0.5	0	0	0	0
11.05.00			No Vol	<0.5	0	0	0	0
12.05.00	25.25		1,385	<0.5	0	0	0	0
13.05.00	21.30		1,157	<0.5	0	0	0	0
14.05.00	24.05		1,287	<0.5	0	0	0	0
15.05.00	25.05		1,347	<0.5	0	0	0	0
16.05.00	24.00		1,274	<0.5	0	0	0	0
17.05.00	24.10		1,289	<0.5	0	0	0	0
18.05.88	23.20		1,245	<0.5	0	0	0	0
19.05.00				NO SAMPLE				
20.05.00				NO SAMPLE				
21.05.00				NO SAMPLE				
22.05.00	96.00		5,166	1.0	0	0	0	0
23.05.00	24.25		1,283	<0.5	0	0	0	0
24.05.00	23.55		1,253	<0.5	0	0	0	0
25.05.00	24.05		1,269	<0.5	0	0	0	0
26.05.00	23.35		1,230	<0.5	0	0	0	0
27.05.00	23.25		1,226	1.0	0	0	0	0
28.05.00	23.45		1,239	<0.5	0	1	0	2
29.05.00	25.25		1,332	<0.5	0	0	0	0

SITE 1

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
30.05.00	23.35		1,217	<0.5	0	0	0	0
31.05.00	22.20		1,328	<0.5	0	0	0	0
01.06.00	24.10		1,257	<0.5	0	0	0	0
02.06.00	23.45		1,241	<0.5	0	0	0	0
03.06.00	22.50		1,176	<0.5	0	0	0	0
04.06.00	23.55		1,262	<0.5	0	0	0	0
05.06.00	25.05		1,293	<0.5	0	0	0	0
06.06.00	24.10		1,247	<0.5	0	0	0	0
07.06.00	24.00		1,239	<0.5	0	0	0	0
08.06.00	24.15		1,243	<0.5	0	0	0	0
09.06.00	25.20		1,306	<0.5	0	0	0	0
10.06.00	21.10		1,075	<0.5	0	0	0	0
11.06.00	24.00		1,228	<0.5	0	0	0	0
12.06.00	25.00		1,282	<0.5	0	0	0	0
13.06.00	22.50		1,167	<0.5	0	0	0	0
14.06.00	23.55		1,230	<0.5	0	0	0	0
15.06.00	25.25		1,304	<0.5	0	0	0	0
16.06.00	25.35		1,306	<0.5	0	0	0	0
17.06.00	21.45		1,082	<0.5	0	0	0	0
18.06.00	23.55		1,219	<0.5	0	0	0	0
19.06.00								

SITE 2

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
09.05.00	23.45	1.5	1389	<0.5	0	0	0	0
10.05.00	25.30	0.7	1511	<0.5	0	0	0	0
11.05.00	22.45	0.5	1238	<0.5	0	0	0	0
12.05.00	24.00	0.5	1352	<0.5	0	0	0	0
13.05.00	23.30	0.5	1328	<0.5	0	10	0	0
14.05.00	24.00	0.6	1351	<0.5	2	4	0	1
15.05.00	24.45	0.5	1405	<0.5	0	0	0	1
16.05.00	23.45	0.5	1333	<0.5	3	1	4	7
17.05.00	28.45	0.5	1627	<0.5	1	11	1	15
18.05.00	19.10	0.5	1092	<0.5	1	7	1	12
19.05.00	26.20	0.5	1516	1.0	6	20	5	21
20.05.00	22.35	1.1	1278	0.5	0	10	4	9
21.05.00	23.55	1.1	1340	<0.5	10	5	1	9
22.05.00	23.20	0.9	1303	<0.5	5	8	12	5
23.05.00	23.50	0.9	1328	<0.5	1	7	1	10
24.05.00	24.00	0.6	1343	<0.5	11	17	0	4
25.05.00	24.20	0.6	1358	<0.5	5	5	2	7
26.05.00	26.00	0.7	1457	<0.5	1	4	1	5
27.05.00	21.30	0.8	1201	<0.5	3	3	1	2
28.05.00	24.50	0.6	1393	<0.5	1	6	1	2
29.05.00	23.25	0.8	1301	<0.5	4	0	1	0

SITE 2

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
30.05.00				NO SAMPLE				
31.05.00	51.50	1.7	2,356	<0.5	14	36	1	4
01.06.00				NO SAMPLE				
02.06.00	46.25	1.3	3,202	<0.5	3	8	4	13
03.06.00	20.40	0.8	1,162	<0.5	0	5	0	0
04.06.00	25.05	0.8	1,394	<0.5	0	10	0	1
05.06.00	27.50	0.8	1,549	<0.5	1	2	0	0
06.06.00				NO SAMPLE				
07.06.00	49.25	1.5	2,799	<0.5	0	0	0	0
08.06.00	21.40	0.7	1,193	<0.5	0	0	1	2
09.06.00	24.30	0.9	1,356	0.5	0	3	0	0
10.06.00	23.25	0.9	1,261	0.5	0	0	0	0
11.06.00	22.00	0.6	1,221	0.5	2	2	0	0
12.06.00	28.25	2.6	1,617	<0.5	9	0	0	0
13.06.00	24.05	0.9	1,343	0.5	0	0	0	0
14.06.00	24.30	0.9	1,368	<0.5	0	0	0	0
15.06.00	20.50	0.6	1,153	<0.5	2	3	0	0
16.06.00	24.30	0.9	1,364	0.5	0	5	0	0
17.06.00	20.15	0.7	1,126	<0.5	1	23	0	1
18.06.00	23.55	0.4	1,331	<0.5	4	33	0	1
19.06.00	27.55	0.9	1,507	<0.5	11	37	1	0
23.06.00	25.55	0.4	1,493	0.5	0	25	0	3

SITE 3

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
16.05.00	24.20	2.25	1,355	<0.5	0	0	0	0
17.05.00	23.30	1.0	1,280	<0.5	0	0	0	0
18.05.00	24.00	0.95	1,290	<0.5	0	0	0	0
19.05.00	24.00		No vol	<0.5	0	0	0	0
20.05.00				NO SAMPLE				
21.05.00			No vol	<0.5	0	0	0	0
22.05.00			No vol	<0.5	0	0	0	0
23.05.00				NO SAMPLE				
24.05.00			No vol	<0.5	0	0	0	0
25.05.00	24.50	0.25	60	<0.5	0	0	0	0
26.05.00	23.40	0.0	13	<0.5	0	0	0	0
27.05.00	23.50	0.0	65	<0.5	0	0	0	0
28.05.00	24.00	0.25	60	<0.5	0	0	0	0
29.05.00	23.50	0.01	66	<0.5	0	0	0	0
30.05.00	23.15	0.0	62	<0.5	0	0	0	0
31.05.00	26.40	1.0	289	<0.5	0	0	0	0
01.06.00				NO SAMPLE				
02.06.00	46.45	1.25	519	1.0	1	1	0	1
03.06.00	22.25	0.75	202	<0.5	0	0	0	0
04.06.00	24.05	0.0	321	<0.5	0	0	0	0
05.06.00	26.10	1.0	327	<0.5	0	0	0	0

SITE 3

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium DAPI +	Cryptosporidium DAPI -	Giardia DAPI +	Giardia DAPI -
06.06.00				NO SAMPLE				
07.06.00	48.25	1.25	531	<0.5	0	0	0	0
08.06.00	22.35	0.75	358	<0.5	0	0	0	0
09.06.00	25.30	1.0	215	<0.5	0	0	0	0
10.06.00	21.55	0.25	213	<0.5	0	0	0	0
11.06.00	23.25	0.0	293	<0.5	0	0	0	0
12.06.00	26.30	0.0	363	<0.5	0	0	0	0
13.06.00	23.55	0.0	267	<0.5	0	0	0	0
14.06.00	23.20	0.0	286	<0.5	0	0	0	0
15.06.00	24.25	0.0	246	1.0	0	0	0	0
16.06.00	23.55	0.25	287	<0.5	0	0	0	0
17.06.00	22.00	0.0	297	<0.5	0	0	0	0
18.06.00	25.35	0.0	323	<0.5	0	0	0	0
19.06.00	24.45	0.75	449	<0.5	0	0	0	0
20.06.00	21.20	0.0	363	<0.5	0	0	0	0
21.06.00	25.00	0.0	205	<0.5	0	0	0	0
22.06.00	23.00	0.0	210	<0.5	0	0	0	0
23.06.00				NO DATA				
24.06.00	22.20	0.0	251	<0.5	0	0	0	0
25.06.00	23.55	0.0	353	<0.5	0	0	0	0
26.06.00	25.05	0.1	348	0.5	0	0	0	0

SITE 4

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
09.05.00	22.35	0.5	1,293	0.5	0	0	0	0
10.05.00	24.00	6.4	1,235	<0.5	0	0	0	0
11.05.00	24.00	6.4	1,174	<0.5	0	0	0	0
12.05.00	24.00	5.2	1,360	<0.5	0	0	0	0
13.05.00	24.25	4.6	1,393	<0.5	0	0	0	0
14.05.00	24.45	3.2	1,398	<0.5	0	0	0	0
15.05.00	22.40	4.3	1,263	<0.5	0	0	0	0
16.05.00	32.50	5.8	1,834	1.0	0	0	0	0
17.05.00	15.00	3.0	874	0.5	0	0	0	0
18.05.00				NO SAMPLE				
19.05.00	30.45	4.6	359	1.0	0	0	0	0
20.05.00	19.25	5.7	1,046	0.5	0	0	0	0
21.05.00	23.40	3.7	1,307	1.0	0	0	0	0
22.05.00	23.20	7.2	1,038	1.0	0	0	0	0
23.05.00				NO SAMPLE				
24.05.00	24.10	6.5	519	0.5	0	0	0	0
25.05.00	24.00	4.0	1,692	1.0	0	0	0	0
26.05.00	23.45	6.5	998	1.0	0	0	0	0
27.05.00	25.00	6.75	348	1.0	0	0	0	0
28.05.00	24.20	6.4	1,730	0.5	0	0	0	0
29.05.00	23.28	5.5	1,803	1.0	0	0	0	0

SITE 4

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
30.05.00	23.05	3.0	833	0.5	0	0	0	0
31.05.00	24.02	6.4	1,320	0.5	0	0	0	0
01.06.00	23.51	6.6	1,048	0.5	0	0	0	0
02.06.00	24.02	6.5	1,073	0.5	0	0	0	0
03.06.00	24.15	4.0	1,378	0.5	0	0	0	0
04.06.00	23.57	6.4	1,323	0.5	0	0	0	0
05.06.00	23.55	6.6	1,158	0.5	0	0	0	0
06.06.00	24.10	6.8	940	<0.5	0	0	0	0
07.06.00	24.20	5.8	1,254	0.5	0	0	0	0
08.06.00	24.35	6.8	800	0.5	0	0	0	0
09.06.00	23.40	7.75	919	0.5	0	0	0	0
10.06.00	23.45	6.9	810	<0.5	0	0	0	0
11.06.00	23.29	6.9	1,034	0.5	0	0	0	0
12.06.00	24.02	3.8	1,218	1.0	0	0	0	0
13.06.00	23.53	7.0	850	1.0	0	0	0	0
14.06.00	24.00	5.5	1,228	1.5	0	0	0	0
15.06.00	23.55	6.0	943	1.0	0	0	0	0
16.06.00	24.00	7.5	568	1.0	0	0	0	0
17.06.00	25.55	6.0	1,217	1.0	0	0	0	0
18.06.00	23.00	5.5	1,176	1.0	0	0	0	0
19.06.00								

SITE 5

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
09.05.00	23.25	0.7	1300	<0.5	0	0	1	0
10.05.00	23.45	0.5	1282	<0.5	0	0	0	0
11.05.00	24.10	0.6	1289	<0.5	0	0	0	0
12.05.00	23.50	0.7	1283	<0.5	0	0	0	0
13.05.00	24.30	0.5	1317	<0.5	0	0	0	0
14.05.00	24.45	0.6	1322	<0.5	0	0	0	0
15.05.00	23.15	0.7	1214	<0.5	0	0	0	0
17.05.00	48.00	0.8	2582	<0.5	54	19	1	8
18.05.00	24.00	1.0	No vol	<0.5	30	54	0	2
19.05.00	28.30	0.6	No vol	<0.5	0	0	0	0
20.05.00	19.15	0.6	1004	<0.5	1	0	1	0
21.05.00	23.55	0.8	1266	<0.5	0	0	0	0
22.05.00	25.40	0.8	1365	<0.5	0	0	0	0
23.05.00	22.30	0.8	1119	<0.5	1	0	0	0
24.05.00	24.30	0.8	1354	<0.5	0	0	0	0
25.05.00	23.40	0.8	1253	<0.5	1	0	0	0
26.05.00	24.25	0.7	1282	<0.5	0	0	0	0
27.05.00	24.35	0.8	1296	<0.5	3	3	1	2
28.05.00	24.45	0.8	1312	<0.5	0	0	0	0
29.05.00	22.30	0.9	1196	<0.5	0	0	0	0
30.05.00				NO SAMPLE				

SITE 5

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
31.05.00	52.55	0.9	4010	<0.5	0	0	0	0
01.06.00				NO SAMPLE				
02.06.00	42.40	0.9	2267	<0.5	0	0	0	0
03.06.00	24.25	1.0	1306	<0.5	1	0	0	0
04.06.00	24.55	1.1	1334	<0.5	0	0	0	0
05.06.00	23.15	0.7	1227	<0.5	4	2	0	0
06.06.00				NO SAMPLE				
07.06.00	49.15	0.8	2603	<0.5	0	0	0	0
08.06.00	27.30	0.7	1444	<0.5	0	0	0	0
09.06.00	18.50	0.7	989	<0.5	0	0	0	0
10.06.00	24.45	0.6	1303	<0.5	9	26	0	0
11.06.00	24.20	0.8	1276	<0.5	2	1	0	0
12.06.00	23.25	0.8	1238	<0.5	0	0	0	0
13.06.00	23.50	0.5	1256	<0.5	0	1	1	0
14.06.00	25.05	0.8	729	<0.5	0	0	0	0
15.06.00	23.20	0.8	1264	<0.5	0	0	0	0
16.06.00	23.30	0.8	1214	<0.5	0	0	0	0
17.06.00	23.25	0.7	1239	<0.5	0	1	0	0
18.06.00	23.50	0.9	669	<0.5	0	0	0	0
19.06.00	28.30	0.7	1811	<0.5	0	0	0	0
23.06.00	26.00	0.7	1417	<0.5	4	0	0	0

SITE 6

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
16.05.00	24.15	5.25	1418	<0.5	0	0	0	0
17.05.00	23.30	5.75	1367	<0.5	0	0	0	0
18.05.00	24.05	6.50	1390	<0.5	0	0	0	0
19.05.00	24.00	6.00	1387	<0.5	0	0	0	0
20.05.00	23.25	5.75	1132	<0.5	0	0	0	0
21.05.00	24.00	4.75	1386	NO DATA				
22.05.00	26.20	5.40	1522	<0.5	0	0	0	0
23.05.00	24.05	5.50	1369	<0.5	0	0	0	0
24.05.00	23.25	5.50	750	<0.5	0	0	0	0
25.05.00	24.45	5.75	2019	<0.5	0	0	0	0
26.05.00	22.55	4.95	1324	<0.5	0	0	0	0
27.05.00	22.50	4.70	1320	1.0	0	0	0	0
28.05.00	24.55	4.20	1433	<0.5	0	0	0	0
29.05.00	23.05	2.70	1320	<0.5	0	0	0	0
30.05.00	24.10	7.10	1106	0.5	0	0	0	0
31.05.00	26.35	9.50	713	1.0	0	0	0	0
01.06.00				NO SAMPLE				
02.06.00	47.50	9.50	1030	1.0	0	0	0	0
03.06.00	22.25	8.00	1231	2.0	0	0	0	0
04.06.00	24.00	7.70	922	2.0	0	0	0	0
05.06.00	26.10	8.00	1860	1.0	0	0	0	0

SITE 6

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
06.06.00				NO SAMPLE				
07.06.00	48.15	9.00	2372	1.0	0	0	0	0
08.06.00	22.40	4.25	1326	<0.5	0	0	0	0
09.06.00	25.25	3.75	1472	<0.5	0	0	0	0
10.06.00	23.10	4.50	1208	<0.5	0	0	0	0
11.06.00	23.30	3.25	1416	<0.5	0	0	0	0
12.06.00	25.35	4.00	1503	<0.5	0	0	0	0
13.06.00	24.40	4.75	1428	<0.5	0	0	0	0
14.06.00	23.30	5.50	1359	<0.5	0	0	0	0
15.06.00	24.15	5.50	1397	<0.5	0	0	0	0
16.06.00	24.00	4.50	1387	<0.5	0	0	0	0
17.06.00	22.00	3.37	1277	<0.5	0	0	0	0
18.06.00	24.40	2.50	1431	<0.5	0	0	0	0
19.06.00	25.40	2.00	1476	<0.5	0	0	0	0
20.06.00	21.25	5.00	1233	0.5	0	0	0	0
21.06.00	24.55	4.50	1444	0.5	0	0	0	0
22.06.00	22.55	4.50	1322	<0.5	0	0	0	0
23.06.00				NO SAMPLE				
24.06.00	22.00	6.30	893	<0.5	0	0	0	0
25.06.00	23.50	2.75	1386	0.5	0	0	0	0
26.06.00	25.10	3.10	851	<0.5	0	0	0	0

SITE 7

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
09.05.00			399	1.0	0	0	0	0
10.05.00	23.45	7.1	1295	1.0	0	0	0	0
11.05.00	24.00		1235	1.0	0	0	0	0
12.05.00	24.00		1340	1.0	0	0	0	0
13.05.00	23.48	5.5	1318	<0.5	0	1	0	9
14.05.00	23.40	6.0	1273	1.0	2	2	0	2
15.05.00	24.32		1280	1.0	0	2	1	13
16.05.00	24.00		1359	1.0	0	0	0	1
17.05.00	24.15	6.2	1340	1.0	0	0	0	2
18.05.00	23.45		1263	0.5	0	0	0	0
19.05.00	24.00		1286	1.0	0	0	0	5
20.05.00	24.00	3.2	1253	0.5	0	0	1	4
21.05.00	24.00	7.0	1275	1.0	0	1	0	0
22.05.00	24.00		1168	1.0	0	1	0	5
23.05.00				NO SAMPLE				
24.05.00	24.00		1285	1.0	0	0	2	11
25.05.00	23.25		1273	1.0	0	0	0	5
26.05.00	24.00		1315	0.5	0	0	0	0
27.05.00	24.05	4.1	1220	0.5	0	2	0	9
28.05.00	24.00	9.2	458	1.5	6	45	10	9
29.05.00	24.00		1298	1.5	0	0	0	0

SITE 7

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	Cryptosporidium		Giardia	
					DAPI +	DAPI -	DAPI +	DAPI -
30.05.00	24.05	8.5	781	1.0	9	2	26	176
31.05.00	23.40	4.5	1312	1.0	1	3	4	31
01.06.00	24.35	8.1	1050	1.0	2	4	1	19
02.06.00	23.35	8.1	1014	1.0	0	0	0	18
03.06.00	24.05	8.2	1020	1.0	0	0	0	3
04.06.00	23.50	8.7	798	1.0	109	20	68	286
05.06.00	24.00	9.8	112	1.0	96	223	77	309
06.06.00	24.00	8.8	572	1.0	24	91	5	199
07.06.00	24.00	8.4	843	1.0	11	9	2	26
08.06.00	23.55	9.2	635	0.5	1	17	0	0
09.06.00	24.05	9.6	186	1.0	2	6	1	1
10.06.00	24.00	9.8	91	1.0	0	6	0	6
11.06.00	24.15	9.7	61	1.0	1	4	0	0
12.06.00	23.45	6.1	1286	1.5	2	0	0	0
13.06.00	23.55	9.7	271	1.0	2	4	0	0
14.06.00	24.15	8.5	368	1.5	0	0	0	0
15.06.00	24.00	9.0	726	2.0	0	0	0	0
16.06.00	23.45	8.0	883	1.0	1	0	0	0
17.06.00	24.00	5.1	1270	1.0	0	0	0	0
18.06.00	24.15	5.5	666	1.0	2	0	0	0

Appendix A.3 Chemistry Results, Phase 2

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
2	11.00	25/09/00	1.0	7.88	405	<1	0.009	61.30	1.40	18.20	12.60	<1.0	19.80	7.10	<1.0	10.30
2	11.00	25/09/00	0.7	8.12	411	<1	0.005	60.30	1.20	18.10	12.40	<1.0	20.10	7.20	<1.0	10.40
2	13.30	25/09/00	0.9	8.63	-	-	-	-	-	-	-	<1.0	20.20	9.10	<1.0	11.30
2	13.30	26/09/00	0.2	7.79	425	<1	<0.002	63.00	1.20	18.80	12.50	<1.0	19.60	7.70	<1.0	10.40
2	13.30	26/09/00	0.4	8.27	413	<1	<0.002	62.40	1.30	18.50	12.70	<1.0	19.80	7.70	<1.0	10.60
2	13.50	27/09/00	0.4	7.87	420	<1	<0.002	63.80	1.30	18.90	12.60	<1.0	19.70	8.10	<1.0	10.30
2	13.50	27/09/00	0.7	8.22	357	<1	<0.002	62.30	1.70	18.70	12.40	<1.0	20.10	8.10	<1.0	10.60
2	13.30	28/09/00	0.8	8.31	-	-	-	-	-	-	-	<1.0	20.30	8.80	<1.0	16.60
2	10.50	29/09/00	0.2	8.00	382	<1	<0.002	59.50	1.20	17.80	12.00	<1.0	20.50	9.00	<1.0	10.30
2	10.50	29/09/00	0.3	8.36	377	<1	<0.002	59.50	1.20	17.70	11.90	<1.0	20.70	9.10	<1.0	10.50
2	7.30	30/09/00	-	7.48	380	<1.0	<0.002	52.14	1.38	16.08	12.64	<1.0	19.65	9.21	<1.0	9.71
2	10.40	01/10/00	-	7.98	407	<1.0	<0.002	51.88	1.68	16.17	12.55	<1.0	19.86	9.70	<1.0	9.70
2	10.40	01/10/00	-	7.92	419	<1.0	<0.002	52.79	1.34	16.43	12.73	<1.0	19.55	9.65	<1.0	9.65
2	11.50	01/10/00	-	6.83	185	<1.0	<0.002	20.43	2.33	5.08	7.88	<1.0	13.28	8.31	<1.0	6.38
2	12.45	02/10/00		7.31	419	<1.0	<0.002	53.05	1.21	16.62	12.79	<1.0	19.67	9.83	<1.0	9.61
2	12.45	02/10/00		7.36	427	<1.0	<0.002	52.38	1.44	16.37	12.73	<1.0	19.86	9.83	<1.0	9.56
2	11.30	03/10/00	-	7.76	425	<1.0	<0.002	52.40	1.25	16.25	13.40	<1.0	21.04	10.04	<1.0	9.67
2	11.30	03/10/00	<0.2	7.71	428	<1.0	<0.002	55.14	1.71	17.26	14.71	<1.0	19.76	9.52	<1.0	8.94
2	13.15	04/10/00	0.3	7.58	426	<1.0	<0.002	54.27	1.38	16.82	13.86	<1.0	19.12	9.49	<1.0	8.85
2	13.15	04/10/00	0.6	7.60	432	<1.0	<0.002	55.20	1.38	17.16	14.06	<1.0	19.15	9.62	<1.0	9.01
2	8.50	05/10/00	0.5	7.75	421	<1.0	<0.002	52.78	2.03	16.38	13.40	<1.0	19.00	9.63	<1.0	8.64
2	8.50	05/10/00	0.6	7.71	424	<1.0	<0.002	54.25	1.42	17.03	13.92	<1.0	18.96	9.55	<1.0	8.76
2	9.20	06/10/00	0.5	7.41	399	<1.0	<0.002	54.41	1.24	16.86	13.73	<1.0	18.74	9.59	<1.0	8.71
2	9.20	06/10/00	0.4	7.45	417	<1.0	<0.002	54.59	1.30	16.97	13.83	<1.0	18.92	9.68	<1.0	8.73
2	9.00	07/10/00	0.6	7.48	424	<1.0	<0.002	55.44	1.34	17.18	13.78	<1.0	18.88	9.90	<1.0	8.78
2	9.00	07/10/00	-	7.43	421	<1.0	-	-	-	-	-	<1.0	19.30	10.00	<1.0	8.89
2	9.40	08/10/00	0.3	7.65	420	<1.0	<0.002	55.31	1.49	17.09	13.68	<1.0	18.90	10.06	<1.0	8.59
2	9.40	08/10/00	0.4	7.49	428	<1.0	<0.002	55.79	1.23	17.22	13.83	<1.0	18.92	10.04	<1.0	8.78
2	12.15	09/10/00	0.7	7.66	427	<1.0	<0.002	54.77	1.71	16.89	13.51	<1.0	19.06	10.21	<1.0	8.72
2	12.15	09/10/00	0.6	7.60	424	<1.0	<0.002	55.51	1.96	17.16	13.75	<1.0	19.30	10.34	<1.0	8.64
2	12.20	10/10/00	1.0	7.61	430	<1.0	<0.002	55.43	1.44	17.01	13.68	<1.0	18.91	10.29	<1.0	8.65
2	12.20	10/10/00	0.4	7.58	428	<1.0	<0.002	55.60	1.57	17.05	13.72	<1.0	19.00	10.35	<1.0	8.64
2	13.40	11/10/00	0.4	7.70	430	<1.0	<0.002	55.87	1.55	16.95	13.64	<1.0	18.92	10.57	<1.0	8.53
2	13.40	11/10/00	0.3	7.29	432	<1.0	<0.002	55.70	1.49	17.03	13.75	<1.0	18.76	10.54	<1.0	8.54
2	11.40	12/10/00	0.3	7.50	425	<1.0	<0.002	55.68	1.17	16.99	13.59	<1.0	18.47	10.58	<1.0	8.44
2	11.40	12/10/00	0.5	7.52	429	<1.0	<0.002	54.68	1.84	16.58	13.33	<1.0	19.07	10.84	<1.0	8.84
2	12.55	13/10/00	0.4	7.70	433	<1.0	<0.002	55.34	1.59	16.80	13.54	<1.0	18.97	10.80	<1.0	8.34

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
2	12.55	13/10/00	0.4	7.69	428	<1.0	<0.002	55.53	1.38	16.84	13.57	<1.0	18.94	10.82	<1.0	8.50
2	10.00	14/10/00	0.2	7.61	425	<1.0	<0.002	55.09	1.62	16.75	13.50	<1.0	18.99	10.83	<1.0	8.37
2	10.00	14/10/00	0.3	7.56	439	<1.0	<0.002	55.73	1.26	16.79	13.50	<1.0	18.95	10.84	<1.0	8.55
2	10.10	15/10/00	0.3	7.60	437	<1.0	<0.002	54.39	1.18	16.52	13.30	<1.0	19.14	10.91	<1.0	8.65
2	10.10	15/10/00	0.6	7.54	436	<1.0	<0.002	53.95	1.14	16.39	13.26	<1.0	18.95	10.84	<1.0	8.45
2	13.30	16/10/00	0.8	7.30	448	<1.0	<0.002	55.53	1.99	16.77	13.74	<1.0	19.84	11.17	<1.0	8.46
2	13.30	16/10/00	0.4	7.34	445	<1.0	<0.002	55.85	1.29	16.87	13.69	<1.0	19.38	11.03	<1.0	8.58
2	12.55	17/10/00	0.5	7.35	432	<1.0	<0.002	54.90	1.26	16.58	13.60	<1.0	19.32	11.07	<1.0	8.49
2	12.55	17/10/00	<0.2	7.37	441	<1.0	<0.002	55.25	1.22	16.76	13.61	<1.0	19.42	11.10	<1.0	8.58
2	13.15	18/10/00	0.3	8.04	417	<1.0	<0.002	56.52	1.48	16.98	13.86	<1.0	23.36	13.51	<1.0	10.95
2	13.15	18/10/00	0.3	8.34	408	<1.0	<0.002	56.10	1.62	16.87	13.84	<1.0	23.46	13.59	<1.0	11.05
2	11.15	20/10/00	0.3	8.43	416	<1.0	<0.002	56.82	1.69	17.07	13.98	<1.0	23.63	13.93	<1.0	11.42
2	11.15	20/10/00	0.1	8.43	420	<1.0	<0.002	56.32	1.61	16.95	13.72	<1.0	23.40	13.85	<1.0	10.95
2	10.40	21/10/00	0.4	8.41	411	<1.0	<0.002	54.83	1.41	16.43	13.41	<1.0	23.37	13.84	<1.0	10.93
2	11.15	22/10/00	0.2	8.42	403	<1.0	<0.002	53.93	1.21	16.09	13.31	<1.0	22.57	12.86	<1.0	10.85
2	13.55	23/10/00	0.2	8.45	259	<1.0	<0.002	34.26	0.66	8.50	11.12	<1.0	17.08	3.49	<1.0	7.65
2	13.55	23/10/00	0.2	8.31	256	<1.0	<0.002	32.85	0.95	8.17	10.76	<1.0	16.79	3.40	<1.0	7.66
2	13.55	24/10/00	0.3	7.50	211	<1.0	<0.002	25.18	0.96	5.67	9.84	<1.0	15.62	<1.0	<1.0	6.26
2	13.35	24/10/00	0.3	7.50	207	<1.0	<0.002	25.27	0.60	5.68	9.83	<1.0	15.35	<1.0	<1.0	6.26
2	13.50	25/10/00	0.4	7.85	190	<1.0	<0.002	23.05	0.54	5.10	9.56	<1.0	13.73	0.47	<1.0	5.61
2	13.50	25/10/00	0.3	7.56	184	<1.0	<0.002	23.16	0.63	5.15	9.64	<1.0	13.47	0.48	<1.0	5.43
2	12.15	26/10/00	0.6	7.46	233	<1.0	<0.002	25.64	1.09	7.05	11.60	<1.0	17.35	4.04	<1.0	6.60
2	12.15	26/10/00	0.4	7.67	224	<1.0	<0.002	25.63	1.27	6.97	11.48	<1.0	17.36	4.06	<1.0	6.53
2	12.00	27/10/00	0.4	7.59	273	<1.0	<0.002	30.35	1.60	8.82	13.01	<1.0	20.16	6.31	<1.0	7.60
2	12.00	27/10/00	0.3	7.35	284	<1.0	<0.002	31.65	1.48	9.25	13.40	<1.0	20.66	6.33	<1.0	7.90
2	9.20	28/10/00	0.3	7.85	345	<1.0	<0.002	38.21	1.88	11.53	15.40	<1.0	24.57	9.38	<1.0	9.30
2	9.30	28/10/00	0.2	7.62	312	<1.0	<0.002	35.38	1.53	10.52	14.56	<1.0	22.85	8.02	<1.0	8.71
2	9.20	28/10/00	0.4	7.75	334	<1.0	<0.002	37.73	1.65	11.36	15.09	<1.0	24.02	9.10	<1.0	9.07
2	9.30	28/10/00	0.3	7.57	312	<1.0	<0.002	34.95	1.49	10.43	14.38	<1.0	22.80	7.89	<1.0	8.73
2	13.30	30/10/00	0.2	7.94	354	<1.0	<0.002	39.80	1.69	12.09	15.61	<1.0	25.77	10.44	<1.0	9.75
2	13.30	30/10/00	0.5	7.68	350	<1.0	<0.002	39.64	1.65	12.05	15.66	<1.0	25.43	10.21	<1.0	9.63
2	12.30	31/10/00	0.1	7.60	365	<1.0	<0.002	40.74	1.62	12.46	15.82	<1.0	26.20	10.88	<1.0	9.92
2	12.30	31/10/00	0.2	7.48	366	<1.0	<0.002	40.38	1.58	12.37	15.72	<1.0	26.38	10.94	<1.0	9.97
2	12.35	02/11/00	0.2	7.60	360	<1.0	<0.002	40.47	1.77	12.49	15.48	<1.0	26.57	11.31	<1.0	10.05
2	8.30	02/11/00	0.2	7.41	368	<1.0	<0.002	41.32	1.72	12.71	16.13	<1.0	26.84	11.20	<1.0	10.19
2	8.50	02/11/00	0.1	7.76	376	<1.0	<0.002	41.48	1.61	12.72	15.87	<1.0	26.89	11.32	<1.0	10.11
2	12.35	02/11/00	0.2	7.87	378	<1.0	<0.002	42.62	1.63	13.16	16.42	<1.0	26.75	11.41	<1.0	10.15

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
2	12.05	03/11/00	0.5	7.27	346	<1.0	<0.002	42.65	1.71	12.95	16.31	<1.0	24.49	10.45	<1.0	9.70
2	12.05	03/11/00	0.5	7.65	360	<1.0	<0.002	42.07	2.82	12.82	16.49	<1.0	24.76	10.43	<1.0	9.36
2	9.00	04/11/00	0.3	7.73	363	<1.0	<0.002	42.69	2.15	13.02	16.36	<1.0	23.10	9.87	<1.0	9.16
2	9.00	04/11/00	0.2	7.44	362	<1.0	<0.002	42.51	2.24	12.95	16.21	<1.0	23.06	9.83	<1.0	9.06
2	8.20	05/11/00	0.5	7.38	357	<1.0	<0.002	42.44	2.25	12.88	16.28	<1.0	23.51	9.90	<1.0	9.27
2	8.20	05/11/00	0.4	7.34	358	<1.0	<0.002	42.62	1.89	12.96	15.91	<1.0	22.97	9.78	<1.0	9.15
3	10.30	25/09/00	0.2	6.40	124	<1	0.002	6.50	0.80	2.10	9.40	<1.0	18.60	2.10	<1.0	7.20
3	10.40	26/09/00	0.5	6.24	129	<1	0.003	6.60	0.80	2.10	9.70	<1.0	21.70	2.30	<1.0	8.40
3	10.30	27/09/00	0.2	6.48	144	<1	0.002	6.70	1.80	2.20	9.90	<1.0	21.70	2.20	<1.0	8.40
3	11.30	28/09/00	0.6	6.47	127	1	0.003	7.00	0.70	2.10	9.50	<1.0	20.90	3.00	<1.0	8.80
3	9.55	29/09/00	0.4	6.00	131	<1	0.003	5.80	0.90	2.10	9.30	<1.0	20.30	2.10	<1.0	8.10
3	9.45	30/09/00	0.3	6.31	185	<1	0.003	5.80	4.60	2.00	9.70	<1.0	24.40	2.50	<1.0	8.40
3	8.55	01/10/00	0.2	6.12	164	<1	0.004	6.00	3.40	2.00	9.60	<1.0	19.60	1.80	<1.0	7.80
3	10.15	02/10/00	0.4	6.20	120	<1.0	0.020	6.34	0.93	2.11	13.39	<1.0	19.39	1.73	<1.0	7.99
3	10.45	02/10/00	<0.2	6.00	117	<1.0	0.002	5.63	0.80	2.05	12.62	<1.0	17.58	1.84	<1.0	6.91
3	10.25	03/10/00	<0.2	5.86	120	<1.0	0.002	5.59	0.83	2.08	12.73	<1.0	17.50	1.79	<1.0	6.93
3	8.45	04/10/00	<0.2	5.99	119	<1.0	0.002	5.67	0.88	2.08	12.61	<1.0	17.73	1.86	<1.0	7.05
3	8.30	05/10/00	<0.2	5.98	118	<1.0	<0.002	5.65	0.65	2.08	12.76	<1.0	17.66	1.71	<1.0	7.04
3	9.30	06/10/00	0.4	5.97	120	<1.0	0.002	5.76	0.89	2.09	12.79	<1.0	17.61	1.77	<1.0	6.93
3	8.35	07/10/00	0.3	5.99	118	<1.0	<0.002	5.80	0.81	2.09	12.66	<1.0	17.94	1.80	<1.0	7.06
3	8.55	08/10/00	0.3	5.97	119	<1.0	0.003	5.82	0.78	2.08	12.70	<1.0	17.79	1.71	<1.0	7.15
3	12.15	09/10/00	0.4	6.01	116	<1.0	0.004	6.21	0.83	2.07	12.81	<1.0	17.84	1.68	<1.0	7.13
3	10.05	10/10/00	0.2	5.96	119	<1.0	0.003	6.11	0.73	2.08	12.63	<1.0	18.06	1.74	<1.0	7.02
3	10.55	11/10/00	0.2	5.88	118	<1.0	0.004	6.26	0.68	2.08	12.83	<1.0	17.91	1.63	<1.0	7.22
3	10.15	12/10/00	0.3	6.01	118	<1.0	0.004	6.31	0.76	2.05	12.82	<1.0	17.98	1.72	<1.0	7.06
3	10.35	13/10/00	0.2	5.99	119	<1.0	0.006	6.27	0.59	2.01	12.80	<1.0	17.79	1.57	<1.0	6.83
3	10.20	14/10/00	0.3	6.02	118	<1.0	0.007	6.30	0.88	2.01	12.84	<1.0	18.02	1.64	<1.0	6.93
3	10.15	15/10/00	0.5	5.88	119	<1.0	0.007	5.90	0.69	2.06	12.85	<1.0	17.72	1.75	<1.0	6.78
3	10.30	16/10/00	0.4	5.96	116	<1.0	0.006	6.16	0.88	2.04	12.92	<1.0	18.14	1.72	<1.0	6.91
3	10.40	17/10/00	0.1	6.24	120	<1.0	0.008	6.28	0.84	2.08	12.85	<1.0	21.63	2.00	<1.0	9.08
3	10.49	18/10/00	0.2	6.36	119	<1.0	0.008	6.14	0.84	2.10	12.96	<1.0	21.78	2.17	<1.0	8.94
3	8.30	19/10/00	0.2	6.33	123	<1.0	0.010	6.10	0.71	2.17	13.05	<1.0	21.58	2.20	<1.0	9.07
3	10.00	20/10/00	0.3	6.24	118	<1.0	0.012	6.41	0.88	2.14	13.08	<1.0	22.23	1.97	<1.0	9.12
3	9.15	21/10/00	0.3	6.19	120	<1.0	0.011	6.55	0.81	2.17	13.15	<1.0	22.19	2.08	<1.0	9.11
3	8.30	22/10/00	0.2	6.20	124	<1.0	0.008	6.47	0.72	2.09	12.94	<1.0	21.91	2.04	<1.0	9.12
3	11.10	23/10/00	0.3	6.17	119	<1.0	0.010	6.41	0.82	2.14	13.11	<1.0	22.01	2.00	<1.0	8.99
3	11.05	24/10/00	0.3	6.28	114	<1.0	0.011	6.29	0.79	2.14	13.33	<1.0	19.10	1.77	<1.0	8.01

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
3	10.25	25/10/00	0.2	6.21	118	<1.0	0.012	6.00	1.10	2.09	13.07	<1.0	19.14	1.88	<1.0	7.96
3	11.20	26/10/00	0.5	6.19	123	<1.0	0.011	6.27	0.92	2.11	13.17	<1.0	19.20	1.78	<1.0	7.87
3	10.35	27/10/00	0.2	6.18	125	<1.0	0.017	6.34	0.99	2.10	13.25	<1.0	19.50	1.86	<1.0	7.90
3	8.45	28/10/00	0.3	6.22	125	<1.0	0.030	6.44	0.82	2.13	13.14	<1.0	19.50	1.79	<1.0	7.87
3	8.40	29/10/00	0.3	6.28	124	<1.0	0.024	6.38	1.05	2.15	13.16	<1.0	19.75	1.87	<1.0	7.92
3	10.40	30/10/00	0.2	6.22	126	<1.0	0.028	6.48	1.08	2.15	13.64	<1.0	20.35	1.90	<1.0	7.89
3	11.10	31/10/00	0.4	6.22	126	<1.0	0.025	6.35	0.82	2.12	13.41	<1.0	19.87	1.88	<1.0	7.99
3	10.16	01/11/00	1.0	6.20	123	<1.0	0.018	6.19	0.66	2.07	13.16	<1.0	19.41	1.74	<1.0	7.95
3	11.00	03/11/00	1.0	6.06	117	<1.0	0.012	6.10	0.83	2.05	13.10	<1.0	17.82	1.54	<1.0	7.69
3	8.30	04/11/00	0.3	5.99	114	<1.0	0.020	6.15	0.81	2.04	13.03	<1.0	16.99	1.51	<1.0	7.32
3	8.50	05/11/00	1.0	5.99	116	<1.0	0.028	6.29	0.83	2.06	13.05	<1.0	17.18	1.49	<1.0	7.27
4	8.05	22/09/00	3.0	7.42	222	2	0.017	22.20	1.30	10.70	9.50	<1.0	21.50	1.00	<1.0	11.00
4	8.10	23/09/00	5.0	7.65	248	6	0.009	21.50	1.40	10.10	9.10	<1.0	20.90	<1.0	<1.0	11.00
4	8.15	24/09/00	3.5	7.22	245	4	0.015	21.50	1.10	10.10	8.40	<1.0	21.10	2.00	<1.0	11.20
4	8.10	25/09/00	2.9	7.12	258	3	0.010	22.30	1.10	10.30	8.90	<1.0	22.60	2.00	<1.0	11.50
4	8.00	26/09/00	2.5	7.17	248	2	0.010	22.00	1.20	10.20	8.90	<1.0	21.30	2.10	<1.0	11.30
4	8.35	27/09/00	1.5	7.00	250	3	0.008	21.40	1.20	9.90	8.80	<1.0	20.30	2.10	<1.0	11.70
4	8.25	28/09/00	0.5	7.63	311	1	0.004	35.90	3.40	8.70	10.30	<1.0	21.30	2.30	<1.0	13.00
4	7.55	01/10/00	0.5	7.35	299	<1.0	0.002	36.39	3.91	8.75	13.19	<1.0	19.57	1.99	<1.0	11.79
4	8.30	02/10/00	0.8	7.25	301	<1.0	0.002	36.77	3.96	8.86	13.27	<1.0	19.61	2.05	<1.0	11.73
4	-	03/10/00	1.2	6.98	231	<1.0	0.014	20.70	1.30	9.91	11.38	<1.0	19.18	2.75	<1.0	10.06
4	8.10	04/10/00	1.5	7.20	291	<1.0	0.008	30.63	3.70	9.80	13.51	<1.0	19.65	2.20	<1.0	11.72
4	-	06/10/00	1.1	6.80	230	<1.0	0.006	20.64	1.35	9.85	11.48	<1.0	18.33	3.36	<1.0	10.04
4	8.30	07/10/00	1.0	7.14	224	<1.0	0.005	20.87	1.25	10.01	11.62	<1.0	18.28	3.43	<1.0	9.96
4	8.20	08/10/00	1.0	7.01	240	<1.0	0.005	20.67	1.23	9.92	11.48	<1.0	18.97	3.51	<1.0	10.14
4	8.10	09/10/00	0.6	7.04	226	<1.0	0.004	20.20	1.09	9.86	11.46	<1.0	19.20	3.58	<1.0	9.97
4	8.20	10/10/00	1.2	7.08	217	<1.0	0.003	19.59	1.12	9.70	11.46	<1.0	14.97	3.55	<1.0	9.92
4	-	11/10/00	1.2	7.03	217	<1.0	0.004	19.92	1.09	9.66	11.37	<1.0	16.08	3.60	<1.0	9.89
4	8.25	12/10/00	1.2	7.02	215	<1.0	0.004	19.16	1.12	9.22	11.11	<1.0	18.28	3.66	<1.0	9.63
4	8.15	13/10/00	1.5	6.99	216	<1.0	0.004	19.53	1.06	9.49	11.32	<1.0	18.31	3.67	<1.0	9.59
4	8.10	14/10/00	1.5	6.94	220	<1.0	0.005	19.50	1.10	9.41	11.34	<1.0	18.84	3.85	<1.0	9.63
4	8.10	15/10/00	1.6	6.87	220	<1.0	0.004	19.56	1.11	9.35	11.27	<1.0	18.64	3.84	<1.0	9.58
4	8.10	16/10/00	1.2	6.93	224	<1.0	0.004	19.82	1.08	9.41	11.23	<1.0	19.74	4.16	<1.0	9.68
4	8.10	18/10/00	1.6	6.95	195	<1.0	0.003	19.42	1.62	9.56	11.97	<1.0	19.38	4.60	<1.0	10.68
4	8.15	19/10/00	-	7.60	-	-	<0.002	-	-	-	-	<1.0	23.48	5.44	<1.0	13.05
4	8.32	20/10/00	1.0	7.33	203	<1.0	0.002	18.94	1.11	9.27	11.34	<1.0	22.59	5.72	<1.0	12.40
4	-	21/10/00	1.0	6.95	213	<1.0	0.003	18.68	1.32	9.09	11.26	<1.0	22.46	5.44	<1.0	12.40

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
4	-	22/10/00	1.0	7.04	218	<1.0	0.003	19.12	1.04	9.23	11.15	<1.0	23.17	6.06	<1.0	12.38
4	8.38	23/10/00	1.0	7.01	209	<1.0	0.002	18.50	1.22	9.16	11.27	<1.0	22.46	6.24	<1.0	12.40
4	8.25	24/10/00	1.0	6.94	210	<1.0	0.003	18.64	1.21	9.34	11.39	<1.0	21.61	6.43	<1.0	12.26
4	8.25	26/10/00	1.3	6.99	180	<1.0	<0.002	18.31	1.55	9.15	11.47	<1.0	18.46	5.77	<1.0	10.58
4	8.25	28/10/00	1.1	6.79	188	<1.0	0.002	18.51	1.56	9.18	11.66	<1.0	18.11	5.79	<1.0	10.36
4	8.15	29/10/00	1.1	7.00	186	<1.0	0.002	18.82	1.18	9.21	11.63	<1.0	18.38	5.75	<1.0	10.35
4	8.25	30/10/00	1.0	7.14	177	<1.0	<0.002	17.52	1.59	8.97	11.72	<1.0	15.39	6.15	<1.0	10.34
4	8.20	31/10/00	1.4	7.02	184	<1.0	<0.002	17.94	1.73	8.84	11.50	<1.0	15.84	6.27	<1.0	10.41
4	8.25	02/11/00	1.5	6.99	206	<1.0	0.002	17.59	1.23	8.64	11.06	<1.0	14.72	5.31	<1.0	8.36
4	8.25	03/11/00	1.8	6.99	207	<1.0	0.002	17.13	1.61	8.53	11.07	<1.0	16.56	6.02	<1.0	9.23
4	8.05	04/11/00	1.5	6.96	204	<1.0	0.003	17.75	1.14	8.64	11.31	<1.0	15.33	5.65	<1.0	8.69
5	12.30	25/09/00	0.5	7.64	197	<1	<0.002	26.90	1.50	6.10	7.50	<1.0	13.30	8.30	<1.0	6.50
5	-	25/09/00	0.5	7.08	201	<1	<0.002	28.00	1.60	6.30	7.70	<1.0	13.80	8.40	<1.0	6.50
5	13.15	26/09/00	0.9	7.48	191	<1	<0.002	26.60	1.20	6.20	7.30	<1.0	13.80	8.70	<1.0	6.70
5	13.15	26/09/00	0.3	7.24	200	<1	<0.002	26.10	1.50	6.20	7.50	<1.0	14.20	9.00	<1.0	6.70
5	11.10	27/09/00	0.3	7.08	191	<1	<0.002	24.90	1.20	5.90	7.30	<1.0	13.20	8.30	<1.0	6.50
5	11.10	27/09/00	0.4	7.20	188	<1	<0.002	25.00	1.20	6.00	7.30	<1.0	13.10	8.20	<1.0	6.70
5	12.40	28/09/00	0.6	6.88	188	<1	<0.002	24.60	1.20	5.80	7.30	<1.0	13.30	8.40	<1.0	6.60
5	12.40	28/09/00	0.6	6.88	187	<1	<0.002	24.10	1.20	5.60	7.20	<1.0	13.10	8.30	<1.0	6.60
5	13.20	29/09/00	0.2	6.74	187	<1	<0.002	23.30	1.30	5.50	7.00	<1.0	13.20	8.40	<1.0	6.90
5	13.20	29/09/00	0.2	6.88	183	<1	<0.002	23.00	1.20	5.40	6.90	<1.0	12.60	8.10	<1.0	6.60
5	8.30	30/09/00	-	7.05	219	<1.0	<0.002	23.11	12.08	5.13	8.34	<1.0	21.15	9.64	<1.0	6.27
5	8.30	30/09/00	-	7.07	187	<1.0	<0.002	22.82	3.08	5.10	8.14	<1.0	13.69	8.36	<1.0	6.38
5	11.10	01/10/00	-	7.14	180	<1.0	<0.002	21.31	2.49	5.26	8.01	<1.0	13.19	8.21	<1.0	6.14
5	8.30	02/10/00	-	7.15	192	<1.0	<0.002	23.22	3.35	5.26	8.00	<1.0	13.99	8.36	<1.0	6.23
5	8.30	02/10/00	-	6.90	192	<1.0	<0.002	23.26	2.21	5.24	8.13	<1.0	13.08	8.12	<1.0	6.28
5	12.45	03/10/00	-	7.02	179	<1.0	<0.002	21.89	2.43	5.40	8.07	<1.0	13.44	8.37	<1.0	6.40
5	12.45	03/10/00	0.4	7.30	190	<1.0	<0.002	22.67	1.32	5.68	8.73	<1.0	11.87	7.61	<1.0	6.16
5	11.10	04/10/00	-	6.89	183	<1.0	<0.002	21.83	1.99	5.34	7.86	<1.0	12.73	8.55	<1.0	6.19
5	11.10	04/10/00	-	6.96	178	<1.0	<0.002	22.33	1.38	5.48	8.17	<1.0	12.73	8.32	<1.0	6.34
5	9.55	05/10/00	-	6.94	181	<1.0	<0.002	22.34	1.28	5.48	8.20	<1.0	12.43	8.18	<1.0	6.34
5	9.55	05/10/00	-	6.86	180	<1.0	<0.002	22.25	1.75	5.47	8.13	<1.0	12.67	8.24	<1.0	6.26
5	9.30	06/10/00	-	7.02	186	<1.0	<0.002	23.54	1.23	5.63	8.20	<1.0	12.82	8.79	<1.0	6.57
5	9.30	06/10/00	-	6.88	191	<1.0	<0.002	23.60	1.25	5.66	8.19	<1.0	56.20	8.81	<1.0	6.77
5	10.10	07/10/00	-	6.76	192	<1.0	<0.002	23.55	1.25	5.68	8.25	<1.0	12.88	8.74	<1.0	6.56
5	10.10	07/10/00	-	6.73	190	<1.0	<0.002	23.54	1.15	5.65	8.16	<1.0	12.67	8.59	<1.0	6.66
5	10.45	08/10/00	-	6.65	185	<1.0	<0.002	23.02	1.16	5.62	8.25	<1.0	12.48	8.52	<1.0	6.47

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
5	10.45	08/10/00	-	6.72	186	<1.0	<0.002	22.89	1.23	5.55	8.19	<1.0	12.39	8.27	<1.0	6.41
5	9.40	09/10/00	-	6.83	189	<1.0	<0.002	23.64	1.42	5.62	8.20	<1.0	12.74	8.63	<1.0	6.54
5	9.40	09/10/00	-	7.02	197	<1.0	<0.002	23.30	1.21	5.53	8.18	<1.0	12.65	8.75	<1.0	6.53
5	14.30	10/10/00	-	6.69	195	<1.0	<0.002	22.45	1.13	5.34	8.17	<1.0	11.99	8.17	<1.0	6.36
5	14.30	10/10/00	-	6.89	191	<1.0	<0.002	22.33	1.30	5.35	8.12	<1.0	12.08	8.14	<1.0	6.62
5	11.50	11/10/00	-	6.70	180	<1.0	<0.002	21.54	1.10	5.36	8.09	<1.0	11.82	7.90	<1.0	6.31
5	11.50	11/10/00	-	6.58	177	<1.0	<0.002	21.90	1.17	5.35	8.19	<1.0	11.78	7.92	<1.0	6.47
5	9.40	12/10/00	-	6.65	182	<1.0	<0.002	21.71	1.12	5.34	8.08	<1.0	12.21	7.88	<1.0	6.35
5	9.40	12/10/00	-	6.81	186	<1.0	<0.002	21.68	1.19	5.32	8.08	<1.0	12.08	7.94	<1.0	6.47
5	9.00	13/10/00	-	6.64	189	<1.0	<0.002	22.23	1.13	5.39	8.09	<1.0	11.91	7.80	<1.0	6.49
5	9.00	13/10/00	-	6.67	188	<1.0	<0.002	22.24	1.14	5.35	8.03	<1.0	12.06	7.84	<1.0	6.54
5	10.55	14/10/00	-	6.70	191	<1.0	<0.002	21.16	1.93	5.29	7.85	<1.0	12.01	7.77	<1.0	6.15
5	10.55	14/10/00	-	6.69	195	<1.0	<0.002	22.29	1.84	5.47	8.04	<1.0	12.51	8.03	<1.0	6.65
5	11.00	15/10/00	-	6.52	194	<1.0	<0.002	22.10	1.47	5.50	8.21	<1.0	12.38	8.05	<1.0	6.52
5	11.00	15/10/00	-	6.58	195	<1.0	<0.002	22.09	1.33	5.46	8.12	<1.0	12.12	7.98	<1.0	6.43
5	14.00	16/10/00	-	6.63	192	<1.0	<0.002	22.77	1.25	5.58	8.15	<1.0	12.27	8.16	<1.0	6.68
5	14.00	16/10/00	-	6.73	201	<1.0	<0.002	22.77	1.59	5.57	8.07	<1.0	12.65	8.48	<1.0	6.70
5	11.00	17/10/00	-	6.56	195	<1.0	<0.002	22.62	1.29	5.65	8.04	<1.0	12.36	8.31	<1.0	6.60
5	11.00	17/10/00	-	6.58	199	<1.0	<0.002	22.07	1.27	5.55	8.03	<1.0	12.60	8.42	<1.0	6.65
5	13.30	18/10/00	0.3	7.74	204	<1.0	<0.002	26.49	1.95	6.62	9.77	<1.0	11.21	9.64	<1.0	8.06
5	13.30	18/10/00	0.1	7.73	200	<1.0	<0.002	26.24	1.74	6.47	9.32	<1.0	13.84	9.47	<1.0	8.12
5	13.40	20/10/00	0.4	7.74	210	<1.0	<0.002	25.94	1.67	6.48	9.05	<1.0	14.17	10.10	<1.0	8.15
5	13.40	20/10/00	0.2	7.90	204	<1.0	<0.002	25.89	1.81	6.44	9.07	<1.0	14.30	10.13	<1.0	8.17
5	9.30	21/10/00	0.2	7.88	208	<1.0	<0.002	26.03	1.65	6.54	9.12	<1.0	14.21	9.99	<1.0	8.00
5	9.50	21/10/00	0.2	7.94	209	<1.0	<0.002	26.52	1.89	6.49	9.09	<1.0	14.25	9.23	<1.0	8.05
5	10.05	23/10/00	0.4	7.44	204	<1.0	<0.002	26.21	2.23	6.57	9.26	<1.0	14.41	10.28	<1.0	8.07
5	10.05	23/10/00	0.5	7.50	213	<1.0	<0.002	27.14	1.42	6.76	9.50	<1.0	14.23	10.21	<1.0	8.09
5	12.35	24/10/00	0.2	7.90	288	<1.0	<0.002	27.52	1.39	6.72	31.69	<1.0	13.90	<1.0	32.89	15.35
5	12.35	24/10/00	0.3	7.93	280	<1.0	<0.002	27.40	1.66	6.69	31.55	<1.0	13.51	1.24	33.26	15.41
5	10.30	25/10/00	0.4	7.04	176	<1.0	<0.002	20.80	1.57	4.96	8.28	<1.0	9.74	6.93	<1.0	5.88
5	10.30	25/10/00	0.5	7.00	180	<1.0	<0.002	20.91	1.79	4.99	8.36	<1.0	9.95	7.08	<1.0	5.94
5	11.55	26/10/00	0.2	7.24	185	<1.0	<0.002	21.22	1.95	5.20	8.23	<1.0	10.83	7.84	<1.0	6.61
5	11.55	26/10/00	0.2	7.71	185	<1.0	<0.002	22.29	1.65	5.45	8.60	<1.0	10.91	7.78	<1.0	6.73
5	9.50	27/10/00	0.2	7.21	178	<1.0	<0.002	21.16	1.80	5.11	8.63	<1.0	10.45	7.22	<1.0	6.66
5	9.50	27/10/00	0.2	7.45	186	<1.0	<0.002	21.37	1.49	5.10	8.45	<1.0	10.30	7.29	<1.0	6.62
5	10.40	28/10/00	0.1	7.22	184	<1.0	<0.002	21.28	1.31	5.25	8.41	<1.0	10.28	7.11	<1.0	6.74
5	10.40	28/10/00	0.1	7.11	171	<1.0	<0.002	21.16	1.09	5.21	8.33	<1.0	10.26	7.15	<1.0	6.60

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
5	10.25	29/10/00	0.2	6.94	179	<1.0	<0.002	20.89	1.31	5.13	8.29	<1.0	10.17	7.02	<1.0	6.64
5	10.25	29/10/00	0.2	7.16	177	<1.0	<0.002	21.45	1.56	5.25	8.42	<1.0	10.44	7.24	<1.0	6.74
5	11.25	30/10/00	0.2	7.27	178	<1.0	<0.002	21.07	2.05	5.24	8.40	<1.0	10.57	7.23	<1.0	7.92
5	11.25	30/10/00	0.1	7.48	184	<1.0	<0.002	21.36	1.45	5.29	8.45	<1.0	10.33	7.14	<1.0	7.03
5	13.00	31/10/00	0.1	7.06	182	<1.0	<0.002	21.35	2.02	5.19	8.09	<1.0	10.61	7.22	<1.0	6.66
5	13.00	31/10/00	0.2	7.03	182	<1.0	<0.002	21.97	1.37	5.41	8.36	<1.0	10.35	7.06	<1.0	6.75
5	11.15	01/11/00	0.1	7.38	185	<1.0	<0.002	21.78	1.28	5.43	8.50	<1.0	10.45	7.19	<1.0	6.82
5	11.15	01/11/00	0.1	7.50	189	<1.0	<0.002	22.06	1.34	5.46	8.57	<1.0	10.42	7.26	<1.0	6.86
5	13.30	02/11/00	0.2	7.04	191	<1.0	<0.002	21.90	1.14	5.43	8.48	<1.0	10.36	6.97	<1.0	6.74
5	13.30	02/11/00	0.2	6.94	182	<1.0	<0.002	21.92	1.14	5.45	8.59	<1.0	10.47	7.20	<1.0	6.93
5	10.00	03/11/00	0.6	7.07	182	<1.0	<0.002	21.76	1.55	5.44	8.42	<1.0	9.59	6.75	<1.0	6.26
5	10.00	03/11/00	0.2	6.99	186	<1.0	<0.002	21.56	1.56	5.41	8.52	<1.0	9.64	6.75	<1.0	6.49
5	10.00	04/11/00	0.8	7.15	189	<1.0	<0.002	21.97	1.45	5.46	8.47	<1.0	9.70	6.74	<1.0	6.49
5	10.00	04/11/00	0.7	7.21	188	<1.0	<0.002	21.47	2.30	5.35	8.28	<1.0	9.64	6.71	<1.0	6.01
5	9.45	05/11/00	0.5	6.77	179	<1.0	<0.002	22.07	1.64	5.50	8.53	<1.0	9.67	6.90	<1.0	6.33
5	9.45	05/11/00	0.6	6.72	185	<1.0	<0.002	22.26	1.65	5.54	8.50	<1.0	9.33	6.62	<1.0	6.05
6	11.00	25/09/00	0.5	7.46	361	2	0.003	15.40	8.10	7.40	41.90	<1.0	23.40	<1.0	<1.0	6.60
6	11.10	26/09/00	0.6	7.82	368	3	0.002	15.40	8.00	7.50	42.40	<1.0	24.00	1.10	<1.0	8.10
6	11.00	27/09/00	0.3	7.36	334	<1	0.009	15.60	7.80	7.50	40.10	<1.0	23.90	<1.0	<1.0	7.90
6	-	28/09/00	0.4	7.33	352	<1	0.005	15.70	8.00	7.80	42.30	<1.0	23.30	<1.0	<1.0	8.00
6	10.20	29/09/00	0.2	7.38	364	<1	0.004	15.30	7.90	7.60	41.50	<1.0	23.60	<1.0	<1.0	8.00
6	10.15	30/09/00	0.5	7.61	362	1	<0.002	15.10	7.80	7.50	44.00	<1.0	23.20	1.30	<1.0	7.60
6	11.15	02/10/00	0.9	7.18	348	<1.0	0.003	15.30	8.16	8.01	47.80	<1.0	21.23	1.38	<1.0	7.80
6	10.40	02/10/00	3.9	7.18	275	<1.0	0.018	16.43	6.46	6.08	40.86	<1.0	27.86	2.79	<1.0	14.88
6	10.50	03/10/00	0.4	7.28	349	<1.0	0.002	15.35	8.23	8.00	49.37	<1.0	20.87	0.48	<1.0	7.12
6	9.10	04/10/00	0.5	7.12	348	<1.0	<0.002	15.36	8.29	8.06	48.49	<1.0	21.26	0.69	<1.0	7.08
6	9.00	05/10/00	0.2	7.25	353	<1.0	0.002	15.23	8.25	8.00	49.36	<1.0	21.37	0.69	<1.0	7.17
6	10.00	06/10/00	0.4	7.27	360	<1.0	0.003	15.04	8.20	7.97	52.14	<1.0	21.00	1.23	<1.0	7.11
6	8.55	07/10/00	0.4	7.30	362	<1.0	0.002	14.58	8.05	7.78	53.59	<1.0	20.43	1.62	<1.0	8.77
6	9.05	08/10/00	0.3	7.27	367	<1.0	0.005	14.48	8.05	7.75	55.32	<1.0	20.91	1.05	<1.0	7.31
6	12.50	09/10/00	0.2	7.05	350	<1.0	0.005	14.70	7.97	7.85	50.00	<1.0	20.24	1.51	<1.0	8.51
6	10.30	10/10/00	2.0	7.15	348	<1.0	0.004	14.57	7.67	7.64	49.47	<1.0	20.49	1.60	<1.0	8.83
6	11.15	11/10/00	3.0	7.22	332	<1.0	0.004	14.41	7.40	7.46	47.26	<1.0	20.32	2.14	<1.0	9.34
6	10.45	12/10/00	1.5	7.21	326	<1.0	0.019	14.97	7.50	7.49	45.22	<1.0	20.15	1.73	<1.0	10.20
6	11.00	13/10/00	0.5	7.16	342	<1.0	<0.002	15.52	7.97	8.13	47.12	<1.0	20.66	1.06	<1.0	8.75
6	9.45	14/10/00	0.4	7.20	346	<1.0	0.004	15.94	8.27	8.38	48.93	<1.0	20.59	0.69	<1.0	8.76
6	10.30	15/10/00	0.4	7.16	348	<1.0	0.003	15.50	8.10	8.24	47.92	<1.0	20.54	0.81	<1.0	8.98

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
6	11.00	16/10/00	0.2	7.12	351	<1.0	0.005	15.79	8.13	8.52	48.11	<1.0	20.77	0.95	<1.0	8.92
6	11.15	17/10/00	0.3	7.35	345	<1.0	<0.002	15.56	8.04	8.47	47.31	<1.0	24.84	1.23	<1.0	12.04
6	11.12	18/10/00	0.2	7.43	342	<1.0	<0.002	16.43	8.59	8.95	50.00	<1.0	24.93	1.37	<1.0	11.75
6	8.50	19/10/00	4.4	7.30	345	<1.0	0.223	16.29	8.51	8.91	49.10	<1.0	25.16	<1.0	<1.0	12.15
6	10.20	20/10/00	0.5	7.23	347	<1.0	0.008	16.61	8.45	9.03	49.36	<1.0	25.33	1.59	<1.0	12.09
6	9.40	21/10/00	0.3	7.41	340	<1.0	<0.002	16.40	8.56	9.01	49.21	<1.0	25.77	1.72	<1.0	12.55
6	9.00	22/10/00	0.3	7.25	343	<1.0	0.005	16.49	8.66	9.02	49.67	<1.0	25.56	1.43	<1.0	11.95
6	10.45	23/10/00	0.2	7.20	338	<1.0	0.002	17.02	8.83	9.29	50.06	<1.0	25.67	1.46	<1.0	12.70
6	11.35	24/10/00	0.2	7.34	308	<1.0	<0.002	15.96	8.89	8.76	48.52	<1.0	21.61	1.65	<1.0	10.40
6	11.00	25/10/00	0.2	7.30	306	<1.0	<0.002	16.09	8.88	8.90	48.34	<1.0	21.44	1.45	<1.0	10.42
6	11.45	26/10/00	0.2	7.19	317	<1.0	0.006	16.06	8.89	8.88	48.12	<1.0	21.91	1.46	0.34	11.30
6	10.55	27/10/00	0.5	7.26	314	<1.0	0.002	16.04	8.91	8.82	47.45	<1.0	21.81	1.60	<1.0	10.77
6	9.10	28/10/00	0.2	7.24	317	<1.0	<0.002	15.95	9.18	8.83	47.40	<1.0	21.92	1.60	<1.0	10.87
6	9.05	29/10/00	2.3	7.21	311	<1.0	<0.002	16.11	8.98	8.85	47.59	<1.0	21.99	1.57	<1.0	10.97
6	11.00	30/10/00	19.0	7.09	251	<1.0	0.002	16.85	5.57	6.57	30.52	<1.0	25.62	2.47	<1.0	10.73
6	11.25	31/10/00	11.0	7.10	257	<1.0	0.002	16.30	5.80	7.03	30.11	<1.0	30.04	4.49	<1.0	13.39
6	10.45	01/11/00	6.6	7.31	266	<1.0	0.002	16.41	5.80	6.28	31.60	<1.0	30.33	3.73	<1.0	15.06
6	11.20	03/11/00	2.0	7.07	300	<1.0	0.012	14.01	5.46	5.71	38.03	<1.0	22.32	2.47	<1.0	12.96
6	8.55	04/11/00	4.5	7.02	320	<1.0	0.005	14.15	5.46	5.91	37.63	<1.0	21.76	2.35	<1.0	12.71
6	8.15	05/11/00	5.0	7.05	315	<1.0	0.004	13.34	5.26	5.83	36.81	<1.0	20.47	1.99	<1.0	12.10
7	-	10/09/00	0.9	7.75	196	<1.0	<0.002	32.79	0.72	3.68	5.01	<1.0	5.38	1.90	<1.0	9.97
7	12.40	18/09/00	4.9	7.72	348	6	0.006	50.00	1.10	7.10	37.40	<1.0	21.70	1.90	21.60	20.60
7	12.45	18/09/00	3.6	7.46	227	4	0.002	39.80	0.70	6.00	6.80	<1.0	6.70	1.20	<1.0	13.60
7	8.35	19/09/00	3.0	7.68	338	6	0.004	43.80	0.90	6.30	33.00	<1.0	22.30	1.70	20.60	22.60
7	8.35	19/09/00	1.5	7.61	281	4	<0.002	44.90	0.60	6.30	7.10	<1.0	6.80	1.60	<1.0	13.10
7	8.45	20/09/00	15.0	7.58	-	13	-	-	-	-	-	-	-	-	-	-
7	8.45	20/09/00	12.0	7.14	157	15	<0.002	19.40	0.90	2.30	12.10	<1.0	4.20	2.90	11.50	15.90
7	-	20/09/00	12.0	7.15	88	19	0.010	19.40	1.60	2.20	3.40	<1.0	3.80	3.00	<1.0	5.90
7	-	20/09/00	10.0	7.21	85	16	<0.002	18.70	1.10	2.10	2.70	<1.0	4.10	2.90	<1.0	5.80
7	8.20	21/09/00	8.5	7.56	266	10	0.007	27.20	1.00	3.60	32.50	<1.0	22.40	2.00	21.00	19.80
7	8.05	21/09/00	5.2	7.27	220	10	<0.002	30.50	0.90	3.80	18.60	<1.0	5.20	1.90	24.00	31.40
7	-	21/09/00	4.5	7.54	126	7	<0.002	29.30	0.90	3.60	3.90	<1.0	5.40	1.90	<1.0	9.20
7	8.20	21/09/00	4.5	7.66	130	8	<0.002	29.30	0.90	3.60	3.80	<1.0	5.30	1.80	<1.0	9.20
7	8.15	22/09/00	-	7.47	195	<1.0	<0.002	32.56	0.89	3.97	4.85	<1.0	5.89	3.03	<1.0	10.70
7	8.15	22/09/00	2.0	7.41	256	8	<0.002	37.40	0.80	4.40	19.20	<1.0	6.20	2.00	22.90	33.10
7	8.30	22/09/00	5.4	7.64	270	11	0.006	36.10	0.80	4.30	20.20	<1.0	25.80	2.60	5.90	16.40
7	8.15	22/09/00	1.5	7.60	200	7	<0.002	37.50	0.90	4.40	4.50	<1.0	5.90	2.00	<1.0	11.00

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
7	8.35	23/09/00	4.1	7.66	308	3	0.005	38.30	0.80	4.50	29.50	<1.0	25.40	2.70	19.20	22.70
7	8.20	23/09/00	1.5	7.23	253	8	<0.002	38.60	0.70	4.50	16.70	<1.0	6.40	1.60	17.60	27.90
7	-	23/09/00	1.5	7.77	152	4	<0.002	37.20	0.80	4.40	4.40	<1.0	6.00	1.90	<1.0	11.50
7	-	23/09/00	1.5	7.68	210	1	<0.002	38.10	0.90	4.40	4.50	<1.0	6.20	2.00	<1.0	11.70
7	8.30	24/09/00	1.0	7.53	273	3	<0.002	41.80	0.80	5.00	21.10	<1.0	6.50	1.60	20.20	30.40
7	8.30	24/09/00	2.4	7.72	340	3	0.003	48.70	1.00	5.80	42.30	<1.0	24.70	1.80	24.30	33.60
7	8.15	24/09/00	1.0	7.76	162	3	<0.002	39.40	0.90	4.60	4.60	<1.0	6.30	1.90	<1.0	12.20
7	8.15	24/09/00	1.0	7.71	222	1	<0.002	39.60	0.80	4.60	4.60	<1.0	6.30	1.90	<1.0	12.20
7	10.30	25/09/00	4.0	7.43	224	6	0.002	31.40	0.80	3.60	17.80	<1.0	5.60	1.30	18.90	25.50
7	10.45	25/09/00	5.2	7.66	282	6	0.003	33.40	0.80	4.00	32.70	<1.0	23.90	1.40	20.10	22.20
7	10.30	25/09/00	3.5	7.71	130	7	0.003	28.20	1.20	3.30	4.20	<1.0	5.60	1.50	<1.0	8.70
7	10.30	25/09/00	3.6	7.64	165	10	0.002	32.00	0.90	3.50	4.30	<1.0	5.70	1.50	<1.0	9.20
7	8.20	26/09/00	1.5	7.47	225	5	0.002	37.00	0.80	4.00	20.00	<1.0	6.10	1.40	20.80	28.60
7	8.35	26/09/00	4.1	7.57	280	6	0.004	34.70	0.80	3.80	32.30	<1.0	26.40	1.70	20.50	19.00
7	8.20	26/09/00	1.2	7.73	157	6	<0.002	35.50	0.80	3.80	4.30	<1.0	6.10	1.60	<1.0	11.10
7	8.20	26/09/00	1.3	7.79	197	3	<0.002	34.70	0.90	3.80	4.30	<1.0	5.90	1.60	<1.0	10.40
7	8.35	27/09/00	6.6	7.57	254	8	0.006	28.20	0.80	3.10	32.40	<1.0	26.30	1.40	19.30	15.60
7	8.15	27/09/00	4.1	7.43	208	7	<0.002	29.80	0.80	3.20	20.80	<1.0	5.10	1.50	25.60	18.70
7	8.15	27/09/00	3.6	7.67	156	6	0.002	26.60	0.80	2.90	3.80	<1.0	5.30	1.30	<1.0	8.70
7	8.15	27/09/00	3.6	7.52	158	7	0.003	27.90	0.90	2.90	4.00	<1.0	5.30	1.30	<1.0	8.80
7	8.10	28/09/00	4.0	7.39	190	7	<0.002	29.70	0.90	3.00	20.10	<1.0	4.80	1.20	23.60	20.00
7	8.10	28/09/00	3.5	7.49	147	8	<0.002	25.80	0.80	2.60	3.70	<1.0	5.00	1.10	<1.0	7.80
7	8.10	28/09/00	2.9	7.34	146	10	0.002	26.30	1.20	2.70	4.10	<1.0	5.00	1.20	<1.0	7.70
7	8.15	29/09/00	1.6	7.44	231	5	<0.002	49.10	1.00	5.10	30.10	<1.0	5.90	1.60	23.80	19.00
7	8.50	29/09/00	4.0	7.60	281	6	0.006	40.30	1.00	4.10	41.70	<1.0	27.80	1.70	23.10	16.90
7	8.15	29/09/00	1.5	7.71	195	5	<0.002	34.70	0.80	3.50	4.30	<1.0	6.00	1.60	<1.0	10.30
7	8.15	29/09/00	1.5	7.54	190	6	0.003	36.00	0.80	3.60	4.40	<1.0	6.00	1.70	<1.0	10.30
7	8.15	30/09/00	1.4	7.39	248	5	<0.002	48.60	0.90	5.00	23.70	<1.0	6.40	1.90	21.50	18.40
7	8.40	30/09/00	4.0	7.59	321	10	0.003	37.60	0.70	3.80	33.50	<1.0	28.30	1.90	24.10	18.70
7	8.15	30/09/00	1.0	7.86	208	5	<0.002	38.40	0.70	3.90	4.40	<1.0	6.20	1.70	<1.0	11.30
7	8.15	30/09/00	1.0	7.69	207	5	<0.002	37.90	0.70	3.90	4.40	<1.0	6.30	1.90	<1.0	11.30
7	8.50	01/10/00	3.1	7.85	-	6	0.003	43.60	1.50	4.70	35.70	<1.0	28.80	2.50	19.10	15.60
7	8.15	01/10/00	1.4	7.44	254	4	<0.002	46.10	0.80	4.90	22.00	<1.0	6.40	2.10	22.10	19.00
7	8.15	01/10/00	0.9	7.69	226	5	<0.002	40.00	0.70	4.20	4.50	<1.0	6.50	1.70	<1.0	12.00
7	8.15	01/10/00	1.0	7.62	228	5	<0.002	40.00	0.70	4.20	4.50	<1.0	6.30	2.10	<1.0	12.50
7	8.40	02/10/00	2.0	7.74	326	6	<0.002	48.40	0.90	5.20	40.80	<1.0	29.20	2.30	22.10	17.00
7	8.30	02/10/00	1.0	7.38	260	5	<0.002	48.10	0.80	5.20	21.40	<1.0	6.50	1.90	20.70	18.60

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
7	8.30	02/10/00	0.8	7.72	225	5	<0.002	40.90	0.80	4.40	4.50	<1.0	6.50	1.70	<1.0	13.00
7	8.30	02/10/00	0.8	7.66	224	5	<0.002	45.70	0.70	4.90	5.10	<1.0	6.60	1.70	<1.0	12.60
7	8.55	03/10/00	2.6	7.51	329	11.6	0.003	36.97	0.97	4.09	36.95	<1.0	28.53	2.23	23.88	21.57
7	8.15	03/10/00	0.3	7.34	235	<1.0	<0.002	39.09	0.52	4.41	5.25	<1.0	6.44	2.04	<1.0	12.84
7	8.30	04/10/00	3.9	7.57	332	<1.0	-	-	-	-	-	-	-	-	-	-
7	8.30	04/10/00	-	7.49	236	<1.0	<0.002	39.83	0.80	4.54	5.28	<1.0	6.44	1.87	<1.0	13.11
7	8.25	05/10/00	3.0	7.68	349	5.5	<0.002	38.81	1.08	4.55	32.72	<1.0	24.03	2.16	21.12	18.48
7	8.45	05/10/00	0.7	7.45	239	<1.0	<0.002	38.83	0.78	4.68	5.35	<1.0	6.71	2.03	<1.0	13.68
7	8.20	06/10/00	3.1	7.67	321	10.3	0.002	37.46	0.96	4.61	30.26	<1.0	23.57	1.90	15.90	17.04
7	8.45	06/10/00	0.6	7.50	237	<1.0	<0.002	39.15	0.99	4.75	5.40	<1.0	6.78	1.83	<1.0	13.37
7	8.35	07/10/00	2.0	7.48	346	<1.0	<0.002	39.52	0.89	4.79	33.58	<1.0	24.07	2.22	22.00	19.12
7	8.10	07/10/00	0.5	7.35	244	<1.0	<0.002	41.06	0.75	4.96	5.45	<1.0	6.69	1.81	<1.0	14.02
7	8.25	08/10/00	4.0	7.43	255	1	0.002	25.23	0.83	3.05	30.23	<1.0	21.82	1.53	19.65	12.11
7	8.05	08/10/00	-	7.27	156	<1.0	<0.002	26.01	0.78	2.91	4.49	<1.0	5.02	1.44	<1.0	7.88
7	8.25	09/10/00	3.0	7.60	296	5.1	0.002	29.56	1.05	3.32	32.63	<1.0	22.36	1.94	22.52	14.10
7	8.15	10/10/00	8.5	7.41	244	7.9	0.003	20.98	1.11	2.21	31.75	<1.0	22.77	1.73	21.39	11.97
7	-	10/10/00	3.5	7.30	138	<1.0	<0.002	23.25	1.02	2.40	4.16	<1.0	4.81	1.88	<1.0	7.46
7	8.20	11/10/00	6.0	7.49	290	10.4	0.003	26.50	0.97	2.79	34.10	<1.0	27.99	1.96	18.76	12.67
7	-	11/10/00	1.0	7.21	173	<1.0	<0.002	28.98	0.73	2.93	4.52	<1.0	5.30	1.66	<1.0	8.84
7	8.25	12/10/00	3.2	7.52	291	5.9	0.002	30.22	0.85	3.11	33.42	<1.0	28.39	1.93	16.90	13.61
7	-	12/10/00	0.6	7.22	194	<1.0	<0.002	32.24	0.90	3.33	4.81	<1.0	5.82	1.79	<1.0	10.11
7	8.25	13/10/00	3.0	7.65	324	1.7	<0.002	32.66	0.92	3.38	32.90	<1.0	30.44	2.14	17.78	14.98
7	-	13/10/00	0.6	7.51	218	<1.0	<0.002	35.99	1.77	3.77	5.02	<1.0	6.75	2.28	<1.0	11.21
7	8.30	14/10/00	3.0	7.78	353	<1.0	<0.002	34.98	0.80	3.72	35.95	<1.0	30.69	2.21	22.83	16.45
7	-	14/10/00	0.6	7.53	224	<1.0	0.005	37.18	1.21	3.99	5.11	<1.0	6.59	2.06	<1.0	11.86
7	8.35	15/10/00	3.5	7.72	354	1.9	<0.002	36.85	0.81	4.04	34.44	<1.0	30.96	2.19	18.87	16.78
7	8.15	15/10/00	0.5	7.34	224	<1.0	<0.002	39.12	0.72	4.30	5.33	<1.0	6.43	1.90	<1.0	12.60
7	8.20	16/10/00	2.0	7.72	353	1.5	<0.002	36.58	0.73	4.10	31.42	<1.0	24.81	2.02	21.19	16.73
7	8.20	16/10/00	0.5	7.26	238	<1.0	<0.002	40.76	0.79	4.49	5.34	<1.0	6.45	1.90	<1.0	12.81
7	8.20	17/10/00	1.5	7.77	334	4.5	<0.002	37.41	0.72	4.20	25.56	<1.0	23.68	2.33	11.95	15.55
7	-	17/10/00	0.4	7.38	250	<1.0	<0.002	41.66	0.77	4.70	5.43	<1.0	6.52	1.96	<1.0	13.28
7	8.25	18/10/00	1.4	7.72	308	1.7	<0.002	38.91	0.64	4.46	20.77	<1.0	15.19	2.15	13.17	15.93
7	-	18/10/00	1.5	7.28	236	<1.0	<0.002	38.77	0.80	4.58	5.43	<1.0	6.51	1.78	<1.0	12.98
7	8.20	19/10/00	2.0	7.82	304	4.62	0.002	40.75	1.29	4.85	28.30	<1.0	17.24	<1.0	22.46	23.06
7	8.10	19/10/00	0.5	7.76	195	<1.0	<0.002	43.10	0.93	5.06	5.98	<1.0	7.02	1.47	<1.0	16.03
7	8.20	20/10/00	1.6	7.97	299	<1.0	<0.002	43.33	0.91	5.07	29.71	<1.0	17.63	<1.0	25.02	24.93
7	8.00	20/10/00	0.5	7.76	207	<1.0	<0.002	46.45	1.29	5.43	6.22	<1.0	7.29	1.71	<1.0	17.24

Private Water Supplies - Phase 2 Chemistry Results

Site No.	Time	Date	Turbidity	pH	Conductivity	* Suspended Solids	Mn	Ca	K	Mg	Na	F	Cl	NO^3	PO^4	SO^4
7	9.10	21/10/00	2.1	7.85	261	2.8	0.002	35.01	0.75	4.29	29.11	<1.0	17.23	<1.0	24.46	23.21
7	9.00	21/10/00	1.1	7.60	176	<1.0	<0.002	38.48	0.91	4.49	5.91	<1.0	6.50	1.49	<1.0	13.16
7	8.30	22/10/00	2.8	7.62	319	4.21	0.002	40.32	0.88	4.54	39.11	<1.0	30.17	<1.0	26.40	24.08
7	8.15	22/10/00	0.7	7.47	199	<1.0	<0.002	43.93	1.02	5.00	6.20	<1.0	6.68	1.80	<1.0	15.16
7	8.40	23/10/00	1.8	7.85	327	1.53	<0.002	42.34	0.96	4.78	35.62	<1.0	31.75	<1.0	20.20	21.06
7	8.30	23/10/00	0.8	7.69	211	<1.0	<0.002	46.10	1.05	5.21	6.17	<1.0	7.39	1.96	<1.0	16.52
7	8.15	24/10/00	2.0	7.73	390	9.26	<0.002	40.97	0.73	4.66	35.70	<1.0	32.70	<1.0	19.81	23.62
7	-	24/10/00	0.8	7.34	243	<1.0	<0.002	42.39	0.99	4.95	6.09	<1.0	6.98	1.55	<1.0	15.43
7	8.10	25/10/00	2.5	7.74	375	5.26	<0.002	38.62	0.91	4.39	36.01	<1.0	30.89	<1.0	21.10	23.71
7	-	25/10/00	6.9	7.57	189	<1.0	<0.002	33.92	1.10	4.02	5.64	<1.0	6.24	1.67	<1.0	12.35
7	8.15	26/10/00	1.5	7.74	311	4.03	0.003	34.35	2.47	3.74	39.66	<1.0	27.40	2.15	20.33	14.72
7	-	26/10/00	1.0	7.54	199	<1.0	<0.002	36.16	2.90	3.87	5.87	<1.0	6.45	2.12	<1.0	10.43
7	8.20	27/10/00	1.6	7.78	331	4.24	<0.002	39.93	1.13	4.26	37.85	<1.0	28.10	2.12	18.08	17.79
7	-	27/10/00	0.5	7.63	228	<1.0	<0.002	42.40	2.37	4.53	6.10	<1.0	6.80	2.48	<1.0	12.41
7	8.25	28/10/00	3.0	8.13	340	4.69	0.002	38.77	1.51	4.18	39.33	<1.0	27.67	2.12	21.95	18.46
7	-	28/10/00	0.7	7.82	229	<1.0	<0.002	41.37	1.41	4.47	5.92	<1.0	6.48	1.98	<1.0	12.56
7	8.20	28/10/00	6.0	7.47	264	9	0.006	34.30	1.00	3.70	41.30	<1.0	27.20	1.80	21.50	17.20
7	8.30	29/10/00	6.2	7.52	262	9.78	0.002	24.10	0.98	2.65	36.28	<1.0	25.52	1.11	20.21	26.41
7	-	29/10/00	6.1	7.45	120	<1.0	0.002	19.20	2.15	2.00	5.29	<1.0	6.69	1.46	<1.0	6.16
7	8.30	31/10/00	9.3	7.72	197	16.67	0.003	14.63	2.19	1.43	30.08	<1.0	21.74	1.57	15.74	8.18
7	8.40	01/11/00	5.2	7.72	256	6.25	0.003	21.71	1.23	2.30	37.40	<1.0	26.54	1.53	20.56	11.46
			(NTU)		(uS/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
			±10%	±5%	±5%	±	±20%	±5%	±5%	±5%	±5%	±10%	±20%	±25%	±20%	±20%

Calcium, magnesium, sodium, potassium and manganese - Thermo Jarrell Ash Atomscan Advantage ICP-OES

Anions - Dionex DX-500 HPLC-IC

pH - Denver Instrument Company Model 220 pH meter

Conductivity - Hanna HI-9033 conductivity meter + Denver Instrument Company Model 220 pH meter

* (Indicative value only) Suspended solids - HACH DR2010 Spectrophotometer

Turbidity - HACH model 2100A turbidimeter

Key to Chemical symbols used above: Mn= Manganese. Ca= Calcium. K= Potassium. Na= Sodium. F= Fluoride. Cl= Chloride NO3= Nitrate. PO4= Phosphate. SO4= Sulphate.

Appendix A.4 Microbiology Results, Phase 2

SITE 1

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
18.06.00	N/A	N/A	N/A	N/A	N/A	NT	<0.000006	0.000006
18.09.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
19.09.00	0	0	0	0	Not Detected	NT	<0.0012	<0.0012
20.09.00	0	0	0	0	Not Detected	NT	<0.0017	<0.0017
21.09.00	0	0	0	0	Not Detected	NT	<0.0005	<0.0005
22.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
23.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
24.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
25.09.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
26.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
27.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
28.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
29.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
30.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
01.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
02.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
03.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
04.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
05.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
06.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
07.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
08.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
09.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
10.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
11.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
12.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009

SITE 1

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
13.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
14.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
15.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
16.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
17.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
18.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
19.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
20.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
21.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
22.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
23.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
24.10.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
25.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
26.10.00	0	0	0	0	Not Detected	NT	<0.0086	<0.0086
27.10.00	0	0	0	0	Not Detected	NT	<0.0087	<0.0087
28.10.00	0	0	0	0	Not Detected	NT	<0.0090	<0.0090
29.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
30.10.00		NO SAMPLE			Not Detected	NT	NO SAMPLE	NO SAMPLE
01.11.00		NO SAMPLE			Not Detected	NT	NO SAMPLE	NO SAMPLE
02.11.00	0	0	0	0	Not Detected	NT	<0.0002	<0.0002
03.11.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
04.11.00		NO SAMPLE			Not Detected	NT	NO SAMPLE	NO SAMPLE

SITE 2

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
25.09.00	3	3	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
26.09.00	2	2	0	0	Not Detected	NT	<0.0006	0.0013
27.09.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
28.09.00	1	1	0	0	Not Detected	NT	<0.0007	<0.0007
29.09.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
30.09.00	0	0	0	0	Not Detected	NT	<0.0009	<0.0009
01.10.00	0	0	0	0	Not Detected	NT	<0.0006	<0.0006
02.10.00	4	4	0	0	Not Detected	NT	0.0007	<0.0007
03.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
04.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
05.10.00	0	0	0	0	Not Detected	0	0.0009	<0.0009
06.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
07.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
08.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
09.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
10.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
11.10.00	0	0	0	0	Not Detected	NT	<0.0007	0.0014
12.10.00	2	2	0	0	Not Detected	NT	0.0032	0.0016
13.10.00	0	0	0	0	Not Detected	NT	0.0007	0.0014
14.10.00	2	2	0	0	Not Detected	NT	<0.0009	<0.0009
15.10.00	3	3	1	0	Not Detected	NT	<0.0007	<0.0007
16.10.00	0	0	0	0	Not Detected	NT	0.0030	<0.0007
17.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
18.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
19.10.00	0	0	0	0	Not Detected	NT	<0.0007	<0.0007
20.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008

SITE 2

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
21.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
22.10.00	0	0	0	0	Not Detected	NT	0.0007	<0.0004
23.10.00	1	1	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
24.10.00	1	1	0	1	Not Detected	NT	0.0007	<0.0004
25.10.00	7	7	1	1	Not Detected	NT	0.0361	0.0876
26.10.00	69	69	38	7	Not Detected	NT	0.0296	0.0421
27.10.00	90	90	37	6	Not Detected	NT	0.0073	0.0784
28.10.00	59	59	7	1	Not Detected	NT	0.0074	0.1148
29.10.00	28	28	9	3	Not Detected	NT	0.0341	0.1771
30.10.00	3	3	0	0	Not Detected	NT	0.0143	0.1672
31.10.00	1	1	0	0	Not Detected	NT	0.0263	0.0589
01.11.00	1	1	0	0	Not Detected	0	0.0148	0.2100
02.11.00	1	1	0	0	Not Detected	NT	0.0077	0.0671
03.11.00	0	0	0	2	Not Detected	NT	0.0061	0.1047
04.11.00	3	3	0	0	Not Detected	NT	0.0093	0.0356
05.11.00	2	1	0	0	Not Detected	NT	0.0054	0.0076
06.11.00		NO SAMPLE			Not Detected	NT	0.0056	0.0433

SITE 3

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
25.09.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
26.09.00	0	0	0	0	Not Detected	NT	<0.0033	<0.0033
27.09.00	0	0	0	0	Not Detected	NT	<0.0032	<0.0032
28.09.00	0	0	0	0	Not Detected	NT	<0.0042	<0.0042
29.09.00	0	0	0	0	Not Detected	NT	<0.0027	<0.0027
30.09.00	0	0	0	0	Not Detected	NT	<0.0024	<0.0024
01.10.00	0	0	0	0	Not Detected	NT	<0.0027	<0.0027
02.10.00	0	0	0	0	Not Detected	NT	<0.0027	<0.0027
03.10.00	0	0	0	0	Not Detected	NT	<0.0066	<0.0066
04.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
05.10.00	0	0	0	0	Not Detected	NT	<0.0033	<0.0033
06.10.00	0	0	0	0	Not Detected	NT	<0.0027	<0.0027
07.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
08.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
09.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
10.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
11.10.00	0	0	0	0	Not Detected	NT	<0.0001	<0.0001
12.10.00	0	0	0	0	Not Detected	NT	0.0304	0.0570
13.10.00	0	0	0	0	Not Detected	NT	0.0408	0.0157
14.10.00	0	0	0	0	Not Detected	NT	0.0173	0.0035
15.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
16.10.00	0	0	0	0	Not Detected	NT	0.0103	0.0064
17.10.00	0	0	0	0	Not Detected	NT	0.0087	0.0058
18.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
19.10.00	0	0	0	0	Not Detected	NT	0.0069	<0.0023
20.10.00	0	0	0	0	Not Detected	NT	0.0155	0.0078

SITE 3

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
21.10.00	0	0	0	0	Not Detected	NT	0.0096	0.0129
22.10.00	0	0	0	0	Not Detected	NT	<0.0023	0.1190
23.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
24.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
25.10.00	0	0	0	0	Not Detected	NT	0.0054	0.0191
26.10.00	0	0	0	0	Not Detected	NT	0.0076	0.0832
27.10.00	0	0	0	0	Not Detected	NT	<0.0026	<0.0026
28.10.00	0	0	0	1	Not Detected	NT	0.0121	0.0181
29.10.00	0	0	0	0	Not Detected	NT	0.0130	0.0078
30.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
31.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
01.11.00	0	0	0	0	Not Detected	NT	0.0061	0.0073
02.11.00	0	0	0	0	Not Detected	NT	0.0034	0.0102
03.11.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
04.11.00	0	0	0	0	Not Detected	NT	0.0346	<0.0038
05.11.00	0	0	0	0	Not Detected	NT	<0.0034	0.0034
06.11.00		NO SAMPLE			Not Detected	NT	0.0171	0.0286

SITE 4

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
22.09.00	0	0	0	>100	Not Detected	NT	NO SAMPLE	NO SAMPLE
23.09.00	0	0	0	>100	Not Detected	NT	0.0041	0.0247
24.09.00	0	0	0	>100	Not Detected	NT	<0.0012	0.0085
25.09.00	0	0	0	>100	Not Detected	NT	<0.0010	0.0010
26.09.00	0	0	0	>100	Not Detected	NT	<0.0012	<0.0012
27.09.00	0	0	0	>100	Not Detected	NT	<0.0011	0.0011
28.09.00	0	0	0	36	Not Detected	NT	<0.0012	<0.0012
29.09.00	0	0	0	21	Not Detected	NT	<0.0161	<0.0161
30.09.00		NO SAMPLE			Not Detected	NT	NO SAMPLE	NO SAMPLE
01.10.00	0	0	0	7	NO SAMPLE	NT	<0.0009	<0.0009
02.10.00	0	0	0	21	Not Detected	NT	<0.0011	<0.0011
03.10.00	0	0	0	>100	Not Detected	NT	<0.0014	<0.0014
04.10.00	0	0	0	36	Not Detected	NT	<0.0012	<0.0012
05.10.00	0	0	0	18	Not Detected	NT	NO SAMPLE	NO SAMPLE
06.10.00	0	0	0	18	Not Detected	NT	<0.0007	<0.0007
07.10.00	0	0	9	21	Not Detected	NT	<0.0014	<0.0014
08.10.00	0	0	0	12	Not Detected	NT	<0.0013	<0.0013
09.10.00	0	0	0	4	Not Detected	NT	<0.0014	<0.0014
10.10.00	0	0	2	0	Not Detected	NT	<0.0013	<0.0013
11.10.00	0	0	0	21	Not Detected	NT	<0.0014	0.0028
12.10.00	0	0	0	24	Not Detected	NT	<0.0019	<0.0019
13.10.00	0	0	0	25	Not Detected	NT	<0.0018	<0.0018
14.10.00	0	0	0	15	Not Detected	NT	<0.0016	<0.0016
15.10.00	0	0	0	2	Not Detected	NT	<0.0013	<0.0013
16.10.00	0	0	0	3	Not Detected	NT	<0.0014	<0.0014
17.10.00	0	0	0	2	Not Detected	NT	<0.0018	<0.0018

SITE 4

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
18.10.00	0	0	0	1	Not Detected	NT	<0.0018	<0.0018
19.10.00	0	0	0	1	Not Detected	NT	<0.0019	<0.0019
20.10.00	0	0	0	1	Not Detected	NT	<0.0018	<0.0018
21.10.00	0	0	0	3	Not Detected	NT	<0.0018	<0.0018
22.10.00	0	0	0	0	Not Detected	NT	<0.0019	<0.0019
23.10.00	0	0	0	0	Not Detected	NT	<0.0021	<0.0021
24.10.00	0	0	0	0	Not Detected	NT	<0.0018	<0.0018
25.10.00	0	0	0	0	Not Detected	NT	<0.0015	<0.0015
26.10.00	0	0	0	5	Not Detected	NT	<0.0013	<0.0013
27.10.00	0	0	0	5	Not Detected	NT	<0.0014	<0.0014
28.10.00	0	0	0	0	Not Detected	NT	<0.0013	<0.0013
29.10.00	0	0	0	1	Not Detected	NT	<0.0031	<0.0031
30.10.00	0	0	0	7	Not Detected	NT	<0.0036	<0.0036
31.10.00	0	0	0	11	Not Detected	NT	<0.0019	<0.0019
01.11.00	0	0	0	0	Not Detected	NT	<0.0013	<0.0013
02.11.00	0	0	0	0	Not Detected	NT	<0.0013	<0.0013
03.11.00	0	0	0	0	Not Detected	NT	<0.0015	<0.0015
04.11.00	0	0	1	0	Not Detected	NT	<0.0013	<0.0013

SITE 5

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
25.09.00	580	580	61	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
26.09.00	145	145	4	0	Not Detected	NT	<0.0007	0.0029
27.09.00	390	390	52	0	Not Detected	NT	0.0049	0.0162
28.09.00	400	400	33	1	PRESENT	NT	0.1023	0.2003
29.09.00	80	80	12	0	Not Detected	NT	0.0080	<0.0007
30.09.00	70	70	9	0	Not Detected	NT	0.0057	<0.0010
01.10.00	46	46	3	0	Not Detected	NT	<0.0007	<0.0007
02.10.00	70	50	0	0	Not Detected	NT	0.0027	<0.0009
03.10.00	48	48	4	0	PRESENT	NT	0.0006	0.0013
04.10.00	37	37	1	0	Not Detected	NT	<0.0008	0.0017
05.10.00	190	190	25	0	Not Detected	0	0.0015	0.0251
06.10.00	90	90	0	0	Not Detected	NT	<0.0005	<0.0005
07.10.00	360	360	33	0	Not Detected	NT	<0.0007	0.0045
08.10.00	150	90	11	0	Not Detected	NT	0.0083	0.1870
09.10.00	37	37	2	0	Not Detected	NT	<0.0009	0.0009
10.10.00	140	140	3	0	Not Detected	NT	0.0132	0.1604
11.10.00	60	60	3	0	Not Detected	NT	0.0060	0.0328
12.10.00	22	22	1	0	Not Detected	NT	0.0060	0.0030
13.10.00	36	36	2	0	Not Detected	NT	0.0041	0.0007
14.10.00	51	51	5	0	Not Detected	NT	<0.0007	<0.0007
15.10.00	13	5	0	0	Not Detected	NT	<0.0008	0.0038
16.10.00	17	14	0	0	Not Detected	NT	0.0007	0.0007
17.10.00	7	7	0	0	Not Detected	NT	0.0017	0.0053
18.10.00	36	36	2	0	Not Detected	NT	<0.0007	<0.0007
19.10.00	19	19	1	0	Not Detected	NT	<0.0008	0.0015
20.10.00	10	9	0	0	Not Detected	NT	<0.0008	<0.0008

SITE 5

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
21.10.00	15	15	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
22.10.00	19	18	0	0	Not Detected	NT	0.0004	0.0042
23.10.00	880	880	114	6	Not Detected	NT	<0.0008	0.0091
24.10.00	110	110	10	0	Not Detected	NT	0.0021	0.0322
25.10.00	1600	1600	74	3	Not Detected	NT	0.0060	0.3705
26.10.00	28	19	3	2	Not Detected	NT	0.0006	0.0115
27.10.00	140	140	16	1	Not Detected	NT	<0.0008	<0.0008
28.10.00	56	56	0	0	Not Detected	NT	0.0074	0.0149
29.10.00	45	15	2	1	Not Detected	NT	0.0008	0.0060
30.10.00	120	60	9	0	Not Detected	NT	0.0007	0.0007
31.10.00	24	10	0	0	Not Detected	NT	0.0007	0.0007
01.11.00	28	23	0	0	Not Detected	0	0.0017	0.0108
02.11.00	25	15	1	0	Not Detected	NT	<0.0007	0.0103
03.11.00	9	3	0	0	Not Detected	NT	0.0009	0.0009
04.11.00	28	8	0	0	Not Detected	NT	<0.0008	0.0008
05.11.00	17	5	1	0	Not Detected	NT	<0.0008	<0.0008
06.11.00		NO SAMPLE			Not Detected	NT	<0.0008	<0.0008

SITE 6

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
25.09.00	3	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
26.09.00	10	5	0	0	Not Detected	NT	<0.0007	<0.0007
27.09.00	14	1	0	0	Not Detected	NT	<0.0007	<0.0007
28.09.00	15	5	0	0	Not Detected	NT	<0.0008	<0.0008
29.09.00	2	2	0	0	NO SAMPLE	NT	NO SAMPLE	NO SAMPLE
30.09.00	2	0	0	0	Not Detected	NT	<0.0007	<0.0007
01.10.00	5	0	0	0	Not Detected	NT	<0.0008	<0.0008
02.10.00	13	0	0	1	Not Detected	NT	<0.0020	<0.0020
03.10.00	0	0	0	0	Not Detected	NT	<0.0049	<0.0049
04.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
05.10.00	11	0	0	0	Not Detected	NT	<0.0007	<0.0007
06.10.00	14	0	0	0	Not Detected	NT	<0.0006	<0.0006
07.10.00	15	0	1	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
08.10.00	2	0	0	0	Not Detected	NT	<0.0006	<0.0006
09.10.00	>300	>300	>300	>300	Not Detected	NT	<0.0008	0.0008
10.10.00	>3000	>3000	>300	>300	Not Detected	NT	<0.0009	0.0028
11.10.00	370	170	>300	74	Not Detected	NT	NO SAMPLE	NO SAMPLE
12.10.00	26	4	6	7	Not Detected	NT	0.0014	0.0045
13.10.00	29	4	0	1	Not Detected	NT	<0.0002	0.0005
14.10.00	20	5	0	2	Not Detected	NT	<0.0008	<0.0008
15.10.00	22	2	1	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
16.10.00	6	2	1	1	Not Detected	NT	<0.0005	<0.0005
17.10.00	16	4	0	1	Not Detected	NT	<0.0007	<0.0007
18.10.00	3	1	0	2	Not Detected	NT	NO SAMPLE	NO SAMPLE
19.10.00	2	2	0	1	Not Detected	NT	<0.0006	<0.0006
20.10.00	16	2	0	5	Not Detected	NT	<0.0008	<0.0008

SITE 6

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
21.10.00	4	0	0	0	Not Detected	NT	<0.0009	<0.0009
22.10.00	5	3	0	0	Not Detected	NT	<0.0008	<0.0008
23.10.00	5	5	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
24.10.00	3	0	1	3	Not Detected	NT	NO SAMPLE	NO SAMPLE
25.10.00	3	1	0	4	Not Detected	NT	<0.0004	0.0010
26.10.00	2	0	0	1	Not Detected	NT	NO RESULT	NO RESULT
27.10.00	0	0	0	0	Not Detected	NT	<0.0005	<0.0005
28.10.00	48	20	19	19	Not Detected	NT	<0.0008	<0.0008
29.10.00	2300	1260	>300	>300	Not Detected	NT	<0.0009	0.0136
30.10.00	530	410	>300	>300	Not Detected	NT	NO SAMPLE	NO SAMPLE
31.10.00	110	90	>300	>300	Not Detected	NT	NO SAMPLE	NO SAMPLE
01.11.00	599	300	>300	>300	Not Detected	NT	0.0341	0.0436
02.11.00	>3000	>1200	>300	>300	Not Detected	NT	0.0078	0.0347
03.11.00	263	43	116	116	Not Detected	NT	NO SAMPLE	NO SAMPLE
04.11.00	125	59	106	225	Not Detected	NT	<0.0011	<0.0011
05.11.00					Not Detected	NT	<0.0013	0.0014
06.11.00					Not Detected	NT	<0.0013	0.0026

SITE 7

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
18.09.00	0	0	0	3	Not Detected	NT	0.0074	0.0720
19.09.00	0	0	0	4	Not Detected	NT	0.0084	0.2530
20.09.00	108	54	3	46	Not Detected	NT	0.0184	0.4675
21.09.00	111	71	9	31	Present	NT	0.0355	0.7478
22.09.00	2	1	0	16	Not Detected	NT	0.0221	0.1576
23.09.00	0	0	0	1	Not Detected	NT	0.0104	0.0693
24.09.00	0	0	0	0	Not Detected	NT	0.0083	0.1208
25.09.00	0	0	0	81	Not Detected	NT	0.0104	0.1516
26.09.00	8	8	0	10	Not Detected	NT	0.0008	0.0025
27.09.00	0	0	0	50	Not Detected	NT	0.0166	0.2754
28.09.00	3	1	0	25	Not Detected	NT	0.0107	0.0808
29.09.00	0	0	0	4	Not Detected	NT	0.0155	0.0140
30.09.00	0	0	0	0	Not Detected	NT	0.0108	0.0267
01.10.00	0	0	0	0	Not Detected	NT	0.0133	<0.0008
02.10.00	0	0	0	0	Not Detected	NT	0.0017	0.0017
03.10.00	0	0	0	0	Not Detected	NT	NO SAMPLE	NO SAMPLE
04.10.00	0	0	0	1	Not Detected	NT	0.0031	0.0015
05.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
06.10.00	0	0	0	1	Not Detected	NT	0.0085	0.0038
07.10.00	0	0	0	0	Not Detected	NT	<0.0008	0.0046
08.10.00	175	15	0	72	Not Detected	NT	0.0334	0.4674
09.10.00	1	0	0	8	Not Detected	NT	0.0084	0.2626
10.10.00	8	8	0	74	Not Detected	NT	0.1332	3.1696
11.10.00	1	1	0	8	Not Detected	NT	0.0551	0.5626
12.10.00	0	0	0	2	Not Detected	0	0.0260	0.0168
13.10.00	0	0	0	1	Not Detected	NT	0.0099	0.0396

SITE 7

Date	Coliforms No./100ml	*Escherichia coli* No./100ml	Enterococci No./100ml	Clostridia No./100ml	Campylobacter Pres/abs	*E.coli* O157	*Cryptosporidium* No./l	*Giardia* No./l
14.10.00	0	0	0	0	Not Detected	NT	0.0023	<0.0008
15.10.00	0	0	0	0	Not Detected	NT	0.0015	0.0015
16.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
17.10.00	0	0	0	0	Not Detected	NT	0.0016	0.0039
18.10.00	0	0	0	0	Not Detected	NT	0.0117	0.0124
19.10.00	0	0	0	0	Not Detected	NT	0.0023	0.0039
20.10.00	0	0	0	0	Not Detected	NT	0.0071	0.0094
21.10.00	0	0	0	60	Not Detected	NT	0.0069	0.2284
22.10.00	0	0	0	1	Not Detected	NT	0.0260	0.1626
23.10.00	0	0	0	2	Not Detected	NT	0.0070	0.2295
24.10.00	0	0	0	0	Not Detected	NT	<0.0008	<0.0008
25.10.00	0	0	0	1	Not Detected	NT	0.0008	<0.0008
26.10.00	0	0	0	3	Not Detected	NT	0.0016	<0.0008
27.10.00	2	2	0	0	Not Detected	NT	0.0243	0.1656
28.10.00	0	0	0	0	Not Detected	NT	0.0040	0.0016
29.10.00	11	11	1	38	Not Detected	NT	0.0273	0.9235
30.10.00		NO SAMPLE			Not Detected	NT	0.0368	1.0000
31.10.00	6	4	0	2	NO SAMPLE	0	0.0708	2.1471
01.11.00	0	0	0	4	Not Detected	NT	0.0160	0.6271
02.11.00		NO SAMPLE			Not Detected	NT	0.0163	0.4322

SITE 1

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
18/09/00	3 Months	3.50	117547	1.5	0	0	1	0
19/09/00	17.35	0.80	813	<0.5	0	0	0	0
20/09/00	23.45	0.60	593	<0.5	0	0	0	0
21/09/00	25.40	0.80	1925	<0.5	0	0	0	0
22/09/00	23.50	0.60	1151	<0.5	0	0	0	0
23/09/00	23.20	1.30	1166	<0.5	0	0	0	0
24/09/00	24.02	0.70	1170	<0.5	0	0	0	0
25/09/00	24.48	0.70	1201	<0.5	0	0	0	0
26/09/00	24.05	0.80	1135	<0.5	0	0	0	0
27/09/00	23.55	0.60	1175	<0.5	0	0	0	0
28/09/00	24.15	0.60	1182	<0.5	0	0	0	0
29/09/00	23.45	0.70	1156	<0.5	0	0	0	0
30/09/00	23.30	0.70	1153	<0.5	0	0	0	0
01/10/00	24.00	0.80	1184	<0.5	0	0	0	0
02/10/00	24.30	1.00	1199	<0.5	0	0	0	0
03/10/00	24.15	0.70	1184	<0.5	0	0	0	0
04/10/00	23.45	0.70	1179	<0.5	0	0	0	0
05/10/00	24.00	1.80	1219	<0.5	0	0	0	0
06/10/00	23.45	0.70	1160	<0.5	0	0	0	0
07/10/00	23.10	0.60	1128	<0.5	0	0	0	0
08/10/00	24.05	0.60	1175	<0.5	0	0	0	0
09/10/00	25.15	0.40	1219	<0.5	0	0	0	0
10/10/00	23.55	0.70	1170	<0.5	0	0	0	0
11/10/00	24.05	0.50	1169	<0.5	0	0	0	0
12/10/00	23.45	0.80	1177	<0.5	0	0	0	0
13/10/00	24.00	0.60	1160	<0.5	0	0	0	0

SITE 1

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
14/10/00	23.00	0.60	1120	<0.5	0	0	0	0
15/10/00	24.00	1.60	1204	<0.5	0	0	0	0
16/10/00	25.00	0.60	1218	<0.5	0	0	0	0
17/10/00	24.10	0.50	1174	<0.5	0	0	0	0
18/10/00	23.50	0.50	1158	<0.5	0	0	0	0
19/10/00	24.10	0.50	1180	<0.5	0	0	0	0
20/10/00	23.50	0.70	1158	<0.5	0	0	0	0
21/10/00	23.00	0.50	1114	<0.5	0	0	0	0
22/10/00	24.00	0.60	1156	<0.5	0	0	0	0
23/10/00	24.45	0.60	1199	<0.5	0	0	0	0
24/10/00	23.25	0.70	1123	<0.5	0	0	0	0
25/10/00	25.00	0.70	1205	<0.5	0	0	0	0
26/10/00	23.50	0.60	1163	<0.5	0	0	0	0
27/10/00	23.50	0.80	1153	<0.5	0	0	0	0
28/10/00	23.10	0.50	1108	<0.5	0	0	0	0
29/10/00	24.00	0.60	1200	<0.5	0	0	0	0
30/10/00				NO SAMPLE				
31/10/00				NO SAMPLE				
01/11/00				NO SAMPLE				
02/11/00	73.00	1.10	4660	<0.5	0	0	0	0
03/11/00	23.45	1.90	1183	<0.5	0	0	0	0

SITE 2

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium*		*Giardia*	
					DAPI +	DAPI -	DAPI +	DAPI -
26/09/00	26.30	0.6	1539	<0.5	0	0	0	2
27/09/00	24.20	0.6	1391	<0.5	0	0	0	0
28/09/00	23.40	0.6	1355	<0.5	0	0	0	0
29/09/00	21.20	0.5	1221	<0.5	0	0	0	0
30/09/00	20.40	0.8	1169	<0.5	0	0	0	0
01/10/00	27.10	0.7	1558	<0.5	0	0	0	0
02/10/00	26.05	0.5	1423	<0.5	1	0	0	0
03/10/00	22.45	0.5	1252	<0.5	0	0	0	0
04/10/00	25.45	0.6	1465	<0.5	0	0	0	0
05/10/00	19.35	0.5	1121	<0.5	0	1	0	0
06/10/00	24.30	0.6	1374	<0.5	0	0	0	0
07/10/00	23.40	0.6	1346	<0.5	0	0	0	0
08/10/00	24.40	0.7	1399	0.5	0	0	0	0
09/10/00	26.35	0.5	1501	<0.5	0	0	0	0
10/10/00	24.05	0.7	1367	<0.5	0	0	0	0
11/10/00	25.20	0.8	1441	<0.5	0	0	1	1
12/10/00	22.00	0.8	1261	<0.5	2	2	2	0
13/10/00	25.15	0.8	1436	<0.5	1	0	2	0
14/10/00	21.05	0.7	1148	<0.5	0	0	0	0
15/10/00	24.10	0.6	1429	<0.5	0	0	0	0
16/10/00	27.20	0.6	1544	<0.5	2	2	0	0
17/10/00	23.25	0.7	1333	<0.5	0	0	0	0
18/10/00	24.20	0.8	1385	1.0	0	0	0	0
19/10/00	23.35	0.6	1344	<0.5	0	0	0	0
20/10/00	22.25	0.7	1275	<0.5	0	0	0	0
21/10/00				NO SAMPLE				

SITE 2

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
22/10/00	48.00	0.8	2739	<0.5	0	2	0	0
23/10/00				NO SAMPLE				
24/10/00	48.20	1.3	2766	0.5	0	2	0	0
25/10/00	26.15	1.0	1495	0.5	51	3	16	115
26/10/00	22.25	1.6	1284	<0.5	7	31	7	47
27/10/00	23.45	1.4	1365	0.5	5	5	14	93
28/10/00	21.30	0.9	1219	0.5	4	5	4	136
29/10/00	23.50	0.8	1406	<0.5	46	2	18	231
30/10/00	28.10	0.7	1603	<0.5	21	2	24	244
31/10/00	23.00	0.6	1291	0.5	25	9	17	59
01/11/00	20.20	0.6	1150	<0.5	15	2	46	195
02/11/00	27.45	0.7	1565	<0.5	6	6	21	84
03/11/00	23.30	0.5	1318	<0.5	8	0	2	136
04/11/00	20.55	0.6	1180	<0.5	10	1	4	38
05/11/00	23.20	0.9	1308	<0.5	4	3	2	8
06/11/00	24.10	0.8	1247	<0.5	7	0	6	48

SITE 3

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
26/09/00	24.10	0.00	302	<0.5	0	0	0	0
27/09/00	23.55	0.75	317	<0.5	0	0	0	0
28/09/00	21.15	0.25	236	<0.5	0	0	0	0
29/09/00	26.00	0.00	364	<0.5	0	0	0	0
30/09/00	23.45	0.25	416	0.5	0	0	0	0
01/10/00	23.20	0.00	375	<0.5	0	0	0	0
02/10/00	25.50	0.00	374	<0.5	0	0	0	0
03/10/00	23.45	0.75	152	<0.5	0	0	0	0
04/10/00				NO SAMPLE				
05/10/00	47.50	0.00	306	<0.5	0	0	0	0
06/10/00	25.00	0.25	377	<0.5	0	0	0	0
07/10/00				NO SAMPLE				
08/10/00				NO SAMPLE				
09/10/00				NO SAMPLE				
10/10/00				NO SAMPLE				
11/10/00	121.20	0.00	17780	<0.5	0	1	0	0
12/10/00	23.20	1.25	263	<0.5	8	0	3	12
13/10/00	24.20	3.50	319	<0.5	9	4	0	5
14/10/00	24.05	0.15	289	<0.5	4	1	0	0
15/10/00				NO SAMPLE				
16/10/00	47.55	1.75	776	<0.5	7	1	2	3
17/10/00	24.05	0.50	344	<0.5	2	1	0	2
18/10/00				NO SAMPLE				
19/10/00	45.40	0.00	432	<0.5	3	0	0	0
20/10/00	25.30	0.00	386	<0.5	6	0	2	1
21/10/00	22.40	0.00	311	<0.5	3	0	0	4

SITE 3

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
22/10/00	23.25	0.00	437	<0.5	0	0	7	45
23/10/00				NO SAMPLE				
24/10/00				NO SAMPLE				
25/10/00	70.50	0.50	1101	<0.5	6	0	2	19
26/10/00	24.55	0.00	529	0.5	2	2	0	44
27/10/00	23.15	0.00	383	<0.5	0	0	0	0
28/10/00	22.10	0.00	331	<0.5	4	0	0	6
29/10/00	23.55	2.00	386	<0.5	5	0	1	2
30/10/00				NO SAMPLE				
31/10/00				NO SAMPLE				
01/11/00	73.35	0.00	825	1.0	4	1	3	3
02/11/00	23.55	0.00	586	<0.5	2	0	2	4
03/11/00				NO SAMPLE				
04/11/00	46.30	0.25	260	1.5	5	4	0	0
05/11/00	23.40	0.00	294	1	0	0	1	0
06/11/00	24.50	0.00	350	0.5	5	1	1	9

SITE 4

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
23/09/00	24.00	3.60	973	1.0	4	0	6	18
24/09/00	24.05	2.40	825	0.5	0	0	0	7
25/09/00	23.55	2.10	970	0.5	0	0	1	0
26/09/00	23.55	1.70	863	<0.5	0	0	0	0
27/09/00	24.10	0.70	902	1.0	0	0	0	1
28/09/00	23.50	0.60	816	<0.5	0	0	0	0
29/09/00	24.05	none	62	0.5	0	0	0	0
30/09/00				NO SAMPLE				
01/10/00	47.25	0.75	1120	1.0	0	0	0	0
02/10/00	24.35	0.65	889	0.5	0	0	0	0
03/10/00	24.00	0.70	729	<0.5	0	0	0	0
04/10/00	24.00	0.70	801	<0.5	0	0	0	0
05/10/00				NO SAMPLE				
06/10/00	48.00	0.90	1145	0.5	0	0	0	0
07/10/00	24.10	0.70	697	0.5	0	0	0	0
08/10/00	23.50	0.70	787	<0.5	0	0	0	0
09/10/00	23.50	0.80	721	<0.5	0	0	0	0
10/10/00	24.05	0.70	771	0.5	0	0	0	0
11/10/00	23.55	1.00	712	<0.5	0	0	0	2
12/10/00	24.15	0.60	538	0.5	0	0	0	0
13/10/00	23.50	0.60	545	<0.5	0	0	0	0
14/10/00	24.05	0.70	614	0.5	0	0	0	0
15/10/00	24.00	0.60	775	0.5	0	0	0	0
16/10/00	23.50	1.10	695	0.5	0	0	0	0
17/10/00	25.10	0.80	549	0.5	0	0	0	0
18/10/00	23.00	0.70	558	<0.5	0	0	0	0

SITE 4

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
19/10/00	24.05	0.70	514	0.5	0	0	0	0
20/10/00	24.00	0.70	547	<0.5	0	0	0	0
21/10/00	23.55	0.70	562	<0.5	0	0	0	0
22/10/00	23.55	0.80	527	<0.5	0	0	0	0
23/10/00	24.15	0.60	479	<0.5	0	0	0	0
24/10/00	23.45	0.80	569	<0.5	0	0	0	0
25/10/00	23.55	1.30	648	<0.5	0	0	0	0
26/10/00	24.00	0.70	785	<0.5	0	0	0	0
27/10/00	23.55	0.80	716	<0.5	0	0	0	0
28/10/00	24.00	0.70	795	<0.5	0	0	0	0
29/10/00	23.55	0.00	325	<0.5	0	0	0	0
30/10/00	24.10	0.00	275	<0.5	0	0	0	0
31/10/00	23.50	0.00	525	<0.5	0	0	0	0
01/11/00	23.15	0.80	785	<0.5	0	0	0	0
02/11/00	24.50	0.70	800	<0.5	0	0	0	0
03/11/00	24.00	0.80	688	<0.5	0	0	0	0
04/11/00	23.45	0.70	776	<0.5	0	0	0	0

SITE 5

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
26/09/00	24.45	0.80	1357	<0.5	0	0	2	2
27/09/00	21.55	0.80	1235	<0.5	6	0	6	14
28/09/00	25.30	0.70	1368	<0.5	100	40	54	220
29/09/00	24.40	0.90	1373	<0.5	10	1	0	0
30/09/00	19.10	1.10	1044	<0.5	6	0	0	0
01/10/00	27.20	0.90	1503	<0.5	0	0	0	0
02/10/00	20.40	1.00	1131	<0.5	1	2	0	0
03/10/00	28.15	0.80	1545	<0.5	0	1	1	1
04/10/00	22.25	0.80	1204	<0.5	0	0	1	1
05/10/00	22.45	0.90	676	<0.5	4	0	1	16
06/10/00	23.35	0.80	1881	<0.5	0	0	0	0
07/10/00	24.40	0.80	1344	<0.5	0	0	1	5
08/10/00	24.35	0.80	1443	<0.5	11	1	1	26
09/10/00	22.55	0.80	1172	<0.5	0	0	0	1
10/10/00	28.40	0.90	1515	<0.5	15	5	65	178
11/10/00	20.40	0.90	1160	<0.5	7	0	8	30
12/10/00	21.50	0.90	993	<0.5	2	4	3	0
13/10/00	23.20	0.90	1462	<0.5	4	2	0	0
14/10/00	25.55	0.90	1405	<0.5	0	0	0	0
15/10/00	24.05	0.90	1326	<0.5	0	0	3	2
16/10/00	27.00	0.90	1469	<0.5	1	0	0	1
17/10/00	21.00	0.90	1137	<0.5	2	0	4	2
18/10/00	26.30	1.00	1443	<0.5	0	0	0	0
19/10/00	24.00	1.00	1291	<0.5	0	0	2	0
20/10/00	24.10	0.90	1308	<0.5	0	0	0	0
21/10/00				NO SAMPLE				

SITE 5

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium*		*Giardia*	
					DAPI +	DAPI -	DAPI +	DAPI -
22/10/00	43.50	0.90	2397	<0.5	0	0	3	7
23/10/00	23.15	0.50	1314	<0.5	0	0	3	9
24/10/00	27.30	0.60	1430	<0.5	3	0	9	37
25/10/00	21.55	0.80	992	0.5	7	5	205	533
26/10/00	25.25	0.80	1570	<0.5	1	0	6	12
27/10/00	21.55	0.90	1192	<0.5	0	0	0	0
28/10/00	24.50	1.00	1345	<0.5	10	0	2	18
29/10/00	23.45	0.90	1332	<0.5	1	0	3	5
30/10/00	25.00	none	1338	<0.5	0	1	1	0
31/10/00	25.35	0.80	1370	<0.5	1	0	0	1
01/11/00	22.15	0.90	1205	<0.5	1	1	3	10
02/11/00	25.15	0.90	1356	<0.5	0	0	3	11
03/11/00	20.30	0.90	1103	<0.5	1	0	0	1
04/11/00	24.00	0.90	1317	<0.5	0	0	1	0
05/11/00	23.45	0.90	1291	<0.5	0	0	0	0
06/11/00	23.15	0.90	1306	<0.5	0	0	0	0

SITE 6

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
26/09/00	24.15	6.00	1388	1.0	0	0	0	0
27/09/00	23.55	6.50	1366	0.5	0	0	0	0
28/09/00	21.20	1.00	1250	0.5	0	0	0	0
29/09/00				NO SAMPLE				
30/09/00	26.10	7.25	1485	1.0	0	0	0	0
01/10/00	23.45	0.75	1332	<0.5	0	0	0	0
02/10/00	25.10	9.50	490	1.0	0	0	0	0
03/10/00	23.30	9.50	201	1.0	0	0	0	0
04/10/00	22.35	7.75	1231	0.5	0	0	0	0
05/10/00	23.40	6.00	1374	2.0	0	0	0	0
06/10/00	25.00	6.00	1453	2.0	0	0	0	0
07/10/00				NO SAMPLE				
08/10/00	47.25	9.50	1782	0.5	0	0	0	0
09/10/00	27.35	0.00	1232	1.0	0	0	1	0
10/10/00	21.30	8.75	1086	2.0	0	0	0	3
11/10/00				NO SAMPLE				
12/10/00	48.15	10.00	840	2.0	5	7	17	21
13/10/00	24.10	9.50	552	<0.5	0	0	1	2
14/10/00	22.45	8.40	1119	0.5	0	0	0	0
15/10/00				NO SAMPLE				
16/10/00	49.20	9.00	1935	NONE	0	0	0	0
17/10/00	24.05	1.50	1377	2.0	0	0	0	0
18/10/00				NO SAMPLE				
19/10/00	45.50	8.75	1750	NONE	0	0	0	0
20/10/00	25.35	8.50	1226	1.0	0	0	0	0
21/10/00	22.40	8.00	1086	<0.5	0	0	0	0

SITE 6

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
22/10/00	24.30	8.75	1207	1.0	0	0	0	0
23/10/00				NO SAMPLE				
24/10/00				NO SAMPLE				
25/10/00	73.20	6.00	2048	1.0	0	0	1	1
26/10/00	24.45	8.50	589	1.5	NO RESULT	NO RESULT	NO RESULT	NO RESULT
27/10/00	23.10	8.00	1849	2.0	0	0	0	0
28/10/00	22.15	8.00	1196	2.0	0	0	0	0
29/10/00	23.55	9.00	1101	1.0	0	0	2	13
30/10/00				NO SAMPLE				
31/10/00				NO SAMPLE				
01/11/00	73.55	10.00	734	1.5	5	20	4	28
02/11/00	23.40	9.25	894	1.5	6	1	3	28
03/11/00				NO SAMPLE				
04/11/00	47.25	10.00	881	1.5	0	0	0	0
05/11/00	24.15	9.00	773	2.0	0	0	5	6
06/11/00	24.40	9.50	761	3.0	0	0	0	2

SITE 7

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
18/09/00	24.00	0.10	1221	0.5	8	1	12	76
19/09/00	24.05	1.60	1423	1.0	5	7	108	252
20/09/00	24.10	2.10	1307	1.5	19	5	155	456
21/09/00	23.35	4.00	1241	1.5	27	17	222	706
22/09/00	24.10	4.20	1358	1.0	21	9	65	149
23/09/00	24.00	0.70	1342	0.5	10	4	29	64
24/09/00	23.55	2.40	1332	0.5	11	0	34	127
25/09/00	26.00	1.70	1438	1.0	13	2	49	169
26/09/00	21.50	2.50	1200	<0.5	10	2	8	183
27/09/00	24.00	2.50	1329	1.5	15	7	30	336
28/09/00	23.45	2.50	1312	1.0	13	1	18	88
29/09/00	24.30	2.70	1358	1.0	16	5	0	19
30/09/00	23.35	2.45	1200	1.0	13	0	7	25
01/10/00	24.10	3.40	1200	1.0	12	4	0	0
02/10/00	24.00	1.50	1200	0.5	0	2	1	1
03/10/00				NO SAMPLE				
04/10/00	23.30	1.60	1301	0.5	4	0	0	2
05/10/00	23.55	1.80	1298	0.5	0	0	0	0
06/10/00	23.55	1.80	1301	NONE	5	6	1	4
07/10/00	24.15	0.90	1313	0.5	0	0	0	6
08/10/00	23.50	2.10	1288	1.0	37	6	33	569
09/10/00	24.00	1.00	1306	1.0	6	5	19	324
10/10/00	23.50	3.70	1291	2.0	29	14	276	747
11/10/00	24.05	5.90	1342	1.0	56	18	94	661
12/10/00	24.05	0.70	1309	1.0	30	4	0	22
13/10/00	24.00	NONE	1314	1.0	9	4	12	40

SITE 7

Date	Sample Time (h)	Head Loss	Sample Volume	Pellet Volume	*Cryptospordium* DAPI +	*Cryptospordium* DAPI -	*Giardia* DAPI +	*Giardia* DAPI -
14/10/00	24.05	3.40	1329	1.0	3	0	0	0
15/10/00	24.05	1.70	1301	0.5	1	1	0	2
16/10/00	23.45	0.30	1300	1.0	0	0	0	0
17/10/00	24.00	1.00	1277	1.0	0	2	1	4
18/10/00	24.05	1.00	1287	1.0	7	8	1	15
19/10/00	23.55	1.50	1284	0.5	2	1	1	4
20/10/00	24.00	1.50	1276	1.0	6	3	2	10
21/10/00	24.20	2.10	1296	1.0	21	2	18	371
22/10/00	23.50	1.60	1267	0.5	15	18	47	158
23/10/00	24.10	0.60	1290	0.5	9	0	14	282
24/10/00	23.35	2.00	1259	1.0	0	0	0	0
25/10/00	23.55	1.80	1284	0.5	0	1	0	0
26/10/00	24.05	2.10	1288	1.0	2	0	0	0
27/10/00	24.05	1.40	1274	1.0	19	12	48	163
28/10/00	24.05	0.40	1258	1.0	4	1	0	2
29/10/00	24.05	1.70	1321	1.0	11	25	389	831
30/10/00	31.45	3.10	1659	2.0	50	11	135	1523
31/10/00	20.15	2.80	1074	3.0	16	60	74	2232
01/11/00	20.10	1.50	1062	1.0	16	1	82	584
02/11/00	25.20	2.10	1291	1.0	6	15	113	445

Appendix A.5 Raw Water Microbiology, Phase 2

SITE 1 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
19.09.00	0	0	0	0
20.09.00	0	0	0	0
21.09.00	0	0	0	0
22.09.00	0	0	0	0
23.09.00	0	0	0	0
24.09.00	0	0	0	0
25.09.00	0	0	0	0
26.09.00	0	0	0	0
27.09.00	0	0	0	0
28.09.00	0	0	0	0
29.09.00	0	0	0	0
30.09.00	0	0	0	0
01.10.00	0	0	0	0
02.10.00	0	0	0	0
03.10.00	0	0	0	0
04.10.00	0	0	0	0
05.10.00	0	0	0	0
06.10.00	0	0	0	0
07.10.00	0	0	0	0
08.10.00	0	0	0	0
09.10.00	0	0	0	0
10.10.00	0	0	0	0
11.10.00	0	0	0	0
12.10.00	0	0	0	0
13.10.00	0	0	0	0
14.10.00	0	0	0	0
15.10.00	0	0	0	0
16.10.00	0	0	0	0

SITE 1 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
17.10.00	0	0	0	0
18.10.00	0	0	0	0
19.10.00	0	0	0	0
20.10.00	0	0	0	0
21.10.00	0	0	0	0
22.10.00	0	0	0	0
23.10.00	0	0	0	0
24.10.00	0	0	0	0
25.10.00	0	0	0	0
26.10.00	0	0	0	0
27.10.00	0	0	0	0
28.10.00	0	0	0	0
29.10.00	0	0	0	0
02.11.00	0	0	0	0
03.11.00	0	0	0	0

SITE 3 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
25.09.00	3	0	0	0
26.09.00	153	14	8	0
27.09.00	49	4	3	0
28.09.00	160	112	9	0
29.09.00	15	2	2	0
30.09.00	10	2	0	0
01.10.00	10	1	0	1
02.10.00	5	5	5	1
03.10.00	19	7	0	0
04.10.00	7	1	0	0
05.10.00	4	1	0	0
06.10.00	12	0	0	0
07.10.00	28	0	0	0
08.10.00	19	0	0	0
09.10.00	160	160	16	7
10.10.00	12	5	13	0
11.10.00	34	34	8	0
12.10.00	400	400	1	1
13.10.00	440	20	0	0
14.10.00	50	23	1	1
15.10.00	100	3	0	0
16.10.00	126	72	0	0
17.10.00	164	4	0	0
18.10.00	28	12	1	0
19.10.00	2	1	0	0
20.10.00	26	9	0	0
21.10.00	52	0	1	0
22.10.00	13	1	0	0

SITE 3 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
23.10.00	45	5	0	1
24.10.00	6	2	0	0
25.10.00	6	1	0	1
26.10.00	16	2	0	0
27.10.00	15	1	0	1
28.10.00	37	1	0	1
29.10.00	148	8	0	2
30.10.00	8	3	0	0
31.10.00	22	1	0	0
01.11.00	96	2	0	5
02.11.00	7	0	0	0
03.11.00	30	0	0	0
04.11.00	27	1	0	0
05.11.00	19	0	0	1

SITE 6 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
26.09.00	149	120	260	48
27.09.00	110	110	29	5
28.09.00	250	19	250	13
29.09.00	15	2	2	0
30.09.00	28	8	4	10
01.10.00	8	2	0	0
02.10.00	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
03.10.00	15	15	4	2
04.10.00	10	0	2	0
05.10.00	9	4	1	0
06.10.00	27	1	2	2
07.10.00	16	2	2	2
08.10.00	15	3	0	1
09.10.00	<3000	<3000	<300	<300
10.10.00	<3000	<3000	<300	<300
11.10.00	<3000	<3000	<300	<300
12.10.00	560	410	<300	35
13.10.00	480	160	25	216
14.10.00	230	90	170	11
15.10.00	303	43	136	12
16.10.00	190	60	79	9
17.10.00	208	36	20	1
18.10.00	135	49	31	3
19.10.00	55	22	12	6
20.10.00	52	19	18	5
21.10.00	53	18	10	4
22.10.00	38	10	11	0
23.10.00	31	7	6	4

SITE 6 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
24.10.00	26	11	6	2
25.10.00	16	9	4	1
26.10.00	17	8	3	3
27.10.00	15	4	6	1
28.10.00	16	4	3	1
29.10.00	76	16	7	21
30.10.00	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE
31.10.00	2360	1100	<300	<300
01.11.00	350	328	<300	<300
02.11.00	230	20	246	20
03.11.00	173	63	85	115
04.11.00	710	502	<300	242
05.11.00	264	80	<300	118

SITE 7 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
18.09.00	750	670	30	20
19.09.00	570	540	20	10
20.09.00	21300	14000	2700	470
21.09.00	6000	4600	720	50
22.09.00	960	650	80	30
23.09.00	570	470	50	40
24.09.00	340	300	10	<10
25.09.00	4000	3600	170	140
26.09.00	310	200	40	80
27.09.00	2800	1100	180	80
28.09.00	2600	1300	250	120
29.09.00	330	220	10	10
30.09.00	720	220	20	30
01.10.00	640	120	<10	<10
02.10.00	310	110	10	<10
03.10.00	640	120	<10	<10
04.10.00	520	120	<10	<10
05.10.00	350	140	<10	<10
06.10.00	410	60	20	<10
07.10.00	230	120	5	0
08.10.00	4600	600	210	80
09.10.00	610	130	28	31
10.10.00	7900	1500	320	160
11.10.00	1250	150	56	110
12.10.00	800	110	36	50
13.10.00	140	40	6	23
14.10.00	50	20	8	12
15.10.00	450	30	3	9

SITE 7 – Raw Water Data

Date	Coliforms No./100ml	Escherichia coli No./100ml	Enterococci No./100ml	Clostridia No./100ml
16.10.00	340	40	2	4
17.10.00	320	20	2	3
18.10.00	960	140	340	150
19.10.00	270	10	3	14
20.10.00	80	40	1	5
21.10.00	260	140	22	120
22.10.00	370	90	2	39
23.10.00	370	20	2	49
24.10.00	90	10	1	68
25.10.00	TNTC	52900	82	210
26.10.00	930	110	6	19
27.10.00	2	0	2	6
28.10.00	3100	100	1	32
29.10.00	TNTC	3300	127	74
30.10.00	NO SAMPLE	NO SAMPLE	NO SAMPLE	NO SAMPLE

Appendix A.6 Pathogen Typing

Pathogen Typing

Nine *Campylobacter* were isolated during the phase 1 survey. Three of the isolates came from site 5 and six from site 7. The isolates were sent to the Public Health Laboratory Service at Colindale for typing. The results of the typing exercise are given in the table below. We are indebted to Dr Gordon Nichols and Dr Jennifer Frost for permission to do the typing and undertaking the work.

CREH Ref	LEP Ref	Species	Serotype	Phage type	R-type
29.5.00 Site 7	C0378180	**C. coli**	untypable	untypable	NxCp
04.06.00 Site 5	C0378190	**C.jejuni**	untypable	73	sensitive
10.06.00 Site 5	C0378240	**C.jejuni**	HS 8	untypable	C
27.05.00 Site 7	C0378230	**C.lari**	HS19	untypable	sensitive
28.05.00 Site 7	C0378210	**C.jejuni**	untypable	RDNC	sensitive
29.5.00 Site 7	C0378200	**C.lari**	untypable	1	NxCp
30.05.00 Site 7	C0378250	**C.lari**	HS19	untypable	sensitive
31.05.00 Site 7	C0378260	**C.lari**	HS 19	untypable	sensitive
10.06.00 Site 5	C0378220	**C.jejuni**	HS 8	RDNC	sensitive

Notes:
RDNC = reacts with the typing phages but does not conform to a designated type.
NxCp = resistant to naladixic acid and ciprofloxacin.
C = resistant to chloramphenicol
A = resistant to ampicillin.

In a letter containing the results Dr Frost expressed interest in the *C. lari* results from serotype HS 19 as this subtype had not been encountered before.

The second isolate at site 5 at the bottom of the above table was as a result of a second colony being subcultured from the isolation plate. The second colony was used to send a second culture to CREH on the assumption that the two isolates were identical. In considering the typing data, the two isolates are clearly not identical. In practice, for work of this nature, where biotyping is proposed, several colonies should be selected from each plate to give the full

range of possible isolates. The incidence clearly shows more that one type may be isolated in culture from one sample.

A further three isolates were obtained during phase 2 of the monitoring. Two of these were from site 5 and one from site 7. These isolates were also sent to Dr Frost for typing. The results are given in the table below.

CREH Ref	LEP Ref	Species	Serotype	Phage type	R-type
28.09.00 Site 5	C0429630	**C. jejuni**	HS 13	73	No data
03.10.00 Site 5	C0429620	**C. jejuni**	HS 13	73	No data
21.09.00 Site 7	C0429610	**A. butzleri**	Untypable	No data	No data

Two of the isolates were confirmed as *Campylobacter jejuni* and one as *Arcobacter butzleri.*

Escherichia coli O157:H7 was isolated from site 7 on one occasion. It was not isolated from any of the other sites. The isolate was sent to Dr Peter Chapman at Sheffield Public Health Laboratory. The following is an extract from the results:-

'We can confirm that it is biochemically typical of *E. coli* O157, it agglutinates to titre with *E. coli* O157 antiserum and it hybridises with labelled DNA probes for the VT_2 and *eaeA* genes, but not with a probe for the VT_1 gene. This profile is characteristic of approximately 75% of strains we have isolated from cattle, sheep and environmental samples over the past five years'.

All the isolates are stored at PHLS Colindale and Sheffield should any further typing work be required.

Appendix B Parasitology Methods

Cryptosporidium was enumerated by 24 hour sampling using Genera Filta-Max™ filters. Assembled filter housings were pressure tested to greater than 5 bar pressure for 15 minutes before being dispatched to samplers. Samples were processed at CREH *Analytical* Limited following the Standard Operating Protocol (SOP) for the monitoring of *Cryptosporidium* oocysts in treated water supplies, part 2 – Laboratory and Analytical Procedures. A small number of modifications were introduced into the method to accommodate the detection of *Giardia.*

Immunomagnetic separation (IMS) was done using the Dynal GC-Combo test kit. Anti-*Cryptosporidium* beads and anti-*Giardia* beads were added to the sample at the same time, according to the manufacturers instructions. Capture was run at room temperature for one hour. The beads were then removed from the sample in the Leighton tube as described in the SOP. Following the second bead concentration in the eppendorf tube, beads were washed, where necessary, with x1 SL buffer to remove excess particulate material. Several wash steps were used with dirty samples. The oocysts and cysts were dissociated from the beads using 50µl of 0.1N hydrochloric acid , incubating for 10 minutes instead of the standard 5 minutes according to the manufacturers instructions. Slides were stained with CelLab anti-*Cryptosporidium* and anti-*Giardia* at the same time using 25µl of each antibody.

Samples were stained with DAPI. The DAPI staining was used to help identify both parasites. Many of the *Giardia* cysts were empty and some contained contents but typical features such as nuclei, flagella axonemes and median body were absent. The parasites were therefore checked for appropriate size and for the presence of DAPI stained nuclei. This was the only feature found to be of use in the majority of parasites observed in the samples.

Appendix C Microbiology Methods

DETECTION AND ENUMERATION OF TOTAL COLIFORMS AND *ESCHERICHIA COLI*

1 SCOPE AND FIELD OF APPLICATION

1.1 The method described is suitable for the isolation of coliforms and *E. coli* from water, sewage and related samples by membrane filtration.

1.2 The normal sample volume for this test is 100ml for coliforms and 100ml for *E. coli*.

1.3 This volume may decrease for heavily contaminated samples where dilution may be necessary.

2 REFERENCES

2.1 British Standard 6068: Section 4.2 1989, ISO 8199:1988
Guide to the Enumeration of Micro-organisms by Culture

2.2 The Microbiology of Water 1994. Part 1 - Drinking Water. Reports on Public Health and Medical Subjects No. 71. HMSO, London. ISBN 0-11-753010-7.

2.3 Guidance on Safeguarding the Quality of Public Water Supplies 1990. HMSO ISBN 0 11 752262 7.

2.4 SARTORY, D. P. AND HOWARD, L. (1992). A medium detecting β-glucuronidase for the simultaneous membrane filtration enumeration of *Escherichia coli* and coliforms from drinking water. Letters in Applied Microbiology, 15, 273 – 276.

2.5 Anon, (1998). Evaluation trials for two media for the simultaneous detection and enumeration of *Escherichia coli* and coliforms. Methods for the Examination of Water and Associated Materials. HMSO, London.

3 PRINCIPLE OF METHOD

3.1 Definition and Description of Organisms

3.1.1 Total coliforms are members of the family Enterobacteriacae and are Gram-negative, non-sporing rods which are oxidase negative. They are capable of growth at 37^{o}C in the presence of surface-active agents with the production of acid from lactose. They have the ability to produce the enzyme β-galactosidase which may be recognised by the production of acid from lactose in the confirmation test, or by biotyping using API 20E (bioMerieux).

3.1.2 *Escherichia coli* is a member of the family Enterobacteriaceae and is a Gram-negative, non-sporing rod which is oxidase negative. It is included in the total coliform group and can grow at 37°C. However, it is distinguished from standard coliform organisms by its ability to usually grow at an elevated temperature of 44°C, to ferment lactose and to produce indole from the amino acid tryptophan. *Escherichia coli* also possesses the enzyme β-glucuronidase, which may be demonstrated by inclusion of the appropriate substrate for the enzyme. Confirmation is by the ability to produce acid from lactose and indole at 44°C, or by biotyping using API 20E.

3.2 **Pathogenicity**

Coliforms and *E. coli* are present in large numbers in the gut of man and other animals. Generally they tend to have a commensal relationship with their host. However, they can be responsible for diarrhoea in very young, very elderly and immuno-compromised individuals. They have been known to cause a variety of other illnesses. Coliforms and faecal coliforms are of importance in water analysis, since they offer an indication of the degree of faecal contamination of water supplies which in turn signifies the presence or absence of primary pathogens associated with faeces of both human and animal origin.

Coliforms and some *E. coli* can multiply in water. In general however, the presence of coliforms and particularly faecal coliforms in water indicates recent pollution and hence the possibility of primary pathogens (eg, *Shigella* spp) being present.

3.3 **General Principle**

This Method details the isolation of total coliforms and *E. coli* from water and associated materials by the use of single membrane filtration. Coliforms produce characteristic colonies on membrane lactose glucuronide agar (MLGA) recognised by the production of yellow colonies at 37°C. *Escherichia coli* produces characteristic green colonies on the same membrane through breakdown of the substrate 5-bromo-4-chloro-3-indolyl-β-D-glucuronide (BCIG). Confirmation of isolates is by inoculation of MacConkey agar at 37°C and 44°C for lactose fermentation and the inoculation of tryptone nutrient agar for the oxidase test and indole production. Isolates which fail to confirm by this procedure or are atypical may be subjected to biotyping using API 20E.

4 HAZARDS

Safety standards appropriate to routine laboratory work should be followed at all times.

All materials which become contaminated during the test procedure should be sterilised before being discarded. Sterilisation is best achieved by autoclaving materials in suitable containers eg. autoclave bags, at 121^{o}C ± 2^{o}C for 15 minutes. Alternatively materials may be placed into a suitable disinfectant (chloros or hycolin) for 12 hours before being discarded.

5 PERFORMANCE DATA

5.1 Limit of Detection

One organism in the volume of sample analysed.

5.2 Interference

High turbidity may make membrane filtration difficult. Large numbers of competing organisms may interfere with the growth of the test organism.

5.3 Time Required for Analysis

Membrane filtration	14 hours minimum and 18 hours for the standard test.
Confirmation	24 – 48 hours.

6 REAGENTS

Reagents used in the preparation of media should always be of analytical quality and media should be prepared with distilled water or water of equivalent quality.

6.1 Membrane Lactose Glucuronide Agar (MLGA) (Sartory and Howard 1992, Anon 1998)

Bacteriological peptone	40.0g
Yeast extract	6.0g
Lactose	30.0g
Phenol red	0.2g
Sodium lauryl sulphate	1.0g
Sodium pyruvate	0.5g
Agar	10.0g
5-Bromo-4-chloro-3-indolyl-β-D glucuronide sodium salt	0.2g
Distilled water	1000ml

Preparation

Dissolve the ingredients in the distilled water distilled water. Adjust the pH to 7.4 ± 0.2. Dispense into bottles of required volumes and

autoclave at 115°C ± 2°C for 10 minutes. After autoclaving, the pH of one bottle must be checked to confirm a pH of 7.4 ± 0.2. Cool the autoclaved medium to approximately 50°C, pour into Petri dishes and allow the medium to set. Prepared agar plates may be stored at 2 – 8°C and should be used within 1 week.

6.2 Confirmation

6.2.1 Tryptone Nutrient Agar

Lab-Lemco powder	1.0g
Yeast extract	2.0g
Peptone	5.0g
Tryptone	10.0g
Sodium chloride	5.0g
Agar	15.0g
Distilled water	1000ml

Preparation

Prepare the ingredients in 1000ml of distilled water and adjust the pH to 6.8 ± 0.2. Sterilise by autoclaving at 121°C ± 2°C for 15 min. The sterile medium may be stored at room and should be used within 1 month. Alternatively, the medium should be cooled to approximately 50°C, poured into sterile Petri dishes and allowed to set. Petri dishes may be stored at 2 – 8°C and should be used within 1 month.

6.2.2 Oxidase Test

Commercially available oxidase test sticks (Oxoid BR 64).

6.2.3 MacConkey Agar

Peptone	20.0g
Lactose	10.0g
Bile salts	5.0g
Sodium chloride	5.0g
Neutral red	0.075g
Agar	12.0g
Distilled water	1000ml

Preparation

Prepare the ingredients in 1000ml of distilled water and adjust the pH to 7.4 ± 0.2 and dissolve by boiling. Sterilise by autoclaving at 121°C ± 2°C for 15 min. The sterile medium may be stored at room and should be used within 1 month. One bottle should be used to confirm a pH of 7.4 ± 0.2. Alternatively, the medium should be cooled to approximately

50°C, poured into sterile Petri dishes and allowed to set. Petri dishes may be stored at 2 – 8°C and should be used within 1 month.

6.2.4 **Kovacs' Reagent**

Para-dimethylaminobenzaldehyde	5g
Amyl alcohol A.R.	75ml
Hydrochloric acid (concentrated)	25ml

Preparation

Dissolve the aldehyde in the alcohol. Add the concentrated acid with care. The reagent should be light yellow to light brown in colour and may be stored at 2-8°C for up to 6 months.

Kovacs' reagent is available commercially and should be stored and used according to the manufacturer's instructions.

6.2.6 **Sterile Distilled Water**

Preparation

Dispense distilled water in 10ml volumes into Universal containers and sterilise by autoclaving at 121°C ± 2°C for 15 min. Sterile bottles may be stored at room temperature and should be used within 3 months.

7 APPARATUS

Incubator 37°C ± 1°C and 44°C ± 0.5°C
Boiling water bath
Membrane filter funnels and manifold
Vacuum pump and reservoir
Forceps and tongs
Petri dishes, 50 - 60mm diameter for membranes, and 90mm for subculturing
Membranes, 47mm diameter, 0.45µm pore size, sterile gridded
Bunsen burner
API 20E strips. API - bioMerieux (UK) Ltd, Basingstoke, Hants.

8 CALIBRATION

8.1 Positive and Negative Controls

In conjunction with the analysis detailed by this method, at the time of testing, a positive control consisting of:

a) an environmental sample known to contain the species of organism enumerated by the method, or:

b) a cell suspension prepared from a reference stock culture

will be prepared and incubated under the same conditions, and at the same time as the material under test to ascertain that the test method and physical parameters, i.e. incubation time and temperature, will enumerate coliforms and *E. coli*.

Similarly, a negative control consisting of a 100ml volume of sterile glass distilled water will also be incubated under the same test conditions to ensure sterility of the test medium.

The results of all positive and negative controls should be recorded. Positive and negative control failures invalidate the test and repeat analysis must be performed.

Where a suitable environmental sample is unavailable for use as a positive control, a suitable reference culture may be used, for example *Escherichia coli* NCTC 9001.

8.2 **Equipment**

All volumetric pipettes and pipetting aids used throughout the test procedure must be calibrated and checked on a daily basis. All incubators and weighing equipment used must also be calibrated and checked on a daily basis.

9 SAMPLE COLLECTION AND PRESERVATION

9.1 Collection, Storage and Transport of Samples for Bacteriological Examination

The prime objective of the method is to obtain a sample that is representative, as far as possible, of the water to be examined. To achieve this, the precautions detailed below are necessary which are common to all sampling procedures for the bacteriological examination of water.

Sterile plastic bacteriological bottles (500ml) should be used.

Although the water may not contain chlorine or chloramines, sufficient sodium thiosulphate must be added to sample bottles to neutralise these substances (this may be provided, already added to the bottles, by the supplier). For low concentrations of chlorine and at pH values normally occurring in water supplies, sodium thiosulphate ($Na_2S_2O_3 5H_2O$) at a concentration of 18mg/litre should neutralise up to 5mg/l of free and combined residual chlorine without significant effect on the bacterial population under test.

0.1ml of a 1.8% (w/v) solution of sodium thiosulphate should be added pro rata for each 100ml of bottle capacity.

Scrupulous care should be taken to avoid accidental contamination of the sample during collection and subsequent handling. The changes which occur in the bacteriological content of water between the time of sampling and examination should be reduced to a minimum by ensuring that the sample is not exposed to light, is kept cool in an insulated container and is transported to the laboratory and processed as quickly as possible.

The sample should be examined within 6 hours of collection.

10 ANALYTICAL PROCEDURE

10.1 The Test

Membrane-filter 100ml of the sample or smaller volumes where heavy contamination is suspected and place the membrane onto MLGA. Membranes are incubated at 30°C ± 1°C for 4 hours followed by 37°C ± 1°C for 14 hours. A positive control should be included with each batch of filtrations. The positive control should be raw water, which may be stored at 2-8°C and used throughout a week. The negative controls are sterile distilled water. A negative control should be tested at the beginning of filtration and after each batch of 20 samples. One additional negative control is filtered at the completion of the samples. This serves to check the sterility of the materials and the medium and the efficiency of pasteurisation of filters between each sample. After 18 h examine the membranes for yellow colonies which are total coliforms and green colonies which are *E. coli* and any other growth, for example non-lactose fermenting colonies. Count and confirm yellow and green colonies.

10.2 Confirmation

Subculture up to ten yellow and 10 green colonies for each positive membrane onto MacConkey agar and Tryptone Agar at 37°C and 44°C. Incubate for 24 ± 4 hours. Examine MacConkey Agar plates to ascertain that the cultures are pure and that the isolates ferment lactose. MacConkey plates which fail to ferment lactose after 24 hours at 37°C should be incubated for a further 24 hours. Mixed cultures should be sub-cultured onto further agar plates and incubated as above, selecting at least one representative of each colony type. Pure cultures on Tryptone Nutrient Agar should be tested for the presence of the enzyme cytochrome oxidase by removing some of a colony with an oxidase stick. If the organism is oxidase positive a blue colouration should appear within 10 seconds. A negative reaction should show no colour change. A positive and negative control is included with each batch of tests. The manufacturer's instructions should also be studied carefully before testing.

Add one or two drops of Kovac's reagent to the Tryptone Nutrient Agar cultures. The development of a red colour in the medium indicates the production of indole from tryptophan.

The confirmation tests should include known positive and negative controls, for example *E. coli* and *Pseudomonas aeruginosa* obtained from a reference culture collection.

10.3 **Atypical Colonies**

Occasionally, blue colonies may be encountered. These are usually non-lactose fermenting *E. coli*. These and any other atypical colonies, for example yellow colonies isolated at 37^{o}C which confirm as *E. coli* should be inoculated into a commercially available biochemical testing kit, for example API 20E (BioMereux) for confirmation of identity.

11 CALCULATIONS

From the volume of sample used, calculate and report the result as the number of coliforms and *E. coli* in 100ml of sample, i.e. cfu/100ml.

12. NOTES

BCIG will be provided by CREH *Analytical*.

DETECTION AND ENUMERATION OF ENTEROCOCCI

1 SCOPE AND FIELD OF APPLICATION

1.1 The Method described is suitable for the isolation of enterococci from water, sewage and related samples by membrane filtration.

1.2 The normal sample volume for this test is 100ml.

1.3 This volume may decrease for heavily contaminated samples where dilution may be necessary.

2 REFERENCES

2.1 BS1 6086, Section 4.4 Detection and Enumeration of Faecal Streptococci by the Membrane Filtration Technique 1989.

2.2 The Microbiology of Water 1994. Part 1 - Drinking Water. Reports on Public Health and Medical Subjects No. 71. HMSO, London. ISBN 0-11-753010-7.

2.3 SLANETZ, L. W. AND BARTLEY, C. H. (1957) Numbers of enterococci in water, sewage and faeces determined by the membrane filter technique with an improved medium. Journal of Bacteriology, 74, 591 – 595.

3 PRINCIPLE OF METHOD

3.1 Definition and Description of Organisms

For routine water examination purposes, enterococci may be described generally in microbiological terms as Gram-positive cocci forming pairs and chains. They are non-sporing, oxidase and catalase negative, possess Lancefield's Group D antigen and can hydrolyse aesculin. They can grow both aerobically and anaerobically in the presence of bile salts and in concentrations of sodium azide which are inhibitory to coliform organisms and most Gram-negative bacteria. *Enterococcus faecalis* and some related species can reduce 2, 3, 5 triphenyltetrazolium chloride (TTC) to the insoluble red dye formazan.

3.2 Pathogenicity

Enterococci are found in the faeces of humans and warm-blooded animals. They occur occasionally in urinary tract infections and sub-acute bacterial endocarditis. They are common in many food products and are often unrelated to direct faecal contamination. Their relationship with food poisoning is questionable.

3.3 General Principle

In the United Kingdom enterococci are regarded as secondary indicators of faecal pollution. Enterococci normally inhabit the intestines of man and other warm-blooded animals and can therefore provide an indication of such pollution. Their survival in the environment is longer than that of faecal coliforms and they are therefore seen as a valuable indicator of remote or intermittent contamination. There is also evidence to suggest that they are a better indicator in the marine environment.

Enterococci can be isolated by growth on Slanetz and Bartley agar, forming
characteristic colonies after 48 hours incubation.

4 HAZARDS

4.1 Safety standards appropriate to routine laboratory work should be followed at all times.

4.2 Sodium azide is toxic. Reference should be made to assessments made under the Control of Substances Hazardous to Health (COSHH). Solutions containing azide should not be discharged through metal pipework or drains as explosive compounds may be formed. Azides can be decomposed by an excess of a nitrite solution. COSHH assessments should also be consulted for precautions to be taken when handling fine powders such as dehydrated culture media.

4.3 All materials that become contaminated during the test procedure should be sterilised before being discarded. Sterilisation is best achieved by autoclaving materials in suitable containers e.g. autoclave bags, at 121^{o}C ± 2^{o}C for 15 minutes. Alternatively materials may be placed into a suitable disinfectant (chloros or hycolin) for 12 hours before being discarded.

5 PERFORMANCE DATA

5.1 Limits of Detection

One organism in the volume of sample analysed.

5.2 Interference

High turbidity may make membrane filtration difficult. Large numbers of competing organisms may interfere with the growth of the test organism.

5.3 Time Required for Analysis

Membrane filtration	48 hours
Confirmation	24 hours

6 REAGENTS

Reagents used in the preparation of media should be of analytical quality and media prepared with glass distilled water or water of equivalent quality.

6.1 Membrane Enterococcus Agar (Slanetz + Bartley, 1957)

Tryptose	20.0g
Yeast extract	5.0g
Glucose	2.0g
Disodium hydrogen phosphate ($Na_2HPO_42H_2O$)	4.0g
Sodium azide	0.4g
Tetrazolium chloride	0.1g
Agar No: 1	10.0g
Distilled water	1000ml

Preparation

Suspend the ingredients in 1 litre of distilled water and bring to the boil to dissolve completely.

EXCESSIVE HEATING MUST BE AVOIDED

An aliquot of medium should be checked to confirm a pH of 7.2 ± 0.2. The medium should be cooled to 45-50^{o}C and poured into sterile 50-60mm Petri dishes. The medium should be stored at 2-8^{o}C and used within 1 month.

6.2 Confirmation Medium - Bile Esculin Agar (BAA)

Tryptone	17.0g
Peptone	3.0g
Beef extract	5.0g
Ox-gall, dehydrated	10.0g
Sodium chloride (NaCl)	5.0g
Aesculin	1.0g
Ammonium iron (111) citrate	0.5g
Sodium azide (NaN_3)	0.15g
Agar	15.0g
Distilled Water	1000ml

Preparation

Dissolve the ingredients in the water by boiling. Adjust the pH, if necessary, with sodium hydroxide (40g/l) or hydrochloric acid (36.5g/l) so that the pH is 7.2 ± 0.2. Distribute the solution into screw capped containers and sterilise for l5 minutes at 121°C ± 2°C, cool to 50°C. Pour into Petri dishes to a depth of at least 3mm. Allow medium to set on a cool, horizontal surface. Store at 2 - 8^{o}C and use within 1 month. The sterile medium may be stored at room temperature and should be used within 1 month.

6.3 Kanamycin Aesculin Azide Agar (KAAA)

Tryptone	20.0g
Yeast extract	5.0g
Sodium chloride	5.0g
Sodium citrate	1.0g
Aesculin	1.0g
Ferric ammonium citrate	0.5g
Sodium azide	0.15g
Kanamycin sulphate	0.020g
Agar	12.0g
Distilled water	1000ml

Preparation

Dissolve the ingredients in the water by boiling. Adjust the pH, if necessary, with sodium hydroxide (40g/l) or hydrochloric acid (36.5g/l) so that the pH is 7.0 ± 0.2. Distribute the solution into screw capped containers and sterilise for l5 min at 121°C ± 2°C, cool to 50°C. Pour into Petri dishes to a depth of at least 3mm. Allow medium to set on a cool, horizontal surface. Store at 2 - 8°C and use within 1 month. The sterile medium may be stored at room temperature and should be used within 1 month.

7 APPARATUS

Incubator, 44°C ± 0.5°C
Boiling water bath
Membrane filter funnel and manifold
Vacuum pump and reservoir
Petri dishes - 50mm, 60mm or 90mm diameter
Membranes - 47mm diameter, 0.45µm pore size, sterile, gridded
Bunsen burner

8 CALIBRATION

8.1 Positive and Negative Controls

In conjunction with the analysis detailed by this method, at the time of testing, a positive control consisting of:

a) an environmental sample known to contain the species of organism enumerated by the method, or,

b) a cell suspension prepared from a reference stock culture

will be prepared and incubated under the same conditions and at the same time as

the material under test to ascertain that the test method and physical parameters, i.e. incubation time and temperature, will enumerate the species of organism sought.

Similarly, a negative control consisting of a 100ml volume of sterile glass distilled water will also be incubated under the same test conditions to ensure sterility of the test medium.

The results of all positive and negative controls should be recorded. Positive and negative control failures invalidate the test and repeat analysis must be performed.

Where a suitable environmental sample is unavailable for use as a positive control, a reference culture may be used, for example, *Enterococcus faecalis* NCTC 00775.

8.2 **Equipment**

All volumetric pipettes and pipetting aids used throughout the test procedure must be calibrated and checked on a daily basis. All incubators and weighing equipment used must also be calibrated and checked on a daily basis.

9 SAMPLE COLLECTION AND PRESERVATION

9.1 **Collection, Storage and Transport of Samples for Bacteriological Examination**

The prime objective of the method is to obtain a sample that is representative, as far as possible, of the water to be examined. To achieve this, the precautions detailed below are necessary which are common to all sampling procedures for the bacteriological examination of water.

Sterile plastic bacteriological bottles (500ml) should be used.

Although the water may not contain chlorine or chloramines, sufficient sodium thiosulphate must be added to sample bottles to neutralise these substances (this may be provided, already added to the bottles, by the supplier). For low concentrations of chlorine and at pH values normally occurring in water supplies, sodium thiosulphate ($Na_2S_2O_35H_2O$) at a concentration of 18mg/litre should neutralise up to 5mg/l of free and combined residual chlorine without significant effect on the bacterial population under test.

0.1ml of a 1.8 % (w/v) solution of sodium thiosulphate should be added pro rata for each 100ml of bottle capacity.

Scrupulous care should be taken to avoid accidental contamination of the sample during collection and subsequent handling.

The changes that occur in the bacteriological content of water between the time of sampling and examination should be reduced to a minimum by ensuring that the sample is not exposed to light, is kept cool in an insulated container and is transported to the laboratory and processed as quickly as possible.

The sample should be examined within 6 hours of collection.

10 ANALYTICAL PROCEDURE

10.1 The Test

Using the membrane filter apparatus, filter volumes or dilutions through a sterile membrane filter 0.45µm pore size. Place the filter on the isolation medium and incubate at 37°C ± 1°C for 4 ± 4 hours, followed by 40 ± 4 hours at 44°C ± 0.5°C.

10.2 Confirmation of Isolates

Suspect colonies should be confirmed by subculturing up to 10 colonies from each membrane to bile-aesculin-azide agar, incubating for 24 hours at 44°C ± 0.5°C and examining for aesculin hydrolysis (development of a black or brown colour in and round the colony). A suitable positive and negative control should be included with the confirmation test, for example, *Enterococus faecalis* and *Escherichia coli*.

11 CALCULATIONS

Dependent upon the volume of sample used, i.e. 0.1, 1.0, 10.0 or 100ml, calculate and report the result as number of organisms in 100ml of sample, i.e. cfu/100ml

12 NOTES

DETECTION AND ENUMERATION OF PRESUMPTIVE *CLOSTRIDIUM PERFRINGENS*

1 SCOPE AND FIELD OF APPLICATION

1.1 The method described is suitable for the isolation of presumptive *Cl. perfringens* from water, sewage and related samples by membrane filtration.

1.2 The normal sample volume for this test is 100ml.

1.3 This volume may decrease for heavily contaminated samples where dilution may be necessary.

2 REFERENCES

2.1 The Microbiology of Water 1994. Part 1 - Drinking Water. Reports on Public Health and Medical Subjects No. 71. HMSO, London. ISBN 0-11-753010-7.

2.2 HAUSCHILD, A. W. H. AND HILLSHEIMER, R. 1974 Enumeration of food-borne *Clostridium perfringens* in egg yolk free tryptose-sulphite-cycloserine agar. Applied Microbiology, 27, 521 – 526.

2.3 SARTORY, D. P. 1986 Membrane filtration enumeration of faecal clostridia and *Clostridium perfringens* in water. Water Research, 20, 1255 – 1260.

3 PRINCIPLE OF METHOD

3.1 Definition and Description of Organisms

Sulphite-reducing clostridia are Gram-positive, spore forming, anaerobic rods. The rods are typically large, straight or slightly curved with slightly rounded ends. Almost all members of the genus are motile, but *Cl. perfringens* is an important exception. The clostridia are biochemically active frequently possessing both saccharolytic and proteolytic properties.

3.2 Pathogenicity

Clostridium species are environmental bacteria. Most species are saprophytic normally inhabiting soil, water and decomposing plant and animal matter. Species such as *Cl. perfringens* are commonly found in the intestine of man and other animals. The presence of such organisms in a water supply can often be regarded as being a result of faecal contamination.

The genus, whilst consisting mainly of saprophytes, does contain some species which are generally regarded as opportunistic pathogens. For example, *Cl. perfringens* is responsible for gas gangrene and also a substantial number of cases of food poisoning.

3.3 General Principle

This method details the isolation of presumptive *Cl. perfringens* from water and associated materials by the use of membrane filtration. The organisms produce characteristic black colonies on Tryptose-Sulphite-Cycloserine Agar. Confirmation is only necessary if the confirmed presence of *Cl. perfringens* is specifically required.

4 HAZARDS

Safety standards appropriate to routine laboratory work should be followed at all times.

All materials which become contaminated during the test procedure should be sterilised before being discarded. Sterilisation is best achieved by autoclaving materials in suitable containers eg. autoclave bags, at 121^{o}C ± 2^{o}C for 15 minutes. Alternatively materials may be placed into a suitable disinfectant (chloros or hycolin) for 12 hours before being discarded.

5 PERFORMANCE DATA

5.1 Limits of Detection

One organism in the volume of sample analysed.

5.2 Interference

High turbidity may make membrane filtration difficult. Large numbers of competing organisms may interfere with the growth of the test organism

5.3 Time Required for Analysis

Isolation - 24 h minimum
48 h maximum

6. REAGENTS

Reagents used in the preparation of media should be of analytical quality and media prepared with glass distilled water or water of equivalent quality.

6.1 Tryptone Sulphite Cycloserine Agar (TSCA) Hauschild and Hillsheimer 1974, Sartory 1986)

Yeast Extract	5.0g
Tryptose	15.0g
Soya Peptone	5.0g
Sodium metabisulphite	1.0g
Ferric ammonium citrate	1.0g
Agar	14.0g
Distilled water	1000ml

Preparation

Prepare the medium by dissolving the ingredients in the water and dispense in suitable volumes in screw-capped containers. Sterilise by autoclaving at 121°C ± 2°C for 15 minutes. The pH should be 7.6 ± 0.2. The sterile medium may be stored at room temperature and should be used within 1 month. For use, melt the basal medium, cool to approximately 50°C and add 4ml of a filter sterilised solution of 100mg/ml D-cycloserine in distilled water. Mix well and dispense into Petri dishes. Prepared medium may be stored at 2 – 8°C for no longer than one week. Plates once removed from the refrigerator should be discarded if not used, and not returned to storage, as the performance of the medium deteriorates.

7 APPARATUS

Incubator, 44°C ± 0.5°C
Boiling water bath
Membrane filter funnels and manifold
Vacuum pump and reservoir
Forceps and tongs
Membrane 47mm diameter, 0.45µm pore size, sterile, gridded
Bunsen burner

8.0 CALIBRATION

8.1 Positive and Negative Controls

In conjunction with the analysis detailed by this method, at the time of testing, a positive control consisting of:

a) an environmental sample known to contain the species of organism enumerated by the method, or,

b) a cell suspension prepared from a reference stock culture

will be prepared and incubated under the same conditions and at the same time as the material under test to ascertain that the test method and physical parameters, i.e. incubation time and temperature, will enumerate the species of organism sought.

Similarly, a negative control consisting of a 100ml volume of sterile glass distilled water will also be incubated under the same test conditions to ensure sterility of the test medium.

The results of all positive and negative controls should be recorded. Positive and negative control failures invalidate the test and repeat analysis must be performed.

Where a suitable environmental sample is unavailable for use as a positive control, a reference culture may be used, for example, *Clostridium perfringens* NCTC 08449.

8.2 **Equipment**

All volumetric pipettes and pipetting aids used throughout the test procedure must be calibrated and checked on a daily basis. All incubators and weighing equipment used must also be calibrated and checked on a daily basis.

9. SAMPLE COLLECTION AND PRESERVATION

9.1 Collection, Storage and Transport of Samples for Bacteriological Examination

The prime objective of the method is to obtain a sample that is representative, as far as possible, of the water to be examined. To achieve this, the precautions detailed below are necessary which are common to all sampling procedures for the bacteriological examination of water.

Sterile plastic bacteriological bottles (500ml) should be used.

Although the water may not contain chlorine or chloramines, sufficient sodium thiosulphate must be added to sample bottles to neutralise these substances (this may be provided, already added to the bottles, by the supplier). For low concentrations of chlorine and at pH values normally occurring in water supplies, sodium thiosulphate ($Na_2S_2O_35H_2O$) at a concentration of 18mg/litre should neutralise up to 5mg/l of free and combined residual chlorine without significant effect on the bacterial population under test.

0.1ml of a 1.8 % (w/v) solution of sodium thiosulphate should be added pro rata for each 100ml of bottle capacity.

Scrupulous care should be taken to avoid accidental contamination of the sample during collection and subsequent handling.

The changes that occur in the bacteriological content of water between the time of sampling and examination should be reduced to a minimum by ensuring that the sample is not exposed to light, is kept cool in an

insulated container and is transported to the laboratory and processed as quickly as possible.

The sample should be examined within 6 hours of collection.

10 ANALYTICAL PROCEDURE

10.1 The Test

Membrane filter volumes or dilutions and place membranes face upwards onto TSCA. Place the Petri dishes into an anaerobe jar together with an anaerobic atmosphere generating pack (e.g. Oxoid Anaerogen) and an anaerobic indicator and seal the jar immediately. Incubate at 44^{o}C ± 0.5^{o}C for 48h. Count and record all the black colonies. In addition record that the indicator demonstrated successful anaerobic conditions.

Note: A fresh sterile filter top must be used for each routine filtration for sulphite-reducing clostridia as pasteurisation in a boiling water bath may not be adequate to kill spores.

11 CALCULATIONS

Calculate and record from the volume of sample used the number of organisms in 100ml of sample, i.e. cfu/100ml.

12 NOTES

DETECTION AND ENUMERATION OF THERMOPHILLIC CAMPYLOBACTER SPECIES

1 SCOPE AND FIELD OF APPLICATION

1.1 The method is suitable for the isolation of thermophillic *Campylobacter* species from water, sewage and related materials by presence/absence or most probable number (multiple tube) analysis.

1.2 The normal sample volume for the test is 1000ml. This may be analysed as a presence absence method or a multiple tube, most probable number, method

1.3 The above sample volume may be decreased for heavily contaminated materials.

2 REFERENCES

2.1 The Microbiological of Water, 1994. Part 1 Drinking Water. Reports on Public Health and Medical Subjects, No.71. HMSO, London.

2.2 The Oxoid Manual, 6th Edition, Brisden, E. Y., 1990 Oxoid, Wade Road, Basingstoke.

2.3 MARCOLA, B., WATKINS, J. AND RILEY, A. (1981) The isolation and identification of thermophilic *Campylobacter* spp. from sewage and river water. Journal of Applied Bacteriology, 51, xii.

2.4 BOLTON, F. J., HUTCHINSON, D. N. AND COATES, D. (1986) Comparison of three selective agars for the isolation of *Campylobacter*. European Journal of Clinical Microbiology, 5, 466 – 468.

3 PRINCIPLE OF THE METHOD

3.1 Definition and Description of the Organism

Campylobacters are slender, spirally curved, Gram-negative rods, 0.2 - 0.8µm in diameter by 0.5 - 8µm in length. Rods may have one or more spirals and may be S shaped or appear typically as 'gulls wings' or 'gulls in flight'. In older cultures coccoid forms may be present and these may be degenerative non-viable forms or viable forms which are not readily cultured. Campylobacters do not form spores and are motile by means of a single polar flagellum at one or both ends of the cell giving a characteristic darting or corkscrew motility. They are micro-aerobic requiring oxygen concentration between 3 - 15% and some will grow anaerobically. The thermotolerant group comprising *C. jejuni, C. coli* and *C. lari (C. laridis)* grow well at 43°C but fail to grow at 25°C.

3.2 **Pathogenicity**

Campylobacter infections give rise to a flu-like illness with malaise, fever and myalgia followed by diarrhoea. The incubation period ranges from 1 - 7 days with an average of 3 days. Most cases occur from the consumption of contaminated raw or improperly cooked foods. The infective dose is low and may be as little as 50 - 100 bacteria. Consumption of raw milk and inadequately treated drinking water has been responsible for large outbreaks of disease. Consumption of contaminated surface waters has also given cases of infection.

Campylobacter jejuni has also been isolated sporadically from aborted bovine foetuses and from cattle with diarrhoea. It is however frequently present in clinically normal cattle. Campylobacters have been shown experimentally to produce mastitis and large numbers of organisms can be excreted in milk. They may cause abortion and enteritis in sheep and may also affect poultry.

3.3 **General Principle**

Campylobacters are not thought to be free living but are obligate parasites of man, animals and birds. They are found in the gastro-intestinal system and being excreted in faeces they can be isolated readily from sewage and surface waters both fresh and saline.

Campylobacters are isolated by enrichment in a selective medium containing charcoal and lysed horse blood, and incubated in a micro-aerobic atmosphere at 37^{o}C for 24 hours and 42°C for a further 24 hours. Enrichment broths are inoculated onto a selective agar and incubated in a micro-aerobic atmosphere at 37°C. Characteristic colonies may be confirmed by Gram stain and the oxidase reaction and sub-cultured for further biochemical testing.

4 HAZARDS

4.1 Safety standards appropriate to routine laboratory work should be followed at all times

4.2 All materials which become contaminated during the test procedure should be sterilised before being discarded. Sterilisation is best achieved by autoclaving materials in suitable containers e.g. autoclave bags at 121°C ± 2°C for 15 minutes. Alternatively, materials may be placed in a suitable disinfectant (chloros or hycolin) for 12 hours before being discarded.

5 PERFORMANCE DATA

5.1 **Limits of Detection**

One organism in the volume of sample analysed.

5.2 **Interference**

Large numbers of competing organisms may interfere with the growth of the test organism.

Very turbid samples may make membrane filtration difficult.

5.3 **Time Required For Analysis**

Isolation minimum – 48 hours, maximum – 96 hours
Confirmation – 24 hours

6 REAGENTS

Reagents used in the preparation of media should be of analytical quality and media prepared with glass distilled water, or water of equivalent quality.

6.1 **Brain Heart Infusion Enrichment Broth (Marcola *et al*., 1981)**

Brain heart infusion	37g
Powdered activated charcoal	20g
Distilled water	950ml

Preparation

Dissolve the ingredients in the water and adjust the pH to 7.0 ± 0.2. Dispense in suitable volumes into screw-capped containers and sterilise by autoclaving at 121°C ± 2°C for 15 minutes. The medium may be stored in the dark at room temperature for up to 1 month.

Preparation of Complete Medium

To 95ml of base medium add 5ml of lysed horse blood and filter sterilised solutions of the following antibiotics:

Bacitracin to a final concentration of 33 units/ml
Colistin sulphate to a final concentration of 20µg/ml
Novobiocin to a final concentration of 6.6µg/ml
Cyclohexamide to a final concentration of 66µg/ml

Butzler antibiotic supplement is available commercially and should be prepared according to the manufacturer's instructions. In order to make the medium more selective it should be added at a concentration of 0.8ml of supplement per 100ml of medium instead of the recommended 0.6ml.

Note: Lysed horse blood is available commercially, but defibrinated horse blood can also be used. It is lysed by dispensing in suitable volumes into sterile containers and freezing at < -15°C. Blood lysed in this way can be kept frozen indefinitely until required.

An aerotolerance supplement is also available to enhance growth of campylobacters. The following should be added as filter-sterilised solutions in distilled water:

Sodium pyruvate to a final concentration of	250µg/ml
Sodium metabisulphate to a final concentration of	250µg/ml
Ferrous sulphate (heptahydrate)	250µg/ml

This growth supplement is available commercially and should be used according to the manufacturer's instructions.

6.2 **Selective Agar**

Columbia agar	39g
Distilled water	950ml

Preparation

Add 39g of the medium to the distilled water, dissolve by boiling, dispense in appropriate volumes in suitable containers and sterilise by autoclaving at 121°C ± 2°C for 15 minutes. Allow the base to set and store in the dark at room temperature for up to 1 month. The final pH should be 7.3 ± 0.2.

Preparation of the Complete Medium

To 95ml of molten Columbia agar at 50°C add 5ml of lysed horse blood and filter sterilised solutions of the following antibiotics:

Cefoperazone	32µg/ml
Amphoteracin B	10µg/ml

Modified CCDA Preston antibiotic supplement is available commercially and should be prepared according to the manufacturer's instructions.

The aerotolerant supplement (6.1) can also be added to the isolation agar to improve recovery.

6.3 ***Campylobacter* Blood Free Medium (Bolton, *et al.*, 1986)**

Nutrient broth No. 2	25.0g
Bacteriological charcoal	4.0g
Casein hydrolysate	3.0g
Sodium deoxycholate	1.0g
Agar	12.0g
Distilled water	1000ml

Preparation

Dissolve the ingredients in the water by boiling. Dispense the resulting solution in appropriate volumes into screw-capped containers and sterilise by autoclaving at 121°C for 15 minutes. After autoclaving the pH of the medium should be checked to confirm a pH of 7.4 ± 0.2. Cool the medium to approximately 50°C, pour into Petri dishes and allow to set. Store plates at 2 – 8°C and use within 1 week. Sterile medium which has been allowed to set in the bottles may be stored in the dark at room temperature and should be used within 1 month.

7 APPARATUS

Incubator or water bath, 37°C and 42°C ± 1.0°C
Membrane filter funnels and manifold
Vacuum pump and reservoir
Anaerobic jar, catalyst, gas pack
Bunsen burner

8 SAMPLE COLLECTION AND PRESERVATION

8.1 Positive and Negative Controls

In conjunction with the analysis detailed by this method, at the time of testing, a positive control consisting of:

a) an environmental sample known to contain the species of organism enumerated by the method, or:

b) a cell suspension prepared from a reference stock culture

will be prepared and incubated under the same conditions, and at the same time as the material under test to ascertain that the test method and physical parameters, i.e. incubation time and temperature, will enumerate campylobacters.

Similarly, a negative control consisting of a 100ml volume of sterile glass distilled water will also be incubated under the same test conditions to ensure sterility of the test medium.

The results of all positive and negative controls should be recorded. Positive and negative control failures invalidate the test and repeat analysis must be performed.

Where a suitable environmental sample is unavailable for use as a positive control, a suitable reference culture may be used, for example *Campylobacter jejuni* NCTC 11322.

8.2 **Equipment**

All volumetric pipettes and pipetting aids used throughout the test procedure must be calibrated and checked on a daily basis. All incubators and weighing equipment used must also be calibrated and checked on a daily basis.

9 SAMPLE COLLECTION AND PRESERVATION

9.1 Collection, Storage and Transport of Samples for Bacteriological Examination

The prime objective of the method is to obtain a sample that is representative, as far as possible, of the water to be examined. To achieve this, the precautions detailed below are necessary which are common to all sampling procedures for the bacteriological examination of water.

Sterile plastic bacteriological bottles (1,000ml) should be used.

Although the water may not contain chlorine or chloramines, sufficient sodium thiosulphate must be added to sample bottles to neutralise these substances (this may be provided, already added to the bottles, by the supplier). For low concentrations of chlorine and at pH values normally occurring in water supplies, sodium thiosulphate ($Na_2S_2O_35H_2O$) at a concentration of 18mg/litre should neutralise up to 5mg/l of free and combined residual chlorine without significant effect on the bacterial population under test.

0.1ml of a 1.8% (w/v) solution of sodium thiosulphate should be added pro rata for each 100ml of bottle capacity.

Scrupulous care should be taken to avoid accidental contamination of the sample during collection and subsequent handling.

The changes which occur in the bacteriological content of water between the time of sampling and examination should be reduced to a minimum by ensuring that the sample is not exposed to light, is kept cool in an insulated container and is transported to the laboratory and processed as quickly as possible.

The sample should be examined within six hours of collection.

10 ANALYTICAL PROCEDURE

10.1 The Test

Dispense the complete enrichment broth in 20ml volumes into sterile universal containers. Membrane-filter 5 aliquots of 100ml and 5 aliquots of 10ml through 0.2µm membrane filters. The smaller volumes (10ml) may be inoculated directly into double strength medium. A further range of 5 x 1ml volumes may also be inoculated

into enrichment broths. For clear waters with low numbers of organisms, filter a 500ml aliquot and 5 x 100ml only. For presence or absence, filter 1000ml. Incubate all universals in an atmosphere of 5% oxygen, 10% carbon dioxide and 85% nitrogen in an anaerobic jar. Commercial gas packs are available for this purpose and should be used according to the manufacturer's instructions. Enrichment broths are incubated at 37°C for 24 hours and 42°C ± 1°C for a further 24 hours, sub-culturing onto selective agar at 24 and 48 hours.

Agar plates are incubated in anaerobic jars containing the appropriate gas mixture at 37°C ± 1°C. Agar plates should be examined after 24 hours incubation and negative plates should be incubated for a further 24 hours and re-examined.

10.2 Identification of Isolates

10.2.1 Colonial morphology

Colonies are typically small, flat, transparent, may be circular or ovoid, and may extend along the line of inoculation. They range in size from pinpoint to up to 4mm in diameter. Size will depend to some extent on the number of competing organisms growing on the agar plate. Large numbers of *Proteus* spp. or *Pseudomonas s*pp. colonies will restrict *Campylobacter* growth and under such circumstances careful examination of each plate with a hand lens is advisable.

Occasionally two colony types occur in one culture. One is typically low convex as above, and the other is smaller and more domed. Subculture of either may well produce the two colony types.

10.2.2 Gram Stain

Prepare smears of typical colonies and stain by the Gram method. The result is typical Gram-negative, curved rods that may look like gulls' wings, S shapes or short spirals. For most purposes typical colonial and cellular morphology are adequate for identification.

10.2.3 Oxidase

Subculture suspect colonies to a blood-free medium and incubate under micro-aerobic conditions for 24 hours at 37°C. Test suspect colonies for the enzyme cytochrome oxidase by removing some of a colony with an oxidase stick. If the organism is oxidase positive a blue colouration should appear within 10 seconds. A negative reaction should show no colour change. A positive and negative control is included with each

batch of tests. The manufacturer's instructions should also be studied carefully before testing.

11 CALCULATIONS

From the volume of sample used, calculate and report the result as the presence or absence of, or the most probable number of organisms in 1 litre of sample.

12 NOTES

The original proposed selective agar contained Preston antibiotic supplement. Unfortunately this was not available at the time of the trials and therefore CCDA selective supplement was chosen as the antibiotic supplement to be used.

DETECTION AND ENUMERATION OF *ESCHERISCHIA COLI* O157:H7

1 SCOPE AND FIELD OF APPLICATION

1.1 The method described is suitable for the isolation of *E. coli* O157:H7 from water, sewage and related samples by membrane filtration.

1.2 The normal sample volume for this test is 1000ml for *E. coli* O157. This may be analysed as a presence absence or a multiple tube, most probable number, method

1.3 This volume may decrease for heavily contaminated samples where smaller aliquots may be processed.

2 REFERENCES

2.1 The Oxoid Manual, 6th Edition, Brisdon, E. Y., 1990 Unipath Ltd, Wade Road, Basingstoke.

2.2 Anon, 1994 The Microbiology of Water 1994. Part 1- Drinking Water. Reports on Public Health and Medical Subjects No. 71. HMSO, London. ISBN 0-11-753010-7.

2.3 BOLTON, F. J., CROZIER, L. AND WILLIAMSON, J. K. (1995) Optimisation of methods for the isolation of *Escherichia coli* O157 from beefburgers. PHLS Microbiology Digest, 12, 67 – 70.

2.4 ZADIK, P. M., CHAPMAN, P. A. AND SIDDONS, C. A. (1993) Use of tellurite for the isolation of verocytotoxigenic *Escherichia coli* O157. Journal of Medical Microbiology, 39, 155 – 158.

3 PRINCIPLE OF THE METHOD

3.1 Definition

Escherichia coli is a member of the family Enterobacteriacae and is a Gram-negative, motile rod that is catalase positive, oxidase negative and facultatively anaerobic. Strains do not ferment sorbitol, are β-glucuronidase negative and grow poorly at 44°C, but are otherwise similar biochemically to other *E. coli* serotypes.

3.2 Pathogenicity

Verocytotoxin-producing *E. coli* is now recognised as a major cause of haemorrhagic colitis (HC) and haemolytic uraemic syndrome (HUS) in England and Wales. The former is acute bloody diarrhoea and the latter renal failure, particularly in children and the elderly. The organism has been isolated from cattle in the United Kingdom and in America, and has been found in beef, beef products and raw milk.

Food-borne outbreaks in beef, milk, apple juice and vegetables have been described as well as person to person spread, and water. A waterborne outbreak has been described in Missouri, in which four people died and in Scotland where a water associated outbreak involved a children's paddling pool. The infective dose is low and may be as little as 10 organisms.

There are a number or other serotypes of *E. coli* that can produce verocytotoxins, and many of these ferment sorbitol as do some strains of O157:H7. In addition, other coliform bacteria may produce HC and HUS.

3.3 General Principle

Isolation is based on membrane filtration for presence absence or most probable number and incubation in Modified Tryptone Soya Broth for 24 hours. Enrichment broths are subjected to immunomagnetic separation (IMS) at 6 hours and 24 hours. Broths are subcultured to sorbitol MacConkey agar containing cefixime and tellurite (CT-SMAC). Typical non-sorbitol-fermenting colonies are confirmed using latex agglutination and biochemical testing. The method will not detect sorbitol fermenting *E.coli* O157:H7 or other strains of Enterobacteriacae capable of causing HC or HUS.

4 HAZARDS

Escherichia coli O157:H7 strains have been reclassified from 'Hazard Group 2' to 'Hazard Group 3' (ACDP 1995). However where samples are not expected to contain *E. coli* O157:H7, the routine examination of water samples may be undertaken in 'Hazard Group' 2 containment. Where substantial subculture work is required, this should be undertaken in 'Hazard Group 3' containment facilities. The positive control strain should not produce verocytotoxin. Suitable strains are available commercially, for example, National Collection of Type Cultures NCTC 12900. Great care should be taken in the disposal of contaminated material. Only properly trained and experienced staff should be allowed to analyse water samples and safety glasses and disposable gloves should be worn during the IMS procedure.

All materials which become contaminated during the test procedure should be sterilised before being discarded. Sterilisation is best achieved by autoclaving materials in suitable containers eg. autoclave bags, at $121^{o}C \pm 2^{o}C$ for 15 minutes. Alternatively materials may be placed into a suitable disinfectant (chloros or hycolin) for 12 hours before being discarded.

5 PERFORMANCE CHARACTERISTICS

5.1 Limit of Detection

One organism in the volume of sample analysed.

5.2 **Interference**

High turbidity may make membrane filtration difficult. Large numbers of competing organisms may interfere with the growth of the test organism.

5.3 **Time Required for Analysis**

Isolation	48 hours
Confirmation	24 – 48 hours.

6 REAGENTS

Reagents used in the preparation of media should be of analytical quality, where this is available, and media prepared with distilled water, or water of equivalent quality.

6.1 **Modified Tryptone Soya Broth (Bolton, *et al*., 1995)**

Tryptone soya broth	30.0g
Bile Salts No.3	1.5g
Di-potassium hydrogen phosphate	1.5g
Novobiocin	20.0mg
Distilled water	1000ml

Preparation

Dissolve the ingredients in the water and adjust the pH to 7.4 ± 0.2. Dispense into screw-capped containers in suitable volumes, and sterilise by autoclaving at 121°C ± 2°C for 15 minutes. Allow to cool, store in the dark at room temperature, and use within 1 month. One bottle should be checked to confirm a pH of 7.4 ± 0.2.

6.2 **Cefixime Tellurite Sorbitol MacConkey Agar (Zadik, *et al*., 1993)**

Peptone	20.0g
Sorbitol	10.0g
Bile salts No.3	1.5g
Sodium chloride	5.0g
Neutral red	0.03g
Crystal violet	0.0001g
Agar	15.0g
Distilled water	1000ml

Preparation

Dissolve the ingredients in the water by boiling. Check that the pH is 7.1 ± 0.2 and dispense into screw-capped containers in suitable volumes. Sterilise by autoclaving at 121°C ± 2°C for 15 minutes.

Allow to set, store in the dark at room temperature and use within 1 month. The pH of one bottle should be checked to assure a pH of 7.1 ± 0.2.

6.3 Cefixime Tellurite (CT) Supplement

Cefixime powder	80mg
Potassium tellurite (hydrate)	250mg
Ethanol	20ml
Distilled water	100ml

Preparation

Dissolve the cefixime powder in the ethanol with occasional mixing. This may take 5 to 10 minutes. Dissolve the tellurite in distilled water and add 1.25ml of cefixime solution. Sterilise the supplement by membrane filtration through a 0.22µm membrane filter and distribute in 1ml aliquots. Store the aliquots at <-15°C until required.

To prepare the complete medium, melt the sorbitol MacConkey agar by boiling or steaming and cool to 45-50°C. Add 1ml of supplement, mix carefully and pour the medium into sterile 90mm Petri dishes. Allow to set, store in the dark at 2-8°C and use within 1 week.

Sorbitol MacConkey agar and CT supplement are available commercially and should be prepared and used in accordance with the manufacturer's instructions.

6.4 Nutrient Agar

Lab-Lemco powder	1.0g
Yeast extract	2.0g
Peptone	5.0g
Sodium chloride	5.0g
Agar	15.0g
Distilled water	1000ml

Preparation

Prepare the nutrient agar by dissolving the ingredients in 1000ml of distilled water and adjust the pH to 6.8 ± 0.2. Sterilise by autoclaving at 121°C ± 2°C for 15 minutes. The sterile medium may be stored at room temperature and should be used within 1 month. The medium may be made specific for the detection of the enzyme β-glucuronidase by the addition of an appropriate substrate for the enzyme, e.g. 4-methylumbelliferyl-D-β-glucuronide, or BCIG, or the use of commercially available media with the appropriate chromogenic substrates. Plates containing substrates for β-glucuronidase must be used within 1 week.

6.5 **Phosphate Buffered Saline (PBS) Tween 20 Solution**

Phosphate buffered saline (PBS)	
Dulbecco A tablets	10 tablets
Polyoxyethelene-sorbitan monolaurate (Tween 20)	0.5ml
Distilled water	1000ml

Preparation

Dissolve the ingredients in the water and check the pH is 7.4 ± 0.2. Bottle in suitable volumes and sterilise by autoclaving at 121°C ± 2°C for 15 minutes. Store in the dark at room temperature and use within 1 month.

7 APPARATUS

Incubator, 37°C ± 1°C
Immunomagnetic particle concentrator (MPC), Dynal
Immunomagnetic beads for *E. coli* O157:H7
Latex agglutination kit for *E. coli* O157:H7

8 CALIBRATION

8.1 **Positive and Negative Controls**

In conjunction with the analysis detailed by this method, at the time of testing, a positive control consisting of:

a) an environmental sample known to contain the species of organism enumerated by the method, or:

b) a cell suspension prepared from a reference stock culture

will be prepared and incubated under the same conditions, and at the same time as the material under test to ascertain that the test method and physical parameters, i.e. incubation time and temperature, will enumerate *E. coli* O157:H7.

Similarly, a negative control consisting of a 100ml volume of sterile glass distilled water will also be incubated under the same test conditions to ensure sterility of the test medium.

The results of all positive and negative controls should be recorded. Positive and negative control failures invalidate the test and repeat analysis must be performed.

Where a suitable environmental sample is unavailable for use as a positive control, a suitable reference culture may be used, for example *Escherichia coli* O157:H7 NCTC 12900.

8.2 **Equipment**

All volumetric pipettes and pipetting aids used throughout the test procedure must be calibrated and checked on a daily basis. All incubators and weighing equipment used must also be calibrated and checked on a daily basis.

9 SAMPLE COLLECTION AND PRESERVATION

The prime objective of the method is to obtain a sample that is representative, as far as possible, of the water to be examined. To achieve this, the precautions detailed below are necessary which are common to all sampling procedures for the bacteriological examination of water.

Sterile plastic bacteriological bottles (1000ml) should be used.

Although the water may not contain chlorine or chloramines, sufficient sodium thiosulphate must be added to sample bottles to neutralise these substances (this may be provided, already added to the bottles, by the supplier). For low concentrations of chlorine and at pH values normally occurring in water supplies, sodium thiosulphate ($Na_2S_2O_35H_2O$) at a concentration of 18mg/litre should neutralise up to 5mg/l of free and combined residual chlorine without significant effect on the bacterial population under test.

0.1ml of a 1.8% (w/v) solution of sodium thiosulphate should be added pro rata for each 100ml of bottle capacity.

Scrupulous care should be taken to avoid accidental contamination of the sample during collection and subsequent handling.

The changes which occur in the bacteriological content of water between the time of sampling and examination should be reduced to a minimum by ensuring that the sample is not exposed to light, is kept cool in an insulated container and is transported to the laboratory and processed as quickly as possible.

The sample should be examined within 6 hours of collection.

10 ANALYTICAL PROCEDURE

10.1 **Analytical Procedure**

Dispense the complete enrichment broth in 20ml volumes into sterile universal containers. Membrane-filter 5 aliquots of 100ml and 5 aliquots of 10ml through 0.45µm membrane filters. The smaller volumes (10ml) may be inoculated directly into double strength medium. A further range of 5 x 1ml volumes may also be inoculated into enrichment broths. For clear waters with low numbers of

organisms, filter a 500ml aliquot and 5 x 100ml only. For presence or absence, filter 1000ml. Incubate all universals

Incubate the sample at 42°C ± 1°C for 24 hours ± 2 hours. Enrichment broths should be subjected to IMS after 6 – 7 hours and again at 24 hours.

10.2 **Immunomagnetic Separation**

Mix the antibody-coated paramagnetic beads by using a vortex mixer and add 20µl to eppendorf tubes. Add 1ml of well-mixed enrichment broth to each tube and place the tubes on a rotary mixer set at 30 revolutions per minute and mix at room temperature for 30 minutes.

Place the tube into the magnetic particle concentrator (MPC) with the magnet in place. Gently rock the MPC from upright to inverted for one minute to concentrate the beads on the side of the tube. Carefully aspirate and discard the supernatant from the tube as well as any liquid in the tube's cap. Remove the magnetic plate from the MPC.

Add 1ml of phosphate buffered saline (PBS) tween 20 solution. Close the cap and invert the tube three times to resuspend the beads. Place in the MPC and concentrate the beads into a small pellet as above. Discard the liquid and repeat the rinsing step one more time.

Add 50µl of PBS tween 20 and resuspend the beads. Inoculate the beads onto CT-SMAC and incubate plates at 37°C ± 1°C for 24 hours. Examine plates for typical non-sorbitol fermenting colonies.

Typical *E. coli* O157:H7 colonies are 2-3mm in diameter and pale orange in colour. Red colonies, particularly those with an opaque halo around them are sorbitol fermenters.
Test all typical non-sorbitol fermenting colonies with O157:H7 specific latex agglutination following the manufacturer's instructions and including appropriate positive and negative controls. Any problems of auto-agglutination may be overcome by heat treatment of the isolate. A turbid saline suspension of the isolate is prepared and boiled for 10 minutes. After cooling, a drop of the suspension is used to repeat the agglutination test.

Subculture any suspect colonies onto nutrient agar and incubate at 37°C ± 1°C for 24 hours. Examine colonies for the absence of cytochrome oxidase, prepare a suspension in sterile distilled water and inoculate into API 20E (BioMerieux) and onto chromocult agar for β-glucuronidase activity. Incubate confirmatory tests at 37°C ± 1°C for 24 hours.

NOTE: Some strains of *E. coli* O157:H7 ferment sorbitol and it may be advisable to subculture some isolates that are sorbitol fermenting and check by the above confirmation tests. Some strains of *E. coli*

O157:H7 may produce atypical biochemical profiles and results should be interpreted with caution.

11 CALCULATION

Where the MPN technique is used, the number of aliquots positive should be recorded and the final result computed from published tables (Anon, 1994).

12 NOTES

CREH *ANALYTICAL LIMITED*

SAFE WORKING PROCEDURE

WORKING WITH *ESCHERICHIA COLI* O157:H7

1. *Escherichia coli* O157:H7 is a dangerous pathogen that has caused outbreaks of disease associated with the consumption of improperly cooked meats, vegetables, raw milk and contaminated water. The disease symptoms may include haemorrhagic diarrhoea and haemolytic uraemic syndrome associated with renal failure. Infection may sometimes be fatal. The infective dose for this pathogen is known to be low. The disease is contracted by ingestion. Safe working will therefore involve rigorous hygiene practice.

2. The Safe Working Procedures in **must** be read in conjunction with this procedure. In view of the nature of the organism, it should only be handled by senior staff who are properly trained and experienced.

3. It is **crucial** that nothing is introduced into the mouth during manipulations with this organism.

4. All contaminated material associated with the analysis of sample known to contain *Escherichia coli* O157:H7 must be placed into a suitable disinfectant e.g. 2% Hycolin, or equivalent, or placed into an autoclave bag and sterilised by autoclaving before being discarded for incineration. All work surfaces must be disinfected after completing any work with the organism.

5. All spillages must be covered **immediately** with a suitable disinfectant, see SWP 20.

6. Laboratory coats should be used only for the purpose of working with the organism. It is not essential to wear gloves but any contamination of hands must be removed by thorough washing with soap and hot water. Contaminated gloves must be discarded **immediately** into an autoclave bag and autoclaved. **General contamination of the environment may lead to infection of other people** and should therefore be avoided. Laboratory staff may wish to wear a protective apron whilst handling the organism to prevent accidental contamination of clothes. Contaminated coats and aprons must be autoclaved before being sent to the laundry.

7. Cultures of the organism must not be kept in the laboratory beyond the time required for biochemical and serological identification. A glycerol suspension maintained at <-15°C is permissible as a source of a positive control.

8. Where there is a risk of aerosols, e.g. after a container has been shaken, the container should be allowed to stand for 10 minutes before opening.

This SWP should be read in conjunction with SWP Nos: 2, 8, 14, 20, and 21.

Appendix D Samplers Log Sheet

Private Water Supply Testing: Samplers log-sheet																
Site:			**Note down the water pressures before and after filter change**						**Tick the boxes that best describe the weather in the last 24 hours**							
Date	**Time**	**Flow meter reading**	***Supply pressure***		**Pressure before filter**		**Pressure at outlet**		**Heavy rain**	**Light rain**	**Showers**	**Overcast**	**Sunny Intervals**	**Clear sky**	**Sampler initials**	**Sampler comments or observations about condition of samples or the water supply**
			Before	***After***	**Before**	***After***	***Before***	***After***								

Appendix E Health Related Review of Private Water Supplies

1. Incidence of gastrointestinal illness in relation to water supply

The link between drinking water and the occasional outbreak of gastrointestinal illness is beyond doubt, but what is less clear is the influence drinking water has on non-outbreak levels of illness and the incidence of illness associated with private water supplies. There are various ways in which this can be explored, including prospective epidemiological intervention-type studies (as pioneered by Pierre Payment and colleagues), studies of risk factors for specific pathogens and retrospective examinations of existing data sources.

2. Review of selected methodologies

2.1 Intervention studies

Work conducted in Canada (Payment *et al*., 1991; 1997) was probably the first to seriously examine the proportion of gastrointestinal illness attributable to drinking water in non-outbreak conditions. The first study, which started in 1988, was an intervention trial carried out on over 600 randomly selected eligible households (Payment *et al*., 1991). Selected households were either supplied with domestic water filters (which eliminated microbial and most chemical contaminants) or continued to use their usual tap water without additional treatment. Gastrointestinal symptoms were determined by the use of a family health diary. On the basis of the difference in annual gastrointestinal illness incidence between the two groups it was estimated that 35% of the total reported gastroenteritis was drinking water-related. The results of a more complex study, which also examined bottled 'tap' water, led to the conclusion that 14-40% of the observed gastrointestinal illness was attributable to tap water meeting current standards (Payment *et al*., 1997). Although these studies have been criticised for failing to blind the study subjects to their exposure status they have been used (with modifications) as a model for other such investigations (Hellard *et al*., 2000; CDC pers. com.).

2.2 Risk factor studies

A number of prospective studies have considered water (drinking and recreational) in terms of a risk factor for certain illnesses. Fewtrell and Delahunty (1995) examined the incidence of infection with *Campylobacter*, *Cryptosporidium*, *Giardia*, *Salmonella* and *Shigella* over a 12-month period in a population of almost 320,000 in relation to various risk factors, including public water supply, private water supply and recreational water use, using a specifically designed questionnaire. In this instance there appeared to be no relationship between the cases of illness and drinking water.

2.3 Existing data sources

It is possible to use data collected for disease surveillance purposes, either prospectively or retrospectively, in an ecological-type study to examine gastrointestinal illness and water supply. The retrospective approach was piloted by Fewtrell and Kay (1996a) in relation to private supplies. Ten local authority areas known to have private supplies were targeted for the acquisition of data on the incidence of *Campylobacter* enteritis and cryptosporidiosis. These data were obtained from local Environmental Health Officers (EHOs) and included information on whether the cases were served by public or private water supplies. Given the small numbers of cases of illness reported from private supplies and the possibility of unknown confounding factors it was not possible to draw firm conclusions.

Attempts have been made to link levels of various routinely monitored indicators (such as turbidity) with health outcomes (such as general levels of gastroenteritis in the community or hospital admissions for gastroenteritis). Fewtrell and Kay (1996b) examined routinely collected potable water quality data (including colony counts, free chlorine levels and turbidity) in relation to water quality zone. They also examined data on gastrointestinal illness in the community on a similar basis. In a small scale study they established that it was possible to determine statistically significant differences in water quality between supply zones on the basis of one and three day bacterial colony count data and also that differences could be seen in rates of gastrointestinal illness between zones. However, it was concluded that the significance of any associations was severely limited by the datasets available. Schwartz *et al*., (1997, 2000) assessed the relationship between hospital admissions for gastrointestinal illness and turbidity using time series analysis. They showed that such hospital admissions in both young children and the elderly were associated with water quality (i.e. turbidity) measured in the days prior to their hospitalisation.

3. Background to the current methodology

On the basis of the project constraints a small-scale retrospective examination of selected waterborne illness was conducted in conjunction with the Public Health Laboratory Service in Chester.

Reviews of the literature (Fewtrell and Kay 1996a; Watkins *et al*., 2001) have revealed that *Campylobacter* enteritis and cryptosporidiosis are the gastrointestinal illnesses most often linked with private water supplies. *Campylobacter* spp., *Cryptosporidium* spp. and *Giardia* spp. were isolated from most of the private supplies examined as part of this project and so the selected illnesses were extended to include giardiasis as well as campylobacteriosis and cryptosporidiosis.

Previous studies, which have generally examined either several different areas (Fewtrell and Kay 1996a) or a wide geographic region (Fewtrell and Delahunty 1995; Fewtrell and Kay 1996c) have highlighted the problems of differential faecal sample examination policies. For this reason a single laboratory (Chester PHL) was chosen, with records taken over an approximate two and a half year period (during which time a consistent examination policy was in place).

The Borough of Macclesfield was targeted as it was known that the area, which lies on the western flank of the Pennines, has a high proportion of properties with private water supplies.

4. Methodology

Anonomised disease data on laboratory confirmed cases of *Campylobacter*, *Cryptosporidium* and *Giardia* infections were collected for a 33-month period (1 Jan, 1998 to Oct 1, 2000) from Chester Public Health Laboratory. These data were matched with postcode information supplied by North West Water Ltd. and Macclesfield Borough Council in order to determine water supply type.

5. Results

During the 33-month period 639 confirmed cases of the selected illnesses were identified (from a population of 151,000). A total of 525 of these were due to *Campylobacter* spp., with 55 and 59 cases due to *Cryptosporidium* spp. and *Giardia* spp. respectively. Less than 10 of these cases could be ascribed to private water supplies. Due to the small number of cases a five-year estimate of cases is also presented (Table 1).

Table 1 Laboratory confirmed cases of selected diseases

Pathogen	Confirmed cases	5 year estimate*	Confirmed cases (private supplies)	5 year estimate*
Campylobacter	525	956	7	13
Cryptosporidium	55	100	1	2
Giardia	59	107	0	0

* rounded to nearest whole number

There are 486 private supplies in the Macclesfield Borough Council area (341 of which are classified as Class F serving single properties). These are summarised by Category and estimated number of users in Table 2. Table 3 outlines the estimated number of illnesses over 5 years per 1,000 population.

Table 2 Private supplies in Macclesfield Borough

Supply class	No.	No. of users per supply*		No. of users per class		No. of users as a % of the pop.	
		Min	Max	Min	Max	Min	Max
Cat 1							
D	23	25	100	575	2300	0.38	1.52
E	68	3	25	204	1700	0.14	1.13
F	341	2.4	2.4	818.4	818.4	0.54	0.54
Total (Cat 1)	432			1597.4	4818.4	1.06	3.19
Cat 2							
3	1	101	500	101	500	0.07	0.33
4	17	10	100	170	1700	0.11	1.13
5	36	3	10	108	360	0.07	0.24
Total (Cat 2)	54			379	2560	0.25	1.70
Total	486			1973.4	7378.4	1.31	4.89

* Users per supply for Category 2 supplies are calculated from a comparison of the average daily volumes supplies between Categories 1 and 2 (Private Water Supplies Regulations 1991)

Table 3 Five-year illness estimates by 1,000 population

Pathogen	Illness in the total pop	Illness in those served by private supplies		Illness assuming all cases are from Cat 1 supplies*	
		Min pop	Max pop	Min pop	Max pop
Campylobacter	6.32	6.6	1.76	8.14	2.69
Cryptosporidium	0.66	1.01	0.27	1.25	0.42
Giardia	0.71	0	0	0	0

* Category 1 supplies serve domestic properties only

It can be seen from Table 3 that the population estimates, in terms of the number of people served by a private supply, greatly affect the estimated number of illnesses. With illness estimates for campylobacteriosis in all private supplies ranging from 1.8 to 6.6 per 1,000 population. A more realistic range of estimates is probably provided by assuming that all the cases of illness derive from domestic supplies. While this assumption is unlikely to be true in practice (there is no reason why a Category 2 supply should cause less illness than a Category 1 supply), the methodology used here (i.e. use of home postcode) means that any cases of illness attributable to Category 2 supplies are extremely unlikely to be identified.

6. Discussion

Previous approaches have all suffered from problems of scale and inadequate or poor data quality. While still small in scale it was agreed in this project to use a novel analysis in pilot form. The approach focuses on a small, localised population and seeks to use postcode data to identify those individuals on private supplies.

While the results do not lend themselves to rigorous statistical analysis there is a suggestion that there may be an elevation of campylobacteriosis and cryptosporidiosis in people served by private supplies in comparison with the population as a whole (although this is dependent upon the estimation of population used). Given the known poor quality of many private supplies (Fewtrell *et al*., 1998; CDR 1995, 1996; Humphrey and Cruickshank 1985) this is hardly surprising. There are, however, numerous factors that mitigate against finding a relationship and quantifying the burden of disease especially when basing the study on a retrospective examination.

- It is known that only a small proportion of gastrointestinal illnesses reach of the stage of laboratory confirmation. Based on the work of Wheeler *et al*., (1999), it is estimated that for every case of gastrointestinal illness detected by laboratory testing almost 100 (97) would have occurred in the community.

- A static population exposed to poor quality water is likely to have a high level of immunity, resulting in far less cases than would be expected. Hunter and Quigley (1998) explored this possibility in relation to outbreaks of cryptosporidiosis in populations supplied by ground water (likely to be generally of good quality) compared with surface water. It was found that Relative Risk vales were far lower for those drinking surface water than those served by ground water. Although this investigation related to public supplies it does illustrate the likely effect of high population immunity.

- Many Category 2 supplies serve a 'changing population'. This clearly has different implications in terms of population immunity, as those exposed are more likely to represent a 'naïve' population. However, using surveillance data it is very unlikely that cases would be correctly ascribed to private water supply exposure in the area under investigation.

- Data currently available is not adequate to describe actual exposure of cases. Home postcode will only allow those individuals served by a supply at their home to be identified. It will not allow cases to be ascribed to exposure at work or during their leisure time (at a campsite for example). Additionally, estimates of the number of people served by a private supply are crude and could be substantially improved.

It is likely that drinking water from private supplies accounts for a significant burden of gastrointestinal illness (relating to selected pathogens) in the UK. It will not be possible, however, adequately to quantify this level without a large-scale prospective study. Examining private supplies (as opposed to public supplies) is likely to raise additional problems for some of the reasons outlined above. However, a study focussing on supplies serving changing populations over a protracted time period will be needed if the objective is to provide disease burden assessments from which to accurately estimate the potential health gain that could derive from investment in adequate water treatment.

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