THE IMPACT OF INTRODUCING TREATED WATER ON ASPECTS OF COMMUNITY HEALTH IN A RURAL COMMUNITY IN KWAZULU-NATAL

IW Bailey

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by

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Report to the Water Research Commission on the Project K5/925
"Assessing the causes and pathways of waterborne disease in rural settlements with limited formal water supply and sanitation"

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EXECUTIVE SUMMARY

Background and motivation

In South Africa, one fifth of the population (7 million people) does not have access to an adequate supply of potable water, and one half of the population (21 million) lacks basic sanitation. It is estimated that there are approximately 24 million incidences of diarrhoea per year in South Africa, of which 2.8 million require treatment at health care facilities and 43 000 people die. The South African Government and water-related agencies are undertaking a vigorous campaign to provide 'water for all'.

The evaluation of the effectiveness of the interventions on disease morbidity and mortality is a challenging task, as the linkages between water and health are complex. Many contend that the introduction of a water supply scheme does not necessarily result in improved health. The most important reason for the international research in this area is that preventable diarrhoea is perceived to be the cause of many deaths worldwide. If the causes of the diarrhoea can be identified and addressed, thousands of lives, especially those of children, would be saved.

Most studies on the effects of water supply on human health over the past fifty years have been criticized as to their validity and usefulness. Lack of adequate control, poor project design, many confounding variables, cultural bias, health indicator recall, health indicator definition and failure to analyse by age have been sited as rendering study results meaningless. Eminent researchers in the field, such as Cairncross, are equally sceptical. While instinctively it is accepted that water and sanitation do improve health, there are many opinions as to how and why.

It has been proved that the quantity of water has a greater impact on health than water quality. An improvement to the proximity of water supply (piped water) not only increases the quantity of water used, but also removes the need for water storage and therefore contamination. This may in turn reduce contamination and the proliferation of disease bearing vectors such as mosquitoes and flies. Owing to the varied results of international research in this field, more South African research was required to:

- Establish the extent of diarrhoeal disease in the rural areas
- Identify the risk factors to diarrhoeal disease, which are extensively associated with the water resources and which are expected to improve with investment in water supply schemes.
- Establish health criteria for consideration in the auditing of water supply schemes

Aims and objectives as specified in contract

The original title was: "Assessing the causes and pathways of waterborne disease in rural settlements with limited formal water supply and sanitation"

- To identify, describe and quantify selected health impacts associated with the microbiological quality of water supply sources and household containers, for the inhabitants of rural settlements with and without the minimum RDP specified water supply (and sanitation) infrastructure.
- To identify and describe the critical factors (pathways) relating (inadequate) water supply (and sanitation) with (negative) health impacts in rural settlements with different water supply levels.
- To identify the most appropriate methodologies and indicators for identifying and evaluating the health impacts of domestic water supply (and sanitation) in settlements with limited formal water supply.

Study design

The Stepped Wedge Design was suggested as an appropriate study design due to the progressive nature of the development over time. The four surveys corresponded where possible to the four phases of the introduction of water supply to the four different areas. Confounding factors were minimized through the selection of settlements located in the same area. Characteristics, such as the sanitation infrastructure, quality of the local water resources, topography, natural physical characteristics, distance from urban areas, settlement density, socio-economic levels, demographic and educational profile characteristics were recorded and expected to be similar. The selection of households to be surveyed was based on a stratified random approach and the number required was based on an anticipated improvement in diarrhoeal prevalence of 15%, with a 95% confidence interval.

The Epi-Info software package was used to capture the data. A team of two research assistants were tasked to sample the 100 households in Vulindlela, visiting each household five times over a 15-month period in January 1999 to March 2000. A Zulu speaking social scientist was responsible for administering all the health questionnaire surveys and water quality samples were collected from the storage containers and water sources of the 100 household sample.

Brief summary of results and conclusions

- The baseline results showed an increasing trend of diarrhoea with respect to water source for the use of communal taps as opposed to taps in the garden.
- 35% of those who were not disinfecting water at all before the supply, had diarrhoea
- The habit of a household fetching water from a local source takes time to change
- The visit to the water collection point provides more services to that household, such as communication with neighbours/ meetings etc.
- There was an overall decrease in diarrhoea from about 40% to 12% over the four phases of the introduction of water supply.
- The reduction in diarrhoea throughout the phases followed the same seasonal sequence as the microbiological parameters from the in-house and source waters. This appears to show an indirect link between the bacteriological quality of source and household water and the prevalence of diarrhoea.
- Although the in-house water quality does not seem to improve greatly, with the introduction of water supply, the diarrhoea appeared to reduce nevertheless.
- This reduction in diarrhoea may be related more to reduction in storage and improvement in hygiene behaviour.

Overall, there was no direct correlation proved between water quality and diarrhoea *per se*. However, there was a marked decrease in diarrhoea with the introduction of the new water supply. There was definite correlation between hygiene behaviours and diarrhoea.

Extent to which objectives were reached and actions to be taken as a result of the findings

The objectives above were refined after consultation with the steering committee and the words in brackets removed, as well as "sanitation", as there were no study sites available within a reasonable distance, where sanitation interventions were planned. Government subsidies for sanitation had been exhausted. The original title was also modified by the steering committee, to better describe the content of the report, in the light of the above changes to the objectives. All of the above-refined objectives were achieved as described in the conclusions, products and recommendations contained in this report.

Diarrhoea would seem to be the health impact associated with water, of choice. The most important reason for the international research in this area is that preventable diarrhoea is perceived to be the cause of many deaths worldwide. If the causes of the diarrhoea can be identified and addressed, thousands of lives, especially those of children, would be saved.

This study has provided many lessons regarding study design and the efficiency of using epidemiological studies as a health impact assessment tool in the water sector. Although double-blinded randomised trials are considered the gold standard for evaluation, it is very difficult to conduct a truly randomised trial for environmental interventions, such as a water supply. There is no placebo for water and in many communities; a cluster effect is experienced because the whole community benefits from the water supply although the Stepped Wedge Design provides some innovative features, which overcome some of the problems. In conclusion, the experience of this study in Vulindlela indicates that the epidemiological approach is fraught with difficulties, which make it difficult to draw firm conclusions.

The research products provided are:

- A technical report on the impact of introducing treated water on aspects of community health in the Vulindlela community.
- A critical literature review to summarize the key debates around the methodologies and problems that are experienced in assessing the effect of water supply on human health.
- A comprehensive health questionnaire in English and Zulu, which was developed throughout the study and extensively field-tested over the five household surveys.

Suggested improvements to water supply interventions:

1. Taps need to be situated inside the house to prevent storage of any sort, which leads to contamination.
2. The point above will necessitate the provision of a drainage system for public health reasons.
3. Hygiene education be addressed as the causes of diarrhoea would appear to be correlated with many basic hygiene procedures, rather than water quality.
4. A post- construction audit process be introduced to assess all aspects of the scheme to assess its effectiveness in operation, appropriateness and its effect on health.

Recommendations for further research and technology transfer

Given the difficulties experienced with epidemiological studies as outlined above it would seem that observational/behavioural methods are better suited. Behavioural components should not be dismissed as cultural idiosyncrasies as there is no Public Health intervention without behavioural change. It is possible to make three recommendations:

1. A generalized Health Impact Assessment Guideline be developed and evaluated for use in assessing health factors in a water supply scheme. Some water utilities are already using a series of key performance indicators to evaluate and monitor rural supply schemes. Current indicators include service performance, financial performance and accountability indicators. Health related indicators would be a valuable addition to such a protocol.

2. Patterns of hygiene behaviour be evaluated for adding to the list of key performance indicators. The WHO Minimum Evaluation Procedure suggests that health improvements are the culmination of a long chain of events from the original construction, through operation and use, which in turn permit changes in hygiene behaviour and possible prevention of disease. Patterns of hygiene behaviour may prove more reliable than measuring disease rates or water quality.

3. Define feasible, acceptable and cost-effective approaches to delivering the intervention

It is recommended that the results of this study be distributed to various authorities involved in policy decisions for water and sanitation supply and health policies, such as the Department of Water Affairs and Forestry; Departments of Health (local, regional and national); and District Municipalities. Feedback to the community involved in this study should be provided, possibly through local radio and environmental health officers. The following papers were presented at conferences.

Papers presented:

L Archer, IW Bailey, G Xaba, C Johnson. An evaluation of the impact of reticulated water on community and environmental health in Vulindlela, KwaZulu-Natal. WISA Biennial Conference Sun City, 2000

IW Bailey. The relationship between water quality and public health in developing countries; health impact and economic assessment from the provision of rural water supply in South Africa. IWA Health-Related Water Microbiology Symposium, Paris 2000

IW Bailey, L Archer. The impact of introducing treated water on aspects of community health in a rural community in KwaZulu-Natal South Africa. Submitted to IWA Health-Related Water Microbiology Symposium Cape Town September 2003

Posters presented:

G Xaba, L Archer, C Johnson, IW Bailey. Community concerns regarding the implementation of water supply in a rural area in KwaZulu-Natal. WISA Biennial Conference Sun City, 2000

C Johnson, M Colvin, L Archer, IW Bailey G Xaba. Measuring the health impact of water supply - challenges of methodology. WISA Biennial Conference Sun City, 2000

Archiving of Data

The detailed results and raw data are retained at Umgeni Water, Pietermaritzburg.

Capacity building

The following were employed or trained:

Principal researcher	Ms L Archer	Umgeni Water
Researcher 1	Ms G Xaba	WRC/Umgeni Water contract
Researcher 2	Ms C Johnson	WRC/Umgeni Water contract
Community assistant 1	Mr P Mnculwane	Vulindlela community
Community assistant 2	Ms S Hlongwane	Vulindlela community
Community assistant 3	Mr C Ngcobo	Vulindlela community
Community assistant 4	Mr P Shozi	Vulindlela community
Statistical Analysis	Ms S Pillay	) Medical Research Council
	Mr K Zuma	) Biostatistics Unit
	Ms F Nxumalo	)

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"Assessing the causes and pathways of waterborne disease in rural settlements with limited formal water supply and sanitation"

The Steering Committee responsible for this project, consisted of the following persons:

Ms APM Oelofse	:	Water Research Commission (Chairperson)
Mr IW Bailey	:	Umgeni Water
Prof WOK Grabow	:	University of Pretoria
Mr SN Venter	:	University of Pretoria
Dr QI Espey	:	Group for Environmental Monitoring, GEM
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Ms B Genthe	:	CSIR, Environmentek
Dr IM Msibi	:	Water Research Commission
Mr MC Nel	:	Magalies Water
Prof DJ Kocks	:	Medunsa
Mr TA Pule	:	Dept of Health
Dr ML van der Walt	:	Water Research Commission (Committee Secretary)

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The Vulindlela community who participated in this research.
Pumezo Jonas, Director Scientific Services, Umgeni water.

Lyn Archer was responsible for guiding the investigating team through the study design and data collection stages. Her involvement was then limited due to new responsibilities at Umgeni Water, although she was the principle author of the first half of this report.

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APPENDICES

1 INTRODUCTION

The morbidity and mortality associated with water borne infection are of great concern to most developing countries. In 1989, the World Health Organisation (WHO) suggested that 200 million more people were drinking contaminated water that posed a health risk than in 1975 and that, at any one time, half the hospital beds in the world were occupied by people with water related diseases (WHO, 1990). In 1993, it was estimated that 3 million children died as a result of diarrhoeal diseases, mainly spread by contaminated water and food (WHO, 1996). *To the issues regarding human health was the added concern that environmental* conditions were also deteriorating.

Health authorities generally believe that health can be improved by providing an adequate water supply and sanitation. *In a speech to the WHO Regional Planning Meeting (Africa* 2000 Initiative for Water Supply and Sanitation, Zimbabwe, October 1999) Ebrahim Samba, WHO's Regional Director, had some simple words of advice for people in an area affected by an outbreak of the infectious disease Cholera: "Get yourselves clean water and good sanitation. The solution is not to bring doctors or cholera vaccines but potable water and sanitation." (WHO 1999)

In South Africa, one fifth of the population (7 million people) does not have access to an adequate supply of potable water, and one half of the population (21 million) lacks basic sanitation (Department of Water Affairs and Forestry, 2002). *It is estimated that there are* approximately 24 million incidences of diarrhoea per year in South Africa, of which 2.8 million require treatment at health care facilities and 43 000 people die (Pegram *et al*, 1997). The South African Government and water-related agencies are undertaking a vigorous campaign to provide 'water for all' (Umgeni Water, 1998a).

The evaluation of the effectiveness of the interventions on disease morbidity and mortality is a challenging task, as the linkages between water and health are complex. Many contend that the introduction of a water supply scheme does not necessarily result in improved health (Birley, 1995).

The most important reason for the international research in this area is that preventable diarrhoea is perceived to be the cause of many deaths worldwide. If the causes of the diarrhoea can be identified and addressed, thousands of lives, especially those of children, would be saved.

One objective of this study is to evaluate the usefulness of diarrhoeal disease as opposed to other health indicators for water associated diseases. There are four broad categories of water-related diseases as described by Cairncross & Feachem (1993):

- *Waterborne (Faecal-oral)* disease: spread through contaminated water or food supplies. This also includes those diseases, which result from a lack of water for personal hygiene (diarrhoea, typhoid, hepatitis A etc.)
- *Water-washed* diseases: spread from one person to another resulting from a lack of water for washing and cleaning (diseases include scabies and trachoma)
- *Water-based* diseases: spread when individuals come into contact with the hosts of pathogenic organisms which are associated with standing water (e.g. schistosomiasis)
- *Water-vectored* diseases: spread by water-related insect vectors (e.g. malaria and trypanosomiasis).

A product of this research is a full literature review, given the importance and complexities of the linkages between water and health and this was carried out aiming to:

- Summarize the key debates around the issues and problems that are experienced in assessing the effect of water supply on human health
- Review the situation in South Africa

Another product is the comprehensive health questionnaire, which was developed throughout the study and extensively field-tested over the five household surveys.
The third product was to be a technical report on the health impacts of limited domestic water supply on the inhabitants of rural settlements.

1.1 Objectives

- To identify, describe and quantify selected health impacts associated with the microbiological quality of water supply sources and household containers for the inhabitants of rural settlements with and without the minimum RDP specified water supply.
- To identify and describe the critical factors relating water supply with health impacts in rural settlements with different water supply levels.
- To identify the most appropriate methodologies and indicators for identifying and evaluating the health impacts of domestic water supply in settlements with limited formal water supply

2 LITERATURE REVIEW

Society intuitively expects that the provision of a potable supply of water will improve the health of recipient communities, and that the effectiveness of the intervention in addressing diarrhoeal disease, a common water related health indicator, should be demonstrable. It is common to hear the phrase that millions of children are dying annually due to waterborne disease. In fact, in a speech at the prestigious "Stockholm Water Symposium", the keynote speaker was reported to have compared the deaths due to waterborne disease to that of a Jumbo Jet crashing every minute for 24 hours with no survivors. If this is the case, then it seems logical that the morbidity and mortality associated with diarrhoea should decrease considerably by simply providing a supply of potable water.

However, Blum and Feachem cast doubt on this when they reviewed 50 studies that were carried out between 1950 and 1980 in all parts of the world. The authors identified several methodological problems in measuring the impact of water supply and sanitation on diarrhoeal diseases (Blum and Feachem, 1983). A considerable number of factors could inhibit the ability to draw definitive conclusions relating to the impact of the intervention on human health, as discussed below.

2.1 The Evaluation of Water Supply Scheme Interventions.

For many decades, health authorities had assumed that water supply schemes improved the health of recipient communities (Van Der Lee, 1999) and many studies have attempted to quantify the benefits or lack thereof from the provision of a treated water supply.

Payment carried out a randomised prospective study in Quebec, Canada where he examined the health effects of differently treated water supplies namely: regular tap water that meets current water quality guidelines (compliant for coliform and chlorine standards), bottled plant water, purified bottled water (tap water that had been treated by reverse osmosis) and tap water from a tap that had been initially purged prior to water consumption. The study found that 14 to 40 percent of the gastrointestinal illnesses could be attributable to a treated water supply (Payment 1994).

But, while science continued to try and find rational answers that would link water supply and health, the development fraternity grew sceptical of the linkage. In 1975, the World Bank convened a panel of experts to discuss the assessment of the impact of water and sanitation on human health. The panel concluded that the Bank should no longer undertake the funding of long-term longitudinal studies[1], as these had proved to be costly exercises that had shown little success in measuring the impact of water supply and sanitation (Cairncross, 1999). Not long thereafter, the World Health Organization declared 1980 to 1990 to be the *International Drinking-Water Supply and Sanitation Decade,* the objective of which was to improve the health of populations that received the interventions of water and sanitation.

At this time, the case-control methodology[2], was introduced to measure the effectiveness of interventions. However, as a means of evaluating the success of the Decade, it had limited success. Attempts to evaluate the effectiveness of water supply schemes on human health continued to be criticized for being poorly designed, and producing meaningless or useless results. Studies in the Water Decade relied heavily on epidemiological methodologies (Feacham, 1984).

One of the more prominent studies is that known as "Drawers of Water 2" which was led by Mr John Thompson of the International Institute of Environment and Development. The study examined the impact of 3 decades of domestic water use on environmental health in East Africa. The results were somewhat sobering:

- diarrhoea and other water related infections were still a problem despite a supply of treated water
- that water-use per capita had declined by 50% mainly due to the unreliable service
- that those households who were linked up to a water supply scheme were using more water than 3 decades earlier, but still not sufficient for good health, which is now recognised as 50 liters per person per day.
- that the deterioration in water supply infrastructure was due both to urban expansion and a lack of maintenance capacity
- that the determinants of water use are wealth and water price (Thompson, J. 2000)

These important lessons show us that despite the investments of the past years the approaches currently adopted by implementation organizations may be lacking and need to be re-evaluated.

[1] A Longitudinal Study observes a cohort of people, or other variables, over a period of time.
[2] Case-control methodology: a comparison of possible disease causes between a group of people with a disease and a group without the disease.

2.2 The Role of Epidemiology

Over 2000 years ago, Hippocrates contended that environmental factors could influence the occurrence of disease (Last, 1994). However, it was the work of John Snow that popularized the concept of epidemiology. Snow found that the risk of cholera in London was related to the water supplied by a particular company. In the process, he clarified and defined the role of polluted water in the transmission of cholera, a diarrhoeal disease (Last, 1994).

The 1988 World Health Assembly recognized the role of epidemiology in its resolution: The Global Strategy for Health for All. Member states were urged to make greater use of epidemiological data to identify the causes of disease with particular emphasis on modifiable environmental factors and to apply epidemiology to prevent disease and promote human health. (Beaglehole *et al*, 1993).

The challenge in environmental epidemiology is to define the exposure (which in this research study is the introduction of the new water supply), measure it, and assess it's affects, while also taking into consideration problems due to confounding, multiple exposures, and inconsistent and variable dose-response relationships. The outcome (which in this study is diarrhoea) is used as an indicator to measure the effects of the exposure (a change in water supply).

It can be said that every disease is either caused by the environment or by genetic factors (including ageing). The relative contributions of the different factors to a disease (such as diarrhoea) are difficult to measure because of multi-factorial causation. In addition, individual characteristics modify the effect of the environmental factors. Table 2 identifies some environmental and individual characteristics that require consideration (Beaglehole *et al*, 1993).

Table 2.1 Individual and environmental characteristics that affect human health

Individual characteristics	Environmental characteristics
Nutrition	Chemical (dust drugs smoke irritants foods)
Disease	Biological (bacteria viruses fungi parasites)
Sex	Physical (climate noise lighting workload)
Age	Psychological (stress shiftwork relationships)
Physical condition	Accidents (hazards speed alcohol drugs)
Personality	
Genetic factors	

A review of the results of studies that were carried out during the Water Decade concluded that epidemiological studies did not prove to be a satisfactory operational tool for the evaluation of water and sanitation interventions (Cairncross, 1990).

However, almost a decade later, the methodological flaws inherent in epidemiological studies designed to show how and why improved water quality and quantity impact on human health are still present. As described in the next section, a review of recent studies highlights five areas of debate in evaluating the impact of water supply schemes on health.

2.3 Key debates: Issues and Problems in Assessing the Effect of Water Supply on Human Health.

From various studies (Blum and Feachem, 1983; Cairncross, 1990; Esrey, 1996; Payment *et al* 1991; Black, 1996; and others), there are five major areas of debate regarding the evaluation of the impact of water supply on human health:

- Efficiency of water supply schemes in reducing diarrhoea
- Choice of diarrhoea as an indicator of health
- Confounding variables (pathways) in diarrhoeal disease
- Bias in study surveys
- Project design.

These are examined in more detail below.

2.3.1 *Efficiency of water supply schemes in reducing diarrhoea*

It is widely acknowledged that a complex relationship exists between water quality, water quantity, sanitation, hygiene and human health, which is extremely difficult, if not impossible, to accurately quantify (Cairncross, 1992; Baqui, 1991; Blum and Feacham, 1983). The general assumption is that an improved water supply, either individually or in conjunction with improved sanitation, will yield positive benefits to the community, resulting in reductions in disease transmission (Cairncross, 1994). A number of descriptive and analytical epidemiological studies have examined the role of improved water supplies (Khan, 1981) or the combination of improved water and sanitation (Esrey and Habicht, 1986; Esrey *et al*, 1991; Genthe and Seager, 1996). The studies showed variable benefits, ranging from a marked decrease in reported diarrhoeal disease to no benefit at all.

During the International Water Decade (1980-1990), Esrey accumulated evidence of the impact of varying degrees of improved water supply interventions on several diseases and quantified the percentage reduction due to the impact. In a meta-analysis of 144 studies, he showed that improved water quality resulted in an average 15% reduction in morbidity, while improved quantity had a greater impact with an average 20% reduction in morbidity. The synergistic effect of water and sanitation, sanitation alone and health education were all more effective in reducing morbidity than water supply. In the studies that reported a health benefit due to water supply, the water was piped directly to the home (Esrey, 1991).

Shuval *et al* (1981) proposed that there is a threshold at which the effectiveness of water and sanitation investments is realized. At both the lower end of the socio-economic spectrum and the higher end of the spectrum investments in water and sanitation do not show substantial benefits. It is suggested that a point of saturation is reached beyond which further significant health benefits cannot be reached.

The Intersectoral Action for Health Committee (WHO, 1986) estimated that safe and sufficient water supplies and sanitation would reduce infant and child mortality by more than 50% and prevent a quarter of all diarrhoeal episodes. They also estimated the impact of water on specific diseases could be summarized as follows:

Table 2.2 Projected reductions in morbidity (disease) after the introduction of a treated water supply (WHO, 1992).

Diseases	Reduction in Morbidity %
Cholera, typhoid, leptospirosis, scabies, dracunculiasis	80-100
Trachoma, conjunctivitis, yaws, schistosomiasis	60-70
Tularaemia, paratyphoid, bacillary and amoebic dysentery, gastro-enteritis, louse-borne diseases, diarrhoeal diseases, ascariasis, skin infections	40-50

Cairncross (1999) concludes that existing literature on impact studies does indicate that improved water supply will result in improved hygiene, which may be reflected in increased water consumption. In the absence of this behavioral change, the benefits that may accrue from an improved water quality alone are minor and even negligible in many settings.

2.3.2 Choice of diarrhoea as an indicator of health

The second debate focuses on indicators used in studies of this nature which (after Blum *et al*, 1983) include:

- Incidence rates of diarrhoea and /or dysentery
- Prevalence rates of excretion of one or more bacterial or protozoan enteric pathogens
- Prevalence rates of intestinal helminthes infections
- Nutritional status
- Prevalence rates of eye or skin infections, and
- Mortality rates.

Although indicators such as nutritional status (Esrey, 1986) and total mortality (Merrick, 1983) have been used in studies to evaluate the health impact of water supply and sanitation projects, the most widely used indicator is still diarrhoeal morbidity. The reason for this may be that the cost of epidemiological studies is large and the expertise to carry out such studies is limited. In addition, the conditions under which many communities in the developing world live do not lend themselves easily to measuring the height and weight of individuals and most studies rely on questionnaire surveys to gather data.

Gastroenteritis is a major cause of morbidity worldwide (Cairncross, 1999). Despite analytical progress with the introduction of molecular biology and sero-typing, 30-70% of episodes of diarrhoea have no identified pathogen (Marx, 1998). The use of indicators such as the prevalence rates of excretion of bacterial, viral, protozoan or helminthes infections should, therefore, be considered with caution.

It has been shown that, while the introduction of potable water has been successful in reducing mortality in children under five in developing countries, the impact on diarrhoeal morbidity (the subject of investigation) is questionable (Blum *et al*, 1983). In turn, the point prevalence of diarrhoeal disease, which is calculated as the proportion of individuals in a study (usually cross-sectional) who were reported to have experienced any phase of an episode of diarrhoea in a pre-determined period, has proved to be an inexpensive and effective indicator of measuring morbidity related to water and sanitation interventions (Thomas and Newman, 1992).

Aetiology of acute diarrhoea among communities in developing countries

Water-borne diseases are typically associated with enteric pathogens that are transmitted via the faecal-oral route, either through infected food or contaminated water supply.

The extrapolation from one country to another of the importance of various pathogens potentially transmissible by water and their risk of infection is problematic (Grabow, 1996). However a systematic review of the aetiology of acute diarrhoea in children (the segment of the population most vulnerable to diarrhoeal disease) in developing countries identified that the pathogens most strongly associated with disease was rotavirus, *Shigella* spp and *enterotoxigenic E. coli* (Huilan *et al*, 1991). Rotavirus are recognized as a major cause of severe gastro-enteritis in infants and children worldwide, and have been estimated to be responsible for up to 70% of hospitalisations for diarrhoea (Cook, 1990). This is also the case in South African studies, where the prevalence of rotavirus is the most important viral pathogen associated with sporadic gastroenteritis in hospitalised patients in South Africa (Wolfaardt, 1997).

In 1992, Taylor *et al* investigated two successive outbreaks of gastro-enteritis in South Africa to identify the etiological agents. Neither pathogenic bacteria nor parasites were evident in either outbreak. In both instances, SRSV UK3/Hawaii virus was implicated as the cause of diarrhoeal disease (Taylor *et al*, 1993).

While the prevalence of diarrhoea is accepted as an indicator of community health and the aetiology of diarrhoeal disease is well described, the definition of diarrhoea and the confounding variables in measuring diarrhoea pose a great challenge.

Definition of diarrhoea.

If studies are to be accurately compared, all health indicators need to be precisely defined. A review of the literature on diarrhoeal disease reveals considerable variability in the definition of diarrhoea. Diarrhoea is not a single disease and has many different causes and aetiologies. The use of different definitions has led to the misclassification of the effects of the disease burden and has limited the comparability of many studies.

Whether community-based epidemiological studies of diarrhoea should rely on the mother's report or should be formulated by specific objective criteria (such as a specified number of loose/liquid/bloody/mucoid/watery stools-per-day) is a difficult issue on which to reach an agreement. Most would not argue against the notion that the mother of a child probably knows best when a child's bowel movement is "out of sorts" within the norm for a specific cultural setting. However, without a predefined definition, it is not possible to either compare or evaluate studies.

Baqui *et al* (1991) in comparing operational definitions of diarrhoea with mother's perceptions of diarrhoea, concluded that "three or more loose stools or any number of loose stools containing blood in a 24 hour period" was acceptable as the best definition for a diarrhoeal episode. Multiple episodes of diarrhoea were considered as distinct if separated by at least two diarrhoeal-free days.

2.3.3 Confounding variables and pathways in diarrhoeal disease.

This third area of debate is focused on the use of diarrhoea as an indicator to evaluate the health impact of an intervention. It has one considerable major draw back: there are many pathways that may lead to diarrhoea in a population and unless these pathways are described and controlled for confounding variables, they will distort the study results. An understanding of all the pathways to diarrhoeal disease is necessary.

The ecological pathways and potential confounding variables to diarrhoeal disease are complex and inter-related. In many studies, researchers have identified pathways and risk factors that will cause diarrhoea, some of which are discussed below.

Molbak *et al* (1997) followed an open cohort of 1,314 children from Guinea-Bissau for three years, conducting weekly diarrhoea recall interviews. Fifty-seven possible pathway variables were considered. Six were associated with an increased incidence of diarrhoea: male sex, being weaned from breast milk, not being looked after by the mother, head of household being less than 30 years old, eating cold left-overs, and drinking water from unprotected public water supplies. Molbak also identified previous diarrhoeal episodes as an important risk factor in the prevalence of diarrhoea. This has implication for the case-control methodology, which is the preferred methodology of present health impact studies. It is commonly found that "controls" for diarrhoeal disease studies develop diarrhoea and revert to cases, thus completely confounding the study (pers comm. Jagals, 1999).

Malnutrition as a risk factor has been investigated in several studies and, in some, it was identified as a risk factor (Baqui, 1993), while other studies failed to find an association. Knight carried out a case-control study in rural Malaysia of risk factors for the transmission of diarrhoea in children aged 4-59 months. The risk factors identified were: drinking unboiled water, eating left-over food, bottle-feeding, animals inside the house, and the absence of water for washing hands after using latrines (Knight, 1992).

Further common confounding variables applicable to most epidemiological studies include: seasonal rainfall, socio-economic status, years of education of the main caregiver, birth order of the child, and the number of people living in the house (Knight, 1992).

The provision of a safe water supply is an important but not the only contribution in breaking the chain of diarrhoeal disease. There is the need however to ensure that the quantities, the quality and the manner in which water provision is introduced is contributing toward health improvement.

2.3.4 Bias in study surveys - Quality Control

This fourth area of debate is focused on study questionnaires and survey personnel, who must be vigilant if bias is not to be introduced in the study. While recall bias can be limited, the problems with manipulation and perception are more difficult to cope with.

Recall bias

In various studies, the recall period for questions related to diarrhoeal morbidity has varied between 24 hours and 12 weeks. Recall periods exceeding 48 hours are considered to be a methodological problem (Blum *et al,* 1983). It has been shown that the reporting of diarrhoeal disease decreases with the increase in days asked to recall information. In other words, when the recall period is more than three days, under-reporting of diarrhoea is to be expected. Several studies have found that the reported duration of episodes of diarrhoea were inaccurate and statistical analysis of the studies had to make adjustments for an increased number of diarrhoeal episodes reported as starting or stopping on or near the day of the interview in cross-sectional or longitudinal studies (Baqui *et al,* 1991; Boerma, 1991).

Cultural bias

The accuracy of response to health related questionnaires is dependent on the degree of cultural and personal shame associated with reporting positive results. For example, the issue of regarding HIV/AIDS as a notifiable disease is problematic because, if the true response is perceived to be shameful, inaccurate responses will cause studies to be erroneous (Colvin, 1998). In the same way, if communities associate the presence of diarrhoea in their family to reflect negatively on the cleanliness of the individual or household, erroneous answers will be recorded and studies will be biased.

In addition, individual risk of exposure can affect self-reporting of symptoms by as much as ten-fold, especially when the individual has a preconceived notion of risk associated with the exposure (Fleisher, 1997).

2.3.5 Project design

The fifth and last major area of debate focuses on project design. Epidemiologists study the occurrence and cause of disease in human populations and apply this knowledge to the prevention and control of health problems. Conversely an intervention, such as the development of a water supply scheme, is perceived to be a possible disease control mechanism and environmental epidemiologists have attempted to quantify this. Observational and experimental epidemiological studies are both used to determine associations between water interventions and health outcomes (Black, 1996). He also suggests that the promotion of experimental methods at the expense of observational methods (analytical case-control and cohort) has limitations.

Environmental interventions are problematic to evaluate. While randomised controlled trials are regarded as the best methodology to use, interventions such as the introduction of a water supply scheme are not always introduced on a random basis. Economic, political, environmental and even health considerations impact on the decision of where and when to build a water supply scheme. It is however important that these confounding variables be identified and controlled.

As previously stated, descriptive disease surveillance surveys, analytical cohort and cross-sectional studies have been criticized as producing meaningless results in trying to evaluate the effectiveness of water supply interventions and case-control studies became the preferred methodology. The criticism is based on the lack of adequate control, one-to-one comparison, failure to record facility usage and failure to analyse by age (Cairncross, 1999).

Many studies have failed to provide adequate controls (Blum *et al*, 1983). Without adequate controls, the benefits or impacts identified as an outcome cannot necessarily be associated with the intervention under study. In addition, the comparability of the control and the sample under study must be established. Baseline studies may be required to assess the situation prior to the introduction of the study. Failure to do so will result in many confounding factors rendering the results of the study useless (Blum *et al*, 1983).

One-to-one comparison is a common methodological error in evaluating the impact of water supplies on health (Blum *et al*, 1983). To minimize costs, a single village with the intervention is commonly compared with the village prior to the installation of water reticulation. Unless households within the village are independent and the implementation of reticulation can be shown to not be village-wide, several clusters of the intervention need to be compared with several clusters without the intervention.

2.4 Review of the Situation in South Africa

Developing countries bear a heavy burden of diarrhoea where, on any given day, 10% of all children aged 0 to 4 years will be suffering from diarrhoea (Cairncross, 1990). Diarrhoea and other water related epidemics in the developing nations are typically blamed on polluted river and ground water resources, as these are the sources of most drinking water. In the developed nations, waterborne epidemics are blamed on poor or negligent water management.

South Africa lacks a comprehensive surveillance system for diarrhoeal disease and, hence, there is little accurate information available on the prevalence of water-borne diseases in the country. Recent work by Pegram *et al* (1997) indicates that diarrhoeal disease in South Africa annually causes about 43,000 deaths, 3 million incidences of illness requiring treatment, and a cost of at least R 4 billion (Pegram *et al*, 1997). However, it may be expected that the risk of waterborne disease in South Africa is no different from any other country and, possibly, may be higher, due to pollution of the limited water sources and the dependability of many rural communities on those polluted water sources (Grabow, 1996)

The legacy of skewed resource allocation throughout South Africa's history has resulted in a society where development is not homogenous. Large sectors of the population still live in conditions with no formal water supply and unimproved sanitation (Netshiswinzhe, 1999). Such conditions contribute to illness and death. Cultural beliefs and poverty have kept communities from addressing these environmental causes of morbidity and mortality.

Following the election of South Africa's first democratic government in 1994, the Reconstruction and Development Program (RDP) was established to redress the lack of development within rural communities. The government response to the demand for potable and accessible water supplies became an important cornerstone of the RDP. This led to the construction of water supply schemes in many areas of South Africa, through which over 1 million more people will have access to potable water. Recent studies carried out by the Mvula Trust (Breslin, 1998) suggest that there is a need for a post construction audit process, as these water schemes have not extended the full benefit to the communities that they were designed to serve.

The South African White Paper on Water and Sanitation Supply (DWAF, 1994) defines the minimum level of service for water supply as follows:

- the nearest water supply point must be located within 200 m from an individual's dwelling
- the water should be available on a regular basis.

Most schemes have aimed to provide 25 litres per day per capita. However, there is little consideration for population density and often many people have to access a single standpipe. No education is provided on the problems associated with water storage. Unlike sanitation projects, the water supply intervention is seldom approached with a discussion on technical choices in water supply design. Decisions about how to build water supply schemes, where to positions taps, and the quantity of water to design for are usually desk-top studies with little community consultation (Breslin, 1998). However, these factors will clearly affect the water management and subsequent health of the community.

2.5 Concluding Remarks in Regard to Literature Review.

Most studies on the effects of water supply on human health over the past fifty years have been criticized as to their validity and usefulness. Lack of adequate control, poor project design, many confounding variables, cultural bias, health indicator recall, health indicator definition and failure to analyze by age have been sited as rendering study results meaningless. Eminent researchers in the field, such as Cairncross, are equally skeptical. While instinctively it is accepted that water and sanitation do improve health, there are many opinions as to how and why.

It has been proved that the quantity of water has a greater impact on health than water quality. An improvement to the proximity of water supply (piped water) not only increases the quantity of water used, but also removes the need for water storage and therefore contamination. This may in turn reduce contamination and the proliferation of disease bearing vectors such as mosquitoes and flies.

Because of the varied results of international research in this field, more South African research is required to:

- Establish the extent of diarrhoeal disease in the rural areas
- Identify the risk factors to diarrhoeal disease, which are extensively associated with the water resources and which are expected to improve with investment in water supply schemes.
- Establish health criteria for consideration in the auditing of water supply schemes

These factors provide the key objectives for this study.

3 METHODOLOGY

3.1 Vulindlela: Background, history and description

Vulindlela is a rural area situated approximately 20km southwest of Pietermaritzburg. It covers an area of approximately 260km^2 with a population of 200,000. Vulindlela, which means "open the way", is made up of five tribal areas, namely: Mpumuza, Inadi, Nxamalala, Mafunze and KwaXimba. Each area is governed by an Amakhosi (Chief) with a tribal council.

The Vulindlela Water Supply Scheme is a Presidential Lead Project, one of twelve identified in 1994 as priority projects under the RDP program. The goal of the RDP scheme is to provide a sustainable water supply of approximately 25 litres per capita per day within 200m of every homestead. The criteria for the placement of taps was amended to the placement of a connection at each homestead instead of communal taps. These taps were however not to be actually inside the houses, but in the yard/garden as there was no provision to be made for drainage. The total cost of the scheme was estimated at R 200 million and the expected completion date was June 1999. Although in late 1999 the scheme was almost complete, many household connections to reticulation lines were still in progress.

Of special note is the size of the Vulindlela Water Supply Scheme which comprises the Groenekloof Pumpstation; nineteen reservoirs; 25 km of rising main and 68 km of gravity main (bulk lines); telemetry links between Midmar Works, the pump-station and five reservoirs; 374 km of reticulation pipe-work in twenty reticulation zones; and thirteen branch offices where water accounts can be paid.

The development of the scheme was carried out by Umgeni Water, in partnership with an executive steering committee made up of 14 members representing the 50 Vulindlela local water committees. All development decisions were made by this steering committee. It was also responsible to provide a liaison between the development/construction teams and the community at large.

Travel in Vulindlela is facilitated by the tarred road linking Pietermaritzburg and Bulwer, which is supplemented by graded gravel roads, together providing access to most areas. Busses and minibus-taxis are the main means of transport. The area is serviced by electricity, as well as telephones. There are several elementary and secondary schools and a network of clinics providing education and health care respectively. There is no industrial activity and a few small stores provide basic provisions.

The area comprises mixed settlement and grazing, mostly cattle and goats. Small-scale subsistence farming is scattered amongst residential wattle and daub homes. Commercial forestry constitutes a small area and is mainly located in the area adjacent to the Pietermaritzburg-Bulwer road.

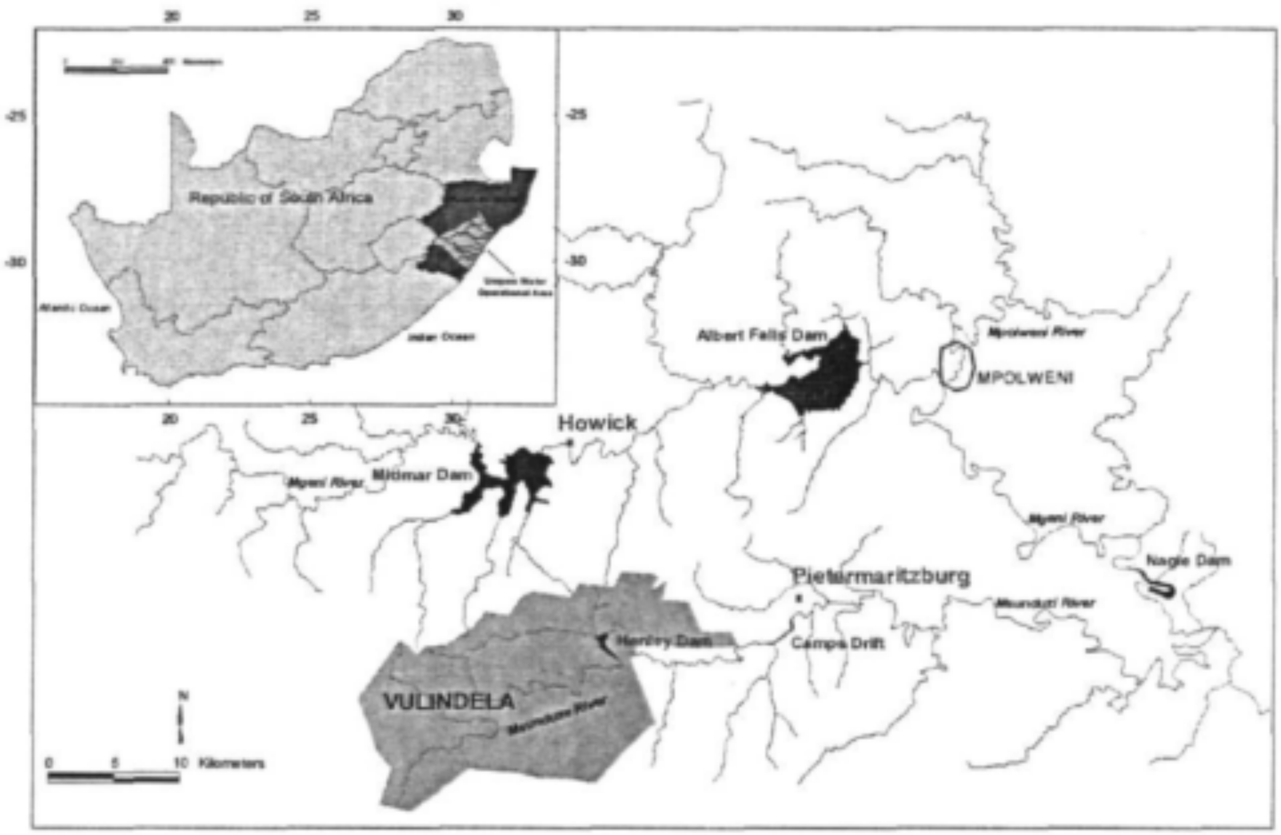


Fig 3.1: Map of Vulindlela area

3.2 Study Design

The Stepped Wedge Design was suggested as an appropriate study design for the Vulindlela Study (Colvin, 1998), due to the progressive nature of the development over time, see fig 4.1. Confounding factors are minimized through the selection of settlements located in the same area. Characteristics, such as the sanitation infrastructure, quality of the local water resources, topography, natural physical characteristics, distance from urban areas, settlement density, socio-economic levels, demographic and educational profile characteristics are expected to be similar.

Fig 3.2 Stepped Wedge Design

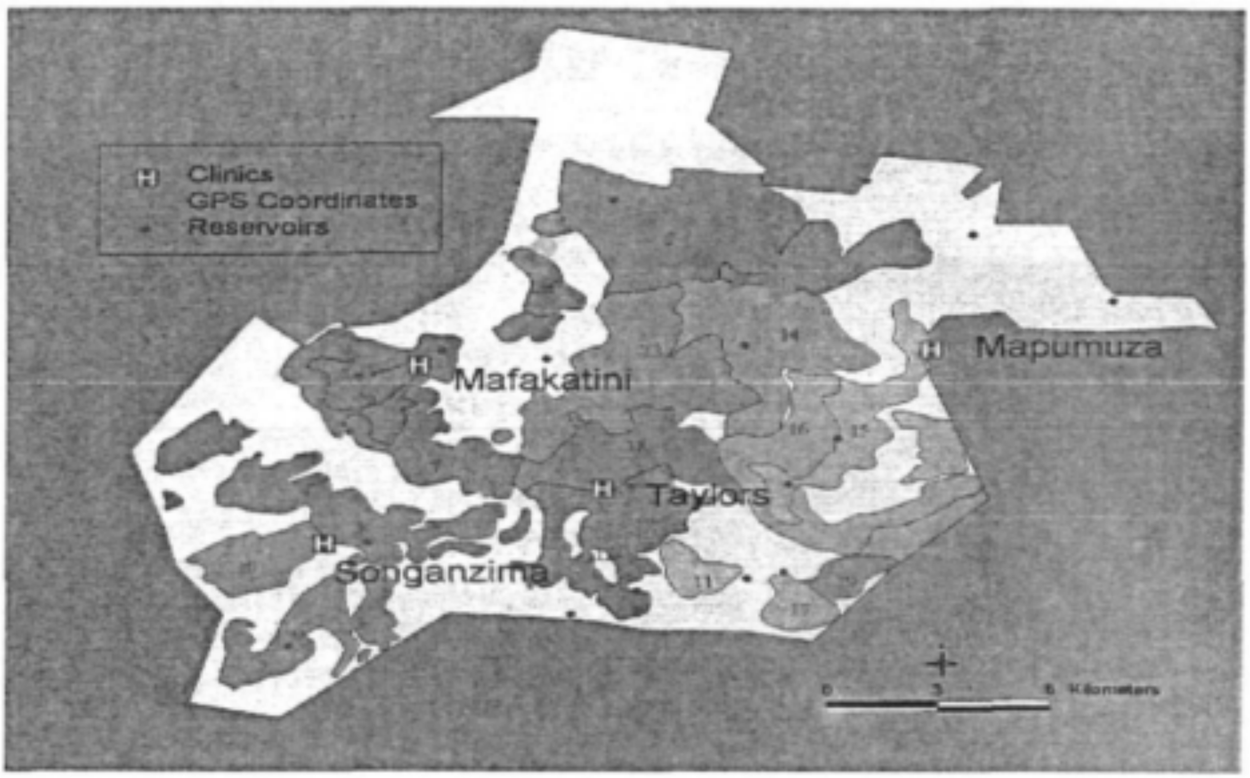
Site/area	Baseline Jan 1999	Survey 2 April 1999	Survey 3 July 1999	Survey 4 Nov 1999	Survey 5 Feb 2000
Mthoqotho Sample size: 25 households	Before UW	UMGENI	UMGENI	UMGENI	UMGENI
Khobogwane Sample size: 25 households	Before UW	Before UW	UMGENI	UMGENI	UMGENI
Shange Sample size: 25 households	Before UW	Before UW	Before UW	UMGENI	UMGENI
Mafakatini Sample size: 25 households	Before UW	Before UW	Before UW	Before UW	UMGENI

The analysis of data from columns in fig. 4.1 can be considered an observational cross-sectional study of a sample of four locations in the Vulindlela area. The analysis of the data over the period of the year (i.e. in each row of the table above) would be a longitudinal study of that population cluster. The power of this methodology clearly lies in the combined analysis both longitudinally and cross-sectionally. Although there are only four clusters in the study, each cluster is being visited five times. Despite an extensive literature search no information could be found on the stepped-wedge-design being used on a non-medical trial. Only one reference was found for a hepatitis vaccination trial in Gambia in 1987 (Gambia

Study Group, 1989). And hence the present study is in many ways ground breaking. The four surveys corresponded where possible to the four phases of the introduction of water supply to the four different areas.

3.2.1 *Sample size and site selection procedure*

The selection of households to be surveyed was based on a stratified random approach. The selection was stratified due to the location of clinics, accessibility of the area, advice of the Vulindlela Water Supply Scheme Executive Committee and most importantly the rate of the Vulindlela Water Connection Program. Within this stratified selection, the household choice was made randomly and each household location was identified using a GPS (see fig 3.3).



Indicates location of households sampled (GPS Coordinates)

Fig 3.3: Map of household sample distribution in Vulindlela

The number of households required for this project was based on an anticipated improvement in diarrhoeal prevalence of 15%[3] with a 95% confidence interval. The Epi-Info software package was used to capture the data.

3.2.2 Data collection

A team of two research assistants were tasked to sample 100 households visiting each household five times over a 15-month period in January 1999 to March 2000. The first assistant, a Zulu speaking social scientist was responsible for administering all the questionnaire surveys, which provided consistency and eliminated variability due to the researchers interpretation of answers to the questions. The questionnaire was drawn up especially by the project team and consisted of both closed and open questions. It was administered in Zulu to the head female in the household and was based on a two-week recall period. The respondents were asked to recall specific diarrhoeal episodes experienced by members in their households over the previous two weeks. The definition of diarrhoea was identified as three or more loose/ liquid/ watery stools or any loose stools containing blood in a 24-hour period (Baqui *et al*; 1991). The questionnaires were modified across the surveys for clarity and questions added regarding the new water supply, whilst others relating to the situational analysis were asked only once. A separate Observational questionnaire was also completed by the second research assistant at Baseline only, regarding the general state of hygiene of the house, whilst the full household questionnaire was being administered. The Baseline (Survey 1) and Survey 5 household questionnaires are included in **Appendix 1,** along with the Observational questionnaire.

To obtain an impression of what the community thought were the health issues in Vulindlela, respondents were asked, using a closed question identifying a selection of common health ailments in both rural and urban South Africa, to indicate what they perceived were the most significant health problems in Vulindlela.

The second research assistant carried out water sampling of the household container and in the case where the water was carried to the household from a nearby source (river, spring, communal tap or borehole), also sampled source. Considerable effort was made to ensure that the source of the water sample in the in-house container was sampled. If they were

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[3] The literature indicates that improvement in water supplies will result in a 15% improvement in the rate of diarrhoeal disease (Esrey *et al* 1996)

already receiving Umgeni tap water, then a sample was taken from the tap. A photographic record was also made of the household and sanitation infrastructure.

3.3 Water quality analysis

Water quality samples were collected from the storage containers and water sources of the 100 household sample in Vulindlela. pH, temperature and residual chlorine (Umgeni tap) were measured on-site. The water samples were stored at 5°C in a cool-box and transported to the Umgeni Water laboratory within 6 hours, where the other analyses took place. The analyses are considered reliable as Umgeni Water's laboratories and its methodologies were accredited to ISO Guide 25 (and now ISO 17025) and audited by SANAS on an annual basis.

3.3.1 Microbiological analysis

The samples were analysed for:
Coliforms, *E. coli, Faecal* Streptococci
Vibrio cholerae (cholera), Salmonella
Giardia, Cryptosporidium

Coliforms, *E. coli* and Faecal Streptococci were by membrane filtration, using membrane lauryl sulphate broth and enterococcus agar respectively, according to Standard methods (APHA 2000), HMSO (1982a).
Vibrio cholerae and Salmonellae by membrane filtration and then enrichment, plating and selection followed by confirmation using API 20 E and specific antisera. SABS (2001), HMSO (1982b)
Giardia and Cryptosporidium by flocculation of 10 litres and detection microscopically with FITC. Vesey et al (1991,1993)

Samples were only taken for analysis for the pathogens *Vibrio cholerae (cholera), Salmonellae, Giardia and Cryptosporidium*, when the household reported diarrhoea, owing to laboratory capacity limitations. Coliforms, *E. coli*, and Faecal Streptococci tests are specified in SABS and international guidelines for assessing drinking water quality. *Giardia* cysts, *Cryptosporidium* oocysts and *Salmonella and Vibrio cholerae (cholera)*, are known to cause diarrhoea, whilst the latter two can cause widespread epidemics. Thus tests for some of the actual pathogens and not only indicator organisms in water were included.

3.3.2 Chemical analysis

The samples were analysed for the following chemical parameters:
pH, Temperature, Turbidity, Conductivity
Calcium, Magnesium, Total hardness
Nitrate, Chloride, Fluoride, Sulphate
Iron, Manganese, Copper, Zinc, Cadmium, Arsenic

pH was measured on a Radiometer PHM 95 pH/ion meter with a temperature compensation probe and thermometer, which was also used to measure the temperature.
Turbidity was determined using a Hach Ratio/XR model 43900 turbidity meter.
Conductivity was measured in mS/m on a conductivity meter using a potassium chloride reference solution (0,0100M) according to a SANAS accredited method.
Calcium, Magnesium, Iron, Manganese, Copper and Zinc were analysed by Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES) on a Varian Radial ICP according to a SANAS accredited method. Hardness was calculated from the Calcium and Magnesium analyses.
Cadmium was analysed by Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES) on a Varian Axial ICP according to a SANAS accredited method.
Arsenic was analysed by Hydride Generation on a PSA Hydride Generator with an Atomic Fluorescence detector and using a SANAS accredited method.
Nitrate Chloride and Sulphate were analysed by a Waters Ion Chromatograph according to a SANAS accredited method.
Fluoride was analysed on a Fluoride Ion Selective Electrode with an Ion meter.
All generally according to Standard methods (2000).

These chemical parameters, although not all originally part of the study, were analysed to characterise the general water quality and for Umgeni waters use. Nitrate, Fluoride, Iron, Manganese, Copper, Zinc, Cadmium and Arsenic, can also be health related.

3.4 Statistical analysis and data capture

The statistical unit of the Medical Research Council was responsible for the capturing and analysis of data. The data was double entered by two data encoders on Epi-Info (Version 6), a software package especially designed for epidemiological studies. The statistical analysis was done using SAS version 6.12 (SAS Institute, Cary N.C.) and S-splus (version 4.5) computer programmes. Descriptive statistics were reported using statistics such as *mean, median, range, etc and* graphical displays used for some variables to investigate the changes and possible patterns in the data.

Microbiological data generally have substantial variations, which cause data not to be normally distributed around the mean. These data also present a high degree of outlying values and positive skewness. Microbiological data usually only takes non-negative values and this violates one of the conditions of a normal distribution to be applied. To produce microbiological data that would approximate a normal distribution, transformations can be used and natural logarithmic (log e) transformation is used in this case to make the data more symmetrical. Zero values in the data were replaced by one in order to avoid the problem of the logarithm of zero being undefined. Most of the exposure data variables were close to normality after transformation and hence it was not necessary to apply non-parametric tests such as Kruskal-Wallis test instead of the parametric analysis of variance (ANOVA) approach. As the mean tended to be sensitive to outlying values, the geometric mean (GM) or the median were therefore preferred.

Chi-squared tests were performed to test for association between two variables and also to test for equality of proportions. Where expected cell frequencies (number of observations) were less than 5, Fisher's Exact test was performed. The strength of association between the exposure variables and diarrhoea was estimated by the odds ratio (OR). Equality of continuous variables such as the transformed microbiological data between two categories was compared using the Student's T-test. In the case of more than two levels of categories, the ANOVA F-test was used to do the comparison. Statistical tables can be used for further assessment of the T and F values.

Data collected within the same family tend to display auto-correlation. For example, if the cause of diarrhoea is contamination of the household water container, household members are likely to be infected with diarrhoea. Also repeated observations within the same unit (e.g. household or individuals), and area in the case of epidemic diseases such as diarrhoea display auto-correlation. Statistical methods that do not take into account such auto-correlation are not adequate and lack efficiency. The Generalized Estimating Equations (GEE) methods of Liang and Zeger (1986) were applied in order to correct for possible area-household cluster sampling. A constant correlation working matrix was assumed for this model. To investigate the relationship between the probability (π) of developing diarrhoea and a set of prognostic factors, a GEE model was constructed to describe the effect on π of changes in the set of prognostic factors. Variables that were statistically significant in the univariate analysis were considered in the model development. The importance of these factors in the model was determined by the significance on a likelihood ratio test. However some confounding variables such as the number of children under five years were also included in the model irrespective of their significance.

Confidence intervals are reported as 95%. All *p*-values were derived from two sided tests. A *p*-value of 0.05 or less was considered to indicate statistical significance. An *intent to treat* data analysis was done, that is subjects were analysed according to the treatment they were supposed to receive at that specific time, i.e. comparisons were made according to the water that they were supposed to have, even if they did not actually receive it.

Conducting Questionnaires

Semi-protected spring

Water storage in Vulindlela house

Collecting water samples

4 RESULTS AND DISCUSSION

4.1 SECTION 1: Baseline Survey

The results of the baseline survey are presented and discussed in three sections:

- The socio-economic situation in Vulindlela
- Health indicators and the prevalence of diarrhoea in Vulindlela
- Health and the water environment in Vulindlela

4.1.1 Socio-economic situation in Vulindlela prior to the introduction of water supply

Vulindlela, meaning "open the way", is a rural area skirting greater Pietermaritzburg where the influences of urban life are being felt. The area of research is divided into four regions viz. Shange, Mthoqotho, Lower Khobongwana and Mafakatini. On average, each household comprises six persons, a little higher than the South African average, which is five (see Table 4.1). The total number of people living in the 100 households sampled was 602 and the household density (crowdedness index) 0.8. Vulindlela is considered a stable community, which is indicative of the relatively larger homes.

Table 4.1 Socio-economic Indicators: Vulindlela and South Africa

(South African data: Community Agency for Social Enquiry, 1995)

Indicator	South Africa	Vulindlela
% of dwellings = shacks	9.5	0
Number of people per household	5	6
Average no. of rooms per household	4	8
Crowdedness index (people/room)	1.25	0.75
% of population five years old or less	16	11
% population older than 16	58	61
% with no formal education	15	9
% Source of water untreated	12	100
% Toilet type = pit latrine	34	100

Table 4.2 Characteristics and socio-economic status of the study population (mean values)

	Khobong. n=25	Mafakatini n=25	Mthoqotho n=25	Shange n=25	Total n=100
Gender (%)					
Male	48.0	64.0	56.0	56.0	56.0
Female	52.0	36.0	44.0	44.0	44.0
Respondent Age (years)					
Mean	54.2	52.2	55.6	58.9	55.3
Median	55	53	56	59	55.5
Range	34 -73	31-79	30-80	36-96	30-96
Children aged (0 – 5 years)					
Mean	0.7	0.9	0.8	0.6	0.8
Median	0	0	0	1	1
Range	0-3	1-3	0-8	0-3	0-4
Rooms in household					
Mean	7.9	7.4	8.2	8.1	7.9
Median	8	7	7	8	8
Range	2-13	2-13	2-15	4-13	2-15
People living in the dwelling					
Mean	5.9	6.6	6.1	6.3	6.2
Median	6	6	5	6	6
Range	1-13	3-13	1-20	1-11	1-20
Crowdedness index people/rm					
Mean	0.78	0.95	0.75	0.79	0.8
Median	0.73	0.88	0.67	0.71	0.76
Range	0.17-1.86	0.38-2.25	0.14-2	0.17-1.43	0.14-2.25

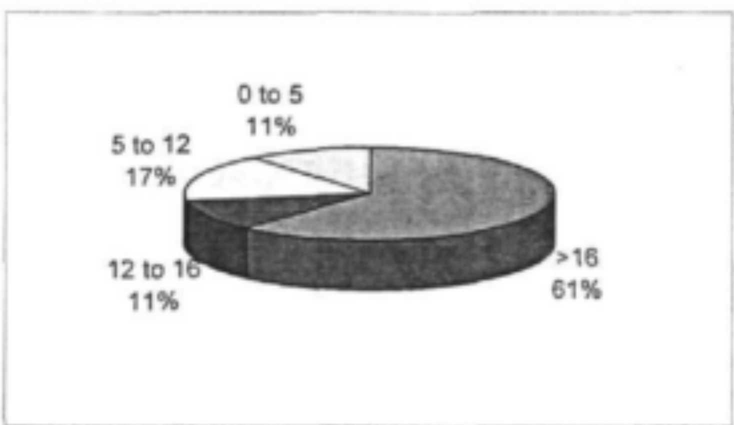


Fig 4.1 Age distributions in Vulindlela

With regard to gender, the study found that 53% of the population in the Vulindlela sample are female and 47% are male. In 56% of the households in Vulindlela, the head of the household is male. In 77% of the households, a female holds the position of second member of the household (fig 4.2).

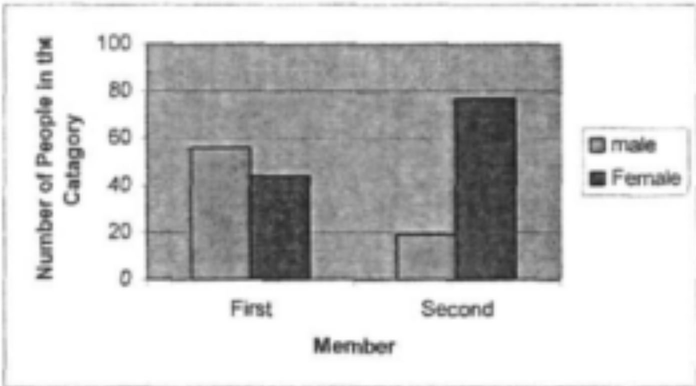


Fig 4.2 Gender of Head of Household

The study found that at least 80 % of the sample had some form of education, while 9% had not attended any form of formal education. However, this includes those family members who have not yet reached school going age. The most common use of spare time among children after school was identified as doing homework, fetching water, watching television and occasionally visiting friends. A significant group said that doing homework was not applicable to their household (40.7%); this might be an indicator of illiteracy rate in the community

Of the people sampled, 17% had employment of some type and included those who were self-employed, hawking, casual employed and permanent employed. It appears that the income from this group and the 9% who are pensioners support the remainder of the population. The people who are classified in the "other" category include those attending school, homemakers and those who were not employed or pensioning, but did not classify themselves as unemployed. The survey reported that the average household income was R522.

Some of the household members are considered as migrants since they do not stay at home permanently. Fifteen (15.2%) people reported that their migrant members come home once a week, four (4%) return once every two weeks, thirteen (13.1%) come home once a month, two (2%) come home once a year and for about sixty-five (65.7%) this was not applicable. This may be because there was no member of the family that was considered a migrant.

There were times when the households were short of food; 44% of the households reported that they were sometimes short of food, whilst most were short of food towards the month-end.

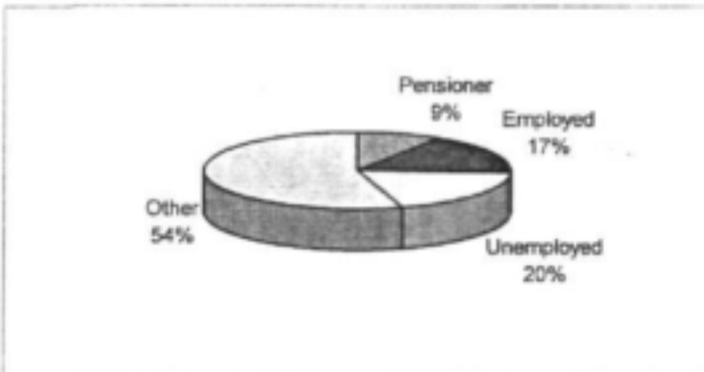


Fig 4.3 Employment status in Vulindlela

No families in the Vulindlela sample live in shacks. This is not surprising as the sample was stratified for those families who had applied and paid for their water connection, suggesting that the sample is possibly biased in favour of the more established members of the community. The majority (78%) of homes were made in the modern rural tradition using wattle, daub and mud blocks with galvanized iron and tin roofs. Other parameters include: 54% kept chickens, 28% kept cattle, 26% kept goats, and 57% kept dogs in or around the property.

Nearly all the households had situated their pit latrines an average of 22 meters down slope of their own dwelling, an indication that there was an understanding of the health hazards associated with a toilet located upslope of the house. Most households have no specific place where they dispose their refuse, whilst a quarter of the households have their own pit. Many people mentioned that they have problems of rats, mosquitoes, dumping rubbish, etc. This could be linked to some of the other diseases that are prevalent in this area.

4.1.2 *Health Indicators and the prevalence of diarrhoea in Vulindlela prior to the introduction of water supply*

Table 4.4 *Perceived* Health Problems in Vulindlela (percent)

Common diseases	Shange	Mthoqotho	Khobongwa	Mafakatini	Total
High Blood Pressure	100	72	88	76	84
Diarrhoea	92	64	80	68	76
Misuse of alcohol	52	84	36	72	61
AIDS	48	12	52	44	39
Cold & Flu	68	40	60	48	54
Tuberculosis	32	60	16	56	41
Malnutrition	4	40	16	36	24
Eye infection	8	8	8	12	9
Skin Infection	20	8	4	0	8
Stress	4	4	0	8	4
Drug Abuse	0	12	0	0	3
Worms	0	8	0	0	2
Bilharzia	0	0	0	4	1

The table above shows that the diseases such as High Blood Pressure and Diarrhoea are *perceived* by the community as being the leading most common diseases in all the four regions, which is followed by misuse of alcohol, AIDS, cold and flu, and other diseases. The perceived prevalence of AIDS is alarmingly high in three of the communities. In comparison, in Mthoqotho, it is significantly less and this could reflect a bias of under-reporting, or reporting symptoms of AIDS such as Tuberculosis, instead. On the positive side, there could be training/health reasons, which warrant better investigation.

The baseline study in Vulindlela reported that 40.4% of the households had at least one member of the household experiencing diarrhoea in the previous two weeks. As there are no data on the full extent of diarrhoeal disease in South Africa, there is little basis for comparison of the above findings at the household level, with a South African household average.

Table 4.5 identifies the number of cases of diarrhoea by gender and for each age group in Vulindlela's survey population.

Table 4.5 Number of cases of diarrhoea by gender and age group in each ward in Vulindlela

Age group		< 5			5 to 11			12 to 16			> 16			Total by area		
Gender Breakdown		Male Yes	Female Yes	Total Sample	Male Yes	Female Yes	Total Sample	Male Yes	Female Yes	Total Sample	Male Yes	Female Yes	Total Sample	Male + Female Yes	Male + Female No	Total Sample
Areas Sampled	Khobongwane	2	1	14	0	1	24	0	1	19	2	4	87	11	133	144
	Mafakatini	3	2	15	1	1	32	1	0	10	6	6	101	20	138	158
	Mthoqotho	0	2	19	0	1	26	0	0	11	2	5	90	10	134	146
	Shange	2	1	14	2	0	19	0	0	16	3	10	105	18	136	154
Total by age		7	6	62	3	3	101	1	1	56	13	25	383	59	541	602

Diarrhoea status of children under 5 may also depend on the method of feeding. In each homestead people were asked to state their method of feeding. 51 people responded to the question. Breast only feeding method was used by 13.7%, breast and bottle method (2%), bottle only (2%), solids (56.9%) and the rest were using a combination of the some of these methods (24.5%).

To evaluate the study on 'costs' of diarrhoeal diseases as described by Pegram et al (1997), a response on whether the presence of a disease within the household resulted in medical treatment at a health institution, was sought. The following health institutions were generally used by people in the region: clinic (52%), mobile unit (14%), general practitioner (34%) and hospital (21%). Only one person claimed that when a member of his/her family is sick visits the traditional healer.

People were asked to state the number of people in their households who had the symptoms of water-related diseases and the number of clinic visits related to each in the two-week recall period. It was established that the category of water-vectored diseases could be eliminated, as there was little possibility that the associated insect vectors would be found in Vulindlela.

Many studies identify that the group most vulnerable to water related diseases is that of children under 5. Therefore this question was asked separately for the younger children (0 to 5 years) and older children and adults. The following table shows the response for all regions together; the lowest and the highest possible value is identified in the brackets.

Table 4.6 Number of persons per household with potentially water-related diseases with 2-week recall (range)

SYMPTOMS	NUMBER OF PERSONS SUFFERING		NUMBER OF CLINIC VISITS	
	0-5 years	> 5 years	0-5 years	> 5 years
Stomach Pain	1(1-1)	1.2(1-2)	0	0.3(0-1)
Bloody diarrhoea	1(1-1)	1(1-1)	1(1-1)	0.1(0-1)
Watery diarrhoea	1(1-1)	1.5(1-4)	0.2(0-1)	0.6(0-5)
Bloody urine	0	1(0-1)	0	0
Itching hair / body	1(1-1)	1.3(1-2)	0	0.8(0-1)
Back pain	0	0.9(0-1)	0	0.4(0-1)
Fever	1.1(1-2)	1.1(1-2)	0.5(0-1)	0.3(0-1)
Eye infection	1(1-1)	1(1-1)	1(1-1)	0.2(0-1)
Scabies	0	0	0	0

Respondents were asked if there were any deaths in the household over the previous year: 11% said that there were, 87% said that there were not and 2% did not respond. Of those that died, 67% were males and 33% were females with the males dying at an average age of 29.6 whilst for the women it was 53 years. The reported reasons for death are recorded in table 5.7, of which one is attributed to diarrhoeal disease.

Table 4.7 Reported causes of death per household in the previous year in the study population

Reason	Frequency
Aids	1
Asthma	1
Diarrhoea	1
Head/Stomach problem	1
High blood pressure	2
Malnutrition	1
Sharp pain	1
Shooting incident	1
TB	2

4.1.3 Health and the Water Environment prior to the introduction of water supply

The relationship between disease and water are dealt with under 6 headings

- Water source
- Water quality
- Water quantity
- Water management
- Water uses
- Sanitation

4.1.3.1 Water Source

Prior to the introduction of the Vulindlela Water Supply Scheme people were using different sources of water and were asked to rank the source of water that they used most often. It should be noted that in several instances there is reference to a tap (communal, garden, household) being the source of water. Through the 1970's and 80's the area was subject to several initiatives to upgrade the water supply through spring protection programs with initial reticulation to communal taps and households of untreated water. However, during years of drought the springs and boreholes dry up and the community is left without a water supply. In fact during the sampling process it was found that only 46% of the taps that required sampling were delivering water at the time. In some cases people had no idea where the water in the taps came from.

People in the different areas had to rank the source of water that they used most often, (Table 4.8). There was a marked area difference at Baseline; Likhobongwane had mainly taps in gardens, whilst Mthoqotho had communal taps and Shange had protected springs. All areas were using rain tanks and unprotected springs.

Table 4.8: % use of the different sources of water in the different areas

	Khobongwa	Mafakatini	Mthoqotho	Shange	Total
Tap in the garden (%)	88.0	24.0	12.0	0.00	31.0
Daily	88.0	24.0	12.0		31.3
Occasionally					0.0
Never	12.0	76.0	88.0	100	68.7
Communal tap (%)	0.00	0.00	80.0	32.0	28.2
Daily			75.0	8.3	20.4
Occasionally			4.2	25.0	7.1
Never	100	100	20.8	66.7	72.4
River (%)	12.0	0.0	0.0	0.0	3.0
Daily	8.0				2.0
Occasionally	4.0				1.0
Never	88.0	100	100	100	96.9
Rain tank (%)	60.0	72.0	76.0	92.0	75.0
Daily			4.2		1.0
Occasionally	60.0	72.0	70.8	92.0	73.7
Never	40.0	28.0	25.0	8.0	25.3
Unprotected spring (%)	28.0	76.0	68.0	76.0	62.0
Daily	12.5	72.0	4.0	66.7	38.8
Occasionally	16.7	4.0	64.0	12.5	24.5
Never	70.8	24.0	32.0	20.8	36.7
Protected spring (%)	12.0	4.0	16.0	48.0	20.0
Daily	4.0		4.0	29.2	9.1
Occasionally	8.0	4.0	12.0	20.8	11.1
Never	88.0	96.0	84.0	50.0	79.8

A Trend test (p-value) was used to establish if there was any relationship between water source and diarrhoeal disease and the results are indicated in table 4.9. It was noticed that there were few observations in some cases and this then reduces power of detecting if any trend existed. Most of the households were getting water from springs, either directly or via reticulation to taps in gardens. The baseline results failed to show any trend of diarrhoea with respect to water source at the 95% confidence level. However, the use of the communal tap *was significant* at the 90% level (P = 0.09), especially as compared to a tap in the garden, as hound in other studies. None had taps inside the house during the baseline survey.

Table 4.9 Relationship between frequency of collection of water source and diarrhoeal disease.

SOURCE OF WATER	USE RANK			Trend test p-value
	1	2	3	
	Daily	Occasionally	Never	
Tap inside house	0	0	99	Uncalculated
Tap in garden	31	0	68	p-value 0.56
Tap Communal	20	7	71	p-value 0.09
River	2	1	95	p-value 0.192
Rain tank	1	73	25	p-value 0.423
Unprotected spring	38	24	36	p-value 0.532
Protected spring	9	11	79	p-value 0.312
Bore-hole	0	0	98	Uncalculated
Dam	0	0	98	Uncalculated
Tanker	0	0	98	Uncalculated

4.1.3.2 Water Quality

Water samples were taken from both household containers at each household and where possible, the source of that water in the container. One limitation of the study is that the water in the household container being sampled, was drawn from the source being sampled some time earlier and as such, water quality in the container cannot strictly be said to have had a starting quality equivalent to the source being sampled. The water quality results of the surveyed sources and household containers are indicated in **Appendix 2.** Although both chemical and microbiological analyses are tabulated, data analysis concentrates on the microbiological results as little variation is seen in the chemical parameters and these are generally within drinking water guidelines (WRC 1998). The following Table 4.9 shows microbiological water quality determinants for the household at baseline. The data is shown for four different regions and the total is put as the last row.

Table 4.9 Mean water quality of household containers at Baseline (colonies/100ml)

Survey	Total Coliforms	*E. coli*	Faecal strep.
Mthoqotho	3169	612	13
Shange	1376	863	130
Khobongwane	21922	7703	Missing*
Mafakatini	614	186	261
All areas	6575	2246	142

*Analysis not performed owing to laboratory problem

It would appear that the two Khobongwane parameters are substantially higher than the other areas, however, the data could have been skewed by outliers. This data is compared through the Phases, as well as log-transformed, later in Section II.

Table 4.10 Comparison of microbiological parameters of in-house water quality and risk of diarrhoea at Baseline (Geometric Means)

Risk factor	Water quality levels	Odds Ratio	95% CI		P-value
Total coliforms	Unacceptable	1.167	0.368	3.697	0.793
	Poor	0.476	0.167	1.356	0.162
	Marginal/Good/Ideal	1			
E. coli	Unacceptable	0.789	0.132	4.738	0.796
	Poor	0.654	0.103	4.136	0.650
	Marginal	0.600	0.076	4.760	0.627
	Good/Ideal	1			
Faecal streps	Unacceptable	1.143	0.284	4.595	0.851
	Poor	1.071	0.256	4.490	0.925
	Marginal	3.429	0.645	18.217	0.139
	Good/Ideal	1			

Referring to Table 4.10, Odds Ratios are interpreted with reference to 1; if OR>1 then this implies an increased risk whilst OR<1 implies a reduced risk. The Confidence Interval (CI) indicates with 95% confidence possible values of the OR and if it includes 1 then there is no significance and if not then there is significance. In this case a continuous variable was broken down into categories and this meant that some power was lost. The p-values show that there were no significant differences between these categories and this means that there was not enough power (sample size) to show any difference if it existed.
However an OR>1 indicating an increased risk of diarrhoea is shown for the Unacceptable class of total coliforms and Unacceptable, Poor and Marginal classes of Faecal streptococci, although this is probably too slight to mean anything. *E. coli is* not indicated as a risk factor.

4.1.3.3 Water Quantity

The provision of an adequate supply of water has most influence on a group of diseases referred to as "water-washed" diseases. Lack of access to sufficient quantities of water supply restricts good hygiene practice, allowing diseases such as scabies, eye infections and skin infections to emerge (Feacham, 1984).
In a 1986 study on strategies to prevent diarrhoeal disease in developing countries, it was suggested that water quantity may have more impact on diarrhoea than water quality (Esrey and Habicht, 1986).

In Vulindlela, water is collected from springs and communal taps, which can result in queues and lengthy waiting periods. In addition, water from these sources can frequently dry up toward the middle of the day. It appears that, in order to allow everyone to access the water source within a reasonable time period and to receive an adequate quota of water, the community has developed a norm of collecting smaller qualities of water more frequently. On average one trip to collect water took about 24.88 (SD=33.2) minutes, and the water was collected 4 (SD=2.6) times a day. Most people collected 50 litres of water at a time whilst others 25 litres and sometimes more than 100 litres. In regard to the total volume of water collected per household per day, Vulindlela households collected between 200 and 400 liters per day, which on average relates to 50 liters per person per day.

Clearly too little water can place constraints on the amount of water available for good household and personal hygiene. Research shows that failure to use water for personal and domestic hygiene is associated with diarrhoeal disease (Maung et al, 1994). However, in the Vulindlela study, there appeared to be correlation between the quantity of water collected and diarrhoea only at the 94% level (p= 0,06), at Baseline. The study therefore explored several water use variables in considering risk factors associated with diarrhoea, as described below.

4.1.3.4 Water Uses

Water use in each area was explored to determine if any particular water use could be associated with diarrhoeal disease. Diarrhoea prevalence can be associated with the common water usage in the household. Table 4.11 shows the household frequency of common water usage and the scores given to each water usage.

Table 4.11 Relationship between water uses and diarrhoeal disease.

ACTIVITY	USE RANK			[4]Trend test
	1	2	3	(p-value)
	Daily	Occasionally	Never	
Washing hands	82	2	0	0.28 (0.63)
Drinking	84	0	0	Uncalculated
Preparing juices	13	65	6	0.46 (0.278)
Milk formulae for babies	10	1	73	**-2.82 (0.005)**
Washing nappies	22	6	52	**-3.55 (0.001)**
Stock watering	1	5	78	0.58 (0.752)
Bathing	82	1	1	0.73 (0.759)
Watering garden	4	3	77	0.99 (0.642)

There is a significant trend of a decrease in diarrhoea prevalence from those who used water daily to those who never use water to wash nappies, p-value=0.001. The prevalence of diarrhoea among those who use water daily to wash nappies can be due to dirty water disposal after washing the nappies, contaminating the household environment (or just having small children wearing nappies.) The same pattern is also seen among those who use water daily to prepare milk formulae for feeding babies and people may be using contaminated water to prepare the formulae. However those who have babies may be more prone to having diarrhoea in the household.

Among those who were using JIK to disinfect their water (Section 4.1.3.5 Water Management), there was a decreasing trend of diarrhoea if they used water daily to prepare milk (Trend= -2.72, p=0.046). This was also the case for those who were using water to wash nappies (Trend=-3.09, p=0.03). This suggests that water in this area needs to be cleaned especially by those who often use water to wash nappies or prepare formulae. Although this was worse for those who were not cleaning water at all compared to those using JIK, one cannot confidently rely on the use of JIK as a water-cleaning agent to prevent all causes of diarrhoea.. The most common storage of food was the pot and fridge and almost everyone used hot water for washing dishes. Fuel is considered a scarce resource in the area.

[4] The sign of a trend test indicate direction, e.g. -ve indicates a decrease in risk with increase in column level

There was no association and trend (Trend=0.58, p-value=0.75) between whether the cattle drink water on the property and diarrhoea cases. People mentioned that cattle do drink from their taps, water container and rainwater tanks, but no association could be tested since a large group said that this was not applicable to them. This might be the group that does not have cattle.

The most common uses of water, apart from drinking seem to be washing clothes, fishing and swimming. Out of those 37 that swim, 97.3% are male children and 2.3% female children.

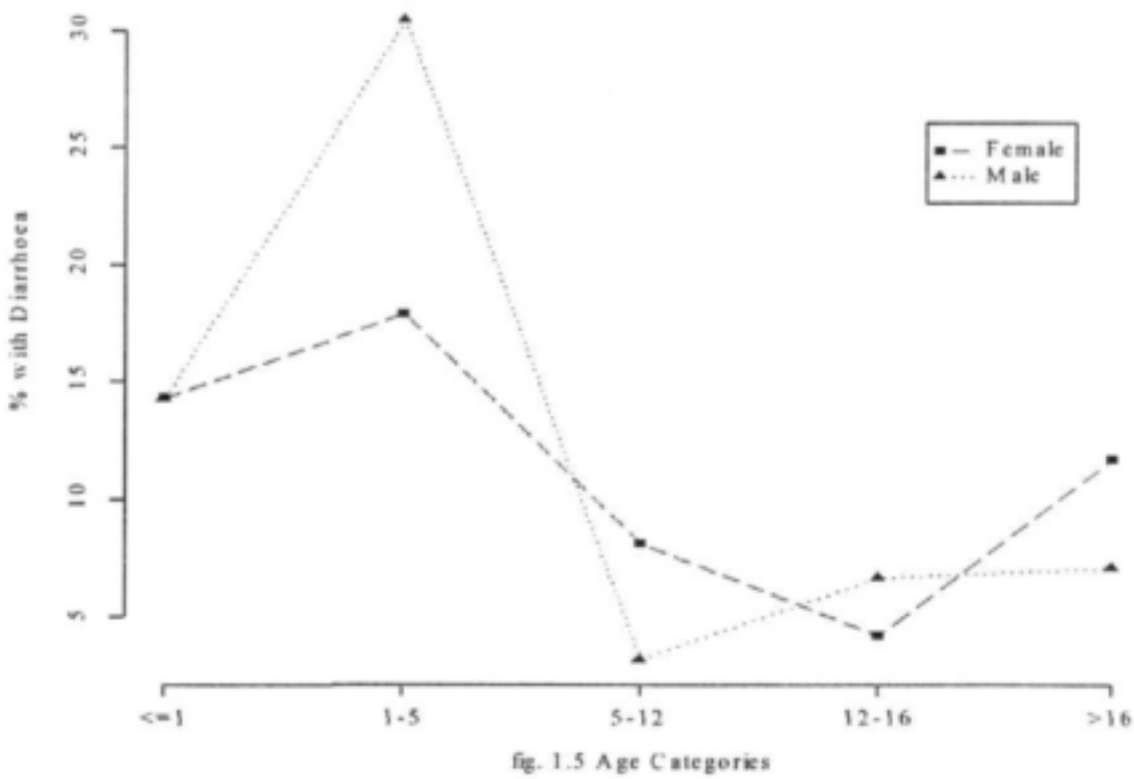


Fig 4.4 Children's prevalence of diarrhoea according to age

The figure above is the prevalence of diarrhoea from ages less than one year to age more than sixteen years for males and females separately. The figure shows that for ages less than five years, the prevalence is much higher for males than females. The fact that about 97.3% of young males are the ones most likely to swim might be contributing to this high prevalence in this group.

4.1.3.5 Water management

Ensuring that the rural and peri-urban family has a supply of water when needed is an arduous, time-consuming task carried out predominantly by women in the traditional household. Decisions about the management of this process need to be made daily. This study considered this process and these decisions as possible routes to diarrhoeal disease.

In most rural communities in KwaZulu-Natal, water is collected from a stream, communal tap, spring or borehole, and it is then carried and stored at the home to ensure that water is available when needed.

Stored water can become contaminated, resulting in diarrhoea. Collection and storage vessels can be made of plastic, pottery, metal or any number of compounds. The study explored this issue to see firstly which type of vessel is used and secondly whether the compound of the vessel itself poses a risk factor toward causing diarrhoea.
Everybody was using plastic containers to collect water. Water was also stored in the plastic container by everybody except one person who stored water in a metal container. Some people had a designated cup and many used just any cup to remove water from the storage container. About 80% of the people clean the inside of their containers on a weekly bases, 18% daily and only 2% said they clean their containers once a month.

There was a significant decreasing trend of diarrhoea among those who were not disinfecting water at all, and those who were using JIK, including those households who were using water to prepare milk formulae and wash nappies. Table 4.12 shows the cases of diarrhoea with respect to the method of water purification for drinking.

35% of those who were not disinfecting water at all had diarrhoea. The prevalence decreases from 3% to 1% from those that were using JIK, to those using tablets. There is a significantly strong association between diarrhoea and the method of water purification used, Fisher Exact test p-value=0.01 < significance level=0.05.

Table 4.12: Relationship between diarrhoea and household water purification

DIARRHOEA	METHOD OF PURIFICATION Number (% of total)				TOTAL
	None	Jik	Boil	Tablets	
Yes	**34** **(35)**	**3** **(3)**	**2** **(2)**	**1** **(1)**	40 (41)
No	**40** **(41)**	**17** **(17)**	**1** **(1)**	**0** **(0)**	58 (59)
TOTAL	74 (75)	20 (20)	3 (3)	1 (1)	98 (100)

4.1.3.6 Sanitation

In the survey people were asked questions relating to general sanitation. All the households have toilets on the property, although in some cases they share it with other households. Nearly all the households had situated their pit latrines an average of 22 meters down slope of their own dwelling, an indication that there was an understanding of the health hazards associated with a toilet located upslope of the house. Other places where people relieved themselves except in the toilet were the yard of dwelling (91.7%) and near the bush (8.3%), of 24 people who responded yes to the question. Apparently most young children (less than 2 years of age) go without nappies hence elders do not know where their children dispose their faeces. Although 55.6% of 54 people who responded say that their children faeces is disposed in the toilet, 38.9% do not know because their children go without nappies, 3.7% said their children use a pit and 1.9% said that they use other means. About 17.9% of the people said that their toilets do overflow during the times of rain. There was no association between the overflow of the toilet and the diarrhoea prevalence, (OR=2.4, p-value=0.10), which is surprising

Most households have no specific place where they dispose their refuse, whilst a quarter of the households have their own pit. Many people mentioned that they have problems of rats, mosquitoes, dumping rubbish, etc. This could be linked to some of the other diseases that are prevalent in this area.

4.1.3.7 Summary of association between diarrhoea and potential risk factors in Vulindlela

The baseline survey in Vulindlela allowed some of these potential risk factors to be explored and the results of the probability analysis and relative significance of the 55 exposure variables explored are shown in Table 4.13. The study identified that the following risk factors were considered significant:

P <0.05 and significant at the 95% level:

- *Number of people in a house, age, non-designated scoop for water, not disinfecting* water, washing nappies, shortage of food, cooking using water.

P <0.1 and significant at the 90% level:

- *Volume of water collected and presence of rats.*

The designation >0.05* means that all categories were not significant at the 95% level.

Table 4.13 Summary of association between diarrhoea and potential risk factors

Variables identified through questionnaire survey	P value	Significance	
		<0.05	<0-1
Crowdedness Index	0.32		
Number of people living in any single house	0.003	X	
Age of person	0.004	X	
Gender	Both >0.05*		
Identification that AIDS is a problem for their community	0.82		
Identification that Bilharzia is a problem for their community	0.22		
Visiting traditional healers	0.22		
WATER SOURCES			
Water source as tap in garden	0.96		
Water source as communal tap	0.13		
Water source as river	0.15		
Water source as unprotected spring	0.88		
Water source as protected spring	0.64		
Water source as rain tank	0.42		
WATER MANAGEMENT			
The length of time taken to fetch water	0.75		
The times/day water collection takes place	0.10		
The volume of water collected	0.06		X
The use of plastic containers for water storage	0.22		
Using the same container to collect and store water	0.28		
Using any cup to scoop water from storage container	0.02	X	
Never cleaning water storage containers	0.43		
Failure to use of some method to disinfect stored water	0.035	X	
SANITATION			
Communal use of latrine	0.30		
Overflowing toilets	0.10		
Method of handling babies feces	0.49		
Dumped rubbish	0.63		
Methods of waste disposal	0.79		
Waste water	0.22		
Animal waste	0.85		
WATER USE/ ACTIVITY			
Swimming in the river	0.39		
Cattle drinking on the property	0.75		
Washing hands as a water use activity	0.78		
Washing nappies as a water use activity	0.001	X	
Washing clothes as a water use activity	0.24		
Bathing as a water use activity	0.34		
FOOD RELATED ACTIVITY			
Shortage of food	0.03	X	
Presence of fridge for storing food	0.81		
Types of energy used for cooking	All > 0.05*		
Use of hot water for washing dishes	0.41		
Bottle feeding of infants	0.50		
Cooking as a water use activity	0.009	X	
ANIMAL VECTOR RELATED VARIABLES			
Rats	0.05		X
Mosquitoes	0.17		
Ants	0.28		
Flies — All houses reported flies being a problem therefore there are no comparative analyses			
Cockroaches	0.71		

4.2 SECTION II: Evaluating the introduction of water

The questionnaire surveys were carried out and corresponded where possible to the phased introduction of water supply to the four different areas as shown in Tables 4.14 and 4.15. Two summers seasons, which are usually hot and wet in KwaZulu-Natal and a winter, normally dryer and cooler are covered during the sampling period and are of importance in the potential influence of climate on cycles of water quality and diarrhoea. This section deals with the results of the questionnaire surveys, both descriptive statistics and simple analysis of variation and correlations etc.

Table 4.14 Phased introduction of water supply

Survey	1	2	3	4	5
Phase of supply	Baseline	1	2	3	4
Date	Jan 1999	April/May 1999	July 1999	Nov/Dec1999	Feb/Mar 2000

4.2.1 Changes in water source over time

Table 4.15 Number of households receiving the new Umgeni Water supply

Site/area	Phase 1	Phase 2	Phase 3	Phase 4
Mthoqotho	8 (32%)	18 (72%)	24 (96%)	25 (100%)
Khobogwane	Before UW 0	22 (88%)	25 (100%)	25 (100%)
Shange	Before UW 0	Before UW 0	10 (40%)	25 (100%)
Mafakatini	Before UW 0	Before UW 6 (24%)	Before UW 12 (48%)	13 (52%)

Table 4.15 shows the number of households that responded as getting water from the new Umgeni Water tap at each phase in each area. In phase 4 (the final phase of the study) 100 households were supposed to be getting their water from Umgeni taps, but only about 88% actually said they were getting their water from these new taps. There could be several reasons for this:

- The habit of a household fetching water from a spring takes time to change
- The visit to the water collection point provides more services to that household such as communication with neighbours/ meetings etc.
- The households are still wary of having to pay for water from the new source and therefore as long as a reliable source is available from the spring, that source is used
- The connection point for the household is not always close to the house and in several instances was further than the spring supply (some households indicated that they could not afford the connection line)
- 1% said that they did not have Umgeni water at the time of sampling and this may have been owing to mains supply problems.

Although reticulation lines from the connection meter on the boundary of the property to the household garden were supplied as part of the scheme in some households, this was not always the case, still causing water to be carried and stored.

It became clear during the study, however that the pattern of the introduction of water was not always 100% consistent with the design. Some of the households received water before they were meant to whilst some received water later than the required time according to the stepped-wedge design of the study. Therefore this could explain some of the anomalies found with the water quality.

4.2.2 Changes in water quantity used over time

The volume of water collected in the household can be used as a hygiene indicator. The following table shows the average amount of water that is collected in each household in each region throughout all the surveys before and after the introduction of Umgeni water.

Table 4.16: Average number of litres collected from the water source per day in the household. (Standard Deviation)

(**Bold** type indicates when each area received Umgeni water)

Area	Baseline	Phase1	Phase 2	Phase 3	Phase 4
Mthoqotho	138 (65)	**130** **(78.0)**	**107** **(47.5)**	**99** **(5.4)**	**70** **(42.9)**
Khobongwane	287 (156)	170 (193.0)	**109** **(80.7)**	**133** **(153.9)**	**52** **(52.0)**
Shange	176 (76.9)	182 (97.5)	179 (96.2)	**131** **(79.0)**	**83** **(65.1)**
Mafakatini	206 (136.2)	150 (104.6)	165 (112.2)	125 (89.9)	**93** **(76.6)**
P-value	**0.0001**	0.512	**0.005**	0.623	0.114

It is rather difficult to precisely estimate the volume of water collected and used. However the closest possible estimate was made by multiplying the estimated amount of water said to be collected at one trip by the number of times water was reported to be collected each day. It is acknowledged that if the distance between the household and the water source is reduced, the volume of water collected is likely to go down and make it even more difficult to better estimate the amount of water used.

Most of the people seemed to collect water daily. There appears to be a decrease in the amount of water people collected and stored as they received an Umgeni Water connection, from an average of 202L down to 75L, a reduction of 63%. This could in itself affect the quality of the water stored and therefore health. The P-values show significant differences between areas at Baseline (when different local sources are in use) and Survey 3 (when 2 areas have/do not have Umgeni water). The Figure 4.5 below confirms the decreasing trend, which slowly coincides with the introduction of Umgeni water. However, the volumes appear to be very low and maybe these do not include activities that could take place at the garden tap like washing clothes and vegetables etc.

The Vulindlela Water Supply Scheme is designed to deliver 50 litres per person per day. The scheme when fully utilized will therefore not necessarily improve the supply in terms of volume per capita, but should improve the convenience of obtaining water. In fact other similar schemes have noted a consumption of well under 25 litres per person per day, when the supply is metered and presumably paid for. It is likely that the old local sources are still used if close by, in order to economise.

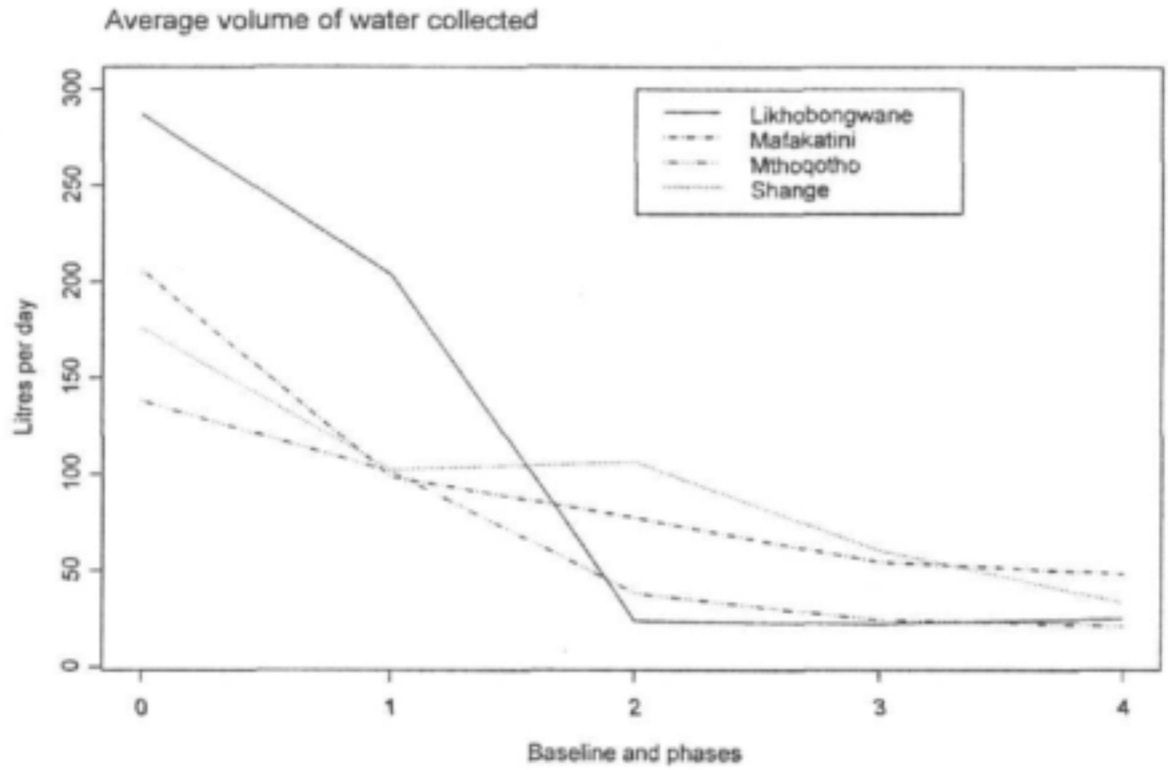


Fig. 4.5 Average volume of water collected through the phases of water supply

About 30% of the people responded that they would still use their old water sources even if they have received Umgeni water.

4.2.3 Changes in water quality over time

This section describes the change in the water quality after the introduction of the Umgeni water system, as described in Section 3. This system comprises a large modern tertiary treatment plant using chlorination for disinfection, situated at a distance of some 25km and fed through a network of mains and service reservoirs.

Three microbiological and seventeen chemical parameters were measured routinely from samples taken from the source. Only the microbiological parameters were analysed from the household container samples, as described in Section 3. The complete results of the microbiological and chemical analysis, along with the source of the water and occurrence of diarrhoea in the household, are listed in **Appendix 2.** The chemical parameters hardly varied at all, however and were generally all within drinking water guidelines (WRC 1998) as shown on each sheet. Turbidity, however was often between 1 and 5 and sometimes >20NTU, when secondary health effects could be expected owing to association with microbiological contamination. In some instances, however when the turbidity was 64 NTU, the iron and manganese were also high and the microbiological contamination was not excessive, indicating that the contamination was probably not organic. The chemical data was not analysed any further.

Samples taken for analysis for the pathogens; *Vibrio cholerae (cholera), Salmonellae, Giardia and Cryptosporidium*, when the household reported diarrhoea, were all negative. These were not included in the Appendix 2, to save space.

Table 4.17 shows the average level of three microbiological measurements taken in the household container at each phase for each area The sequence in the table is the order in which the areas received the new water supply. The bold print shows the values that were obtained when the source of water in the storage container was that supplied by the Vulindlela Water Supply Scheme (Umgeni water).

Table 4.17 Mean counts in household containers at each phase for each area (Bold face indicates when each area received Umgeni water)

	Total Coliforms/100ml				*E. coli/100ml*				*Faecal strep/100ml*			
Phase	1	2	3	4	1	2	3	4	1	2	3	4
Survey	2	3	4	5	2	3	4	5	2	3	4	5
Mthoqotho	**2642**	**95**	**5054**	**1875**	**376**	**7**	**1572**	**1253**	**30**	**9**	**35**	**15**
Khobong	125026	**3767**	**3371**	**280**	22957	**11**	**1211**	**186**	98	**12**	**41**	**55**
Shange	6139	160	**6390**	**495**	6139	36	**1247**	**83**	207	93	**71**	**60**
Mafakatini	1393	76	12484	**122141**	34	18	59	**9314**	32	117	50	**178**
P-values	0.32	0.11	0.68	0.34	0.13	**0.006**	0.65	0.08	**0.02**	0.2	0.3	**0.003**

The p-values that are reported at the bottom row are the analysis of variance (ANOVA) p-values comparing if the mean levels of each measurement among the areas are significantly different (**<0.05** level or close). There appears to be much variation in these data with no consistent improvement in the microbiological indicators of water quality in the household containers over time after the introduction of a new water supply. However, the above initial analysis are untransformed data using means, which are easily skewed and mask any trends.

The microbiological values were also classified into categories of quality as broadly outlined in the WRC/DWAF Assessment Guide (WRC 1998), as follows (Table 4.18). Values for *E. coli* and faecal streptococci were taken as being equivalent to those for faecal coliforms in the guide, for simplicity.

Table 4.18 Classification of categories of quality

(WRC/DWAF Assessment Guide 1998)

	Total coliforms	**E. coli/Faecal strep**
Ideal	=0	=0
Good	0< - <=10	0< - <=1
Marginal	10< - <=100	1< - <=10
Poor	100< - <=1000	10< - <=100
Unacceptable	>1000	>100

Tables 4.19-4.21 of water quality descriptive statistics were compiled in preparation for log transformation. The *Before* column was derived from the Baseline data, when none of the areas had received water supply and the *After* column from Phase 4, when all the areas had received the supply.

The Arithmetic means are generally much greater than the medians or geometric means, showing that occasional high values skew the data set. The *in-house* coliforms median level is an order of magnitude than the *source* quality, before the water supply was introduced. Although there is some improvement in the in-house containers water quality after the supply, it is still the same order of magnitude, whereas the source improves to almost zero. The upper quartile from the containers however shows little improvement after the supply, showing that the worst cases of contamination in the household remain the same.

The same trends are followed by the *E. coli* levels except that the sources are generally very low and the containers some two orders of magnitude higher. After water supply the levels in the containers drop to a half, although the maximums are similar. With the Faecal streptococci, the values are generally much lowered overall and only slightly higher in the containers than the source and fairly similar both before and after the supply. The overriding factor may not therefore be the *quality* of the source water, but how it is *stored*.

The percentage of households having the water quality of that specific classification are represented graphically below in Figs 4.6-4.8.The comparisons were made for the *household before UW*, *household after UW*, *source before UW* and *source after UW*.

- There was little improvement in the coliform class at the household after introducing Umgeni water with most Unacceptable and Poor, although some were Good. The sources class before was mostly Poor and Marginal but Umgeni water as a source was of ideal quality.
- The *E. coli* class in the household containers was mostly Unacceptable and Poor both before and after receiving water although the Ideal category improved from 6% to 20%. The sources before and after were both mostly Ideal.
- The faecal streptococci for the household quality were fairly evenly spread between the classes and were similar before and after the water supply. The sources were mostly ideal quality both before and after.

The pattern of improvement of water at the source was evident in all three microbiological agents discussed. However, the water quality deteriorated at the household level and hardly improved when the Ideal class of source tap water was introduced.

Table 4.19 Summary statistics: Total Coliforms - comparing In-house and Source at Baseline (Before) and Phase 4 (After) new water supply

	Before In-house	Before Source	After In-house	After Source
Sample size	96	94	87	97
Arithmetic mean	6 575	663	2 839	20
Median	550	71	166	0
Geometric mean	428	77	156	3
Minimum	0	0	0	0
Maximum	280 000	2 100	92 000	720
Lower quartile	89	18	32	0
Upper quartile	1 330	310	1 000	6
95th percentile	17 000	2 400	15 000	112
% = Unacceptable	42.7	10.6	33.7	None
% = Poor	21.9	34.0	22.1	5.2
% = Marginal	3.1	40.4	14.0	17.5
% = Good	31.3	8.5	24.4	13.4
% = Ideal	1.0	6.4	5.8	63.9

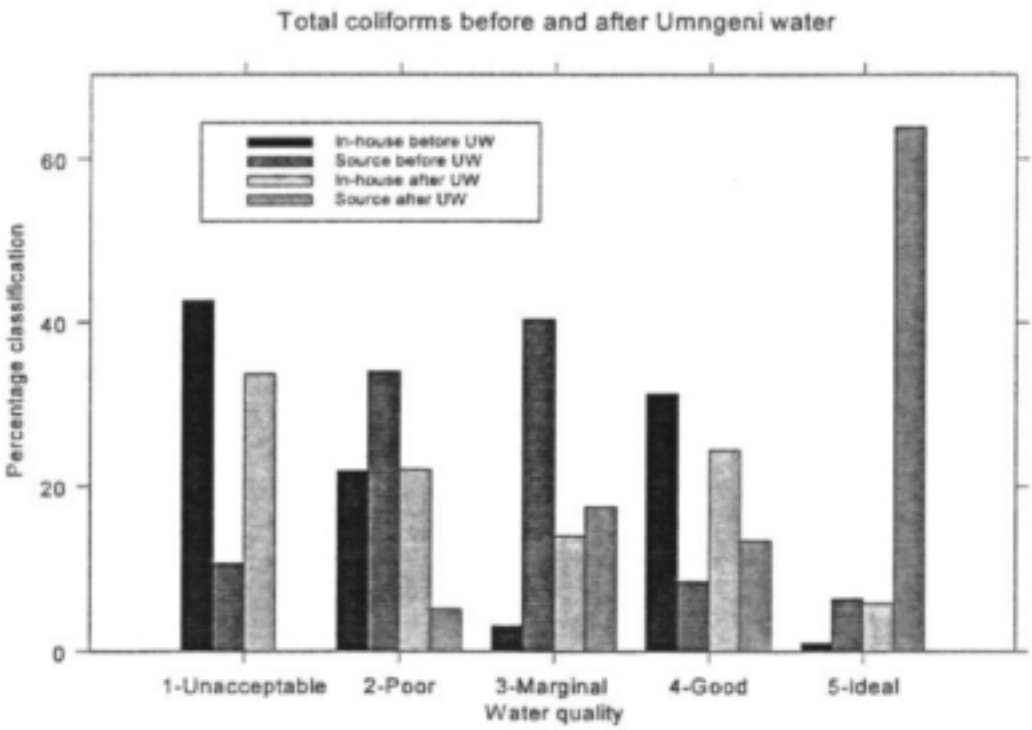


Fig 4.6 % Coliforms classes before and after Umgeni Water

Table 4.20 Summary statistics: E. coli - comparing In-house and Source at Baseline (Before) and Phase 4 (After) new water supply

	Before In-house	Before Source	After In-house	After Source
Sample size	97	94	86	97
Arithmetic mean	2 246	118	1706	7
Median	104	7	66	0
Geometric mean	110	2	46	2
Minimum	0	0	0	0
Maximum	124 000	1480	92 000	98
Lower quartile	20	2	6	0
Upper quartile	770	72	218	0
95^{th} percentile	4 200	700	2 420	54
% = Unacceptable	50.5		41.9	
% = Poor	32.0	13.4	26.7	13.4
% = Marginal	11.3	8.2	11.6	8.2
% = Good				
% = Ideal	6.2	78.4	19.8	78.4

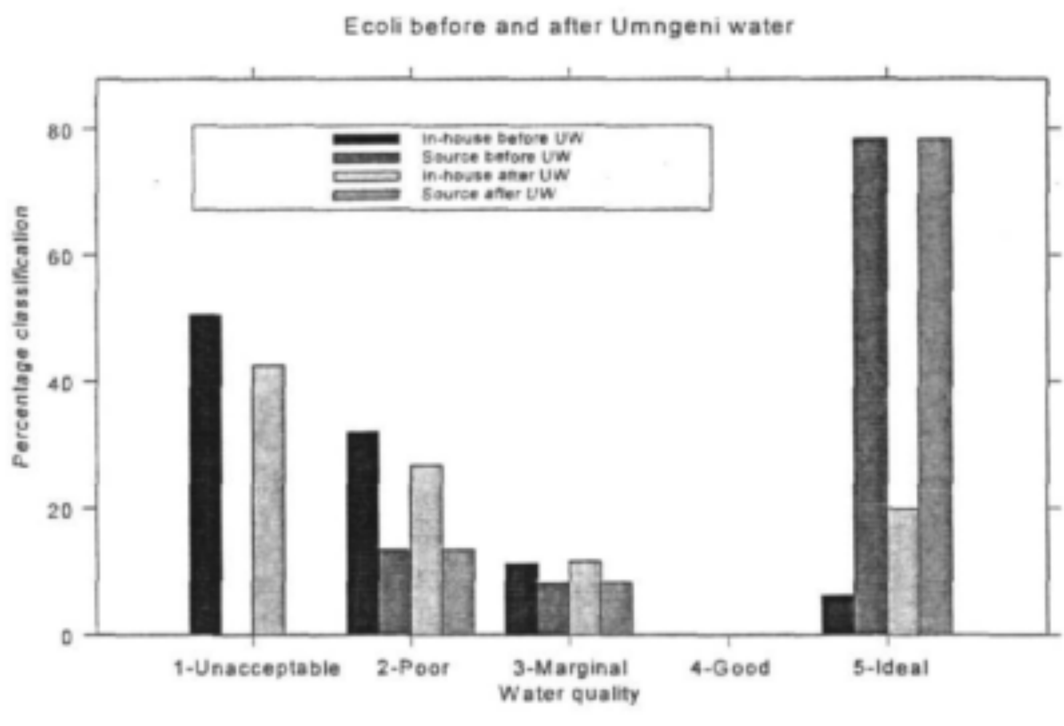


Fig 4.7 % E.coli classes before and after Umgeni Water

Table 4.21 Summary statistics: Faecal streptococci - comparing In-house and Source at Baseline (Before) and Phase 4 (After) new water supply

	Before In-house	Before Source	After In-house	After Source
Sample size	67	76	87	97
Arithmetic mean	142	97	77	19
Median	16	12	10	0
Geometric mean	20	3	15	2
Minimum	0	0	0	0
Maximum	2480	1000	960	100
Lower quartile	2	0	2	0
Upper quartile	124	72	106	2
95^{th} percentile	370	1 000	266	66
% = Unacceptable	31.3	3.1	25.3	3.1
% = Poor	26.9	13.4	24.1	13.4
% = Marginal	22.4	9.3	31.0	9.3
% = Good			1.1	
% = Ideal	19.4	74.2	18.4	74.2

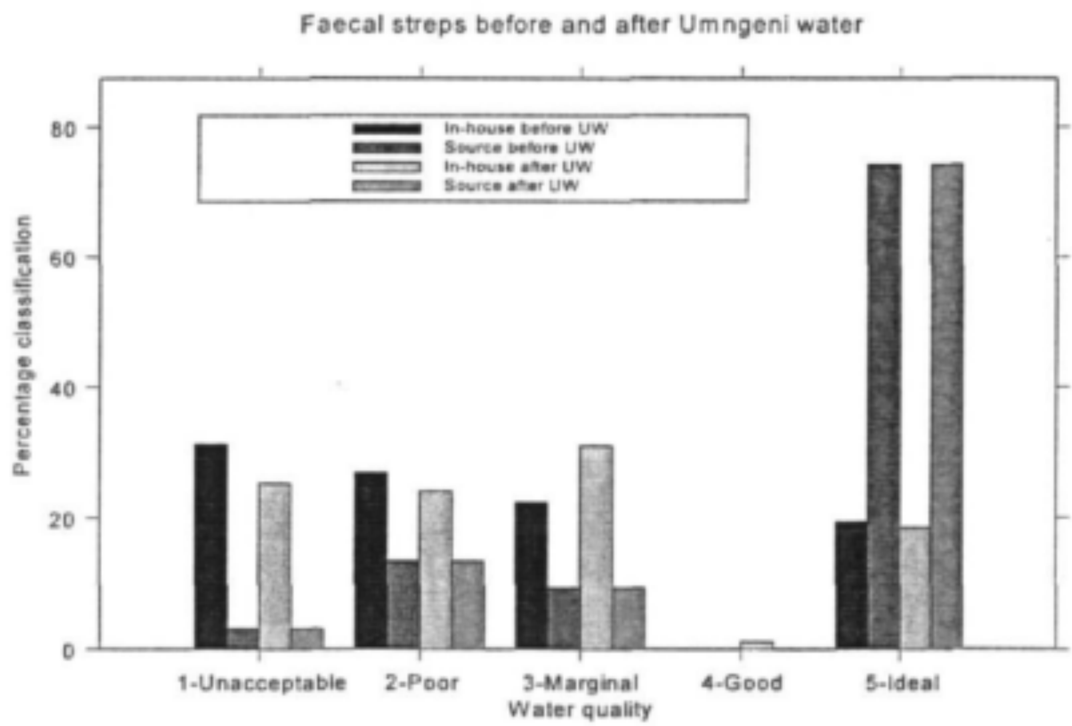


Fig 4.8 % Faecal streptococci classes before and after Umgeni Water

Table 4.22 below compares the water quality in the house with the tap or source before and after UW. Most categories showed significant differences apart from the faecal streptococci in-house before and after the introduction of UW and in-house container vs. the source before Umgeni water.

Table 4.22 Comparison of bacteriological parameters for significance before and after Umgeni water supply (Comparison on Log_e bacteria counts + 1)

	Before In-house vs source	**After In-house vs Umgeni Tap**	**In-house Before vs After**	**Source Before vs After**
Tot. coliforms	t-test = 5.51 p = **0.0001**	t-test = 11.79 p = **0.0001**	t-test = 2.36 p = **0.02**	t-test = 11.80 p = **0.0000**
E. coli	t-test = 5.65 p = **0.0000**	t-test = 9.84 p = **0.0001**	t-test = 2.01 p = **0.04**	t-test = 8.4 p = **0.0000**
Faecal streps	t-test = 1.18 p = 0.239	t-test = 7.16 p = **0.0001**	t-test = 0.70 p = 0.49	t-test = 6.10 p = **0.0000**

Significant difference in **bold**

- After the introduction of UW, the in-house water quality was still statistically significantly different from the water source (UW tap), for all the microbiological agents (p-value less than the 0.05 classical significance level), with in-house waters being more contaminated.
- The traditional sources and the UW tap quality were also statistically significantly different, as expected.
- Comparing the water in the house before and after the introduction of UW, there was also a statistically significant difference between the Total Coliforms and the *E. coli*, but not the faecal streps.

With the ***stepped-wedge design*** used in this study, it is important to look at the change in the water quality as more households receive the new water system. The following graphs in Figures 4.9 to 4.11 compare the water quality at the Household (left bars) and at the source (right bars) from Baseline up to Phase four. The ranges are the 95% Confidence Interval (CI) (within which 95% of the data would be expected to lie) and the mean data is on a log *e* (natural) scale, thus the CI may take negative values. Even at Phase 4 the means of the source microbiological parameters are not at zero. Although the majority of households would have received Umgeni water a few would still be using spring water etc., especially Mafakatini, of which only 52% received UW water, during the course of this study.

The 95% Confidence interval (CI) ranges overlap one another owing to the large spread of the data. This therefore indicates no significant difference between in-house and source quality throughout the study period, at this level. However, trends are apparent as the means generally become further apart through the Phases 1-4, as would be expected with the widening difference between in-house and source water quality.

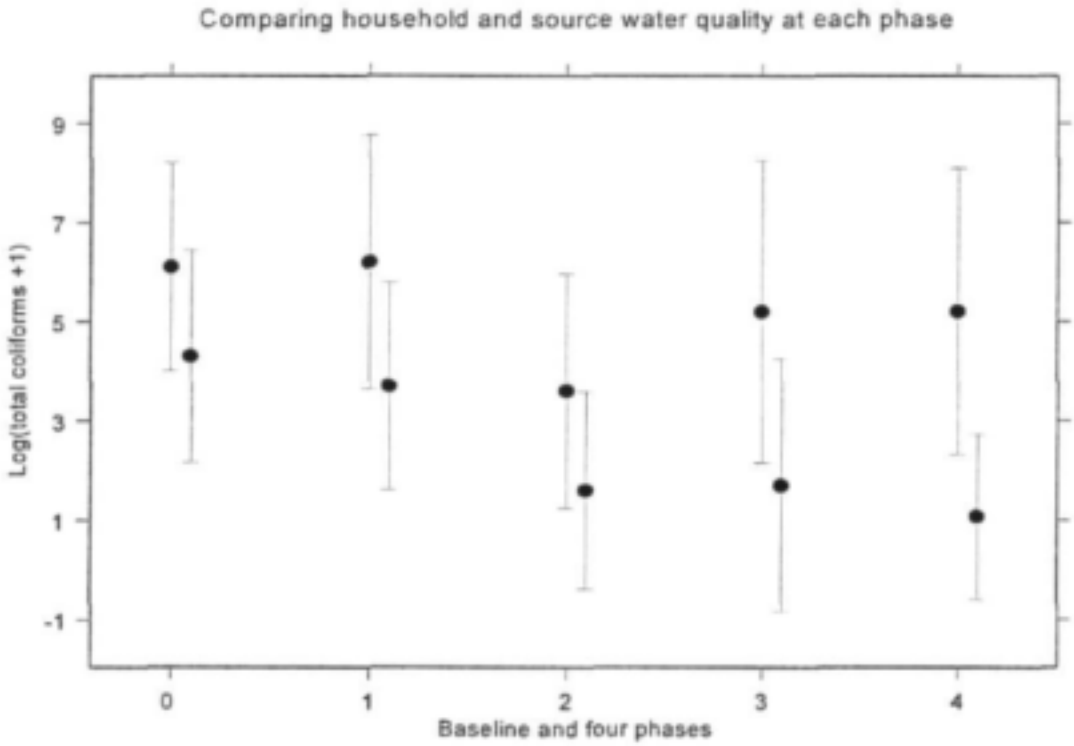


Fig 4.9 Log$_e$ Mean Coliforms at Household (left bars) and at source (right bars)

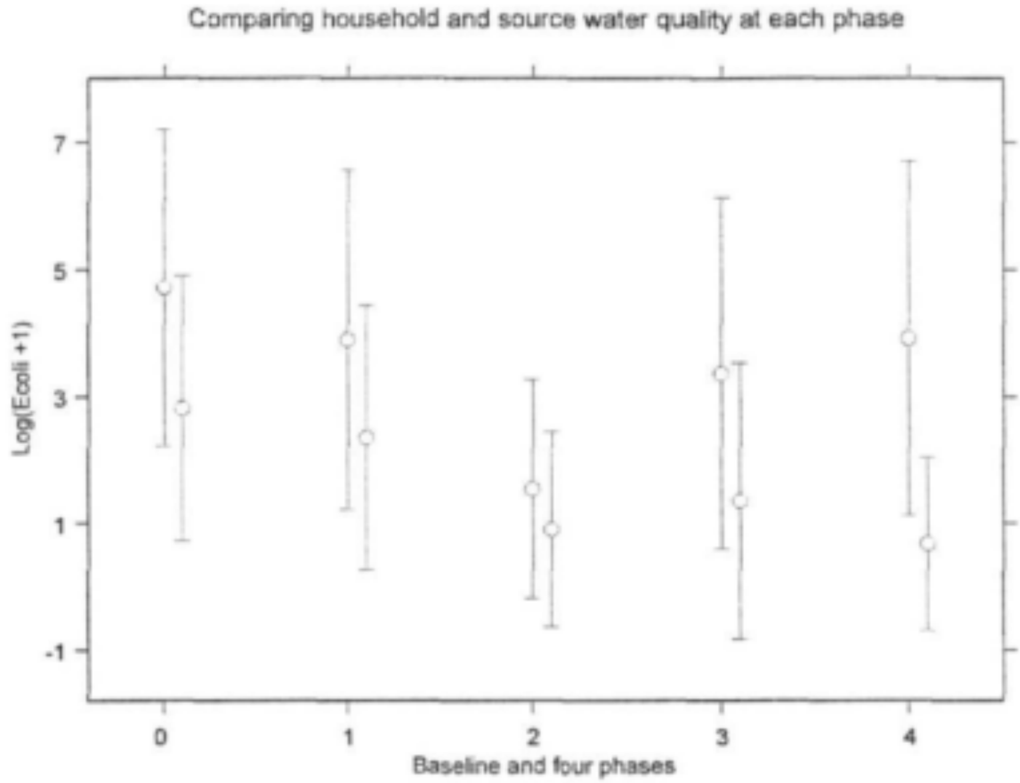


Fig 4.10 Log$_e$ Mean E. coli at Household (left bars) and at source (right bars)

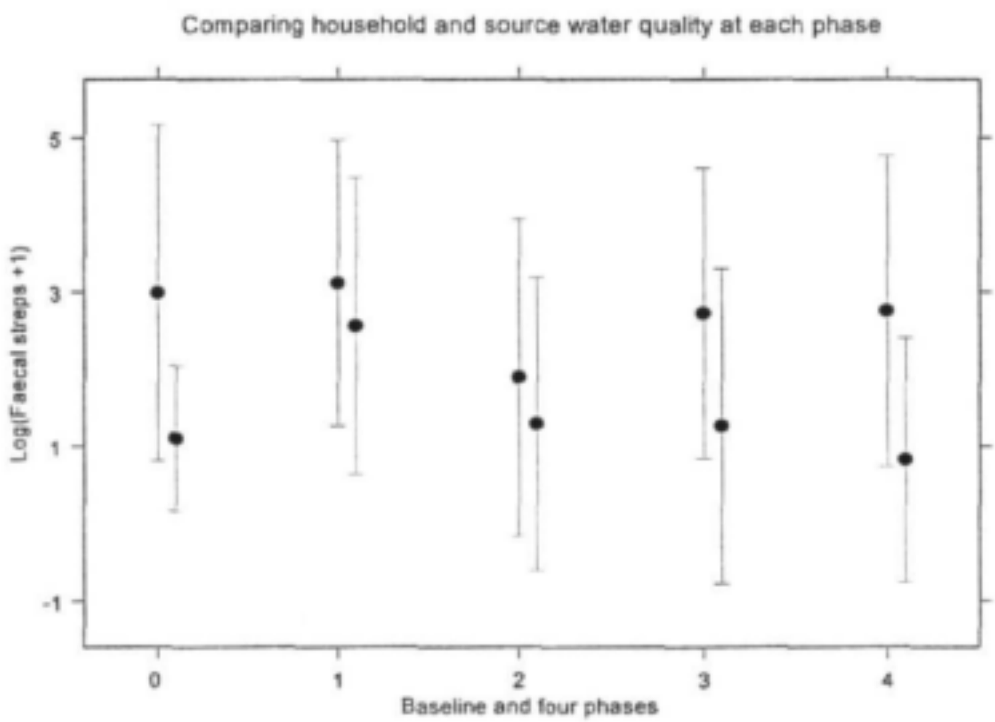


Fig 4.11 Log$_e$ Faecal strep. at Household (left bars) and at source (right bars)

There is clear evidence from the above figures that the source regardless of whether it is UW or not, is always cleaner than the water in the household container and that water becomes contaminated in the household containers irrespective of the source. The quality of the sources gradually improve as UW is introduced. However the quality in the household containers appears to improve dramatically in Phase 2 and then declines again in Phases 3 and 4, to arrive eventually at only a slightly lower level. This would seem to be a seasonal effect as discussed later. This means introducing UW decreases the amount of contamination at the source, but has little effect at the household.

The four different areas received UW in the following sequence; *Mthoqotho, Khobongwane, Shange* and *Mafakatini.* The following graphs Figs 4.12 to 4.14 show the change in the water quality in-house and at the source over the period of the sequence of the introduction of the new water system and each line refers to a different area. The left panel is the water quality at the house whilst the right panel refers to the water quality at the source at each phase. These graphs show much more information, when the data is split into areas as total means, medians etc tend to "average" the data. These show that the different areas in both the source and household have different levels of contamination at Baseline; from highest to lowest: Shange, Likhobongwane, Mthoqotho, Mafakatini. The same pattern is shown by all three sets of graphs for the three parameters. All show an apparent marked decrease at phase 2 followed by a sharp increase again for the household and a lesser one for the sources. This is probably a seasonal effect as this corresponds to the dry, colder mid-winter month of July (see Table 4.12). It is well known that bacteriological parameters (and waterborne diseases) exhibit lower levels during this season.

The Sources graphs show Mthoqotho and Likhobongwane, which received their water first decreasing sharply first, followed by, Shange and Mafakatini which received their water later. The in-house quality graphs follow the same pattern, but then rise sharply again, as explained above, as summer approaches (Phase 3 November/December and Phase 4 February/March). Shange and Likhobongwane, which showed the highest contamination at Baseline, show the biggest reduction, Mthoqotho remains similar and Mafakatini actually increases contamination by Phase 4, (although we know that this area only received 52% connection.)

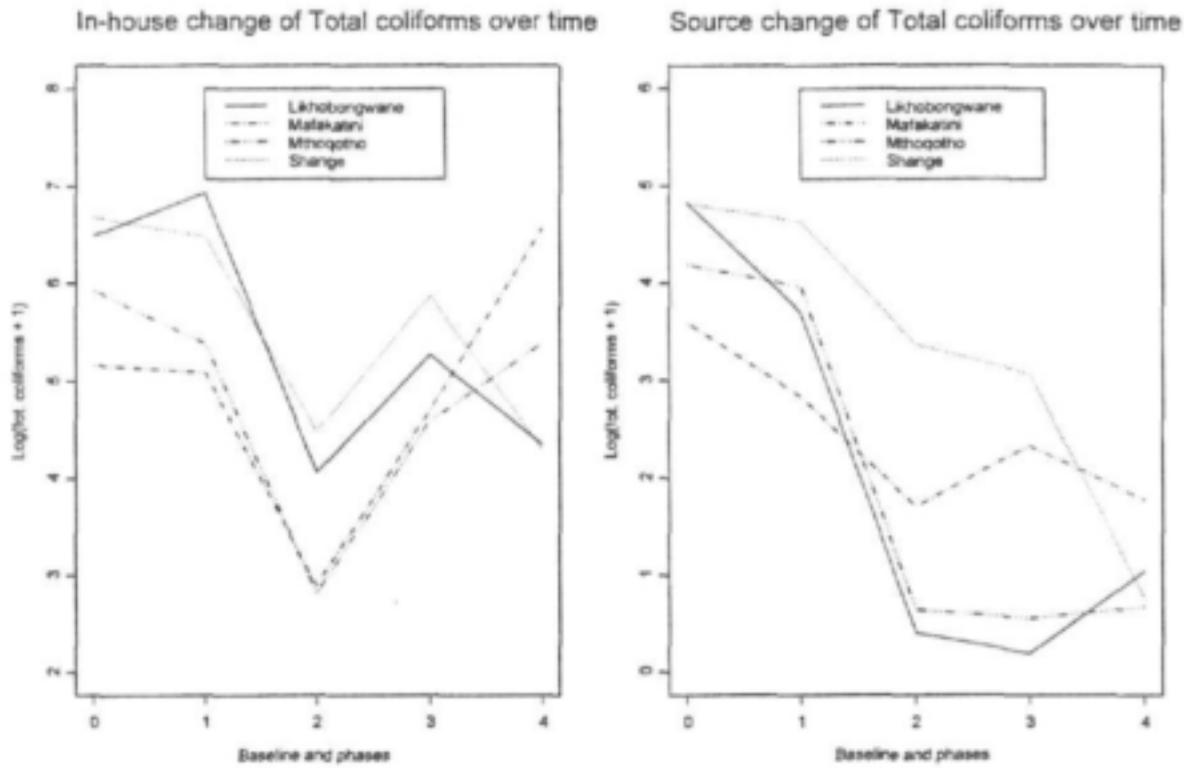


Fig 4.12 Change in Log_e coliforms in-house and at the source by water Phase in each area

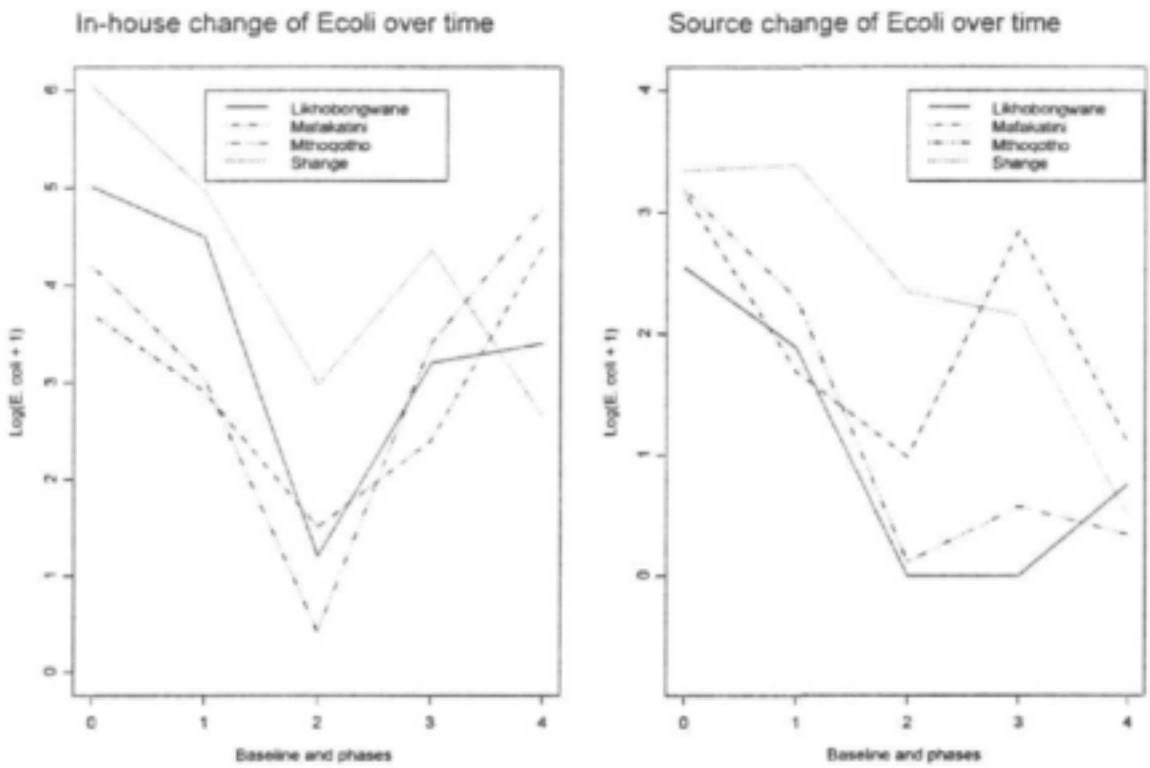


Fig 4.13 Change in Log_e E. coli in-house and at the source by water Phase in each area

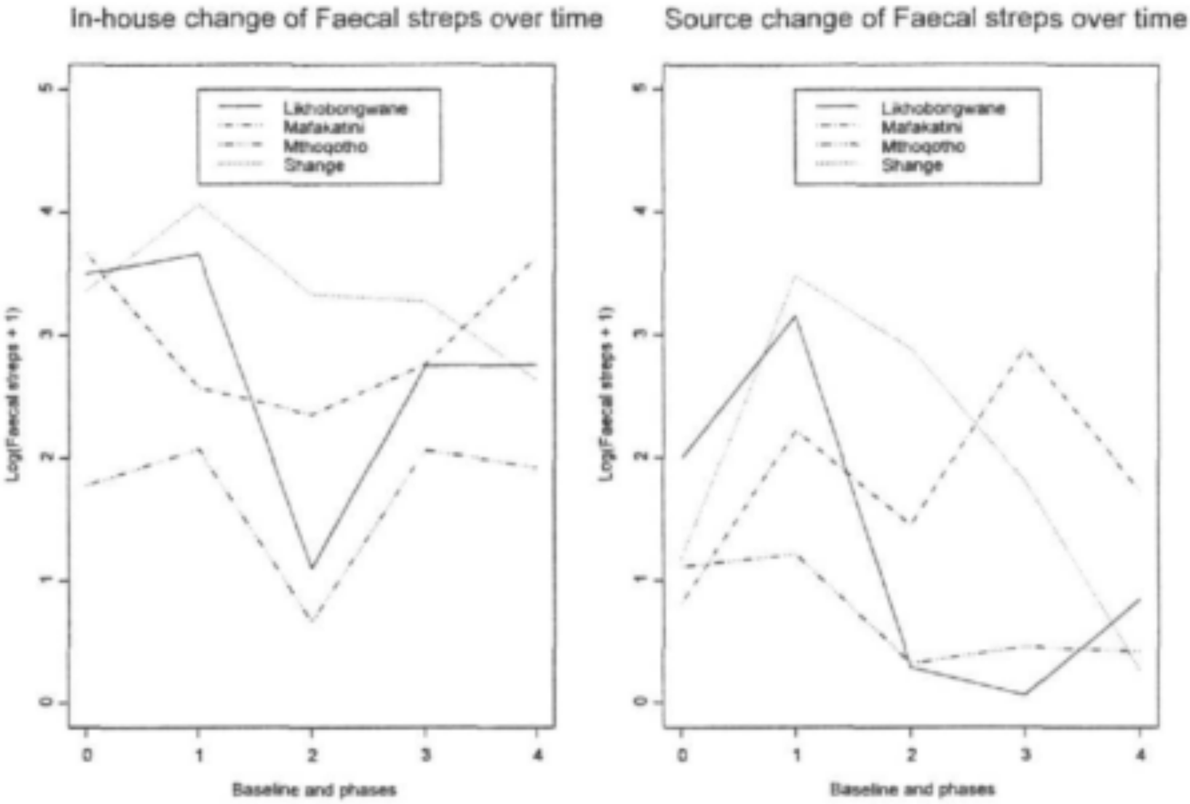


Fig 4.14 Change in Log_e Faecal streptococci in-house and at the source by water introduction Phase in each area

Table 4.23 shows an ANOVA F-test and p-values comparing water quality between the four areas at each Phase separately, for the household containers (HC) and source and microbiological parameters. Also whether the tests reached statistical significance for differences between the study areas ($P<0.05$; the F values can also be compared with statistical tables for significance if necessary.)

Table 4.23 Analysis Of Variance (ANOVA) comparing water quality between the four areas at each Phase separately.

	Baseline		Phase 1		Phase 2		Phase 3		Phase 4	
	HC	Source	HC	Source	HC	Source	HC	Source	HC	Source
Total colifms	F=2.51 P=0.06 No sig.	F=0.14 P=0.82 No sig.	F=1.76 P=0.16 No sig.	F=3.39 P=0.02 Sig.	F=3.05 P=0.03 Sig.	F=15.6 P=0.00 Sig.	F=0.74 P=0.53 No sig.	F=13.8 P=0.00 Sig.	F=3.18 P=0.03 Sig.	F=2.3 P=0.08 No Sig.
E. coli	F=4.80 P=0.01 Sig.	F=1.74 P=0.16 No sig.	F=4.01 P=0.01 Sig.	F=4.12 P=0.01 Sig.	F=12.6 P=0.00 Sig.	F=18.0 P=0.00 Sig.	F=1.99 P=0.12 No sig.	F=11.8 P=0.00 Sig.	F=2.86 P=0.04 Sig.	F=1.42 P=0.24 No sig.
Faecal streps	F=5.01 P=0.01 Sig.	F=3.26 P=0.03 Sig.	F=7.10 P=0.00 Sig.	F=7.67 P=0.00 Sig.	F=11.1 P=0.00 Sig.	F=13.7 P=0.00 Sig.	F=1.62 P=0.19 No sig.	F=13.0 P=0.00 Sig.	F=2.90 P=0.04 Sig.	F=4.04 P=0.00 Sig.

Sig. = significance

The results do broadly show a difference in water quality between the study areas both in the household container and sources. This is to be expected in the cases where some areas have the water supply and some have not. Even at phase 4, when most areas have received water, although the coliforms and E. coli are similar, the faecal streptococci are not.

Coliforms show no difference in the household containers between the areas for 3 surveys out of the 5, whilst for E. coli and faecal streptococci there is a difference four surveys out of five. The sources showed no difference for coliforms and E. coli at Baseline and Phase 4 only.

4.2.4 Descriptive statistics of water quality in relation to behavioural factors and diarrhoea

4.2.4.1 Water quality and water management

Table 4.24 Comparison of water quality with water management - total coliforms' geometric means/100ml

Baseline behaviour	Before			After		
	In-house	Source	P-value	In-house	UW Tap	P-value
Container storing water						
Plastic	428	73	**0.000**	158	3	**0.000**
Metal	262	8022	N=1	98	113	N=1
p-values	0.819	**0.029**		0.861	**0.026**	
Same storage as container						
Yes	392	83	**0.001**	202	4	**0.000**
No	459	73	**0.000**	134	3	**0.000**
p-values	0.728	0.772		0.490	0.327	
Removing water from						
container	433	71	**0.004**	122	3	**0.000**
Designated cup	403	80	**0.000**	183	3	**0.000**
Any cup	0.874	0.788		0.493	0.698	
p-values						
How container cleaned						
Rinsed out water	358	67	**0.002**	105	3	**0.000**
Scrubbed with soap	455	196	0.166	137	2	**0.000**
Scrubbed with other	498	88	**0.000**	204	4	**0.000**
p-values	0.819	**0.011**		0.680	0.312	
How often containers						
cleaned	324	128	0.225	174	3	**0.000**
Daily	458	67	**0.000**	107	3	**0.000**
Weekly	1043	118	*0.597			
Monthly	0.717	0.493		0.676	0.481	
p-values						

Table 4.25 Comparison of water quality with *water* management - *E. coli* geometric means/100ml

Baseline behaviour	Before			After		
	In-house	Source	P-value	In-house	Tap	P-value
Container storing water						
Plastic	108	16	**0.000**	48	2	**0.000**
Metal	260	2	N=1	15	40	N=1
p-values	0.729	**0.043**		0.677	**0.029**	
Same storage as container						
Yes	84	14	**0.000**	69	2	**0.000**
No	133	20	**0.000**	34	2	**0.000**
p-values	0.378	0.455		0.230	0.648	
Removing water from container	102	17	**0.001**	41	2	**0.000**
Designed cup	109	16	**0.000**	47	2	**0.000**
Any cup	0.889	0.921		0.844	0.938	
p-values						
How container cleaned						
Rinsed out water	102	11	**0.001**	50	2	**0.000**
Scrubbed with soap	104	48	0.217	49	2	**0.000**
Scrubbed with other	125	10	**0.000**	41	2	**0.000**
p-values	0.933	**0.005**		0.971	0.476	
How often containers cleaned						
Daily	62	18	0.130	21	2	**0.004**
Weekly	124	16	**0.000**	54	2	**0.001**
Monthly	119	55	N=2	85	1	N=2
p-values	0.579	0.699		0.472	0.685	

Table 4.26 Comparison of water quality with water management - Faecal streptococci geometric means/100ml

Baseline behaviour	Before			After		
	In-house	Source	P-value	In-house	Tap	P-value
Container storing water						
Plastic	4	3	0.212	3	1	**0.000**
Metal	2	2	None	8	None	
p-values	0.862	0.699		0.339		
Same storage as container						
Yes	3	3	0.627	3	2	**0.000**
No	4	3	0.275	4	2	**0.000**
p-values	0.540	0.893		0.213	0.501	
Removing water from container						
Designed cup	3	3	0.708	3	1	**0.000**
Any cup	4	3	0.226	4	2	**0.000**
p-values	0.200	0.585		0.098	0.163	
How container cleaned						
Rinsed out water	4	3	0.065	4	2	**0.000**
Scrubbed with soap	4	3	0.573	3	1	**0.002**
Scrubbed with other	3	3	0.491	3	1	**0.000**
p-values	0.516	0.146		0.623	0.625	
How often containers cleaned						
Daily	3	2	0.842	3	2	0.124
Weekly	4	3	0.216	3	1	**0.000**
Monthly	3	4	0.636	3	1	N=1
p-values	0.343	0.540		0.945	0.866	

Referring to Table 4.24, almost every household was using plastic type containers to collect water (only one metal and therefore statistics were unreliable). The tables' columns show that there is basically no difference in the amount of total coliforms in-house either before or after Umgeni water whatever container, storage, cup or cleaning is used. Similarly there is no difference in the source quality related to any of the behavioural factors (apart from scrubbing containers with soap!). Comparing the tables' rows shows the amount of total coliforms in-house and from source either before or after Umgeni water is basically different whatever container, storage, cup or cleaning is used (again soap is the anomaly and seems to make the source worse.) In the case of *E. coli* (Table 4.25) the situation is very similar to coliforms as above. For faecal streptococci (Table 4.26) the situation is similar except that there is no difference between the in-house and source for all the behavioural factors, before the Umgeni water supply.

The observational survey was limited to the Baseline and not at the subsequent surveys. Therefore, it is strongly assumed that behaviour such as water storage, how containers were cleaned etc., did not change. The tables compare microbiological parameters in containers and source for different water handling factors both before and after Umgeni Water was received (UW Tap).

4.2.4.2 In-house water quality, general sanitation and diarrhoea prevalence

Referring to Table 4.27:

- The percentage of diarrhoea reduced considerably in all cases, after the Umgeni water supply.
- The water quality of all three parameter,s also appeared to improve in some cases, after the Umgeni water supply.
- Higher diarrhoea incidence and decrease in water quality was associated with *Relieve in other places, Relieves themselves in Yard dwelling; Childs' feaces disposed in pit, toilet, Goes without nappies; Family purifies water with Boiled water; Household dispose refuse in No specific place.*
- Higher diarrhoea incidence after water supply was associated with *Share toilet with others; Childs' feaces disposed in toilet; Household dispose refuse anywhere*

Table 4.27 Comparison of in-house water quality, general sanitation and diarrhoea prevalence before and after Umgeni water (Geometric Means)

	Before Umgeni water				After Umgeni water			
	Coliform /100ml	E.coli /100ml	F.strep /100ml	Diarr (%)	Coliform /100ml	E.coli /100ml	F.strep /100ml	Diarr (%)
Toilet on site								
Yes	428	4	4	40.0	156	45	3	12.5
Share toilet								
Yes	270	78	3	29.4	898	221	4	17.7
No	464	117	4	42.7	110	33		11.4
Relieves other places								
Yes	925	376	925	58.3	416	113	4	8.3
No	327	75	327	37.3	81	24	3	10.8
Relieves themselves in:								
Yard dwelling	944	376	5	63.6	498	120	3	9.1
Nearby bush	721	428		*0.0*	69	69	5	*0*
Childs' feaces :								
No nappies								
Pit	550	204	204	53.4	90	27	3	0
Toilet	4316	944	944	50.0	183	133	5	2/2*
Other	473	130	130	65.5	242	67	3	21.4
	821	369	369	0.00				
Household dispose refuse:								
Own pit	296	65	396	36.8	279	89	4	10.6
Anywhere	584	162	584	43.6	96	24	3	18.2
Other	72	69	72	25.0	57	20	3	6.25
Family purifies water with:								
Boiling	262	247	8	66.7				
JIK	330	66	3	15.0				
Tablets	85	43	26	1/1*				
None	464	118	4	46.0	155	47	3	12.5

* there were only two households in this category and they both had diarrhoea.

4.2.4.3 Water quality, problems in and around the house and diarrhoea prevalence

Table 4.28 Comparison of in-house water quality, problems in and around the household and diarrhoea prevalence before and after UW (Geometric Means)

	Before UW				After UW			
	Coliform /100ml	F.strep /100ml	E.coli /100ml	Diarr (%)	Coliform /100ml	F.strep /100ml	E.coli /100ml	Diarr (%)
Rats								
Yes	384	4	102	45.2	200	4	50	17.1
No	590	3	138	22.7	134	3	43	9.1
Mosquitoes								
Yes	403	2	70	25.0	309	4	65	21.4
No	428	4	119	43.4	140	3	43	11.0
Ants								
Yes	354	3	86	44.4	53	3	14	25.5
No	602	5	167	33.3	197	3	59	10.1
Flies								
Yes	424	4	109	40.4	155	3	48	14.5
No					159	3	35	
Cockroaches								
Yes	735	4	189	42.9	162	4	34	17.9
No	321	4	82	39.1	152	3	51	10.3
Dumping								
Yes	464	4	158	37.5	213	2	82	25.0
No	403	3	87	42.4	148	3	42	10.0
Waste water								
Yes	483	4	189	48.6	146	4	84	27.3
No	399	4	82	35.9	156	3	43	10.6
Animal waste								
Yes	692	5	204	41.7	64	3	1	11.1
No	330	3	79	39.7	44	3	1	12.6

Referring to Table 4.28:

- The percentage of diarrhoea reduced considerably in all cases, after the Umgeni water supply.
- The water quality of coliforms and *E. coli* also appeared to improve considerably in all cases, after the Umgeni water supply.
- Higher diarrhoea incidence and often decrease in water quality was associated with *Rats, Ants, Flies, Cockroaches, Waste water and Animal waste*

4.2.5 Association between diarrhoea and potential risk factors

The use of diarrhoea as an indicator to evaluate the health impact of an intervention has one serious drawback; there are many pathways that may lead to diarrhoea in a population. The ecological pathways and potential confounding variables to diarrhoeal disease are complex and inter-related.

The surveys allowed some of these potential risk factors to be explored. The study identified that four exposure variables had a *p* value of <0.05 and are considered significantly associated with diarrhoea. The results of the probability analysis are shown in Table 4.30 Unfortunately, gaps in the table were caused by insufficient or no data to complete comparison calculations eg. when everybody gave the same answer to that question hence giving no variability. However, it would seem that time taken to fetch water is associated with diarrhoea only at the start of the study, before water supply is phased in and also the washing of nappies becomes likewise unimportant. Number of children and unprotected springs were also associated with diarrhoea, but only at phase 2.

Table 4.30 Association between diarrhoea and potential risk factors between phases

Variables identified through survey	P values			
	PHASE1	PHASE2	PHASE3	PHASE4
Number of People	0.584	0.633	0.133	
Number of Children	0.307	**0.0298**	0.832	
WATER SOURCES				
Tap in garden	0.763	0.450	1	0.627
Communal Tap	0.093	0.665		
River	1	0.621		0.262
Unprotected Spring	0.942	**0.001**	0.628	0.558
Protected Spring	0.747	1		0.140
Rain Tank	0.289	1	1	1
WATER MANAGEMENT				
Length of time taken to fetch water	**0.0323**	**0.0218**	0.2897	
Volume of water collected	0.497	0.359	0.2128	
Times/Day water collected takes place	0.216	0.466	0.165	0.587
SANITATION				
Dumped Rubbish	Uncalculated			
Waste Water	Yes to all			
Animal Water	Yes to all			
ANIMAL VECTOR RELATED				
Rats	Yes to all			
Mosquitoes	Yes to all			
Ants	Yes to all			
Flies	Yes to all			
Cockroaches	Yes to all			
FOOD RELATED ACTIVITIES				
Milk	0.062	1		1
WATER USE				
Cattle	0.384	0.05	0.094	0.516
Nappies	**0.005**	0.577	1	0.211
Clothes	0.234	0.786	0.342	0.362
Toilet	1	1	1	1

4.2.5.1 Association between diarrhoea and water use after receiving a water supply

Water use in each area was explored to determine if any particular water use could be associated with diarrhoeal disease after they received Umgeni water. Table 4.31 shows the household frequency of common water usage and the scores given to each.

Table 4.31 Common water usage by households and Trend of risk of diarrhoea

Umgeni Water usage	USE RANK 1	2	3	Trend (p-value)
	Daily	**Occasionally**	**Never**	
	Households (% diarrhoea)	Households (% diarrhoea)	Households (% diarrhoea)	
Cooking	14 (7.5)	4 (16.7)	6 (22.2)	+2.62 (0.004)
Washing clothes	2 (5.7)	14 (8.4)	8 (22.2)	+2.33 (0.010)
Bathing	12 (6.7)	5 (17.9)	7 (23.3)	+3.13 (0.001)
Washing dishes	13 (7.1)	4 (16.0)	7 (24.0)	+3.02 (0.001)
Drinking	14 (7.5)	4 (16.0)	6 (22.0)	+2.58 (0.005)
Household maintenance	13 (7.1)	4 (18.2)	7 (21.2)	+2.75 (0.003)

There is a significantly increasing (+) Trend of diarrhoea from those who use water daily to those who use water occasionally for each purpose of water usage. This implies that the lesser one uses UW for each purpose described above, the more likely is the risk of diarrhoea. Using Umgeni water seems to increase resistance to diarrhoea.

It should be noted that these trends are not cluster adjusted. However, it is assumed that the areas are similar once they have received Umgeni water; hence there is no need to adjust for area difference effect.

Table 4.32 Association between most common daily water uses and diarrhoea at each Phase

Risk factors					
	Baseline	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**
Water source					
Garden tap	0.98 (0.957)	0.90(0.819)	2.06(0.273)	1.68(0.513)	0.29(0.606)
Communal tap	0.57 (0.321)	2.03(0.246)	0.50(0.362)	1.68(0.513)	None
River	*0.28(0.514)	None	1.20(0.602)	None	None
Rain tank	0.48 (0.401)	5.69(0.171)	None	25.57(0.110)	None
Unprot. spring	1.12 (0.835)	0.73(0.478)	**5.42(0.001)**	3.06(0.107)	2.27(0.371)
Prot. spring	1.96 (0.479)	1.55(0.716)	0.60(0.642)	2.87(0.377)	22.57(0.122)
Umgeni water		0.24(0.255)	**0.15(0.002)**	**0.16(0.006)**	0.51(0.315)
Water use					
Wash hands	0.67 (1.000)	All	All	All	All
Drinking	All drank	All	All	All	All
Prep. juices	0.62(0.579)	0.19(0.134)	0.73(0.779)	1.01(1.000)	0.30(0.238)
Milk formulae	**8.27(0.006)**	**4.28(0.037)**	0.44(0.437)	1.01(1.000)	0.69(1.000)
Wash nappies	**4.11(0.003)**	**3.68(0.005)**	1.16(0.785)	1.71(0.433)	1.18(0.729)
Wash clothes	0.59(0.238)	2.25(0.129)	1.02(0.974)	2.66(0.182)	4.10(0.156)
Stock watering	0.48(0.408)	0.88(0.834)	1.26(0.804)	3.51(0.192)	0.48(0.302)
Bathing	0.67(0.780)	All	All	All	All
Water garden	0.35(0.340)	1.84(0.253)	0.58(0.728)	2.57(1.000)	None
Container					
Rinse water	1.95(0.109)	2.11(0.170)	0.56(0.550)	**5.34(0.019)**	0.31(0.201)
Scrub soap	0.76(0.550)	5.70(0.350)	None	0.42(0.683)	1.36(0.659)
Scrub other	1.56(0.470)	2.46(0.143)	1.80(0.465)	2.60(0.259)	2.20(0.218)
Clean daily	0.77(0.637)	**2.56(0.049)**	1.76(0.250)	1.79(0.374)	0.91(1.000)
Clean weekly	1.60(0.383)	0.71(0.442)	0.60(0.298)	0.58(0.413)	1.10(1.000)

OR>1 implies an increased risk and OR<1 implies a reduced risk

Referring to Table 4.32, for the surveys, people had to rank each potential risk factor as to how often they used them and only those that were used more often were analysed. For example, if the communal tap was used most of the time, then that was the relationship explored. It would be pointless trying to establish an association between the risk of diarrhoea and a water source that people did not use often, since the association would then be due to other factors and not the variable on which the calculations were based. The bold type indicates whether significance was reached and showed that preparing milk formulae and washing nappies were significantly associated with an *increased risk* of diarrhoea at Baseline and Phase 1, before water supplies are received. As noted previously, this may be due to just the presence of babie,s as these tend to have more diarrhoea than adults. Unprotected springs and rinsing containers only with water also had an *increased risk* at Phase 2 and 3 respectively, (and also cleaning the container daily at Phase 1). Using Umgeni water was associated with a *decreased risk* of diarrhoea in phases 2 and 3.

Table 4.33 Association between Environmental and food preparation risk factors and diarrhoea at each Phase

Risk factors	Odds Ratio (P-value)				
	Baseline	Phase 1	Phase 2	Phase 3	Phase 4
Toilet					
Shared toilet	0.56(0.310)	1.02(1.000)	1.17(0.753)	1.19(1.000)	1.69(0.436)
Relieve other	2.35(0.074)	1.23(0.802)	**3.48(0.037)**	1.25(0.717)	0.77(1.000)
Childs' faeces disposal					
No nappy	1.86(0.222)	1.53(0.396)	**5.53(0.002)**	1.48(0.695)	0.13(0.188)
Toilet	**4.43(0.001)**	0.90(1.000)	0.90(1.000)	8.80(0.209)	2.74(0.173)
Refuse disposal					
Own pit	0.88(0.835)	0.65(0.401)	0.42(0.138)	1.12(1.000)	0.75(0.782)
Any place	1.36(0.539)	**3.31(0.017)**	**3.44(0.021)**	1.02(1.000)	2.07(0.332)
Water treatment					
Boil	3.05(0.564)	0.61(1.000)	1.20(1.000)	2.57(1.000)	None
JIK	**0.20(0.011)**	1.64(0.509)	0.38(0.684)	1.52(1.000)	None
None	2.69(0.053)	1.20(0.804)	2.94(0.449)	1.21(1.000)	All
Cooked food stored					
Plate	0.48(0.645)	1.91(0.610)	1.25(1.000)	0.82(1.000)	**8.40(0.072)**
Pot	1.27(0.675)	0.88(0.830)	1.65(0.449)	1.08(1.000)	**0.27(0.055)**
Fridge	1.02(0.967)	0.72(0.638)	**0.22(0.040)**	1.02(1.000)	2.08(0.302)
Table	0.57(0.698)	2.67(0.236)	4.17(0.108)	1.38(0.570)	1.47(0.553)
Raw food stored					
Cupboard	0.47(0.112)	0.66(0.474)	0.45(0.159)	0.57(0.470)	0.45(0.293)
Rack	0.72(1.000)	0.92(1.000)	2.63(0.286)	0.56(1.000)	1.86(0.487)
Fridge	1.51(0.683)	4.07(0.180)	0.26(0.337)	1.68(0.513)	4.10(0.156)
Cooking					
Firewood	1.46(0.409)	1.76(0.285)	1.83(0.319)	1.25(1.000)	**0.30(0.065)**
Gas stove	0.62(0.462)	0.83(0.804)	**0.14(0.037)**	0.35(0.450)	0.70(1.000)
Electric stove	0.84(0.827)	0.50(0.181)	**0.28(0.046)**	0.78(1.000)	2.30(0.198)
Other	1.19(0.824)	2.04(0.117)	1.67(0.418)	4.74(0.032)	2.73(0.173)
Dishes hot water					
Always	2.08(1.000)	0.18(0.350)	All	0.39(1.000)	All
Sometimes	1.66(0.352)	1.93(0.234)	3.97(0.089)	0.89(1.000)	1.05(1.000)

OR>1 implies an increased risk and OR<1 implies a reduced risk

In the table 4.33 above, the bold face indicates whether significance was reached and showed that relieving in places other than a toilet and having a child with no nappy were significantly associated with an *increased risk* of diarrhoea at Phase 2 (also child's faeces in toilet at Baseline, but this may be just the occurrence of children). Household refuse disposal anywhere also showed an *increased risk* at Phase 1 and 2.

Cooked food stored on the plate was associated with increased risk at Phase 4, whilst in the pot or fridge indicated a *decreased risk* (the latter may indicate affluence however). Using a gas or electric stove to prepare food also indicated a *decreased risk*, but this could indicate affluence once again.

4.2.5.2 Association between diarrhoea and new supply problems

The following Table 4.34 shows the problems experienced by people with the Umgeni water supply. This is based on the final visit when almost all the households supposedly had access to UW. There was no association found between diarrhoea and any of the problems that were experienced with UW (not shown in table).

Table 4.34 Frequency of problems encountered with the Umgeni water supply

Problems with UW	Frequently n (%)	Sometimes n (%)	Never n (%)
Irregular flow daily		46 (52)	42 (48)
No flow		42 (48)	46 (52)
Irregular flow in winter		49 (56)	39 (44)
Dirty water		56 (64)	32 (36)
Broken tap	3 (3)	2 (2)	82 (94)
Tap always dripping	2 (2)	1 (1)	84 (97)

4.2.6 Wastewater management

47% of people said there was an increase in wastewater on the property since they received UW. Table 4.35 shows that the majority (38%) of the people had no specific place where they disposed of water after washing clothes. However, the common places where people disposed of water were drainage channel, vegetable garden and outside the homestead. After washing dishes water was disposed of in no specific place (36%), vegetable garden, drainage channel and outside the homestead. Only 21% of the people disposed water at the same place every time.

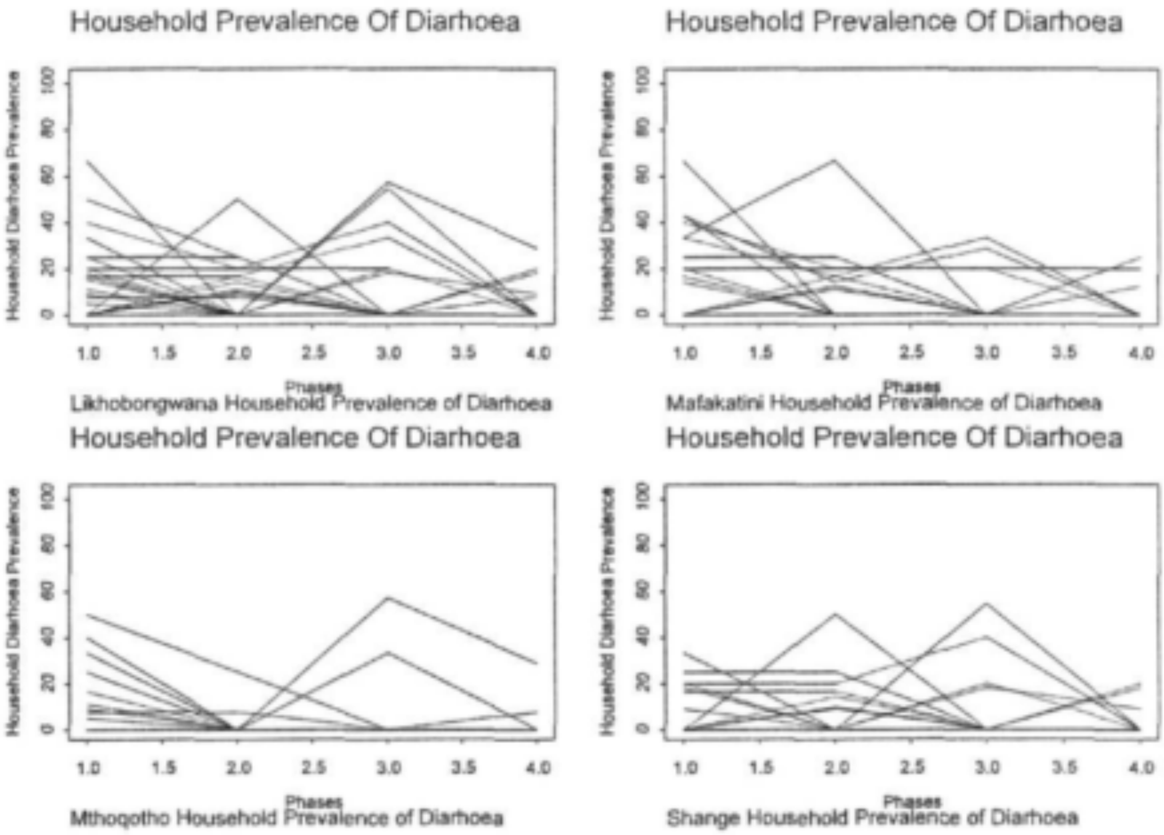
Table 4.35 Dirty water disposal %

	Clothes water	Dish water
No specific place	38	36
Drainage channel	23	24
Vegetable garden	24	25
Outside homestead	15	15
Same place	21	21

An increase of wastewater on the property after the connection to the water supply is obviously very likely, as no provision was made for drainage. This could have a negative effect on health, by attracting livestock, insect vectors and children who could play and defecate therein.

4.2.7 Prevalence of diarrhoea throughout the areas during the study

The individual households prevalence of diarrhoea in each area are shown in the graphs Figs 4.32 below and there seems to be much variation. The overall



prevalence for each area is shown in Fig 4.33.

Figure 4.32 Household % prevalence of diarrhoea throughout the Phases

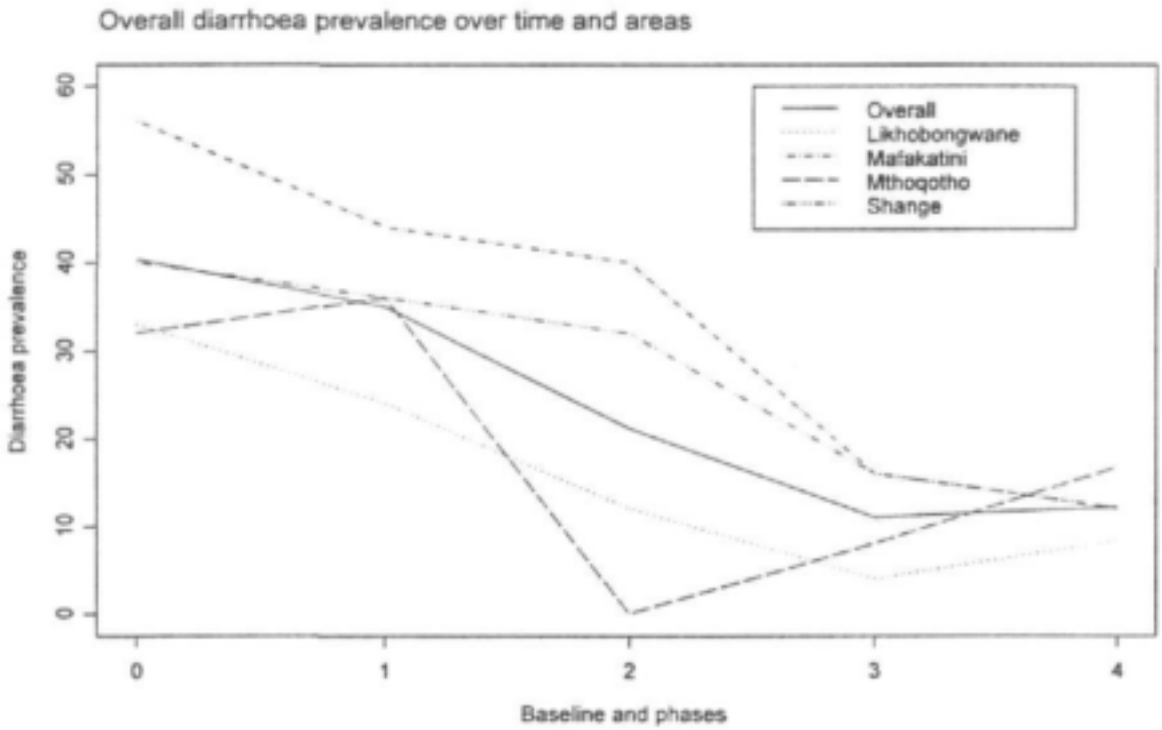


Fig 4.33 Overall % prevalence of diarrhoea throughout the Phases for each area (15 months)

There appears to be an overall decrease in diarrhoea from an average of 40% to 12% over the four phases of the introduction of water supply. The different areas had different diarrhoea prevalence's at the start of the surveys however. Two areas had prevalence's of around 30%, (untreated garden and communal taps), one at 40 % (protected springs) and one at around 55% (unprotected springs). They all decreased to approximately the same level in the end, when most have the same Umgeni water. The graphs above followed the same sequence as the microbiological parameters from the source and household waters, Figures **4.14- 4.16**. Likhobongwane and Mthoqotho areas decreased first as they received water first, towards Phase 2 (which is probably partly a seasonal effect as explained previously), followed by the other two areas, which received their water later.

This then therefore points to the link between the bacteriological quality of source and household water and the prevalence of diarrhoea.

SECTION III

4.3 Cross-sectional, Univariate and Multivariate analysis

4.3.1 Cross-sectional analysis

This section considers a cross-sectional survey at Phase 2, where two areas had received Umgeni water and the other two had not, thus giving most power to make cross-sectional comparisons. Comparison of these two areas is made with respect to diarrhoea infection as an outcome with possible risk factors selected from previous analyses.

Table 4.34 Comparison of microbiological data by water supply areas at Phase 2 (Geometric Mean)

Microbiology data/100ml	No water supply (Baseline)	Umgeni supply (Phase 4)	T-test	P-value
Total coliform	72	22	-2.49	**0.005**
E. coli	16	2	-6.60	**0.0001**
Faecal streps	27	2.6	-6.56	**0.0001**

The above Table 4.34 shows a very significant difference between the three bacteriological parameters from the household supplied and non-supplied areas at Phase 2.

4.3.2 Univariate analysis

Table 4.35 Univariate risk factors of diarrhoea at Phase 2

Risk factors	Odds Ratio	[95% CI]	P-value
Receiving Umgeni water	0.22	0.08-0.62	**0.003**
Relieving other place than toilet	3.48	1.20-10.10	**0.018**
Child goes with no nappy	1.16	0.40 - 3.40	0.786
Prepare milk formulae with water	0.44	0.05 - 3.71	0.437
Refuse disposed anywhere	4.46	1.38 - 14.49	**0.008**

OR>1 implies an increased risk and OR<1 implies a reduced risk

Table 4.35 shows that the risk of having diarrhoea was significantly *reduced* if you were receiving Umgeni water than when you were not receiving Umgeni water (OR=0.22, 95% CI [0.08 – 0.62], p-value=0.003. Relieving other places beside the toilet and disposing household refuse anywhere significantly *increased the* risk of having diarrhoea.

4.3.3 Multivariate analysis

Variables that seemed to show importance in predicting diarrhoea, from previous data analysis were selected for the Multivariate model. The following Table 4.36 shows the multivariate model that was fitted to the data. The outcome of interest is the status of diarrhoea. The model development was based on the significance of the *likelihood ratio test*. However some of the variables were included in the model irrespective of their significance. These variables (such as number of children under five years, whether children go without nappies) were considered to be possible confounders of the risk of diarrhoea infection.

Table 4.36 Multivariate statistical model of the risk factors of diarrhoea

Risk factor/variable	Odds ratio	95% CI	P-value
Receive Umgeni water (1=Yes, 0=No)	0.38	0.15 - 1.00	**0.050**
Refuse disposed anywhere (1=Yes, 0=No)	2.73	0.97 - 7.62	**0.056**
Number of children			
No child	1		
One child	1.26	0.43 - 3.72	0.679
Two children	1.38	0.42 – 4.52	0.599
More than two children	3.17	0.55 – 18.32	0.197
Children go without nappies (1=Yes, 0=No)	1.29	0.37 - 4.38	0.688
Time (surveys 0,1,2,3,4)	0.80	0.63 – 1.02	0.070

OR>1 implies an increased risk and OR<1 implies a reduced risk

The above Table 4.36 shows that:

- The risk of having diarrhoea is significantly reduced to about 38% if receiving Umgeni water, than if not receiving Umgeni water.
- The number of children increases the risk of diarrhoea in the family and although this was not statistically significant, it indicates however that families that have more children are more likely to report having diarrhoea. (It is also well known that diarrhoea is more common among children under five years).
- Disposing household refuse anywhere significantly *increased the* risk of having diarrhoea.

The model fitter here accounts for intra-cluster correlation between the observations taken within the same family and area effect. The deviance and the scaled deviance were very similar (Table 4.37), which was an indication that the model fitted the data well.

Table 4.37 Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	968	820.5927	0.8477
Scaled Deviance	968	820.5927	0.8477
Pearson Chi-Square	968	975.9354	1.0082
Scaled Pearson X2	968	975.9354	1.0082
Log Likelihood		-410.2964	

5 CONCLUSIONS

5.1 Health impacts associated with water

One objective of this study is to evaluate the usefulness of diarrhoeal disease as opposed to other health indicators for water associated diseases:

- *Faecal-oral* disease: (e.g. diarrhoea, typhoid, hepatitis A)
- *Water-washed* diseases: (e.g. scabies and trachoma)
- *Water-based* diseases: (e.g. schistosomiasis)
- *Water-related* diseases: (e.g. malaria and trypanosomiasis, can be ignored in this case)

The locally perceived most common diseases in all the four regions were High Blood Pressure.(84%) and Diarrhoea (76%), which are followed by misuse of alcohol, AIDS and diseases such as Eye infection 9%, Skin Infection (8%), Worms (2%) and Bilharzia (1%).

The baseline study in Vulindlela reported that 40.4% of the households had at least one member of the household experiencing diarrhoea in the previous two weeks. As there are no data on the full extent of diarrhoeal disease in South Africa, there is little basis for comparison of the above findings at the household level. The most prevalent water associated disease in Vulindlela from the surveys, appears to be Stomach Pain, Bloody diarrhoea and Watery diarrhoea.

Therefore diarrhoea would seem to be the health impact associated with water, of choice. As previously discussed, the most important reason for the international research in this area is that preventable diarrhoea is perceived to be the cause of many deaths worldwide. If the causes of the diarrhoea can be identified and addressed, thousands of lives, especially those of children, would be saved.

5.2 Risk factors relating water and health impacts at Baseline

- Of the 55 exposure variables explored, seven had a p value of <0.05 and are considered significant at the 95% level: Number of people in a house, age, non-designated scoop for water, not disinfecting water, washing nappies, shortage of food, cooking using water. Two were significant at the 90% level ($p<0.1$): Volume of water collected and rodent problems.

- The baseline results showed an increasing trend of diarrhoea with respect to water source for the use of communal taps which was significant at the 90% level (P=0.09), especially as compared to taps in the garden (P=0.56).
- Vulindlela households collected between 200 and 400 litres per day from local sources, which on average relates to 50 litres per person per day. There appeared to be a negative correlation between the quantity of water collected and diarrhoea, at the 94% level (p= 0,06), at Baseline.
- There was a significant trend of a decrease in diarrhoea prevalence from those who used water daily to those who never use water to wash nappies. The same pattern is also seen among those who use water daily to prepare milk formulae for feeding babies. However those who have babies may be more prone to having diarrhoea in the household.
- The prevalence of diarrhoea from amongst children showed that for ages less than five years, the prevalence is much higher for males than females. The fact that about 97.3% of young males are the ones most likely to swim might be contributing to this high prevalence in this group.
- 34.7% of those who were not disinfecting water at all had diarrhoea. There is a significantly strong association between diarrhoea and the method of water purification used.

5.3 Evaluating the introduction of water

5.3.1 Changes in Household Water Source

- The habit of a household fetching water from a local source takes time to change
- The visit to the water collection point provides more services to that household, such as communication with neighbours/ meetings etc.

5.3.2 Changes in water quantity used over time

There appeared to be a decrease in the amount of water people collected and stored as they received an Umgeni Water connection, from an average of 202L down to 75L, a reduction of 63%. However, the volumes appeared to be very low and perhaps these do not include activities that could take place at the yard tap, like washing clothes and vegetables etc. In these cases the volume would not have been measured as the water was not "collected" as such.

The Vulindlela Water Supply Scheme is designed to deliver 50 litres per person per day. The scheme when fully utilized will therefore not necessarily improve the supply in terms of volume per capita, but should improve the convenience of obtaining water. In fact other similar schemes have noted a consumption of well under 25 liters per person per day, when the supply is metered and presumably paid for. It is likely that the old local sources are still used if close by, in order to economise.

47% of people said there was an increase in wastewater on the property since they received UW (with the implied health risk).

Comparing household and source water quality at each phase

- The source regardless of whether it is Umgeni water or not, is always cleaner than the water in the household container and that water becomes contaminated in the household containers irrespective of the source.

Comparison of in-house water quality, general sanitation and diarrhoea prevalence

- The percentage of diarrhoea reduced considerably in all cases, after the Umgeni water supply.
- Higher diarrhoea incidence and decrease in water quality was associated with: *Relieves in other places (than toilet); Relieves in Yard of dwelling; Childs' feaces disposed in pit, toilet; Goes without nappies; Purifies water by Boiling; Disposes refuse anywhere.*
- Higher diarrhoea incidence after water supply was associated with: *Share toilet with others; Childs' feaces disposed in toilet; Disposes refuse anywhere*

However, just having children may increase the likelihood of diarrhoea.

The study identified that four exposure variables were considered significantly associated with diarrhoea:

- *Time taken to fetch water* was associated with diarrhoea only at the start of the study, before water supply is phased in and also the *washing of nappies* becomes likewise unimportant.
- *Number of children and unprotected springs* were also associated with diarrhoea, but only at phase 2.

- There was a significantly increasing (+) Trend of diarrhoea from those who use water daily to those who use water occasionally for each purpose of water usage. This implies that the lesser one uses UW for each purpose described above, the more likely is the risk of diarrhoea *(Cooking, Washing clothes, Bathing, Washing dishes, Drinking, Household maintenance).*
- There was no association between diarrhoea and any of the supply problems that were experienced with Umgeni water.

Association between bacteriological quality of water and the prevalence of diarrhoea.

- There would seem to be an overall decrease in diarrhoea from about 40% to 12% over the four phases of the introduction of water supply.
- The graphs of reduction in diarrhoea throughout the phases followed the same sequence of seasons as the microbiological parameters from the source waters. This appears to show a direct link between the bacteriological quality of source and household water and the prevalence of diarrhoea.
- Although the in-house water quality does not seem to improve greatly, with the introduction of water supply, the diarrhoea appeared to reduce nevertheless.
- This reduction in diarrhoea may be related more to reduction in storage and improvement in hygiene behaviour.

Cross-sectional Comparison of microbiological data by water supply areas

- There appeared to be a significant difference between the three bacteriological parameters, from the households in the supplied versus the non-supplied areas at Phase 2.

Univariate risk factors of diarrhoea

- The risk of having diarrhoea was significantly *reduced* if you were receiving Umgeni water than when you were not receiving Umgeni water.
- Relieving other places beside the toilet and disposing household refuse anywhere significantly *increased the* risk of having diarrhoea.

Multivariate statistical model of the risk factors of diarrhoea

- The risk of having diarrhoea is significantly reduced to about 38% if receiving Umgeni water, than if not receiving Umgeni water.

- The number of children increases the risk of diarrhoea in the family and although this was not statistically significant, it indicates however, that families that have more children are more likely to report having diarrhoea
- Disposing household refuse anywhere significantly *increased the* risk of having diarrhoea.

Overall, there was no direct correlation proved between water quality and diarrhoea *per se*. However, there was a marked decrease in diarrhoea with the introduction of the new water supply. There was definite correlation between hygiene behaviours and diarrhoea.

5.4 Appropriate methodologies and indicators for health impact assessments of rural water supply schemes

In Vulindlela, an attempt has been made to take into consideration as many confounding variables as possible. While it was possible to take into consideration many confounding factors (such as age and gender), there was no observation of facility usage. While water quality has been rigorously analysed, there is little proof that diarrhoea, or the absence thereof, has any direct relationship to the water quality of the storage container at the time. However, this may mean that our indicators are not appropriate, or diarrhoea is caused by other non water-related organisms, such as rotavirus. It is also difficult to correlate the prevalence of diarrhoeal disease over a two-week period prior to the interview with the quality of water at source on the day of the interview. Other important confounders could be the apparent decrease in water usage. Obviously, storage is a key issue and the provision of taps inside the house to reduce this.

To minimize costs, a single village with the intervention is commonly compared with the village prior to the installation of water reticulation. Unless households within the village are independent and the implementation of reticulation can be shown to not be village-wide, several clusters of the intervention need to be compared with several clusters without the intervention. It is for this reason that, in the Vulindlela study, a "stepped-wedge" multi-cluster study was introduced. Not only does this innovative study design allow for more clusters, but it also allows both cross-sectional and longitudinal analysis to be carried out.

Most interventions are, however, not delivered under 'trial' conditions that allow for epidemiologically accurate studies. It is therefore necessary to rather explore non-epidemiological methodologies, such as Public Health Effectiveness Trials and Health Impact Assessments.

De Zoysa *et al* make a case for 'Public Health Effectiveness Trials' which measure the impact of an intervention delivered under normal program conditions (de Zoyse *et al*, 1998). It is suggested that these designs, which are still required to control for confounding and other influences, can adopt a more pragmatic evaluation design than the randomized controlled trial. This form of evaluation also allows for a consideration of how the intervention is delivered and how the new facilities are used. In the case of a water supply scheme, problems such as breakage in the bulk-line associated with the deterioration in water quality and quantity, failure on the part of the household to utilize the water supply because of cost, reduced pressure due to under-design can blunt or obscure the intended health impact; this methodology makes allowances for such considerations.

This study has provided many lessons regarding study design and the efficiency of using epidemiological studies as a health impact assessment tool in the water sector. Although double-blinded randomised trials are considered the gold standard for evaluation, it is very difficult to conduct a truly randomised trial for environmental interventions, such as a water supply. There is no placebo for water and in many communities; a cluster effect is experienced because the whole community benefits from the water supply although the Stepped Wedge Design provides some innovative features, which overcome some of the problems. In conclusion, the experience of this study in Vulindlela indicates that the epidemiological approach is fraught with difficulties, which make it difficult to draw firm conclusions.

6 RECOMMENDATIONS

6.1 Assessments of rural water supply schemes

Given the difficulties experienced with epidemiological studies as outlined above it would seem that observational/behavioural methods are better suited. Behavioural components should not be dismissed as cultural idiosyncrasies as there is no Public Health intervention without behavioural change. It is possible to make three recommendations:

1. A generalized Health Impact Assessment Guideline be developed and evaluated for use in assessing health factors in a water supply scheme. Some water companies, such as Umgeni Water, are already using a series of key performance indicators to evaluate and monitor rural supply schemes. Current indicators include service performance, financial performance and accountability indicators. Health related indicators would be a valuable addition to such a protocol.

2. Patterns of hygiene behaviour be evaluated for adding to the list of key performance indicators. The WHO Minimum Evaluation Procedure suggests that health improvements are the culmination of a long chain of events from the original construction, through operation and use, which in turn permit changes in hygiene behaviour and possible prevention of disease. Patterns of hygiene behaviour may prove more reliable than measuring disease rates or water quality.

3. Define feasible, acceptable and cost effective approaches to delivering the intervention

6.2 Suggested improvements to water supply interventions

1. Taps need to be situated inside the house to prevent storage of any sort, which leads to contamination.
2. The point above will necessitate the provision of a drainage system for public health reasons.
3. Hygiene education be addressed as the causes of diarrhoea would appear to be correlated with many basic hygiene procedures, rather than water quality.
4. A post- construction audit process be introduced to assess all aspects of the scheme to assess its effectiveness in operation, appropriateness and its effect on health.

6.3 Summary of conclusions

1. A post-construction audit process is required e.g. Health Impact Assessment (HIA)
2. Observational methods of assessment are better than epidemiological.
3. Patterns of behaviour are better indicators than water quality *per se*
4. Stored water quality is more important than that of the source
5. Diarrhoea reduces with the introduction of water, even though the (in house) water quality does not substantially improve.
6. Water quality is not directly correlated to the prevalence of diarrhoea
7. Hygiene behaviour has more effect than water quality *per se*, on the prevalence of diarrhoea.
8. Taps are necessary inside the house

7 TECHNOLOGY TRANSFER

It is recommended that the results of this study be distributed to various authorities involved in policy decisions for water and sanitation supply and health policies, such as the Department of Water Affairs and Forestry; Departments of Health (local, regional and national); and District Municipalities. Feedback to the community involved in this study should be provided, possibly through local radio and environmental health officers. The following papers were presented at conferences.

Papers presented:

L Archer, IW Bailey, G Xaba, C Johnson. An evaluation of the impact of reticulated water on community and environmental health in Vulindlela, KwaZulu-Natal. WISA Biennial Conference Sun City, 2000

IW Bailey. The relationship between water quality and public health in developing countries; health impact and economic assessment from the provision of rural water supply in South Africa. IWA Health-Related Water Microbiology Symposium, Paris 2000

IW Bailey, L Archer. The impact of introducing treated water on aspects of community health in a rural community in KwaZulu-Natal South Africa. Submitted to IWA Health-Related Water Microbiology Symposium Cape Town September 2003

Posters presented:

G Xaba, L Archer, C Johnson, IW Bailey. Community concerns regarding the implementation of water supply in a rural area in KwaZulu-Natal. WISA Biennial Conference Sun City, 2000

C Johnson, M Colvin, L Archer, IW Bailey G Xaba. Measuring the health impact of water supply - challenges of methodology. WISA Biennial Conference Sun City, 2000

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APPENDIX 1a

Household Questionnaires

GENERAL QUESTIONNAIRE: BASELINE
An Evaluation of the Impact of RDP levels of Water Supply on Community and Environmental Health.
Ucwaningo ngohlelo lokufakwa kwamanzi yiRDP ezimpilweni zabantu.

Questionnaire No:
Inombolo :
Area/Location :
Indawo :
Reservoir Zone # :
Date :
Usuku :
Interviewer :
Umcwaningi :
HOUSE NUMBER:
INOMBOLO YENDLU :

1 per sample unit.
Sample unit = 1 fenced lot.

The purpose of this study is :
Inhloso yocwaningo :

- to establish the incidence of illness amongst children under 5 that may be related to water in Vulindlela (Diarrhoea, Scabies, Bilharzia, Dysentery and Hepatitis).
- *ukubhekela ukudlanga kwesifo sohudo, isichenene kanye nezinye izifo ezingadalwa amanzi ezinganeni ezineminyaka engaphansi kwemihlanu zasemphakathini waseVulindlela.*
- to explore the possible risk factors associated with water borne diseases
- *ukuthola izinto ezinobungozi obuhambelana nezifo ezidalwa amanzi*
- to evaluate the impact of the Vulindlela Water Supply Scheme on the Health of the community.
- *ukubhekisisa umthelela wamanzi ezimpilweni zabantu baseVulindlela.*
- to contribute toward the definition of criteria for future Umgeni Water Health Impact Assessment
- *ukufaka isandla ohlelweni lwaseMgeni oluzobhekela umthelela wamanzi ezimpilweni zomphakathini esikhathini esizayo.*

Definition
Diarrhoea: Three or more loose/ liquid/ watery stools or any number of loose stools containing blood in a 24-hour period (Baqui AH *et al*; 1991).
Isifo sohudo: Uhudo olunamanzi noma igazi olwenzeka izikhathi ezingaphezulu kwezintathu ngosuku olulodwa.

1. Name of respondent

....

Igama lophendulayo: ....

2. Number of children aged 0-5yrs living in the house

:..

Inani lezingane ezineminyaka emihlanu nengaphansi ezihlala kulelikhaya:

....

3. Relationship of respondent to head of household:

....

Ubuhlobo nenhloko yekhaya:

....

OBJECTIVE: HOMESTEAD DESCRIPTIONS
INHLOSO: INCAZELO NGEKHAYA

4. Number of rooms in the homestead:
Inani lamakamelo:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

5. Number of people living in this dwelling for four consecutive days per week?
Inani labantu abahlala kulelikhaya okungenani izinsuku ezine esontweni?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

6. Did any of your family members suffer from diarrhoea during the last **2 weeks**?
Ingabe likhona yini ilunga lomndeni elike laphathwa isifo sohudo ***emasontweni amabili edlule*** *?*

yes / *yebo*	no /*cha*

7. Description of people living in this dwelling.
Incazelo ngabantu abahlala kulelikhaya.

Sex: Male = M; Female = F
Ubulili: *Abesilisa = M; Abesifazane = F*

Relation to head of house: Self = 1; Spouse = 2; Child = 3; Sibling = 4; Parent = 5; Grandchild = 6; Grandparent = 7; Other = 8
Ubuhlobo nenhloko yekhaya: *Umninimuzi=1; Unkosikazi=2; Ingane=3; Isihlobo=4; Umzali=5; Umzukulu=6; Ugogo/Umkhulu = 7; Okunye = 8*

Employment status: Housewife = 1; Preschool = 2; School/Tertiary = 3; Pensioner = 4; Permanent Employed = 5; Casual Employed = 6; Self-employed formal = 7; Self employed hawking = 8; Unemployed = 9

Isimo ngokomsebenzi: *Umgcini wekhaya = 1; Inkulisa=2; Isikole=3; Uhola impesheni=4; Usebenza ngokugcwele=5; Usebenza itoho = 6; Uyazisebenza ngokugcwele = 7; Uyazisebenza ngokudayisa = 8; Akasebenzi = 9.*

Place of work: Home = 1; Vulindlela = 2; outside Vulindlela = 3
Indawo Yokusebenza : *Ekhaya=1; Vulindlela=2; ngaphandle kwaseVulindlela*

Place of school: Local community = 1; Vulindlela = 2; Other = 3
Ufundaphi : *Eduze kwasekhaya=1; Vulindlela=2; Other=3*

8. How often does the migrant laborer come home?
Ubuya kangaki ekhaya ?

Migrant	1x week *kanye esontweni*	1x every 2 weeks *kanye emasontweni amabili*	1x month *kanye ngenyanga*	1x every 3 months *kanye ezinyangeni ezintathu*	1x every 6 months *kanye ezinyangeni eziyisithupha*	1x year *kanye onyakeni*
a						
b						
c						
d						
e						

Name of household member *Igama lelunga lomndeni*									
Age ***Iminyaka yobudala***									
Sex / Gender *Ubulili*									
Relation to head of home. *Ubuhlobo nomninimuzi*									
Does your child attend a creche? Name? *Ingabe ingane iyaya enkulisa? Igama?*									
Formal education (highest std passed) *Ibanga eliphezulu eliphasiwe*									
Employment status *Isimo ngokomsebenzi*									
Occupation *Umsebenzi owenzayo*									
Place of work *Indawo yomsebenzi*									
Financial household contribution in last month *Imali ekhishwe amalulnga omndeni ngenyanga edlule*									
Had diarrhoea in the last **2 weeks** *Ube nesifo sohudo emasontweni* ***amabili edlule***									
Does this person collect water for this house regularly ? *Ingabe uwe ovamise ukukha amanzi ?*									

9. Is this household ever short of food? *Ingabe lomndeni uke ukuswele ukudla ?*

yes / *yebo*	no / *cha*

10. When is this household short of food? *Ukuswela nini ukudla lomndeni ?*

1x week *kanye ngesonto*	month end *ekupheleni kwenyanga*	winter *ebusika*	summer *ehlobo*	middle month *phakathi nenyanga*

OBJECTIVE: HEALTH
INHLOSO : EZEMPILO

11. What are the common health problems in your community?
Iziphi izifo eziyizinkinga ezejwayelekile emphakathini ?

Bilharzia *Isichenene*	TB *Isifuba*	Malnutrition *Indlala*	High blood pressure *Isifo sikashukela*	Stress *Ukukhathazeka emoyeni*
Diarrhoea *Isifo sohudo*	Colds & flu *Umkhuhlane*	Misuse of alcohol *Ukuphuza ngokweqile*	Drug abuse *Izidakwamizwa*	Worms *Izikelemu*
skin infections *Izifo zesikhumba*	eye infections *Amehlo Abuhlungu*	Aids *Ingculaza*		

12. Which of the following symptoms have people in your home experienced in the last **2** weeks?
Yiziphi izimpawu kulezi ezilandelayo umndeni osuke wahlangabezana nazo emasontweni ama 2 adlule ?

a. Adults (≥ 6yrs) suffered from any of the diseases
a. Abadala (abaneminyaka eyisithupha nangaphezulu) abanalesisifo
b.

Symptom / *Izimpawu*	No persons suffering *Inani labantu abanalesisifo*	No clinic visits *Uye kangaki emtholampilo*
stomach pain *isisu esibuhlungu*		
bloody diarrhoea *uhudo olunegazi*		
Symptom / *Izimpawu*	No persons suffering *Inani labantu abanalesisifo*	No clinic visits *Uye kangaki emtholampilo*
watery diarrhoea *uhudo olungamanzi*		
bloody urine *umchamo onegazi*		
itching hair/body. *ukuluma komzimba / nezinwele*		
back pain *ubuhlungu beqolo*		
fever *umkhuhlane*		
eye infection *amehlo abuhlungu*		
scabies *utwayi*		

b. Children (0 - 5 yrs) suffered from any of the diseases
b. Izingane (0-5 iminyaka) ezinalesisifo

Symptom / *Izimpawu*	No persons suffering *Inani labantu abanalesisifo*	No clinic visits *Uye kangaki emtholampilo*
stomach pain *isisu esibuhlungu*		
bloody diarrhoea *uhudo olunegazi*		
watery diarrhoea *uhudo olungamanzi*		
bloody urine *umchamo onegazi*		
itching hair/body. *ukuluma komzimba / nezinwele*		
back pain *ubuhlungu begolo*		
fever *umkhuhlane*		
eye infection *amehlo abuhlungu*		
scabies *utwayi*		

13. What is the method of feeding for children under 5 in this homestead?
Iyiphi indlela esetshenziswayo yokupha izingane ezineminyaka engaphansi kwemi5 ukudla ?

Child	Breast only *Ibele lodwa*	breast & bottle *Ibele nebhodlela*	bottle only *Ibhodlela lodwa*	solids *Ukudla okuqinile*	breast & solids *Ibele nokudla okuqinile*	breast & bottle and solids *Ibele nebhodlela nokudla okuqinile*	bottle & solids *Ibhodlela nokudla okuqinile*
a							
b							
c							
d							
e							

14a. Where there any deaths in your family last year
Kuke kwashonwa emndenini ngonyaka odlule ?

yes / *yebo*	No / *cha*

14b. Complete details
Gcwalisa imininingwane

Age *Iminyaka*	Sex *Ubulili*	reason *Isizathu*

15. When any members of your family are sick do they visit a
Uma kukhona owomndeni ogulayo kungabe bayaya e

clinic *emtholampilo*	mobile unit *kumahamba nendlwana*	GP *kudokotela*	hospital *esibhedlela*	traditional healer *enyangeni/ sangoma*

16. What is the mobile unit/clinics name?
Yini igama lomtholampilo/ umahamba nendlwana?

17. Do you give your child a sugar/salt solution when it has diarrhoea?
Uma ingane inohudo kungabe niyayinika inhlanganisela kashukela nosawoti ?

YES / *YEBO*	NO / *CHA*

18. What are the quantities of sugar (teaspoons) and salt (teaspoons) when making up a 1L sugar/salt solution?
Ufaka isikali esingakanani sikashukela nosawoti uma wenza elitheni eyodwa yamanzi?

Sugar / *Ushukela*	Salt / *Usawoti*

19. Is there any particular time of the year when your family is more likely to get diarrhoea?
Ingabe sikhona isikhathi esithile onyakeni lapho umndeni uphathwa isifo sohudo?

Spring *Intwasahlobo*	autumn *Intwasabusika*	winter *ebusika*	summer *ehlobo*	after the rains *emuva kwezimvula*	draught *ngesomiso*	Do not know *Angazi*

OBJECTIVE: WATER SUPPLY AND STORAGE
INHLOSO: UKUTHOLWA KWAMANZI NOKUWALONDOLOZA

20. Where do you get your water from? Use the last column to rank the source you use most often.
Niwathathaphi amanzi ? Sebenzisa isikhala esisekugcineni ukusho lapho enijwayele ukukha khona amanzi.

Source of water ***Imvelaphi yamanzi***	**Yes** ***Yebo***	**No** ***Cha***	**Rank** ***Izinga***
Tap in house *Umpompi endlini*			
Tap in garden *Umpompi engadini*			
*Communal Tap *Umpompi womphakathi*			
*River*Umufula*			
Rain Tank *Ethangini lamanzi emvula*			
*Unprotected spring *Umthombo/ Isiphethu esingavikelwe*			
*Protected spring *Umthombo/ Isiphethu esivikelwe*			
*Bore-hole*Ipitsi*			
*Dam*Idamu*			
Tanker *Ithangi*			

Daily = 1; occasionally = 2; Never = 3 / *Nsukuzonke = 1; kuqabukela =2; akukaze = 3*

21. Where does the water that comes out of your tap come from?
Ingabe lamanzi asempompini asukaphi?

River *Umfula*	Spring *Umthombo/ Isiphethu*	Bore-hole *Ipitshi*	Rain tank *Ithangi lemvula*	Tanker *Ithangi*	Umgeni

22. How long does one trip take you to collect water? ....
Kuthatha isikhathi esingakanani ukuya kanye uyokha amanzi ?.........

23. How many times a day is water collected for the household ? ___________
Amanzi akhiwa kangaki ngosuku ekhaya ?

1 time *kanye*	2 times *kabili*	3 times *kathathu*	4 times *kane*	5 times *kahlanu*

24. How much water do you collect at one time?
Ukha amanzi angakanani ngesikhathi ?

<25L	25 L	50L	50-100L	> 100L

25. Which of the following water uses are more common in your household?
Ikuphi kulokhu okulandelayo okuvamise ukusetshenziselwa amanzi ekhaya ?

Activity / ***Ukusetshenziswa kwamanzi***	**Rank /** ***Izinga***
Washing hands *Ukuwasha izandla*	
Drinking *Ukuphuza*	
Preparing juices *Ukwenza iziphuzo*	
Preparation of milk formulaes for babies *Ukwenza ubisi lwezingane*	
Washing nappies *Ukuwasha amanabukeni*	
Washing clothes *Ukuwasha izingubo*	
Stock Watering *Ukunika imfuyo*	
Bathing *Ukugeza*	
Watering garden *Ukuchelela ingadi*	

Daily = 1; occasionally = 2; Never = 3 / *Nsukuzonke = 1; kuqabukela=2; akukaze=3*

26. What type of container is used to collect and carry water in?
Iluphi uhlobo lwesitsha olusetshenziswayo ekukheni amanzi?

Plastic / *Ipulasitiki*	Metal *Insimbi*	clay pot *Isitsha sobumba*	Other *Okunye*

27. What type of container is water stored in ?
Iluphi uhlobo lwesitsha olusetshenziswa ekulondolozeni amanzi ?

Plastic *Ipulasitiki*	Metal *Insimbi*	clay pot *Isitsha sobumba*	other *Okunye*

28. Is the storage container the same as the collection container ?
Kungabe isitsha sokukha amanzi siyefana nesokulondoloza amanzi ?

YES / *YEBO*	NO / *CHA*

29. How is water removed from the storage container? *Amanzi akhiwa kanjani esitsheni sokuwalondoloza ?*

Designated cup *Ngenkomishi ebekelwe ukukha amanzi kuphela*	any cup *noma ngayiphi inkomishi*	other *Okunye*

30. How is the container cleaned? *Sihlanzwa kanjani isitsha samanzi ?*

Rinsed out with water *Sihlanjululwa ngamanzi*	scrubbed with soap and a cloth *sihlanzwa ngensipho nendwangu*	scrubbed with sack and soap *sihlanzwa ngesaka nensipho*	scrubbed with steel wool & soap *sihlanzwa ngesteel wool nesipho*
scrubbed with steel wool *sihlanzwa nge steel wool*	scrubbed with handy andy *sihlanzwa nge handy andy*	scrubbed with liquid soap *sihlanzwa ngensipho engamanzi*	scrubbed with steel wool, handy andy and liquid soap *sihlanzwa ngesteel wool, handy and nensipho engamanzi*

31. How often do the water containers get cleaned? *Zihlanzwa kangaki izitsha zamanzi ?*

Daily *Nsukuzonke*	Weekly *Masonto onke*	Monthly *Nyanga zonke*	Never *azikaze zihlanzwe*

OBJECTIVE: GENERAL SANITATION
INHLOSO: UKUHLANZEKA KWEKHAYA

32. Do you have a toilet on this property? *Ikhona indlu yangasese kulelikhaya ?*

Yes / *yebo*	No / *cha*

33. Do you share a toilet with other households?
Kungabe indlu yangasese niyisebenzisa kanye nomakhelwane na ?

Yes / *yebo*	No / *cha*

34. Does anyone in your household use places other than the toilet to relieve themselves?
Ukhona osebenzisa enye indawo ngaphandle kwendlu yangasese uma efuna ukuzikhulula ?

Yard of dwelling *Ibala lomuzi*	Nearby bush *ehlathini eliseduze*	river bank *umsebe womfula*

35. Where is the childs' (≤2) faeces disposed of?
Amakaka ezingane ezineminyaka engaphansi kweminyaka emibili atshtingwa kuphi ?

Child goes without a nappy, so don't know. *Ingane ayiliggoki inabukeni, angazi*	Pit *umgodi*	Toilet *endlini yangasese*	Outside yard *ngaphandle komuzi*	Other *Okunye*

36. Where does your household dispose of its refuge?
Utshingwa kuphi udoti kulelikhaya ?

Own Pit *Emgodini wekhaya*	Communal pit *Emgodini womphakathi*	No specific place *Ayikho indawo ecacile lapho utshingwa khona*	River banks *Emsebeni womfula*	Burn it *Uyashiswa*

37. How does your family purify its water for drinking? *Niwahlanza kanjani amanzi okuphuza?*

Boil / *Bilisa*	JIK / *Ujikhi*	Tablets / *Amaphilisi*	None / *Lutho*	Other / *Okunye*

38. What activities do your household members conduct in the river? *Yiziphi izinto enizenza emfuleni?*

Washing clothes *Ukuhlanza izingubo*	fishing *ukudoba*	swimming *ukubhukuda*	religious ceremonies *ukubhabhadisa*	bathing *ukugeza*	washing car *ukuhlanza imoto*	other *okunye*

39. Who swims in the river? *Obani ababhukuda emfuleni?*

children males *Izingane zabafana*	children female *Izingane zamantombazane*	adult male *Abesilisa*	adult female *Abesifazane*

40. Rank in order from 1to 4 the most common use of spare time by school children after school finishes each day:
Sebenzisa izinombolo kusukela ku 1 kuya ku 4 ukuhlela indlela izingane zesikole ezisebenzisa ngayo isikhathi emuva kwesikole:

Activity *Umsebenzi*	**Rank** *Izinga/ Inombolo yohlelo*
Doing their homework *Zenza umsebenzi wesikole*	
Watching television *Zibukela umabonakude*	
Fetching water from the river, communal tap, spring *Ziyokha amanzi emfuleni, empompini womphakathi, esiphethwini*	
Visiting friends *Zivakashela abangani*	

41. Do the cattle drink water on your property? *Ingabe izinkomo ziyawaphuza amanzi emzini wakho?*

Sometimes *Kwesinye isikhathi*	Always *Njalo*	Never *Azikaze*

42. Where do they drink from? *Ziwaphuzaphi amanzi ?*

Tap *empompini*	water ontainer *esitsheni samanzi*	water puddles *Izincibi zamanzi*	rainwater tank *ethankini lamanzi emvula*	container specific for animal *isitsha sokuphuzela izilwane*

43. When it rains, does your toilet overflow? *Uma lina i-toilet liyachichima ?*

Yes / *yebo*	No / *cha*

OBJECTIVE : ENVIRONMENTAL CONSIDERATIONS
INHLOSO: OKUPHATHELENE NENDAWO

44. Do you have any of the following problems in or around the house?
Unazo yini lezinkinga endlini nangaphandle ?

Rats *Amagundane*	Mosquito *ominyane*	ants *izintuthwane*	flies *izimpukane*	cockroaches *amaphela*
Dumping rubbish *ukuchithwa kukadoti noma ikuphi*	Waste water *amanzi angcolile*	Animal waste *ukungcola kwezilwane*	Other *okunye*	

<u>OBJECTIVE: PROCEDURE IN FOOD PREPERATION</u>
<u>INHLOSO : INDLELA YOKULUNGISA UKUDLA</u>

45. Where is cooked food stored? *Kubekwaphi ukudla okuphekiwe ?*

On a plate *epuletini*	in a pot *ebhodweni*	in a fridge *efrijini*	on a table *etafuleni*

46. Where is raw food stored? *Kubekwaphi ukudla okungakaphekwa ?*

In a cupboard *ekhabethweni*	in a vegetable rack *esitsheni semifino*	in a fridge *efrijini*	in another room *kwenye indlu*
in the dishes *ezitsheni*	in buckets *emabhakedeni*	in the trunk *ethilankini*	

47. What is used to cook food? *Nisebenzisani ukupheka ukudla ?*

fire -dung *ubulongo*	Fire - wood *izinkuni*	gas stove *isitofu segesi*	electric stove *isitofu sikagesi*
paraffin stove *isitofu sikaphalafini*	other *okunye*		

48. If fire, how available is the fuel? *Uma kuyizinkuni, zitholakala kanjani?*

Scarce / *Ziyindlala*	Moderate / *Zikhonyana*	Highly / *Ziningi*

49. Do you use hot water to wash your dishes? *Niyawasebenzisa amanzi ashisayo ukuwasha izitsha ?*

Yes /*Yebo*	No /*Cha*	Sometimes / *Kwesinye isikhathi*	Always *Njalo*

50. List **3** advantages of having tap water within 200m of your homestead?
Yisho izinto ezi 3 ezinhle ngokuba namanzi ompompi ebangeni elinga 200m nekhaya lakho.

----

51. List **3** disadvantages of having tap water within 200m of your homestead?
Yisho izinto ezi 3 ezimbi ngokuba namanzi ompompi ebangeni elinga 200m nekhaya lakho.

----

52. What does your community need to improve its health of all its members?
Yini umphakathi oyidingayo ekwenzeni ngcono izinpilo zawo ?

---

53. What are the **3** worst problems facing your community?
Yiziphi izinkinga ezinzima ezintathu ezibhekekene nomphakathi ?

APPENDIX 1b

Household Questionnaires

<u>GENERAL QUESTIONNAIRE: SURVEY 5</u>

<u>An Evaluation of the Impact of RDP levels of Water Supply on Community and Environmental Health.</u>

<u>Ucwaningo ngohlelo lokufakwa kwamanzi yiRDP ezimpilweni zabantu.</u>

Questionnaire No:
Inombolo :
Area/Location :
Indawo :
Reservoir Zone # :
Date :
Usuku :
Interviewer :
Umcwaningi :
HOUSE NUMBER:
INOMBOLO YENDLU :

1 per sample unit.
Sample unit = 1 fenced lot.

The purpose of this study is :
Inhloso yocwaningo :

- to establish the incidence of illness amongst children under 5 that may be related to water in Vulindlela (Diarrhoea, Scabies, Bilharzia, Dysentery and Hepatitis).
- *ukubhekela ukudlanga kwesifo sohudo, isichenene kanye nezinye izifo ezingadalwa amanzi ezinganeni ezineminyaka engaphansi kwemihlanu zasemphakathini waseVulindlela.*
- to explore the possible risk factors associated with water borne diseases
- *ukuthola izinto ezinobungozi obuhambelana nezifo ezidalwa amanzi*
- to evaluate the impact of the Vulindlela Water Supply Scheme on the Health of the community.
- *ukubhekisisa umthelela wamanzi ezimpilweni zabantu baseVulindlela.*
- to contribute toward the definition of criteria for future Umgeni Water Health Impact Assessment
- *ukufaka isandla ohlelweni lwaseMgeni oluzobhekela umthelela wamanzi ezimpilweni zomphakathini esikhathini esizayo.*

<u>Definition</u>
Diarrhoea: Three or more loose/ liquid/ watery stools or any number of loose stools containing blood in a 24-hour period (Baqui AH *et al*; 1991).
Isifo sohudo: Uhudo olunamanzi noma igazi olwenzeka izikhathi ezingaphezulu kwezintathu ngosuku olulodwa.

1. Name of respondent:……………………………………………………………………………………
   Igama lophendulayo: ……………………………………………………………………………………

2. Number of children aged 0-5yrs living in the house
   Inani lezingane ezineminyaka emihlanu nengaphansi ezihlala kulelikhaya

………………………………

3. Relationship of respondent to head of household…………………………………………………
   Ubuhlobo nenhloko yekhaya:

……………………………………………………………………………………………

OBJECTIVE: HOMESTEAD DESCRIPTIONS
INHLOSO: INCAZELO NGEKHAYA

4. Number of people living in this dwelling for four consecutive days per week?
Inani labantu abahlala kulelikhaya okungenani izinsuku ezine esontweni?

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20

5. Did any of your family members suffer from diarrhoea during the last **2 weeks**?
Ingabe likhona yini ilunga lomndeni elike laphathwa isifo sohudo ***emasontweni amabili edlule*** *?*

yes / *yebo*	no /*cha*

6. Description of people living in this dwelling. *Incazelo ngabantu abahlala kulelikhaya.*

Sex: Male = M; Female = F ***Ubulili:*** *Abesilisa = M; Abesifazane = F*

Relation to head of house: Self = 1; Spouse = 2; Child = 3; Sibling = 4; Parent = 5; Grandchild = 6; Grandparent = 7; Other = 8
Ubuhlobo nenhloko yekhaya*: Umninimuzi=1; Unkosikazi=2; Ingane=3; Isihlobo=4; Umzali=5; Umzukulu=6 Ugogo/Umkhulu = 7; Okunye = 8………………………………*

Employment status: Housewife = 1; Preschool = 2; School/Tertiary = 3; Pensioner = 4; Permanent Employed = 5; Casual Employed = 6; Self-employed formal = 7; Self employed hawking = 8; Unemployed = 9
Isimo ngokomsebenzi: *Umgcini wekhaya = 1; Inkulisa=2; Isikole=3; Uhola impesheni=4; Usebenza ngokugcwele=5; Usebenza itoho = 6; Uyazisebenza ngokugcwele = 7; Uyazisebenza ngokudayisa = 8; Akasebenzi = 9.*

Place of work: Home = 1; Vulindlela = 2; outside Vulindlela = 3
Indawo Yokusebenza : *Ekhaya=1; Vulindlela=2; ngaphandle kwaseVulindlela*

Place of school: Local community = 1; Vulindlela = 2; Other = 3
Ufundaphi : *Eduze kwasekhaya=1; Vulindlela=2; Other=3*

7. Does this household have any migrant laborers?
Ingabe bakhona abasebenza bangabuyi layikhaya?

Yes *Yebo*	No *Cha*

Vulindlela Questionnaire Survey 5

Name of household member *Igama lelunga lomndeni*									
Age ***Iminyaka yobudala***									
Sex / Gender *Ubulili*									
Relation to head of home. *Ubuhlobo nomninimuzi*									
Does your child attend a creche? Name? *Ingabe ingane iyaya enkulisa? Igama?*									
Formal education (highest std passed) *Ibanga eliphezulu eliphasiwe*									
Place of school *Ufundaphi*									
Employment status *Isimo ngokomsebenzi*									
Occupation *Umsebenzi owenzayo*									
Place of work *Indawo yomsebenzi*									
Financial household contribution in last month *Imali ekhishwe amalulnga omndeni ngenyanga edlule*									
Had diarrhoea in the last **2 weeks** *Ube nesifo sohudo* ***emasontweni amabili*** *edlule*									

8. Which of the following symptoms have people in your home experienced in the last **2** weeks?
   Yiziphi izimpawu kulezi ezilandelayo umndeni osuke wahlangabezana nazo emasontweni ama 2 adlule ?

a. Adults (≥ 6yrs) suffered from any of the diseases
a. Abadala (abaneminyaka eyisithupha nangaphezulu) abanalesisifo

Symptom / *Izimpawu*	No persons suffering *Inani labantu abanalesisifo*	No clinic visits *Uye kangaki emtholampilo*
stomach pain *isisu esibuhlungu*		
bloody diarrhoea *uhudo olunegazi*		
watery diarrhoea *uhudo olungamanzi*		
bloody urine *umchamo onegazi*		
itching hair/body. *ukuluma komzimba / nezinwele*		
back pain *ubuhlungu beqolo*		
tever *umkhuhlane*		
Eye infection *amehlo abuhlungu*		
scabies *utwayi*		
headache *ikhanda elibuhlungu*		

b. Children (0 - 5 yrs) suffered from any of the diseases
b. Izingane (0-5 iminyaka) ezinalesisifo

Symptom / *Izimpawu*	No persons suffering *Inani labantu abanalesisifo*	No clinic visits *Uye kangaki emtholampilo*
stomach pain *isisu esibuhlungu*		
bloody diarrhoea *uhudo olunegazi*		
watery diarrhoea *uhudo olungamanzi*		
bloody urine *umchamo onegazi*		
itching hair/body. *Ukuluma komzimba / nezinwele*		
back pain *ubuhlungu beqolo*		
fever *umkhuhlane*		
eye infection *amehlo abuhlungu*		
scabies *utwayi*		
headache *ikhanda elibuhlungu*		

9. What is the method of feeding for children under 5 in this homestead?
Iyiphi indlela esetshenziswayo yokupha izingane ezineminyaka engaphansi kwemi5 ukudla ?

Child *Ingane*	Breast only *Ibele lodwa*	breast & bottle *Ibele nebhodlela*	bottle only *Ibhodlela lodwa*	solids *Ukudla okuqinile*	breast & solids *Ibele nokudla okuqinile*	breast & bottle and solids *Ibele nebhodlela nokudla okuqinile*	bottle & solids *Ibhodlela nokudla okuqinile*
A							
B							
C							
D							
E							

10a. When last did you visit a traditional healer ?
Ugcine nini ukuya kumthandazi, enyangeni noma esangomeni?

....

10b. What was the problem? 10 *b. Wawunani ?*

....

OBJECTIVE: WATER SUPPLY
INHLOSO: UKUTHOLWA KWAMANZI

11. Where do you currently get your water from? Use the last column to rank the source you use most often.
Niwathathaphi amanzi ? Sebenzisa isikhala esisekugcineni ukusho lapho enljwayele ukukha khona amanzi.

Source of water ***Imvelaphi yamanzi***	**Yes** ***Yebo***	**No** ***Cha***	**Rank** ***Izinga***
Old Tap in house *Umpompi endlini*			
Old Tap in garden *Umpompi engadini*			
*Communal Tap *Umpompi womphakathi*			
*River *Umufula*			
Rain Tank *Ethangini lamanzi emvula*			
*Unprotected spring *Umthombo/ Isiphethu esingavikelwe*			
*Protected spring *Umthombo/ Isiphethu esivikelwe*			
*Bore-hole *Ipitsi*			
*Dam *Idamu*			
Tanker *Ithangi*			
New Umgeni Water Tap *Umpompi waseMgeni*			

Daily = 1; Occasionally = 2; Never = 3 *Nsukuzonke = 1; Kuqabukela = 2; Akukaze = 3*

12. Which of the following water uses are more common in your household?
Ikuphi kulokhu okulandelayo okuvamise ukusetshenziselwa amanzi ekhaya ?

Activity ***Ukusetshenziswa kwamanzi***	**Rank** ***Izinga***
Washing hands *Ukuwasha izandla*	
Drinking *Ukuphuza*	
Preparing juices *Ukwenza iziphuzo*	
Preparation of milk formulaes for babies *Ukwenza ubisi lwezingane*	
Washing nappies *Ukuwasha amanabukeni*	
Washing clothes *Ukuwasha izingubo*	
Stock Watering *Ukunika imfuyo*	
Bathing *Ukugeza*	
Watering garden *Ukuchelela ingadi*	

Daily = 1; Occasionally = 2; Never = 3 *Nsukuzonke = 1;Kuqabukela = 2;Akukaze = 3*

13. If using an old garden or house tap: *Uma kuwumpompi, wasengadini, noma wasendlini:*

Where does the water that comes out of your tap come from? *Ingabe lamanzi asempompini asukaphi?*

River *Umfula*	Spring *Umthombo/ Isiphethu*	Bore-hole *Ipitshi*	Rain tank *Ithangi lemvula*	Do not know *Angazi*

14. Which of the following problems have you experienced with your old tap in the past?
Yiziphi izinkinga kwezilandelayo oke wahlangabezana nazo kumpompi wakho omdala?

Problem/ *Inkinga*	**Sometimes** *Kwesinye isikhathi*	**A lot** ***Kakhulu***	**Never** ***Akukaze***
Irregular flow daily *Awaphumi kahle nsukuzonke*			
Irregular flow in winter *Awaphumi kahle ebusika*			
Dirty water *Amanzi angcolile*			
Broken tap *Ukuphuka kompompi*			

15. Will you continue using this tap once you have an Umgeni tap?
Uzoqhubeka uwusebenzise umpompi omdala uma usunowaseMgeni?

Yes *Yebo*	No *Cha*

16. Which of the following will you/ do you use the water from the old tap for?
Iziphi izinto ozisebenzisela umpompi omdala kulezi ezilandelayo?

	Sometimes *Kwesinye isikhathi*	**Always** *Njalo*	**Never** *Akukaze*
Washing Clothes *Ukuwasha izingubo*			
Washing Dishes *Ukuwasha izitsha*			
Bathing *Ukugeza*			
Neighbours will use it *Izosetshenziswa omakhelwane*			
Watering garden *Ukuchelela ingadi*			

17a. Do you have an Umgeni Water connection? *Unawo amanzi aseMgeni?*

Yes *Yebo*	No *Cha*

17b. When was your Umgeni Water connection installed? *Wawafakelwa nini amanzi aseMgeni?*

< week *< kwesonto*	7 - 13 days *izinsuku eziyi 7-13*	2 - 3 weeks *amasonto ama 2 - 3*	> 3 weeks *>kwamasonto amathathu*

17c. Have you have any cut - offs in the last 2 weeks? *Ake angamuka amanzi emasontweni amabili adlule?*

Yes *Yebo*	No *Cha*

17d. How many cut - offs did you have in the last 2 weeks?
Angamuke kangaki amanzi emasontweni amabili adlule?

Everyday *Nsukuzonke*	2 -3 times a week *2 - 3 ngesonto*	once a week *kanye ngesonto*

17e. What was your longest cut off? *Yisikhathi esingakanani esaba side kakhulu engamukile?*

< 1 hour *< kwehora*	1- 6 hours *amahora ayi 1- 6*	7 - 12 hours *amahora ayi 7-12*	13 - 24 hours *amahora ayi 13-24*	> 1 day *> kosuku*

18. Why have you applied for Umgeni Water water? *Yini eyakwenza wafaka isicelo samanzi aseMgeni?*

....

....

20a. Do you think that there should be communal standpipes for those people who cannot afford a household connection on the new Umgeni Water Supply Scheme?
Ingabe ucabanga ukuthi kufanele kube nompompi abakhelwa abantu abangakwazi ukufaka amanzi aseMgeni?

Yes *Yebo*	No *Cha*

20b. If **no**, why not. *Kungani kungafanele?*

----

19. What activities have you used your Umgeni tap water for since your connection
Amanzi aseMgeni uwasebenzisa kuziphi izinto?

Activity/ Umsebenzi	**Rank/ *Izinga***
Cooking/ *Ukupheka*	
Washing clothes/ *Ukuhlanza izingubo*	
Bathing/ *Ukugeza*	
Washing dishes/ *Ukuhlanza izitsha*	
Drinking/ *Ukuphuza*	
Watering cattle/ *Ukuphuzisa izinkomo*	
Ceremonies/ *Imicimbi*	
Crop watering/ *Ukunisela izitshalo*	
Selling/ *Ukuwadayisa*	
Household maintenance *Ukugcinwa kwekhaya*	
Building/ Repairing houses *Ukwakha/ ukulungisa izindlu*	
Fire fighting / *Ukucisha umlilo*	

Daily = 1, Occasionally = 2, Never = 3 *Nsukuzonke = 1, Kugabukela = 2, Akukaze = 3*

OBJECTIVE: WATER STORAGE
INHLOSO: UKULONDOLOZWA KWAMANZI

21. How often do you collect water? *Uwakha kangaki amanzi ?*

Daily *Nsukuzonke*	2 days *Emuva kwezinsuku ezimbile*	3 days *Emuva kwezinsuku ezintathu*	4 days *Emuva kwezinsuku ezine*	5 days *Emuva kwezinsuku ezinhlanu*	6 days *Emuva kwezinsuku eziyisithupha*	weekly *Njalo NgeSonto*

22. How many times a day is water collected for the household? *Amanzi akhiwa kangaki ngosuku ekhaya ?*

1 time *kanye*	2 times *kabili*	3 times *kathathu*	4 times *kane*	5 times *kahlanu*

23. How long does one trip take you to collect water? ....
Kuthatha isikhathi esingakanani ukuya kanye uyokha amanzi ?.........

24. How much water do you collect at one time? *Ukha amanzi angakanani ngesikhathi ?*

<25L	25 L	50L	50-100L	> 100L

25. Which of the following would best describe your kitchen water storage facility
Unezitsha ezingakanani zokulondoloza amanzi?

Container number size/ *Inombolo yesitsha*	1	2	3	4
5L				
10L				
20L				
25 L				
50 L				
75 L				
100 L				
Estimated total water storage volume = *Isilinganisa somthamo wamanzi alondoloziwe esewonke =*				

26. How often do your water containers get cleaned? *Zihlanzwa kangaki izitsha zamanzi ?*

Daily *Nsukuzonke*	Weekly *Masonto onke*	Monthly *Nyanga zonke*	Never *azikaze zihlanzwe*

27. When last were your water storage containers cleaned?
Ugcine nini ukuhlanza izitsha zokulondoloza amanzi?

....

28. How and with what did you clean them? *Uzihlanza ngani?*

....

OBJECTIVE : WASTE WATER DISPOSAL
INHLOSO : UKUCHITHWA KWAMANZI ANGCOLILE

29. Where do you dispose of waste water after washing clothes?
Uwachithaphi amanzi emuva kokuhlanza izingubo?

Vegetable garden *Engadini yezitshalo*	drainage channel *Emseleni wamanzi*	no specific space *Ayikho indawo ecacile lapho echithwa khona*	outside homestead *Ngaphandle komuzi*

30. Where do you dispose of waste water after washing dishes?
Uwachithaphi amanzi emuva kokuhlanza izitsha?

Vegetable garden *Engadini yezitshalo*	drainage channel *Emseleni wamanzi*	no specific space *Ayikho indawo ecacile lapho echithwa khona*	outside homestead *Ngaphandle komuzi*

31. Is waste water disposed of in the same place every time ?
Ingabe amanzi achithwa endaweni efanayo/ eyodwa njalo?

Yes *Yebo*	No *Cha*

32. Now that you have UW where are you going to install a tap in the next year:
Ngoba manje usunamanzi aseMgeni uzowufaka kuphi nendawo umpompi?

Location/ *Indawo*	**Yes /*Yebo***	**No / *Cha***
Garden/ *Engadini*		
Kitchen sink *Endaweni yokuwasha izitsha esekhishini*		
Bathroom basin/ *Esitsheni sokugezela izandla*		
Bathroom bath / *Esitsheni sokugezela*		
Flush toilet/ *Endlini yangasese*		

33. If yes to toilet, where will the outlet from the toilet be directed?
Uma kusendlini yangasese, kuzophumela kuphi ukungcola?

Garden *Engadini*	outside of homestead *ngaphandle komuzi*	stream *emseleni*	septic tank *Ithangi lokuthululela indle*
do not know *angazi*	informal (homemade) septic tank *Umgodi wokuzenzela ekhaya*		

34. Since you have been using your Umgeni Water tap has there been an increase in waste water on your property?
Ingabe kukhona ukwenyuka kwezinga lamanzi achithekayo selokhu wasesebenzisa umpompi aseMgeni?

Yes *Yebo*	No *Cha*

35. Which of the following problems have you experienced with your Umgeni Water tap in the past?
Iziphi ezalezizinkinga oke uhlangabezana nazo ngompompi wakho waseMgeni?

Problem/ *Inkinga*	**Sometimes?** ***Ngesinye isikhathi***	***A lot kakhulu***	**Never** ***Akukaze***
Irregular flow daily *Ukungaphumi kwamanzi njalo*			
No Flow/ *Ukungaphumi kwamanzi*			
Irregular flow in winter *Ukungaphumi kahle kwamanzi ebusika*			
Dirty water *Amanzi agcolile*			
Broken tap *Ukuphuka kompompi*			
Tap always dripping *Umpompi ohlale uconsa*			

36. Who will you contact if you have a problem with your water flow/ supply?
Ubani ongaxhumana naye uma unezinkinga ngokuphuma kwamanzi?

....

<u>OBJECTIVE: GENERAL SANITATION</u>
<u>*INHLOSO: UKUHLANZEKA KWEKHAYA*</u>

37. Where does your household dispose of its refuge?
Utshingwa kuphi udoti kulelikhaya ?

Own Pit *Emgodini wekhaya*	Communal pit *Emgodini womphakathi*	No specific place *Ayikho indawo ecacile lapho utshingwa khona*	River banks *Emsebeni womfula*	Burn it *Uyashiswa*	Drum *Idilamu*

38. How does your family purify its drinking water? *Niwahlanza kanjani amanzi okuphuza?*

Boil *Bilisa*	JIK *Ujikhi*	Tablets *Amaphilisi*	None *Lutho*	Other *Okunye*

39. If Jik / tablets, did you purify the water in your storage container within the last day?
Uma kuwu Jik noma amaphilisi, uwahlanzile amanzi asesitsheni sokulondoloza izolo?

Yes *Yebo*	No *Cha*

40. Rank in order from 1 to 5 the most common use of spare time by school children after school finishes each day:
Sebenzisa izinombolo kusukela ku 1 kuya ku 5 ukuhlela indlela izingane zesikole ezisebenzisa ngayo isikhathi emuva kwesikole:

Activity *Umsebenzi*	**Rank *Izinga/ Inombolo yohlelo***
Doing their homework *Zenza umsebenzi wesikole*	
Watching television *Zibukela umabonakude*	

Fetching water from the river, communal tap, spring *Ziyokha amanzi emfuleni, empompini womphakathi, esiphethwini*	
Visiting friends *Zivakashela abangani*	
Other *Okunye*	

41. Do the cattle drink water on your property?
Ingabe izinkomo ziyawaphuza amanzi emzini wakho?

Sometimes *Kwesinye isikhathi*	Always *Njalo*	Never *Azikaze*

42. Where do they drink from? *Ziwaphuzaphi amanzi ?*

Tap *empompini*	water container *esitsheni samanzi*	water puddles *ezichibini zamanzi*	rainwater tank *ethankini lamanzi emvula*	container specific for animal *esitsheni sokuphuzela izilwane*

OBJECTIVE : ENVIRONMENTAL CONSIDERATIONS
INHLOSO: OKUPHATHELENE NENDAWO

43. Do you have any of the following problems in or around the house?
Unazo yini lezinkinga endlini nangaphandle ?

Rats *Amagundane*	Mosquito *omiyane*	ants *izintuthwane*	flies *izimpukane*	cockroaches *amaphela*
Dumping rubbish *ukuchithwa kukadoti noma ikuphi*	Waste water *amanzi angcolile*		Animal waste *ukungcola kwezilwane*	Other *okunye*

44. List 3 advantages of having Umgeni tap water within 200m of your homestead?
Yisho izinto ezi 3 ezinhle ngokuba namanzi ompompi waseMgeni ebangeni elinga 200m nekhaya lakho.

----

45. List 3 disadvantages of having Umgeni tap water within 200m of your homestead?
Yisho izinto ezi 3 ezimbi ngokuba namanzi ompompi waseMgeni ebangeni elinga 200m nekhaya lakho

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46. Do you have any concerns/ worries regarding the Umgeni Water Supply Scheme?
Ingabe unezikhalo/ nemibono mayelana nohlelo lokufakelwa kwamanzi lwaseMgeni?

....

....

....

APPENDIX 1c

Household Questionnaires

VULINDLELA OBSERVATIONAL QUESTIONNAIRE

A. HOUSEHOLD DESCRIPTION

GPS Fix: ……………………………

1. Type of dwelling

Cement blocks	wattle & daub	tin	shack	other

2. Household structures

Kraal	fence	outside rooms	vegetable garden	pit	toilet

3. Has the vegetable garden been maintained

Yes	No

4. Rainwater tank

Present	Absent

5. Is the tank

Open	Closed
Rusted	Not rusted
Leaking	Not leaking
Clad	
Made of galvanised iron	Steel

6. Is the roof

galvanised iron	painted

7. Gutters

Galvanised	PVC	Absent

8. Are there any water storage containers outside

Yes	No

9. If yes, are they covered or open

Covered	Open

10. Is the house floor made of dung

Yes	No

B. ANIMALS

11. Presence of animals

cattle	goats	chicken	dogs	other

12. Are any of the animals drinking from containers/ taps/ buckets/ puddles of water on the property

Yes	No

13. Do the cattle defecate on the property

Yes	No

SANITATION

14. Distance of toilet from homestead

50m	100m	150m	200m	250m

15. Position of toilet from homestead

Up-slope	Down-slope	Level

16. Toilet description

pit	VIP	*Phungalutho*	*nothing*

17. Does the toilet smell

Yes	No

18. Are there flies around the toilets

Yes	No

19. Presence of faeces

yard of dwelling	nearby bushes	near water collection point

WATER SOURCE

20. What are the nearby water sources

river	dam	protected spring	unprotected spring	bore-hole

21. Activities usually carried out in the river by members of the household

Swimming	washing clothes	bathing	fishing	washing car	religious ceremonies

22. Cattle presence at water source

Yes	No

23. Distance between the above water collection points and the house.

Source of water	0-100m	101-200m	201-500m	>500m
Communal Tap				
River				
Rain Tank				
Unprotected spring				
Protected spring				
Bore-hole				
Dam				
Water Tanker				

WATER STORAGE CONTAINER

24. What shape are the water containers

Battery shaped narrow opening	drum shaped wide opening	drum shaped narrow opening	Bucket shaped wide opening	Other

25. What size are the water containers

25L	>25L

GENERAL HYGIENE

26. Soap and water for washing hands

Present	Absent

27. Dirty dishes

Present	Absent

28. Left over food lying around

Present	Absent

WATER INFRASTRUCTURE.

29. Is there a tap on the household property?

yes	no

30. Identify the source of water coming through the household tap.

new Vulindlela reservoir	old reservoir	Spring	Borehole	River

31. Identify if any of the following health hazards apply to the household tap if present (elaborate in space provided if necessary):

Broken infrastructure	inappropriate position	poor access route (steep slope etc.)	No provision for waste water drainage	Inadequate rate of flow

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32. Waste water control.

Directed to garden	directed off property	no control.ponding seen	no waste water seen

33. Does the household have access to and use a communal tap?

yes	no

34. Identify if any of the following health hazards apply to the communal tap if used (elaborate in space provided if necessary):

Long waiting periods queues)	Broken tap	Tap dripping/ flowing	Inappropriate tap height	Poor water taste	Bad water odour
Broken standpipe	inappropriat e position	poor access route (steep slope etc.)	No provision for waste water drainage	Potential water contamination by animals, i.e. not fenced	Inadequate rate of flow

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APPENDIX 2
Water Quality Data

Figure 1 : Mthoqotho. Water Quality Results - Survey 1.

Mthoqoto	S*	Temp	pH	Coliforms	E. coli	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l $CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.010	0.01		
Jan-99																							
24098S1	AS			90	40	8	2.72	6.35	21.92	3.6	3.1	0.1	0.01	1.04	4.95	<0.1		<0.05	<0.03	<0.001	<0.002		
24098HC				1340	290	14													0.12	<0.001			√
24098S	AS			11	0	3	0.15	5.62	12.00	1.8	1.8	0.06	0.02	3.61	5.76	<0.1		<0.06	0.4	<0.001			
24098HC				1340	290	14																	√
23726S	AS			1170	288	>1000	4.18	5.62	13.80	2	2.1	0.08	0.02	3.58	5.68	<0.1		0.07	<0.03	<0.001			
23726HC				980	194	7																	
24070S	AS			1170	288	>1000	4.18	5.62	13.80	2	2.1	0.08	0.02	3.58	5.88	<0.1		0.07	<0.03	<0.001			
24070HC				48	12	2																	
24006S	AS			18	5	3	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		
24006HC				64	15	13																	
24134S	AS			90	40	8	2.72	6.35	21.90	3.6	3.1	0.1	0.01	1.04	4.95	<0.1		<0.05	<0.03	<0.001	<0.002		
24134HC				1260	4	12																	
23705S	AS	20.7	5.55	20	4	0	1.28	6.06	14.80	1.2	2.1	0.04	0.09	3.87	5.74	<0.1	0.9	0.08	0.04	<0.001			
23705HC				670	150	0																	
32053S	AS	23	6.53	42	18	10	0.47	4.52	12.30	1.9	1.8	0.02	<0.01	0.49	4.75	<0.1	0.28	0.06	<0.03	<0.001			
32053HC				34	2	24																	√
24464S	AS	22.5	5.82	36	6	14	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		
24464HC				14000	3100	0																	
24099S	AS	21.2	5.92	6	6	0	0.24	5.61	12.60	1.9	1.9	0.03	0.02	3.66	5.24	<0.1	0.29	0.1	<0.03	<0.001			
24099HC				24	8	2																	√
32055S	AS			6	6	0	0.24	5.61	12.60	1.9	1.9	0.03	0.02	3.66	5.24	<0.1	0.29	0.1	<0.03	<0.001			
32055HC				90	50	16																	
24146S	AS			18	5	3	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		
24146HC				380	130	2																	
24143S	AS			1170	288	>1000	4.18	5.62	13.80	2	2.1	0.08	0.02	3.58	5.68	<0.1		0.07	<0.03	<0.001			
24143HC				28000	1500	40																	√
24001S	AS			1170	288	>1000	4.18	5.62	13.80	2	2.1	0.08	0.02	3.58	5.68	<0.1		0.07	<0.03	<0.001			
24001HC				2	2	0																	√
24135S	AS			18	5	3	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		

Figure cont. 1 : Mthoqotho. Water Quality Results - Survey 1.

Mthoqolo	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lCaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.010	0.01		
24135HC				840	470	114																	
24010S	AS			18	5	3	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		
24010HC				1100	48	8																	
24015S	AS	24.7		21000	700	2	0.27	5.4	12.33	1.6	2	0.02	0.02	3.72	7.56	<0.1		<0.05	<0.03	<0.001	<0.002		
24015HC				40	0	0																	
24121S	AS	26.2	6.27	740	510	130	3.4		7.17	1.2	<1.0	0.1	0.04					<0.05	0.34	0.002			
24121HC				17000	900	4																	
24133S	AS	25.4	5.81	0	0	2	0.34	5.42	12.33	1.6	2	0.04	0.02	3.67	7.5	<0.1		<0.05	0.03	<0.001	<0.002		
24133HC				16	2	2																	
23741S	AS	30.6	6.5	10	2	0	2.95	4.26	9.92	2.3	<1.0	0.2	0.01	0.28	8.45	<0.1		<0.05	0.47	<0.001	<0.002		
23741HC				5800	2400	2																	
24020S	AS			18	5	3	0.5	5.51	12.40	1.8	1.9	0.02	0.02	3.76	5.69	<0.1		<0.05	0.07	<0.001	<0.002		
24020HC				26	12	4																	
32059S	AS			4	4		0.34	5.42	12.33	1.6	2	0.04	0.02	3.67	7.5	<0.1		<0.05	0.03	<0.001	<0.002		
32059HC				630	64																		
24053S	AS			4	4		0.34	5.42	12.33	1.6	2	0.04	0.02	3.67	7.5	<0.1		<0.05	0.03	<0.001	<0.002		
24053HC				1070	520																		√
23736S	AS	23.9	7.14	220	156		16.5	2.14	23.00	3.2	3.8	0.19	0.01	0.82	7.14	<0.1	2.76	<0.05	0.53	<0.001	<0.002		
23736HC				74	10 .																		√
32052S	AS	22.4	6.62	820	148		7.58	7.31	20.50	3.7	2.7	0.16	0.01	0.99	6.83	<0.1	3.25	<0.05	<0.03	<0.001	<0.002		
32052HC				5400	5400																		
33507S	AS	no sample																				ns	
33507HC				360	24																		√

Figure2 : Mthoqotho. Water Quality Results - Survey 2.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l			per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std						0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
May-99																									
24098S	AS²	17	6.9			132	18	4	0.18	5.42	12.17	1.7	1.9	<0.02	0.02	3.98	6.45	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24098HC						14	0	2																	√
23726S		18.7	6.3			118	18	2	0.17	5.31	14.08	1.8	2.3	<0.02	0.02	3.99	6.45	<0.18	<100	<0.05	<0.03	<0.001	<0.002		
23726HC						50	0	2																	√
24070S				0.05	0.05	0	0	0	0.54	9.6	33.67	9.3	2.5	0.03	<0.01	0.32	8.86	<0.1	1.49	<0.05	0.03	<0.001	<0.002		
24070HC	no sample																							ns	
24006S	AS	18.7	6.1			480	252	4	0.27	5.41						3.4	5.86	<0.1	0.09				<0.002		
24006HC						36	14	12																	
24134S	AS					156	156	0	0.14	20.9	12.58	1.7	2	<0.02	0.02	3.42	5.97	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24134HC						0	0	6																	
23705S	AS								0.18	20.3	10.83	1	2	<0.02	0.11	3.61	5.82	<0.1	0.47	<0.05	<0.03	<0.001	<0.002		
23705HC						11800	6800	0																	
32053S	AS²	no sample																						ns	
32053HC						120	10	26																	
24464S	AS²	17.8	6.7			60	2	0	0.18	20.5	13.00	1.7	2.1	<0.02	0.02	3.36	5.98	<0.1	0.15	<0.05	<0.03	<0.001	<0.002		
24464HC						150	24	2																	√
24099S	AS	19.5	6.5			34	0	0	0.14	20.5	13.00	1.7	2.1	<0.02	0.02	3.55	5.91	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24099HC						156	44	8																	√
32055S	AS	19.5	6.5			34	0	0	0.14	20.5	13.00	1.7	2.1	<0.02	0.02	3.35	5.91	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
32055HC						2900	218	132																	√
24146S	AS	17.8	6.7			60	2	0	0.18	20.5	13.00	1.7	2.1	<0.02	0.02	3.36	5.98	<0.1	0.15	<0.05	<0.03	<0.001	<0.002		
24146HC						2	0	0																	√
24143S		19.8	7.6	0.05	0.05				0.37	9.61	19.92	3.8	2.5	0.02	<0.01	0.3	8.93	<0.1	1.69	<0.05	0.05	<0.001	<0.002		

HD*: Household Diarrhoea present
OA: Overall assessment
HC: Household Container
S: Source
AS: Alternate Source (pre-supply)

Figure 2 cont. : Mthoqotho. Water Quality Results - Survey 2.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l			per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l $CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std						0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
24143HC						72	0	2																	
24001S	AS	17	6.9			168	18	0	0.15	5.78	13.25	1.8	2.1	<0.02	0.02	3.47	6.12	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24001HC						96	56	10																	
24135S	AS	17.7	6.7			156	156	0	0.14	20.9	12.58	1.7	2	<0.02	0.02	3.42	5.97	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24135HC						2000	58	4																	
24010S	AS	19.8	8.8			0	0	0	0.32	9.62	35.92	10.2	2.5	<0.02	<0.01	0.33	8.87	<0.1	1.48	<0.05	0.04	<0.001	<0.002		
24010HC		no sample																						ns	
24015S	AS	19	6.5			182	156	0	0.13	5.46	12.58	1.7	2	<0.02	0.01	3.36	5.92	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24015HC						130	86	0																	√
24121S	AS	15.8	6.7			2800	10	176	1.78	2.94	<6.67	<1.0	<1.0	0.05	0.03	0.33	2.03	<0.1	3.61	<0.05	4.3	<0.001	<0.002		
24121HC						10600	4	184																	√
24133S	AS[2]	no sample																						ns	
24133HC						360	102	2																	
23741S		17	6.4			42	4	66	3.24	5.15	17.17	3.2	2.2	0.07	0.01	0.39	3.37	<0.1	0.98	<0.05	<0.03	<0.001	<0.002		
23741HC						960	12	74																	
24020S	AS[2]	17.8	6.7			60	2	0	0.18	20.5	13.00	1.7	2.1	<0.02	0.02	3.36	5.98	<0.1	0.15	<0.05	<0.03	<0.001	<0.002		
24020HC						2900	16	0																	
32059S	AS	18.5	5.6			10	6	72	1.4	5.35						3.69	6.03	<0.1	0.35				<0.002		
32059HC						24	2	2																	
24053S	AS	19.5	6.3			58	10	0	0.15	5.42	12.58	1.7	2	<0.02	0.02	3.49	6.04	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24053HC						236	58	8																	
23735S		20	7.2	0.05	0.05	0	0	0	0.28	9.33	114.58	39	4.1	<0.02	0.15	0.27	9.04	<0.1	1.78	<0.05	<0.03	<0.001	<0.002		
23735HC						28000	1000	74																	
32052S	AS	17.9	6.4			250	192	22	1.17	7.37	20.33	3.8	2.6	0.1	<0.01	1	6.75	<0.1	3.09	<0.05	<0.03	<0.001	<0.002		
32052HC						152	142	132																	
33507S	AS	17	6.4			42	4	66	3.24	5.15	17.17	3.2	2.2	0.07	0.01	0.39	3.37	<0.1	0.98	<0.05	<0.03	<0.001	<0.002		
33507HC						124	8	2																	√

Figure 3 : Mthoqotho. Water Quality Results - Survey 3.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l $CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Jul-99																										
24098S	AS†	no sample																								
24098HC		10.7	7.13			4	0	0																		
23726S		no sample																							ns	
23726HC		18.6	7.92			236	0	0																		
24070S		14.5	6.66	0.2	<0.05	0	0	0	0.35	9.04	31.33	8.2	2.6	0.02	<0.01	0.23	0.23	6.97	<0.1	1.68	<0.05	<0.03	<0.001	<0.002		
24070HC		12.3	8.43			0	0	0																		
24006S		16.2	8.59	<0.1	<0.1	0	0	0		8.86	31.20	8.3	2.5	0.03	<0.01	3.48	3.48	4.63	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
24006HC		20.5	8.41			6	0	0																		
24134S		16.5	8.45	<0.1	<0.1	0	0	0	0.31	8.86	31.40	8.3	2.6	0.02	<0.01	0.23	0.23	7.42	<0.1	1.61	<0.05	<0.03	<0.001	<0.002		
24134HC		17.4	8.03			0	0	2																		
23705S	AS†	17.3	5.38			0	0	6	0.14	5.15	10.30	1	1.9	<0.02	0.1	3.81	3.81	5.45	<0.1	0.46	<0.05	<0.03	<0.001	<0.002		
23705HC		18.4	5.52			14	0	0																		
32053S		17.4	8.4	<0.05	<0.05				0.35	0.78	31.80	8.4	2.8	0.02	<0.01	0.35	0.35	7.2	<0.1	1.7	<0.05	<0.03	<0.001	<0.002		
32053HC		18.3	8.12			48	0	0																		
24464S		15.5	8.38	<0.3	<0.1	0	0	0	0.3	6.8	31.10	8.4	2.6	0.02	<0.01	0.21	0.21	7.35	<0.1	1.63	<0.05	<0.03	<0.001	<0.002		
24464HC		no sample																							ns	
24099S	AS†	no sample																							ns	
24099HC		21.1	8.01			0	0	6																		
32055S	AS†	no sample																							ns	
32055HC						110	0	0																		
24148S		13.9	8.17	<0.1	<0.1	0	0	0	0.34	0.93						0.4	0.4	7.22	<0.1	1.61				<0.002		
24148HC		16	8.26			0	0	0																		
24143S		18.3	8.48	0.2	<0.1	0	0	0	0.31	8.82	30.80	8.5	2.6	<0.02	<0.01	0.2	0.2	7.32	<0.1	1.79	<0.05	<0.03	<0.001	<0.002		
24143HC		15	8.35			940	102	0																		

HD*: Household Diarrhoea present
OA: Overall Assessment
HC: Household Container
S: Source
AS: Alternate source (pre-supply)
AS†: Alternate source usage - choice

Figure cont. : Mthoqotho. Water Quality Results - Survey 3.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l $CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	*	
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
24001S		16	8.52	<0.1	<0.05	0	0	0	0.32	8.78	31.10	8.2	2.6	0.02	<0.01	0.32	0.32	7.03	<0.1	1.63	<0.05	<0.03	<0.001	<0.002		
24001HC		16.4	8.28			0	0	0																		
24135S		16.9	8.32	<0.1	<0.1	0	0	0	0.35	8.87	32.20	8.5	2.7	<0.02	<0.01	0.22	0.22	7.46	<0.1	1.6	<0.05	<0.03	<0.001	<0.002		
24135HC		15.1	7.62			110	0	0																		
24010S		14.7	8.52	0.4	<0.1	0	0	0	0.4	0.79	32.2	8.2	2.6	0.02	<0.1	0.19	<0.05	7.88	<0.1	1.7	<0.05	<0.03	<0.001	<0.002		
24010HC		15	6.96			136	0	122																		
24015S		14.4	8.43	0.2	<0.1	0	0	0	0.3	8.87	31.1	8.2	2.6	<0.02	<0.01	0.25	<0.05	7.36	<0.1	1.6	<0.05	<0.03	<0.001	<0.002		
24015HC		15	7.87			32	0	0																		
24121S	no sample																								ns	
24121HC	no sample																								ns	
24133S		16.6	8.34	<0.05	<0.05	0	0	0	0.31	8.81	31.2	8.4	2.5	0.23	<0.01	0.41	<0.05	7.26	<0.1	1.63	<0.05	0.03	<0.001	<0.002		
24133HC		15.5	7.74			28	0	0																		
23741S	AS[2]	20.6	6.19			54	0	0	2.2	5.21	16.1	3	2.1	0.07	0.01	0.32	<0.05	3.01	<0.1	0.86	<0.05	<0.03	<0.001	<0.002		
23741HC		21.6	6.35			134	0	0																		
24020S		16.4	8.58	<0.05	<0.05	0	0	0	0.32	8.79	31.1	8.2	2.6	0.04	<0.01	0.2	<0.05	7.79	<0.1	1.69	<0.05	<0.03	<0.001	<0.002		
24020HC		17.5	8.48			0	0	0																		
32059S		20	7.73	<0.05	<0.05	0	0	0	0.48	9.15	32.6	8.8	2.6	0.06	<0.01	0.48	<0.05	7.79	<0.1	2	<0.05	<0.03	<0.001	<0.002		
32059HC		19.6	7.8			6	0	0																		
24063S		17.9	7.68	<0.05	<0.05	0	0	0	2	9.15	32.6	8.8	2.6	0.08	<0.01	0.41	<0.05	7.5	<0.1	1.72	<0.05	<0.03	<0.001	<0.002		
24063HC		17.9	7.68			120	0	0																		
23735S		16.8	7.65	<0.05	<0.05	0	0	0	0.98	9.13	44.4	8.4	6.9	0.08	<0.01	0.31	0.07	7.54	1	1.61	<0.05	<0.01	<0.001	<0.002		
23735HC		17.8	7.81			0	0	0																		
32062S	AS[2]	19.4	6.44			188	8	58	4.6	7.15	21	3.8	2.8	0.17	<0.01	0.94	<0.05	6.5	<0.1	2.93	<0.05	<0.03	<0.001	<0.002		
32062HC		19.9	6.79			64	2	32																		
33507S	AS[2]	18.8	6.25			16	0	0	1.6	5.06	16.1	3	2.1	0.05	<0.01	0.33	<0.05	2.87	<0.1	0.93	<0.05	<0.03	<0.001	<0.002		
33507HC		19.5	6.82			180	50	46																		

Figure 4 : Mthoqotho. Water Quality Results - Survey 4.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	*	
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Nov-99																										
24098S		22.9	8.01	<0.05	<0.05	0	0	0	0.27	10.5	32.583	8.7	2.6	0.11	<0.01	0.24	0.18	8.69	<0.1	2.11	0.12	<0.03	<0.001	<0.002		
24098HC		23.6	7.77			9	4	154																		
23726S		22.6	8.09	<0.05	<0.05	0	0	0	0.25	9.15	33.5	8.9	2.7	0.09	<0.01	0.21	0.19	8.41	<0.1	1.8	<0.05	<0.03	<0.001	<0.002		
23726HC		24.7	7.81			4000	1320	17																		
24079S		23.3	8.27	<0.05	<0.05	0	0	0	0.28	9.11	32.833	8.8	2.6	0.03	<0.01	0.24	0.2	8.39	<0.1	1.91	<0.05	<0.03	<0.001	<0.002		
24079HC		23.8	8.17			34	0	1																		
24006S		24.6	8.37	<0.05	<0.05	0	0	0	0.62	9.04	32.083	8.5	2.6	0.08	<0.01	0.2	0.14	8.55	<0.1	1.96	<0.05	<0.03	<0.001	<0.002		
24006HC		27.3	8.06			0	0	0																		
24134S		23.1	7.92	<0.05	<0.05	0	0	0	0.31	9.11	33.917	8.9	2.8	0.04	<0.01	0.22	0.15	8.19	<0.1	1.83	<0.05	<0.03	<0.001	<0.002		
24134HC		no sample																							ns	
23705S		25.4	8.16	<0.05	<0.05	0	0	0	0.21	9.66	33.583	9.1	2.6	0.1	<0.01	0.26	0.17	8.39	<0.1	1.93	<0.05	<0.03	<0.001	<0.002		
23705HC		no sample																							ns	
32053S		26.6	7.99	<0.05	<0.05	0	0	0	0.29	9.04	31.417	8.4	2.5	0.12	<0.1	0.36	0.13	9.08	<0.1	1.83	<0.05	0.04	<0.001	<0.002		
32053HC		28.1	7.75			254	78	34																		
24464S		22.7	7.92	<0.05	<0.05	680	294	63	0.34	9.11	33.5	8.9	2.7	0.03	<0.01	0.51	0.18	10.2	<0.1	2.49	<0.05	<0.03	<0.001	<0.002		
24464HC		24.5	8.07			1010	370	42																		
24099S		no sample																							ns	
24099HC		22.7	6.62			50000	30000	104																		
32055S		21.7	7.52	<0.05	<0.05	0	0	0	0.24	9.51	32.883	8.8	2.6	0.05	<0.01	0.22	0.19	8.09	<0.1	1.95	<0.05	0.03	<0.001	<0.002		
32055HC		22.8	6.22			38	34	52																		Y
24146S		21.9	7.69	<0.05	<0.05	0	0	0	0.23	9.4	34.25	9.2	2.7	0.03	<0.01	0.4	<0.05	8.11	<0.1	1.91	<0.05	0.03	<0.001	<0.002		
24146HC		22.4	7.9			194	194	0																		
24143S		21.5	7.93	<0.05	<0.05	302	96	5	0.25	9.26	32.667	8.9	2.5	0.04	<0.01	0.25	0.19	8.2	<0.1	1.88	<0.05	<0.03	<0.001	<0.002		
24143HC		22.5	7.66			0	0	2																		
24001S		23.6	8.06	<0.05	<0.05	0	0	0	0.24	9.14	33.5	8.9	2.7	<0.02	<0.01	0.21	0.18	8.32	<0.1	1.8	<0.05	<0.03	<0.001	<0.002		
24001HC		25	7.49			63	2	0																		

HD*: Household Diarrhoea present
OA: Overall Assessment
HC: Household Container
S: Source
AS: Alternate source (pre-supply)

Figure 4 cont. : Mthoqotho. Water Quality Results - Survey 4.

Mthoqoto	S*	Temp	pH	Coliforms	Free Cl	Tot Cl	E. coli	F. strep	Turb.	Cond.	THmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	mg/l	mg/l	per 100ml	per 100ml	NTU	mS/m	$CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0.05-2.5	0.1-2.5	0	0	1	70	20-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.010	0.01		
24135S		22.1	7.34	<0.05	<0.05	0	0	0	0.34	9.16	32.43	8.8	2.5	0.07	<0.01	0.32	0.1	8.23	<0.1	1.89	<0.05	0.1	<0.001	<0.002		
24135HC		22.5	7.48	0			0	0																		
24010S		22.6	8.27	0	<0.05	<0.05	0	0	0.28	9.13	33.08	8.9	2.6	0.06	<0.01	0.21	0.15	7.92	<0.1	1.89	<0.05	<0.03	<0.001	<0.002		
24010HC		no sample																							ns	
24015S		22	8.18	0	<0.05	<0.05	0	0	0.26	9.1	31.42	8.4	2.5	0.04	<0.01	0.28	0.15	8.45	<0.1	1.89	<0.05	<0.03	<0.001	<0.002		
24015HC		23.3	8.23	34			2	0																		
24121S		23.7	8.14	0	<0.05	<0.05	0	0	0.24	9.17	33.33	9	2.6	0.05	<0.01	0.2	0.15	7.8	<0.1	1.93	<0.05	0.03	<0.001	<0.002		
24121HC		23.4	7.96	960			680	4																		
24133S		23.9	7.93	0	<0.05	<0.05	0	0	0.24	9.14	33.58	9.1	2.6	0.02	<0.01	0.31	0.14	8.21	<0.1	1.93	<0.05	<0.03	<0.001	<0.002		
24133HC		24.9	7.68	960			588	2																		
23741S		25.6	8.1	0	<0.05	<0.05	0	0	0.31	9.11	33.58	9.1	2.6	0.03	<0.01	0.21	0.21	8.29	<0.1	1.82	<0.05	<0.03	<0.001	<0.002		
23741HC		25.4	7.76	1360			150	8																		
24020S		21.4	8.18	0	<0.05	<0.05	0	0	0.24	9.13	33.08	8.9	2.6	0.04	<0.01	0.2	0.15	8.06	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
24020HC		22.3	8.19	0			0	0																		
32069S		26.1	7.68	0	<0.05	<0.05	0	0	0.33	9.09	31.42	8.4	2.5	0.03	<0.01	0.37	0.09	9.07	<0.1	1.94	<0.05	0.03	<0.001	<0.002		
32069HC		29	7.68	7000			1000	2																		
24053S		25.4	7.73	0	<0.05	<0.05	0	0	0.33	9.04	31.83	8.4	2.6	0.03	<0.01	0.34	0.08	8.77	<0.1	1.86	<0.05	0.03	<0.001	<0.002		
24053HC		25.3	7.75	16			0	0																		
23735S		25.4	8.04	0	<0.05	<0.05	0	0	0.23	9.06	31.00	8.4	2.4	0.03	<0.01	0.28	0.15	8.9	<0.1	1.88	<0.05	0.03	<0.001	<0.002		
23735HC		26	7.98	20			0	76																		
32052S		25.9	8.06	0	<0.05	<0.05	0	0	0.32	9.14	33.33	9	2.6	0.03	<0.01	0.24	0.19	8.39	<0.1	1.88	<0.05	<0.03	<0.001	<0.002		
32052HC		26.9	7.7	94			94	48																		
33507S	AS[2]	24.8	7.06	202			28	116	3.05	5.2	15.50	2.7	2.1	0.25	0.03	0.09	<0.05	3.71	<0.1	0.48	<0.05	<0.03	<0.001	<0.002		√
33507HC		25.9	7.14	158			70	232																		

Figure 5 : Mthoqoto Water Quality Results - Survey 5.

Mthoqoto	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli.	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
24098S		no sample																								
24098HC		25.9	6.99			182	128	31																		√
23726S		23.6	7.05	<0.05	<0.05	0	0	0	0.28	10.3	36.92	10.6	2.5	0.03	<0.01	0.63	<0.05	8.83	<0.1	2.06	<0.05	<0.18	<0.001	<0.002		
23726HC		25.1	7.29			17200	6200	12																		
24070S		24.5	6.66	<0.05	<0.05	0	0	0	0.62	10.2	39.58	11	2.9	0.02	<0.01	0.65	<0.05	6.84	<0.1	2.37	<0.05	0.11	<0.001	<0.002		
24070HC		25.1	7.06			22	12	47																		
24006S		24.1	7.21	<0.05	<0.05	0	0	0	0.39	9.84						0.57	<0.05	8.72	<0.1	2.05						
24006HC		24	7.12			150	84	10																		
24134S		24.7	7.06	<0.05	<0.05	0	0	0	0.53	10.1	36.42	10.4	2.5	0.04	<0.01	0.65	<0.05	9.51	<0.1	2.23	<0.05	0.14	<0.001	<0.002		
24134HC		26.6	7.52																						ns	
23705S		22.2	6.84	<0.05	<0.05	2	0	0	0.32	9.91	37.75	10.6	2.7	0.03	<0.01	0.56	<0.05	8.78	<0.1	2.11	<0.05	0.04	<0.001	<0.002		
23705HC		22.3	7.06			256	168	4																		
32053S		25.4	7.17	<0.05	<0.05	0	0	0	0.25	10.2	36.92	10.6	2.5	0.06	<0.01	0.59	<0.05	9.04	<0.1	2.12	<0.05	0.14	<0.001	<0.002		
32053HC		26.1	7.28			1560	1200	8																		
24464S		25.5	7.2	<0.05	<0.05	0	0	0	0.26	10.2	36.83	10.4	2.6	0.04	<0.01	0.55	<0.05	8.8	<0.1	2.2	<0.05	0.08	<0.001	<0.002		
24464HC		no sample																							ns	√
24099S		22.6	6.99	<0.05	<0.05	0	0	0	0.36	9.79	36.42	10.4	2.5	0.07	<0.01	0.52	<0.05	8.7	<0.1	2.01	<0.05	0.15	<0.001	<0.002		
24099HC		22.4	7.11			1920	1520	50																		
32055S		24.9	6.96	<0.05	<0.05	0	0	0	0.29	10.2	36.25	10.5	2.4	0.04	<0.01	0.63	<0.05	8.95	<0.1	2.65	<0.05	0.14	<0.001	<0.002		
32055HC		25.9	7.14			320	156	78																		
24146S		26.6	6.49	<0.05	<0.05	0	0	0	0.29	10.3	37.25	10.4	2.7	0.03	<0.01	0.6	<0.05	9	<0.1	2.29	<0.05	0.33	<0.001	<0.002		
24146HC		25.1	7.1			64	17	1																		
24143S		25.6	6.74	<0.05	<0.05	0	0	0	0.29	9.95	36.58	10.3	2.6	0.02	<0.01	0.64	<0.05	8.96	<0.1	2.1	<0.05	0.1	<0.001	<0.002		
24143HC		24.5	7.23			108	82	6																		
24001S		24.2	7.15	<0.05	<0.05	0	0	0	0.26	10.2	37.42	10.8	2.5	0.02	<0.01	0.7	<0.05	9.08	<0.1	2.39	<0.05	0.17	<0.001	<0.002		
24001HC		24.1	7.33			0	0	0																		
24135S		26.5	6.9	<0.05	<0.05	148	88	>1000	0.4	9.98	36.58	10.3	2.6	0.02	<0.01	0.62	<0.05	8.86	<0.1	2.38	<0.05	0.12	<0.001	<0.002		

HD: Household Diarrhoea Present
OA: Overall Assessment
HC: Household Container
S: Source
AS: Alternate Source (pre-supply)

Figure 5 cont: Mthoqoto Water Quality Results - Survey 5.

Mthoqoto	S*	pH	Temp	Free Cl	Tot Cl	Coliforms	E. coli.	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		mg/ℓ	°C	mg/ℓ	mg/ℓ	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l $CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
24135HC		7.2	26.1			1	0	0																		
24010S		7.14	24.7	<0.05	<0.05	0	0	0	0.27	10.2	37.167	10.7	2.5	0.03	<0.01	0.52	<0.05	8.65	<0.1	2.3	<0.05	0.16	<0.001	<0.002		
24010HC		no sample																							ns	
24015S		6.99	23.2	<0.05	<0.05	24	4	0	0.34	9.71	36.167	10.3	2.5	0.02	<0.01	0.56	<0.05	8.87	<0.1	2.12	<0.05	0.14	<0.001	<0.002		
24015HC		7.09	23.9			182	122	0																		
24121S		7.19	21.7	<0.05	<0.05	2	0	2	0.38	9.8	35.5	10.2	2.4	0.04	<0.01	0.61	0.09	8.87	<0.1	2.12	<0.05	0.12	<0.001	<0.002		√
24121HC		no sample																							ns	
24133S		7.06	25.4	<0.05	<0.05	0	0	0	0.25	10.2	37.167	10.7	2.5	0.03	<0.01	0.57	<0.05	8.64	<0.1	2.1	<0.05	0.22	<0.001	<0.002		
24133HC		7.27	26.5			12500	11700	0																		
23741S		7.23	22.5	<0.05	<0.05	0	0	0	0.33	9.77	36.333	10.2	2.6	0.02	<0.01	0.63	<0.05	8.81	<0.1	2.42	<0.05	0.12	<0.001	<0.002		
23741HC		6.92	23.4			680	290	32																		√
24020S		7.08	24.6	<0.05	<0.05	0	0	0	0.25	10.2	37.333	10.8	2.6	0.02	<0.01	0.6	<0.05	8.9	<0.1	2.32	<0.05	0.17	<0.001	<0.002		
24020HC		7.23	26.5			8	0	0																		
32059S		6.99	24.6	<0.05	<0.05	8	0	0	0.72	9.65	35.5	10.2	2.4	0.04	<0.01	0.62	<0.05	9.04	<0.1	2.09	<0.05	0.06	<0.001	<0.002		
32059HC		7.23	24.8			1960	1380	8																		
24053S		6.95	22	<0.05	<0.05	0	0	0	0.96	9.81	36.417	10.4	2.5	0.05	<0.01	0.57	<0.05	8.65	<0.1	2.01	<0.05	0.06	<0.001	<0.002		
24053HC		6.97	22			318	314	2																		
23735S		6.6	23.6	<0.05	<0.05	0	0	0	0.66	9.9	36.833	10.4	2.6	0.03	<0.01	0.59	<0.05	8.72	<0.1	2.24	<0.05	0.09	<0.001	<0.002		
23735HC		6.13	24.4			62	26.	4																		
32052S		no sample																							ns	
32052HC		7.24	21.8			1360	640	4																		
33507S	AS[2]	6.58	22.5			16	4	4	0.92	3.12	7.417	1.3	<1.0	<0.02	<0.01	0.46	0.05	4.9	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
33507HC		6.93	23.8			528	266	24																		

Figure 6 : Khobongwane Water Quality Results - Survey 1

L. Kob	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Jan-99																							
29425S	AS	26.6	6.91	520	72	390	6	22.5	76.30	15	9.3	0.17	0.01	7.29	15.3	<0.1	5.17	<0.05	<0.03	<0.001	<0.002		
29425HC				2200	2200																		X
29393S	AS			520	72	390	6	22.5	76.30	15	9.3	0.17	0.01	7.29	15.3	<0.1	5.17	<0.05	<0.03	<0.001	<0.002		
29393HC				64	28																		
29373S	AS	26.6	6.91	58	36	80	0.32	2.78	6.92	1.1	<1	0.02	<0.01	0.44	4.03	<0.1	0.33	<0.05	0.03	<0.001	<0.002		
29373HC				56	54																		
29375S	AS	23.6	6.86	74	20	54	0.68	2.82	7.58	1.2	1.1	0.05	<0.01	0.33	3.69	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
29375HC				370	64																		X
29377S	AS	25.2	7.26	26	4	40	0.68	6.95	24.90	5.3	2.8	0.1	<0.01	0.21	4.6	<0.1	0.72	0.12	0.08	<0.001			
29377HC				32	0																		
29378S	AS			29	4	40	0.68	6.95	24.90	5.3	2.8	0.1	<0.01	0.21	4.6	<0.1	0.72	0.12	0.08	<0.001			
29378HC				62	16																		
29406S	AS			58	36	80	0.32	2.78	6.92	1.1	<1	0.02	<0.01	0.44	4.03	<0.1	0.33	<0.05	0.03	<0.001	<0.002		
29406HC				190	28																		X
29370S	AS			8	2		0.68	6.95	24.90	5.3	2.8	0.1	<0.01	0.21	4.6	<0.1	0.72	0.12	0.08	<0.001			
29370HC				140	24																		X
29382S	AS			290	2		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29382HC																						ns	
29374S	AS			290	2		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29374HC				320	20																		
29430S	AS			290	2		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29430HC				820	370																		
29414S	AS			210	64		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29414HC				280000	124000																		X
29379S	AS			30	22		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29379HC				340	20																		
29388S	AS	26.5	6.95	18	18		0.52	2.72	6.92	1	<1	0.03	<0.01	0.4	4.04	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29388HC				340	104																		
29469S	AS	24.6	6.88	280	6		0.41	2.05	6.92	1.1	<1	0.02	<0.01	0.27	2.99	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		

HD: Household diarrhoea Present
OA: Overall Assessment DWAF
HC: Household Container
S: Source
AS: Alternate Source

Figure cont .6 : Khobongwane Water Quality Results - Survey 1.

Site	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	0.5	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
29469HC				2070	1390																		
29476S	AS	no sample																				ns	
29476HC				720	430																		
29471S	AS	no sample																				ns	
29471HC																						ns	
29368S	AS			280	6		0.41	2.05	6.92	1.1	<1	0.02	<0.01	0.27	2.99	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
29368HC				180000	33000																		
29470S	AS			280	6		0.41	2.05	6.92	1.1	<1	0.02	<0.01	0.27	2.99	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
29470HC				740	74																		X
29472S	AS			280	6		0.41	2.05	6.92	1.1	<1	0.02	<0.01	0.27	2.99	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
29472HC				29000	11000																		
29396S	AS	25	6.87	320	12		0.35	2.9	<6.67	<1	<1	0.08	<0.01	0.37	4.01	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29396HC				88	22																		
29418S	AS			240	14		0.35	2.9	<6.67	<1	<1	0.08	<0.01	0.37	4.01	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		
29418HC				68	68																		
29386S	AS	20.7	6.77	84	8		0.28	2.81	<6.67	<1	<1	0.04	<0.01	0.31	3.57	<0.1	0.22	<0.05	<0.03	<0.001	<0.002		
29386HC				580	2																		
29381S	AS			630	30		0.75	2.95	6.92	1	<1	0.04	<0.01	0.3	3.58	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
29381HC				420	58																		X
294080S	AS	no sample																				ns	
294080HC				5600	4200																		X

Figure 7: Khobongwane. Water Quality Results - Survey 2

L Kob	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Apr-99																							
29425S	AS	no sample																					
29425HC				162	16	22																	
29393S	AS		7.19	2160	1570	156	16	19	57.25	10.4	7.5	0.17	0.01	2.91	14.7	<0.1	8.85	<0.05	<0.03	<0.001	<0.002		
29393HC				64	18	116																	
29373S	AS	no sample							0.00													ns	
29373HC				760	12	20																	
29375S	AS		6.87	26	2	50	0.21	2.81	<6.67	<1.0	<1.0	<0.02	<0.01	0.32	4.42	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29375HC				140	36	64																	
29377S	AS	23.5	7.23	16	0	4	0.49	6.95	23.58	5.1	2.6	0.08	<0.01	0.35	4.52	<0.1	0.81	<0.05	0.04	<0.001	<0.002		
29377HC				4500	13	22																	
29378S	AS			10	0	2	0.46	6.98	22.92	5	2.5	0.02	<0.01	0.34	4.31	<0.1	0.03	<0.05	0.03	<0.001	<0.002		
29378HC				580	48	20																	
29406S	AS	20.9	6.87	24	6	46	0.22	2.74	<6.67	<1.0	<1.0	0.03	<0.01	0.32	3.94	<0.1	0.38	<0.05	<0.03	<0.001	<0.002		
29406HC				18000	5	102																	
29370S	AS	23	7.18	10	0	2	0.55	6.96	23.17	5.1	2.5	0.02	<0.01	0.54	4.68	<0.1	1.06	<0.05	<0.03	<0.001	<0.002		
29370HC				2700000	365000	56																	
29382S	AS			78	14	48	0.48	2.69	<6.67	<1.0	<1.0	0.05	<0.01	0.35	3.72	<0.1	0.43	<0.05	<0.03	<0.001	<0.002		
29382HC				170	148	420																	
29374S	AS			78	14	48	0.48	2.69	<5.67	<1.0	<1.0	0.05	<0.01	0.35	3.72	<0.1	0.43	<0.05	<0.03	<0.001	<0.002		
29374HC				10	16	0																	
29430S	AS			78	14	48	0.48	2.69	<6.67	<1.0	<1.0	0.05	<0.01	0.35	3.72	<0.1	0.43	<0.05	<0.03	<0.001	<0.002		
29430HC				920	320	720																	X
29414S	AS	23.9	6.89	102	80	50	0.32	2.7	<6.67	<1.0	<1.0	0.06	0.02	0.38	3.93	<0.1	0.44	<0.05	<0.03	<0.001	<0.002		
29414HC				154000	120000	136																	X
29379S	AS	21.9	6.21	2	0	4	1.16	1.53	<6.67	<1.0	<1.0	0.2	0.08	0.41	0.95	<0.1	1.85	<0.05	2.72	<0.001	<0.002		
29379HC				104	0	2																	
29388S	AS	22.5	6.93	100	18	14	0.26	2.78	<6.67	<1.0	<1.0	0.02	<0.01	0.35	5.04	<0.1	0.29	<0.05	<0.03	<0.001	<0.002		
29388HC				100	4	9																	
29469S	AS	26.7	6.71	30	2	14	0.41	2.04	<6.67	<1.0	<1.0	0.02	<0.01	0.41	3.04	<0.1	0.1	<0.05	<0.03	<0.001	<0.002		

HD*: Household Diarrhoea present
OA: Overall assessment DWAF
HC: Household Container
S: Source
AS: Alternate source

Figure 7 cont. : Khobongwane. Water Quality Results - Survey 2.

Site	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
29469HC				460	32	50			0														
29476S	AS	26.7	6.71	40	2	40	0.46	2.01	<6.67	<1.0	<1.0	0.02	<0.01	0.43	2.89	<0.1	0.22	<0.05	<0.03	<0.001	<0.002		
29476HC				18300	610	150																	
29471S	AS	26.7	6.71	70	6	24	0.41	2	<6.67	<1.0	<1.0	<0.02	<0.01	0.42	3.23	<0.1	0.09	<0.05	<0.03	<0.001	<0.002		
29471HC				26000	3400	4																	
29368S	AS	23.4	6.74	10	6	34	0.63	2.02	<6.67	<1.0	<1.0	<0.02	<0.01	0.54	3.39	<0.1	0.27	<0.05	<0.03	<0.001	<0.002		
29368HC																							1
29470S	AS	25.2	6.63	40	2	28	0.48	2.06	<6.67	<1.0	<1.0	0.03	<0.01	0.42	2.89	<0.1	0.09	<0.05	<0.03	<0.001	<0.002		
29470HC				110	28	24																	1
29472S	AS	26.7	6.63	50	0	22	0.56	2.04	<6.67	<1.0	<1.0	0.02	<0.01	<0.05	2.84	<0.1	0.43	<0.05	<0.03	<0.001	<0.002		
29472HC				60	6	20																	
29396S	AS	23.5	6.99	54	0	46	0.7	2.7	<6.67	<1.0	<1.0	0.05	<0.01	0.36	3.78	<0.1	0.43	<0.05	<0.03	<0.001	<0.002		
29396HC				392	0	140																	
29418S	AS	26.5	6.98	110	16	38	0.36	2.69	6.67	1	<1.0	0.03	<0.01	0.37	3.91	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
29418HC				74000	60000	54																	
29386S	AS	24.2	6.95	130	24	30	0.28	2.71	<6.67	<1.0	<1.0	0.04	<0.01	0.33	3.52	<0.1	0.37	<0.05	<0.03	<0.001	<0.002		
29386HC				200	14	9																	
29381S	AS	26.1	6.99	110	6	22	0.47	2.74	<6.67	<1.0	<1.0	0.03	<0.01	0.36	3.83	<0.1	0.33	<0.05	<0.03	<0.001	<0.002		
29381HC				470	104	140																	X
294080S	AS	26.6	6.23	0	12	10	1.26	2.08	<6.67	<1.0	<1.0	0.05	0.01	0.43	2.78	<0.1	0.11	<0.05	<0.03	<0.001			
294080HC				1160	1160	46																	X

Figure 8: Khobongwane. Water Quality Results -Survey 3.

L Kob	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Jul-99																								
29425S		14.3	7.82	0	0	0	0.52	10.7						0.42	<0.05	8		1.83				<0.002		
29425HC		15.4	7.47	15300	38	6																		
29393S		14.4	7.82	0	0	0	0.44	10.7	39.25	12.2	2.1	0.04	<0.01	0.47	<0.05	8.14	<0.1	1.88	<0.05	<0.03	<0.001	<0.002		
29393HC		14.8	7.53	10	4	0																		
29373S		15.8	7.97	0	0	0	0.35	10.9	39.00	12.1	2.1	0.02	<0.01	0.41	<0.05	8.1	<0.1	1.96	<0.05	<0.03	<0.001	<0.002		
29373HC		18.9	7.72	2	0	0																		
29375S		16	7.98	2	0	0	0.42	11	39.25	12.2	2.1	<0.02	<0.01	0.48	<0.05	8	<0.1	2.02	<0.05	<0.03	<0.001	<0.002		
29375HC		18.7	7.59	13400	40	24																		
29377S		16.7	8	4	0	0	1.11	10						0.38	<0.05	0.39	<0.1	1.75				<0.002		
29377HC		17.1	7.85	0	0	0																		
29378S		17.7	8.82	0	0	0	0.87	10.6	43.67	13.8	2.2	<0.02	<0.01	0.37	<0.05	0.46	<0.1	2.2	<0.05	<0.03	<0.001	<0.002		
29378HC		17.6	7.82	8	0	0																		
29406S		18	8.37	0	0	0																		
29406HC		18	7.81	92	4	0																		
29370S		18.6	8.3	0	0	0	0.3	10.8	45.75	13.3	3	<0.02	<0.01	0.4	<0.05	8.44	<0.1	1.76	<0.05	<0.03	<0.001	<0.002		
29370HC		20.7	8.26	0	0	0																		
29382S		17.2	9	4	0	0	0.22	9.32	34.50	9.8	2.4	0.03	<0.01	0.25	<0.05	7.67	<0.1	1.61	<0.05	<0.03	<0.001	<0.002		
29382HC		21.6	8.74	2	0	6																		x
29374S		19.5	8.96	0	0	0	0.4	9.35	34.25	9.7	2.4	0.03	<0.01	0.26	<0.05	7.52	<0.1	1.51	<0.05	<0.03	<0.001	<0.002		
29374HC		20.9	8.67	184	24	6																		
29430S		19.1	8.21	0	0	0	0.63	9.38	34.25	9.7	2.4	0.03	<0.01	0.24	<0.05	7.72	<0.1	1.53	<0.05	<0.03	<0.001	<0.002		
29430HC		18.7	8.87	108	0	8																		
29414S		18.6	8.96	0	0	0	1.05	9.4	34.25	9.7	2.4	0.04	<0.01	0.26	<0.05	7.96	<0.1	1.77	<0.05	0.03	<0.001	<0.002		
29414HC		23.2	8.72	16	0	0																		
29379S		16.3	8.57	0	0	0	4.65	9.9	35.25	10.6	2.1	0.02	<0.01	0.32	0.05	8.87	<0.1	1.81	<0.05	<0.03		<0.002		
29379HC		16.1	8.5	0	0	0																		
29388S		15.6	8.98	0	0	0	0.23	9.33						0.2	<0.05	8.09	<0.1	1.37				<0.002		
29388HC		15.5	8.75	0	0	0																		
29469S				2	0	0	0.53	10.7	38.83	12.2	2	0.02	<0.01	0.46	<0.05	9.25	<0.1	1.64	<0.05	0.08	<0.001	<0.002		

HD*: Household Diarrhoea Present
OA: Overall assessment DWAF
HC: Household Container
S: Source
AS: Alternate source

Figure 8 cont. : Khobongwane. Water Quality Results - Survey 3.

L Kob	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				*0*	*0*	*0*	*1*	*70*	*22-300*	*150*	*70*	*0.2*	*0.05*	*10*	*1*	*250*	*1*	*200*	*0.5*	*1*	*0.01*	*0.01*		
29469HC				145	0	6																		
29476S		16.6	6.97	0	0	2	0.29	2.06						0.31	<0.05	3.81	<0.1	<0.16						
29476HC		15.6	7.09	60000	2	0																		
29471S		15.7	7.75	0	0	0	0.35	10.8	39.08	12.3	2	<0.02	<0.01	0.57	<0.05	0.77	<0.1	1.94	<0.05	<0.03		<0.002		
29471HC		17	7.7	164	2	4																		
29368S		16.4	7.07	2	0	4	0.27	2.05	<6.67	<1.0	<1.0	<0.02	<0.01	<0.05	<0.05	2.94	<0.1	0.34						
29368HC		16.9	7.12	124	16	22																		
29470S		15.8	7.03	0	0	8	0.27	1.95	<6.67	<1.0	<1.0	0.03	<0.01	<0.05	<0.05	0.31	<0.1	3.21	0.21	0.12	<0.001	<0.002		
29470HC		14.7	6.94	20	0	0																		x
29472S		19.3	6.76	2	0	0	0.42	9.99						2.86	<0.05	2.86	<0.1	<0.16						
29472HC		19.7	6.71	228	6	0																		x
29396S		19.9	8.55	0	0	0	0.67	10.5	36.67	11	2.2	0.03	<0.01	0.35	0.05	7.7	<0.1	1.69	<0.05	<0.03	<0.001	<0.002		
29396HC		22.5	8.3	102	6	20																		
29418S		20.9	8.21	0	0	0	0.57	10.5	39.67	12.2	2.2	0.02	<0.01	0.4	<0.05	8.24	<0.1	1.8	<0.05	<0.03	<0.001	<0.002		
29418HC		23.1	7.72	240	128	168																		
29386S		13.8	7.18	18	0	6																		
29386HC		13.8	7.31	156	0	0																		
29381S		no sample																					ns	
29381HC		16.9	6.77																					
294080S		17.8	8.85	0	0	0	0.24	9.74	34.42	10.1	2.2	<0.02	<0.01	0.26	0.08	7.23	<0.1	1.48	<0.05	0.06		<0.002		
294080HC		19.3	8.84	108	2	0																		

Figure 9 : Khobongwane Water Quality Results - Survey 4.

Site #	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli.*	F. strep	Turb.	Cond.	THR	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	mg/lcaco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	0.5	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29425S		24.4	7.96	<0.05	<0.05	0	0	0	0.3	9.75	32.8	9.3	2.3	0.03	<0.01	0.38	<0.05	9.23	<0.1	1.9	<0.05	<0.03	<0.001	<0.002		
29425HC		no sample																							ns	
29393S		23.4	7.91	<0.05	<0.05	0	0	0	0.26	7.69	32.2	9.2	2.2	<0.02	<0.01	0.4	<0.05	9.1	<0.1	1.9	<0.05	<0.03	<0.001	<0.002		
29393HC		25	7.91			6	2	2																		
29373S		22.9	8.01	<0.05	<0.05	0	0	0	0.29	9.64	32.4	9.3	2.2	<0.02	<0.01	0.4	<0.05	9.09	<0.1	1.81	<0.05	<0.03	<0.001	<0.002		
29373HC		24.2	7.97			72	2	8																		
29375S		22.8	8.08	<0.05	<0.05	0	0	0	0.31	9.64	35.2	10.1	2.4	<0.02	<0.01	0.41	<0.05	9.04	<0.1	1.88	<0.05	<0.03	<0.001	<0.002		
29375HC		24.1	7.91			52	0	12																		
29377S		24.7	8.32	<0.05	<0.05	0	0	0	0.2	9.57	33.6	9.6	2.3	<0.02	<0.01		<0.05	9.1	<0.1	1.84	<0.05	0.04	<0.001	<0.002		
29377HC		no sample																							ns	
29378S		25.7	8.24	<0.05	<0.05	0	0	0	0.2	9.59	33.6	9.6	2.3	<0.02	<0.01	0.39	<0.05	9.21	<0.1	1.89	<0.05	0.03	<0.001	<0.002		
29378HC		28	8.19			0	0	0																		
29406S		24.4	8.15	<0.05	<0.05	0	0	0	0.57	9.6	33.6	9.8	2.3	0.05	<0.01	0.36	<0.05	9.3	<0.1	1.86	<0.05	0.07	<0.001	<0.002		
29406HC		26.1	8.13			40	0	0																		
29370S		27.1	8.19	<0.05	<0.05	0	0	0	0.19	9.58	33.6	9.6	2.3	<0.02	<0.01	0.37	<0.05	8.39	<0.1	1.92	<0.05	0.03	<0.001	<0.002		
29370HC		no sample																							ns	
29382S		22.2	8.45	<0.05	<0.05	0	0	0	0.21	9.75	34.3	9.9	2.3	<0.02	<0.01	0.37	<0.05	8.7	<0.1	1.96	<0.05	<0.03	<0.001	<0.002		
29382HC		no sample																							ns	
29374S		22.3	8.33	<0.05	<0.05	0	0	0	0.22	9.55	34.1	9.8	2.3	<0.02	<0.01	0.38	<0.05	8.52	<0.1	1.83	<0.05	0.04	<0.001	<0.002		x
29374HC		23.1	8.2			72	2	8																		
29430S		23.4	8.38	<0.05	<0.05	0	0	0	0.21	9.54	33.8	9.8	2.3	<0.02	<0.01	0.38	<0.05	8.68	<0.1	1.9	<0.05	0.03	<0.001	<0.002		
29430HC		no sample																							ns	
29414S		23.5	8.55	<0.05	<0.05	0	0	0	0.21	9.53	33.8	9.7	2.3	0.02	<0.01	0.37	<0.05	8.63	<0.1	1.87	<0.05	0.04	<0.001	<0.002		
29414HC		25.6	7.94			7200	1900	38																		
29379S		25.8	8.16	<0.05	<0.05	0	0	0	0.31	9.53	34.6	10	2.3	0.03	<0.01	0.4	<0.05	8.94	<0.1	1.77	<0.05	<0.03	<0.001	<0.002		
29379HC		27	7.65			6300	1300	24																		
29388S		24.9	8.43	<0.05	<0.05	0	0	0	0.2	9.55	34.5	9.8	2.4	<0.02	<0.01	0.39	<0.05	8.92	<0.1	1.84	<0.05	<0.03	<0.001	<0.002		

HD*: Household diarrhoea present
OA: Overall assessment DWAF
HC: Household container
S: Source

Figure 9 cont: Khobongwane Water Quality Results - Survey 4.

L. Kob	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli.	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/ℓ	mg/ℓ	mg/ℓ	/100ml	/100ml	/100ml	NTU	mS/m	caco3	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29388HC		25.4	8.49			0	0	5																		
29469S		21.7	7.3	<0.05	<0.05	0	0	0	0.13	9.87	33.4	9.7	2.2	<0.02	<0.01	0.38	<0.05	9.43	<0.1	1.94	<0.05	0.03	<0.001	<0.002		
29469HC		22	7.59			21300	800	108																		
29476S		20.9	8.07	<0.05	<0.05	0	0	0	0.31	9.57	34.1	9.8	2.3	<0.02	<0.01	0.41	<0.05	9.48	<0.1	1.88	<0.05	<0.03	<0.001	<0.002		
29476HC		21.3	8.16			186	10	2																		
29471S		21	7.98	<0.05	<0.05	36	0	4	0.3	9.59	33.7	9.8	2.2	<0.02	<0.01	0.4	<0.05	9.22	<0.1	1.79	<0.05	0.03	<0.001	<0.002		
29471HC		21.1	7.69			28	0	0																		
29368S		21.1	7.61	<0.05	<0.05	0	0	0	2.15	9.63	33.7	9.8	2.2	0.02	<0.01	0.4	<0.05	9.29	<0.1	1.89	<0.05	0.04	<0.001	<0.002		
29368HC		21	7.69			22700	18300	196																		
29470S		21.9	8.24	<0.05	<0.05	2	0	0	0.2	9.53	33.8	9.7	2.3	<0.02	<0.01	0.39	<0.05	9.33	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
29470HC		21.6	7.53			54	18	20																		
29472S		23.5	8.3	<0.05	<0.05	0	0	0	0.22	9.86	35	10	2.4	<0.02	<0.01	0.38	<0.05	8.45	<0.1	1.85	<0.05	<0.03	<0.001	<0.002		
29472HC		25.1	8.02			560	36	82																		
29396S		24.4	7.81	<0.05	<0.05	0	0	0	8.69	9.66	35.1	10.2	2.3	0.15	0.01	0.36	<0.05	8.38	<0.1	1.85	<0.05	0.06	<0.001	<0.002		
29396HC		26.3	7.63			4200	80	10																		
29418S		27.4	7.68	<0.05	<0.05	0	0	0	1.39	9.66	35.1	10.2	2.3	0.03	<0.01	0.38	<0.05	8.38	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
29418HC		29.9	7.6			1200	500	116																		
29386S		22.7	8.54	<0.05	<0.05	0	0	0	0.3	9.55	34.3	9.9	2.3	<0.02	<0.01	0.4	<0.05	9.5	<0.1	1.94	<0.05	<0.03	<0.001	<0.002		
29386HC		24.4	8.59			8	0	18																		
29381S		21.1	7.61	<0.05	<0.05	0	0	0	0.24	9.48	33.2	9.6	2.2	0.24	<0.01	0.45	<0.05	9.87	<0.1	2.03	<0.05	0.05	<0.001	<0.002		
29381HC		20.8	7.52			84	74	138																		
294080S		21.3	8.32	<0.05	<0.05	0	0	0	0.2	9.56	34.1	9.8	2.3	<0.02	<0.01	0.39	<0.05	9.39	<0.1	1.92	<0.05	0.03	<0.001	<0.002		
294080HC		21.1	7.64			5600	560	92																		

Figure10 : Khobongwane Water Quality Results - Survey 5.

Khob	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli.	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/ℓ	mg/ℓ	mg/ℓ	per 100ml	per 100ml	per 100ml	NTU	mS/m	$CaCO_3$	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29425S		22	7.85	<0.05	<0.05	0	0	0	0.72	10.2	37.7	11.4	2.2	0.06	<0.01	0.6	<0.05	8.59	<0.1	2.33	<0.05	<0.03	<0.001	<0.002		
29425HC		22.6	7.48			930	170	0																		X
29383S		22.7	7.45	<0.05	<0.05	2	0	0	0.31	10.2	37.7	11.4	2.2	<0.02	<0.01	0.51	<0.05	8.32	<0.1	2.28	<0.05	0.05	<0.001	<0.002		
29383HC		22.5	7.38			12	10	2																		
29373S		23.1	7.56	<0.05	<0.05	0	0	0	0.21	10.1	37.7	11.4	2.2	0.03	<0.01	0.47	<0.05	8.39	<0.1	2.22	<0.05	<0.03	<0.001	<0.002		
29373HC		23.4	7.51			1560	1270	4																		
29375S		24	7.74	<0.05	<0.05	34	24	4	0.2	10.1	37.7	11.4	2.2	<0.02	<0.01	0.56	<0.05	8.58	<0.1	2.41	<0.05	<0.03	<0.001	<0.002		
29375HC		24.1	7.63			0	0	0																		
29377S		24.5	7.45	<0.05	<0.05	0	0	0	0.13	10	37.8	11.3	2.3	<0.02	<0.01	0.48	<0.05	8.36	<0.1	2.15	<0.05	0.04	<0.001	<0.002		
29377HC		26.4	7.37			84	78	90																		
29378S		27.4	7.6	<0.05	<0.05	0	0	0	0.15	10	37.8	11.2	2.3	<0.02	<0.01	0.55	<0.05	8.55	<0.1	2.11	<0.05	<0.03	<0.001	<0.002		
29378HC		27.4	7.47			2	0	18																		
29406S		24.2	7.6	<0.05	<0.05	20	20	<10	1.56	10.1	38.2	11.6	2.2	0.03	<0.01	0.97	<0.05	8.51	<0.1	2.47	<0.05	0.05	<0.001	<0.002		
29406HC		24.6	7.85			8	4	2																		
29370S		25.7	7.54	<0.05	<0.05	0	0	0	0.17	10.2	38.8	11.5	2.4	0.05	<0.01	0.51	<0.05	8.46	<0.1	2.25	<0.05	0.06	<0.001	<0.002		
29370HC		no sample																							ns	
29382S		25.1	7.7	<0.05	<0.05	2	0	0	0.37	10.2	39.0	11.6	2.4	<0.02	<0.01	0.51	<0.05	8.49	<0.1	2.19	<0.05	<0.03	<0.001	<0.002		
29382HC		no sample																							ns	
29374S		19.8	7.73	<0.05	<0.05				0.16	10.1	38.9	11.4	2.5	0.03	<0.01	0.5	<0.05	8.46	<0.1	2.13	<0.05	0.03	<0.001	<0.002		
29374HC		19.3	7.48			112	90	50																		
29430S		20	7.58	<0.05	<0.05	2	0	0	0.15	10.1	38.9	11.4	2.5	<0.02	<0.01	0.52	<0.05	8.69	<0.1	1.98	<0.05	0.05	<0.001	<0.002		
29430HC		no sample																							ns	
29414S		20.4	7.59	<0.05	<0.05	152	84	0	0.14	10.1	39.2	11.5	2.5	0.02	<0.01	0.51	<0.05	8.57	<0.1	2.05	<0.05	0.03	<0.001	<0.002		
29414HC		no sample																							ns	X
29379S		24.7	7.75	<0.05	<0.05	0	0	0	0.18	10.2	38.8	11.7	2.3	0.02	<0.01	0.53	<0.05	8.43	<0.1	2.02	<0.05	<0.03	<0.001	<0.002		
29379HC		25.9	7.79			60	34	0																		
29388S	AS	25.9	6.9			60	54	198	4.56	2.79	7.2	1.2	<1.0	0.16	0.02	0.23	<0.05	3.74	<0.1	<0.16	<0.05	0.14	<0.001	<0.002		

HD* Household diarrhoea present
OA Overall assessment DWAF
HC Household Container
S Source
AS Alternate source

Figure 10 cont: Khobongwane Water Quality Results - Survey 5.

L Kob	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli.	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	/100ml	/100ml	NTU	mS/m	CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29388HC		25.9	7.1			284	156	62																		
29469S		20.1	7.72	<0.05	<0.05	0	0	0	0.24	10.1	38.0	11.2	2.4	0.02	<0.01	0.56	<0.05	8.2	<0.1	2.4	<0.05	<0.03	<0.001	<0.002		
29469HC		20.4	7.49			152	152	36																		
29476S		21.3	7.16	<0.05	<0.05	0	0	0	0.22	10.1	38.7	11.3	2.5	0.02	<0.01	0.62	<0.05	8.26	<0.1	2.09	<0.05	0.06	<0.001	<0.002		
29476HC		21.3	7.56			74	50	22																		
29471S		23.1	7.6	<0.05	<0.05	0	0	0	0.21	10	37.2	11.2	2.2	0.02	<0.01	0.53	<0.05	8.16	<0.1	2.2	<0.05	<0.03	<0.001	<0.002		
29471HC		21.5	7.99			92	92	66																		
29368S		21.5	6.41	<0.05	<0.05	8	0	0	6.01	2.11	<6.667	<1.0	<1.0	0.12	0.01	0.36	<0.05	2.79	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
29368HC		no sample																							ns	
29470S		21.1	7.99	<0.05	<0.05	0	0	36	0.23	10.1	38.8	11.5	2.4	<0.02	<0.01	0.55	<0.05	8.54	<0.1	2.38	<0.05	<0.03	<0.001	<0.002		
29470HC		no sample																							ns	
29472S		21.4	7.79	<0.05	<0.05	0	0	0	0.16	10.1	38.9	11.4	2.5	0.05	<0.01	0.54	<0.05	8.61	<0.1	2.1	<0.05	0.03	<0.001	<0.002		
29472HC		21	7.6			104	44	0																		
29396S		25.5	7.51	<0.05	<0.05	0	0	0	3.24	10.2	38.8	11.7	2.3	0.03	<0.01	0.57	<0.05	8.46	<0.1	2.08	<0.05	<0.03	<0.001	<0.002		
29396HC		26.6	7.43			104	66	216																		
29418S		28.5	6.83	<0.05	<0.05	0	0	0	11.8	10.1	37.9	11	2.5	0.12	0.01	0.41	<0.05	9.03	<0.1	2.23	<0.05	0.08	<0.001	<0.002		
29418HC		26.5	6.43			416	216	162																		
29386S		24.2	7.88	<0.05	<0.05	0	0	0	0.21	10.1	38.8	11.5	2.4	0.02	<0.01	0.57	<0.05	8.95	<0.1	2.03	<0.05	0.03	<0.001	<0.002		
29386HC		25	7.99			36	24	4																		
29381S	AS	20.2	6.6			36	36	66	0.46	2.59	<6.667	<1.0	<1.0	0.04	<0.01	0.28	<0.05	3.6	<0.1	0.2	<0.05	<0.03	<0.001	<0.002		
29381HC		19.9	6.43			1040	920	210																		
294080S		22.5	8.09	<0.05	<0.05	0	0	28	0.16	10.1	39.0	11.6	2.4	0.02	<0.01	0.53	<0.05	8.16	<0.1	2.37	<0.05	0.03	<0.001	<0.002		
294080HC		22	6.47			248	156	106																		

Figure 11: Shange Water Quality Results - Survey 1.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	/100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Jan-99																							
29236S	AS			36	6	26	0.59	5.93	17.8	3.3	2.3	0.05	<0.01	0.89	4.64	<0.1	0.53	<0.05	<0.03	<0.001	<0.002		
29236HC				840	770	240																	
33414S	AS			1260	510	22	5.68	9.8	26.1	4.1	3.8	0.44	0.04	3.43	9.18	<0.1	1.36	<0.05	<0.03	<0.001	<0.002		
33414HC				3600	960	42																	
29067S	AS			14	4	0	0.4	7.36	26.8	5.4	3.2	0.34	<0.01	0.26	4.61	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
29067HC				1380	410	42																	
29202S	AS			930	4	16	2.53	7.14	12.2	2.2	1.6	0.19	0.02	2.5	9.76	<0.1	0.4	<0.05	<0.03	<0.001	<0.002		
29202HC				700	480	0																	√
29156S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29156HC				4	4	2																	
29217S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29217HC				1400	1170	160																	√
29215S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29215HC				2200	1970	88																	√
29216S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29216HC				4200	4200	36																	
2137S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
2137HC				2400	1400	184																	
29036S	AS			36	4	0	0.34	6.75	11.2	1.8	1.6	0.13	<0.01	3.79	8.14	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
29036HC				710	70	0																	
2081S	AS			0	0	0	0.18	8.38	29	5.6	3.6	0.15	<0.01	0.93	4.52	<0.1	1.81	<0.05	<0.03	<0.001	<0.002		
2081HC				520	258	370																	√
29120S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29120HC				1070	820	328																	
29161S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29161HC				2200	1800	254																	
29004S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29004HC				420	380	144																	√
29005S	AS			310	214	72	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		

HD: household diarrhoea present
OA: Overall Assessment DWAF
HC: Household container
S: Source
AS: Alternate Source

Figure 11 cont. : Shange Water Quality Results - Survey 1.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THmg/l	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	/100ml	/100ml	/100ml	NTU	mS/m	$CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	μg/l	μg/l		
Standard				0	0	0	1	70		0.01	70	0.2	0.05	10	250	1	200	0.5	1	0.005	0.05		
29005HC				4200	1180	388																	
2083S	AS			14	4	0	0.4	7.36	25.8	5.4	3.2	0.34	<0.01	0.28	4.61	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
2083HC				1270	880	12																	
29023S	AS	no sample																				ns	√
29023HC		no sample																				ns	
29086S	AS			42	2	0	0.53	9.2	28.3	5.3	3.6	<0.02	<0.01	0.52	4.73	<0.1	3.22	<0.05	<0.03	<0.001	<0.002		
29086HC				84	36	0																	
39095S	AS			0	0	0	0.18	8.38	29	5.6	3.6	0.15	<0.01	0.93	4.52	<0.1	1.81	<0.05	<0.03	<0.001	<0.002		
39095HC				1320	970	0																	
29063S	AS			12	0	16	2058	13.4	48.2	9.6	5.8	0.08	<0.01	3.29	11.7	<0.1	1.39	<0.05	<0.03	<0.001	<0.002		
29063HC				1800	1400	356																	
33329S	AS	25.2	6.44	12	0	16	2058	13.4	48.2	9.6	5.8	0.08	<0.01	3.29	11.7	<0.1	1.39	<0.05	<0.03	<0.001	<0.002		
33329HC				220	84	2																	
2073S	AS			190	2	2	2.53	7.14	12.2	2.2	1.6	0.19	0.02	2.5	9.76	<0.1	0.4	<0.05	<0.03	<0.001	<0.002		√
2073HC				670	30	0																	
2122S	AS			190	2	2	2.53	7.14	12.2	2.2	1.6	0.19	0.02	2.5	9.76	<0.1	0.4	<0.05	<0.03	<0.001	<0.002		√
2122HC				950	760	2																	
2051S	AS			8000	1100	102	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		√
2051HC				260	260																		
29134S	AS			8000	1100	102	4.83	5.31	9.16	1.5	1.3	0.21	0.02	2.12	6.12	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		√
29134HC				620	450	344																	

Figure 12 : Shange Water Quality Results - Survey 2.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	/00ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Apr-99																							
29236S	AS	19.8	6.67	700	116	320	3.71	6.07	17.17	3.2	2.2	0.1	<0.01	0.98	3.76	<0.1	0.45	<0.05	<0.03	<0.001	<0.002		
29236HC				320	272	160																	√
33414S	AS	19.5	6.16	510	92	100	3.43	9.83	26.33	4.2	3.8	0.23	0.02	3.71	7.43	<0.1	1.59	<0.05	<0.03	<0.001			
33414HC				140	140	230																	√
29067S	AS	21.3	5.71	650	464	410	2.69	6.09	10.92	1.7	1.6	0.13	0.01	3.08		<0.1	0.29	<0.05	<0.03	<0.001	<0.002		
29067HC				0	500	460																	√
29202S	AS	19.4	5.96	30	10	2	1.28	0.92	16.83	2.9	2.3	0.1	<0.01	2.39	9.34	<0.1	0.72	<0.05	<0.03	<0.001	<0.002		
29202HC				52000	10200	2																	
29156S	AS	21.9	5.82	1800	500	760	5.86	6.02	11.17	1.8	1.6	0.14	0.01	3.03	6.2	<0.1	0.1	<0.05	<0.03	<0.001	<0.002		
29156HC				600	400	194																	
29217S	AS	18.9	6.99	330	80	80	1.35	5.84	10.92	1.7	1.6	0.07	0.01	3.04	7.15	<0.1	0.38	<0.05	<0.03	<0.001	<0.002		
29217HC				100	58	82																	√
29215S	AS	18.9	5.99	340	76	98	1.44	5.86	10.92	1.7	1.6	0.1	0.01	2.99	7.07	<0.1	0.25	<0.05	<0.03	<0.001	<0.002		
29215HC				500	58	132																	
29216S	AS	18.9	5.99	320	106	90	1.24	5.86	10.50	1.7	1.5	0.06	0.01	2.99	7.24	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29216HC				90	10	12																	
2137S	AS			480	224	420	2.04	5.94	9.33	1.4	1.4	<0.02	<0.01	3.18	7.61	<0.1	0.21	<0.05	<0.03	<0.001	<0.002		
2137HC				880	250	352																	
29036S	AS	22	5.49	130	4	142	0.52	7.16	12.75	2.1	1.8	0.06	0.01	4.14	9.73	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
29036HC				250	4	50																	√
2081S	AS	22.8	6.51	20	0	0	0.15	8.38	30.75	5.8	3.9	0.02	<0.01	1.19	6.2	<0.1	2.23	<0.05	<0.03	0.0017	<0.002		
2081HC				230	8	0																	√
29120S	AS	22.5	5.77	230	174	28	1.32	6.03	16.00	2.9	2.1	0.05	<0.01	3.11	5.41	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
29120HC				900	560	256																	
29161S	AS	20.1	5.83	310	36	84	1.54	5.89	10.50	1.7	1.5	0.11	0.01	3.14	0.35	<0.1	0.4	<0.05	<0.03	<0.001	<0.002		
29161HC				5200	520	130																	
29004S	AS	21.9	5.82	2300	400	440	5.89	6.07	10.92	1.7	1.6	0.1	0.01	3.04	6.81	<0.1	0.2	<0.05	<0.03	<0.001	<0.002		
29004HC				50000	10000	2000																	
29005S	AS	22.5	5.77	1150	550	436	6.44	5.99	10.92	1.7	1.6	0.12	0.01	3.08	5.56	<0.1	0.3	<0.05	<0.03	<0.001	<0.002		

Figure 12 cont. : Shange Water Quality Results - Survey 2.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	/100ml	/100ml	/100ml	NTU	mS/m	$CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
29005HC				23000	2000	300																	√
2083S	AS	22.5	5.77	1100	540	520	7.9	5.95	10.50	1.7	1.5	0.11	0.01	3.12	5.67	<0.1	0.39	<0.05	<0.03	<0.001	<0.002		
2083HC				1250	0	240																	
29023S	AS	22.8	6.51	0	0	0	0.13	0.31	30.33	5.8	3.8	0.02	<0.01	1.14	6.02	<0.1	2.08	<0.05	<0.03	<0.001	<0.002		
29023HC				6500	4200	44																	√
29086S	AS	21.6	6.5	6	0	0	0.7	0.7	29.33	5.4	3.8	0.02	<0.01	0.46	5.59	<0.1	3.29	<0.05	<0.03	<0.001	<0.002		
29086HC				40	6	0																	
39095S	AS	22.8	6.51	0	0	0	0.15	8.31	30.50	5.7	3.9	<0.02	<0.01	1.17	6.07	<0.1	2.08	<0.05	<0.03	<0.001	<0.002		
39095HC				4000	220	42																	
29063S	AS	22.2	6.27	0	0	0	1.07	13.1	46.17	9.3	5.5	0.04	<0.01	2.87	10.5	<0.1	1.13	<0.05	<0.03	<0.001	<0.002		
29063HC				1100	64	45																	√
33329S	AS	22.2	6.27	4	2	0	1.52	13.1	46.17	9.3	5.5	0.07	<0.01	2.86	10.6	<0.1	0.79	<0.05	<0.03	<0.001	<0.002		
33329HC				1150	600	2																	
2073S	AS	21.1	6.48	20	5	4	1.77	8.89	16.00	2.9	2.1	0.11	<0.01	3.39	11.5	<0.1	0.72	<0.05	<0.03	<0.001	<0.002		
2073HC				14	6	0																	
2122S	AS	21.1	6.48	22	22	14	2.15	8.08	16.00	2.9	2.1	0.1	<0.01	3.41	11.6	<0.1	0.42	<0.05	<0.01	<0.001	<0.002		
2122HC				70	2	128																	
2051S	AS	20.1	5.83	220	48	108	2.81	6	10.92	1.7	1.6	0.12	0.01	3.13	6.03	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
2051HC				3200	534	158																	
29134S	AS	22	6.03	350	216	24	4.83	9.27	29.50	5.3	3.9	0.3	0.01	1.48	6.68	<0.1	1.18	<0.05	<0.03	<0.001	<0.002		
29134HC				1950	1600	174																	√

Figure 13 : Shange Water Quality Results - Survey 3.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	TH mg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	/100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Jul-99																								
29236S	AS	18.3	6.77	194	4	2	5.59	5.71	17.42	3.3	2.2	0.1	<0.01	0.96	<0.05	4.85	<0.1	0.31	<0.05	<0.03	<0.001	<0.002		
29236HC				124	12	6																		√
33414S	AS	15.3	6.4	92	28	52	17.7	10.2	27.33	4.6	3.8	1.52	0.06	3.59	<0.05	9.48	<0.1	1.39	<0.05	<0.03	<0.001	<0.002		
33414HC				900	52	216																		√
29067S	AS	16.9	5.99	186	94	560	12.4	5.58	10.08	1.7	1.4	0.29	0.02	2.62	<0.05	7.58	<0.1	0.25	<0.05	<0.03	<0.001	<0.002		
29067HC				180	44	50																		√
29202S	AS	23.2	6.4	404	340	140	5.12	8.61	16.00	2.9	2.1	0.2	<0.01	3.46	<0.05	11.3	<0.1	0.55	<0.05	<0.03	<0.001	<0.002		
29202HC				18	8	0																		√
29156S	AS	16.9	5.99	106	52	134	12	5.63						2.74	<0.05	6.8	<0.1	0.37				<0.002		
29156HC				176	82	264																		
29217S	AS	16.6	6	56	2	12	2.45	5.6	10.42	1.5	1.6	0.09	0.01	2.87	<0.05	6.88	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
29217HC				82	32	148																		
29215S	AS	16.6	6	26	6	8	2.45	5.6	10.42	1.5	1.6	0.09	0.01	2.87	<0.05	6.88	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
29215HC				70	22	48																		
29216S	AS	16.6	6	30	2	12	2.45	5.6	10.42	1.5	1.6	0.09	0.01	2.87	<0.05	6.88	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
29216HC				170	20	42																		
2137S	AS	16.6	6	42	6	14	2.45	5.6	10.42	1.5	1.6	0.09	0.01	2.87	<0.05	6.88	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
2137HC				74	6	2																		
29036S	AS	18.2	5.69	6	2	2	2.3	6.74	11.42	1.9	1.6	0.1	0.02	3.62	<0.05	0.77	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
29036HC				22	10	12																		
2081S	AS	19.4	6.69	0	0	0	0.17	8.28	30.83	6	3.8	<0.02	<0.01	0.94	<0.05	4.36	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
2081HC				0	0	0																		√
29120S	AS	17.2	6.15	134	80	370	10.1	5.58	9.42	1.6	1.3	0.18	0.01	2.75	<0.05	6.86	<0.1	0.21	<0.05	<0.03	<0.001	<0.002		
29120HC				142	74	94																		
29161S	AS	17.2	6.15	160	86	298	13.9	5.59	9.83	1.6	1.4	0.19	0.01	2.68	<0.05	6.85	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
29161HC				70	46	192																		
29004S	AS	17.2	6.15	88	36	196	10.4	5.57	11.08	2.1	1.4	0.19	0.01	2.77	<0.05	6.83	<0.1	0.35	<0.05	<0.03	<0.001	<0.002		
29004HC				226	122	680																		√
29005S	AS	16.9	5.99	188	112	640	10.2	5.52	10.08	1.7	1.4	0.25	0.02	2.6	<0.05	6.9	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		

Figure 13 cont. : Shange Water Quality Results - Survey 3.

Shange	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/ℓ	/100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29005HC				128	62	148																		
2083S	AS	18.5	5.96	54	16	108	2.59	5.51	9.17	1.5	1.3	0.1	<0.01	2.67	<0.05	6.59	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
2083HC				268	30	166																		√
29023S	AS	19.4	6.69	0	0	0	0.17	8.28	30.83	6	3.8	<0.02	<0.01	0.94	<0.05	4.36	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
29023HC				182	112	20																		
29086S	AS	18.8	6.59	0	0	0	0.49	8.91	29.42	5.6	3.7	0.02	<0.01	0.42	<0.05	4.51	<0.1	3.23	<0.05	<0.03	<0.001	<0.002		
29086HC				8	0	14																		
39095S	AS	19.4	6.69	0	0	0	0.17	8.28	30.83	6	3.8	<0.02	<0.01	0.94	<0.05	4.36	<0.1	1.86	<0.05	<0.03	<0.001	<0.002		
39095HC				66	4	0																		
29063S	AS	21.1	6.45	4	2	0	0.89	12.9	47.58	9.7	5.6	0.05	<0.01	2.98	<0.05	11.1	<0.1	1.29	<0.05	<0.03	<0.001	<0.002		
29063HC				2	2	0																		
33329S	AS	21.1	6.45	2	2	2	0.89	12.9	47.58	9.7	5.6	0.05	<0.01	2.98	<0.05	11.1	<0.1	1.29	<0.05	<0.03	<0.001	<0.002		
33329HC				158	70	6																		
2073S	AS	no sample																					ns	
2073HC				560	6	44																		
2122S	AS	23.2	6.4	178	148	98	5.12	8.61	16.00	2.9	2.1	0.2	<0.01	3.46	<0.05	11.3	<0.1	0.55	<0.05	<0.03	<0.001	<0.002		
2122HC				126	60	54																		
2051S	AS	17	6.07	54	0	8	0.79	5.56	10.00	1.5	1.5	0.04	<0.01	2.67	<0.05	6.45	<0.1	0.29	<0.05	<0.03	<0.001	<0.002		
2051HC				120	12	88																		
29134S	AS	19.1	6.28	22	12	2	7.24	8.83	30.58	5.4	4.1	0.33	0.01	1.52	<0.05	7	<0.1	1.63	<0.05	<0.03	<0.001	<0.002		
29134HC				142	10	36																		√

Figure 14 : ShangeWater Quality Results - Survey 4.

Shange	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*	source
Units		°C	mg/l	0.05-2.5	0.1-2.5	/100ml	/100ml	/100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l			
Std						0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01			
Nov-99																											
29236S		19.5	8.05	<0.05	<0.05	140	60	2	0.62	9.43	12.2	7.7	2.4	0.02	<0.01	0.38	0.09	7.3	<0.1	2.06	<0.05	<0.03	<0.001	<0.002			ut
29236HC		19.2	6.63			0	0	0																			
33414S	AS	18.8	6.1			112	40	170	4.54	8.89	26.1	3	3.1	0.2	<0.01	1.55	0.05	6.92	<0.1	1.14	<0.05	<0.03	<0.001	<0.002			L
33414HC		19.5	6.48			8	6	0																			
29067S		21.2	8.92	0.1	<0.05	48	4	134	0.45	9.72	33.2	9.8	2.2	0.03	<0.01	0.36	0.05	7.26	<0.1	2.03	<0.05	0.1	<0.001	<0.002			ut
29067HC		no sample																							ns		
29202S	AS	18.7	6.76			118	22	16	0.83	9.74	29.2	4.3	3.1	0.06	<0.01	0.27	0.06	4.08	<0.1	0.32	0.06	0.12	<0.001	<0.002			M
29202HC		19.4	7.12			184	134	12																			
29156S		20.9	8.4	0.1	<0.05	0	0	0	0.34	9.57	29.2	9.6	2.2	0.02	<0.01	0.33	0.06	7.43	<0.1	2.1	<0.05	0.07	<0.001	<0.002			ut
29156HC		20.7	7.32			104	44	52																		√	
29217S	AS	22	6.75			18	6	2	0.82	9.5	20.4	4.4	3.2	0.02	<0.01	0.22	0.06	4.32	<0.1	0.38	<0.05	0.09	<0.001	<0.002			J
29217HC		24.1	7.16			710	170	28																			
29215S	AS	22	6.75			28	8	2	0.82	9.5	20.4	4.4	3.2	0.02	<0.01	0.22	0.06	4.32	<0.1	0.38	<0.05	0.09	<0.001	<0.002			J
29215HC		22	6.75			330	146	56																		√	
29216S	AS	22	6.75			20	8	16	0.82	9.5	20.4	4.4	3.2	0.02	<0.01	0.22	0.06	4.32	<0.1	0.38	<0.05	0.09	<0.001	<0.002			J
29216HC		19.7	6.11			76	12	8																			
2137S	AS	18.8	5.78			330	250	132	13	5.47	7.3	1.1	1.1	0.23	0.02	2.08	0.09	5.68	<0.1	0.36	<0.05	<0.03	<0.001	<0.002			A
2137HC		19.7	6.11			250	192	90																			
29036S	AS	19.9	5.79			264	178	26	2.27	6.52	33.7	1.9	1.8	0.09	<0.01	1.67	0.06	7.3	<0.1	0.49	<0.05	<0.03	<0.001	<0.002			K
29036HC		20.6	6.18			112	90	96																			
2081S	AS	22.9	6.53			0	0	0	0.62	8.46	23.7	4.6	3.5	<0.02	<0.01	0.93	0.09	4.29	<0.1	2.28	<0.05	<0.03	<0.001	<0.002			D
2081HC		22.2	6.79			4	0	0																			
29120S		21.4	8.51	1	<0.05	0	0	0	0.35	9.64	33.2	9.6	2.2	0.03	<0.01	0.37	0.06	7.33	<0.1	2.09	<0.05	0.1	<0.001	<0.002			ut
29120HC		20.7	8.71			114	22	0																			
29161S		21	6.72	<0.05	<0.05	0	0	0	0.32	9.6	24.3	9.6	2.3	0.11	<0.01	0.36	0.06	7.41	<0.1	2.07	<0.05	0.1	<0.001	<0.002			A
29161HC		21.7	7.09			312	164	38																			
29004S		19.5	8.82	<0.05	<0.05	124	104	96	0.29	9.97	29.2	8	2.2	0.02	<0.01	0.33	0.06	7.28	<0.1	2.14	<0.05	0.11	<0.001	<0.002			ut

Figure 14 cont. : Shange Water Quality Results - Survey 4.

Shange	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*	source
Units		°C	mg/l			/100ml	/100ml	/100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l			
Std						0	0	0	1	70	22-300	0.01	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01			
29004HC		19.8	7.58			19000	17000	118																			ut
29005S		19.9	8.41	<0.05	<0.05	108	0	0	0.36	9.32	29.1	7.8	2.3	0.02	<0.01	0.39	0.06	7.4	<0.1	1.97	<0.01	0.1	<0.001	<0.002			
29005HC		19.3	8.49			360	160	96																			M
2083S	AS	19.6	6.86			5800	480	2	2.53	7.55	24.3	4.4	3.2	0.08	<0.01	0.23	0.06	4.24	<0.1	0.38	0.06	0.08	<0.001	<0.002			
2083HC		18.5	6.91			176	136	84																			D
29023S	AS	23	6.62			0	0	0	0.38	8.44	26.8	4.7	3.6	0.03	<0.01	0.91	0.07	4.2	<0.1	2.32	<0.05	<0.03	<0.001	<0.002			
29023HC		25	6.79			31000	400	204																		√	E
29086S	AS	21.3	6.43			16	4	4	0.9	8.85	25.6	4.4	3.5	0.06	<0.01	0.38	0.08	4.09	<0.1	3.18	<0.05	<0.03	<0.001	<0.002			
29086HC		23.5	6.63			52000	164	52																			D
39095S	AS	22.9	6.53			6	0	0	0.62	8.46	23.7	4.6	3.5	<0.02	<0.01	0.93	0.09	4.29	<0.1	2.28	<0.05	<0.03	<0.001	<0.002			
39095HC		22.8	6.94			39000	10000	152																			ut
29063S		20.6	7.81	<0.05	<0.05	0	0	0	0.28	9.63	29.1	7.8	2.3	0.06	<0.01	0.3	0.07	7.25	<0.1	1.86	<0.05	0.11	<0.001	<0.002			
29063HC		20.2	7.9			400	2	30																			C
33329S	AS	19	6.6			360	250	290	6.57	13.4	41.5	8.1	5.1	0.19	<0.01	2.86	0.06	11.5	<0.1	1.61	<0.05	0.08	<0.001	<0.002			
33329HC		19.4	6.7			1820	440	350																			ut
2073S		19.8	8.48	<0.05	<0.05	0	0	0	0.4	9.68	29.2	8	2.2	<0.02	<0.01	0.36	0.06	7.11	<0.1	1.87	<0.05	0.16	<0.001	<0.002			
2073HC		19.6	8.51			290	264	30																			ut
2122S		19.9	8.64	<0.05	<0.05	0	0	0	0.21	9.6	28.9	7.9	2.2	0.03	<0.01	0.38	0.06	7.39	<0.1	2.04	<0.05	0.11	<0.001	<0.002			
2122HC		19.5	8.36			52	0	2																			A
2051S	AS	18.8	5.78			6200	480	156	13	5.47	7.3	1.1	1.1	0.23	0.02	2.08	0.09	5.68	<0.1	0.36	<0.05	<0.03	<0.001	<0.002			
2051HC		19	6.19			6900	294	10																			H
29134S	AS	16.7	6.85			0	0	0	1.25	3.48	<6.67	<1.0	<1.0	0.05	0.01	0.23	0.1	0.84	<0.1	2.5	<0.05	4.7	<0.001	<0.002			
29134HC		17.7	6.9			178	106	196																		√	

Figure15 : Shange Water Quality Results - Survey 5.

Shange	S*	Tem	pH	Free Cl	Tot Cl	coliforms	E. coli	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA	HD*
Units		°C	mg/ℓ	mg/ℓ	mg/ℓ	/100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29236S		25	7.94	<0.05	<0.05	0	0	0	0.13	10.7	38.5	11.4	2.4	<0.02	<0.01	0.56	<0.05	8.85	<0.1	2.17	<0.05	0.04	<0.001	<0.002		
29236HC		25.4	7.87			4	0	2																		
33414S		24.8	7.6	<0.05	<0.05	0	0	0	0.27	10.3	38	11.2	2.4	<0.02	<0.01	0.53	<0.05	8.58	<0.1	2.3	<0.05	0.05	<0.001	<0.002		
33414HC		26.1	7.5			12	0	4																		
29067S		24.3	8.4	<0.05	<0.05	0	0	0	0.18	10.6	39.1	11.3	2.6	<0.02	<0.01	0.52	<0.05	14.5	0.14	2.37	<0.05	0.04	<0.001	<0.002		
29067HC		24.9	8.44			6	2	168																		
29202S		24.6	8.14	<0.05	<0.05	0	0	0	0.16	10.7	39.6	11.5	2.6	<0.02	<0.01	0.53	0.05	8.72	0.13	1.96	<0.05	0.04	<0.001	<0.002		
29202HC		24.6	8.13			0	0	0																		
29156S		24.5	8.01	<0.05	<0.05	0	0	0	0.17	10.6	39.3	11.4	2.6	<0.02	<0.01	0.56	<0.05	8.67	0.12	1.98	<0.05	0.04	<0.001	<0.002		
29156HC		24.5	8.05			108	18	266																		
29217S		23.4	7.99	<0.05	<0.05	0	0	0	0.16	10.5	39.7	11.7	2.5	<0.02	<0.01	0.4	0.09	8.28	<0.1	2.12	<0.05	0.03	<0.001	<0.002		
29217HC		24.1	8.12			0	0	0																		√
29215S		23.1	8.1	<0.05	<0.05	0	0	0	0.08	10.5	39.7	11.7	2.5	<0.02	<0.01	0.44	0.06	8.27	0.12	1.9	<0.05	0.04	<0.001	<0.002		√
29215HC		23.7	8.05			800	218	130																		
29216S		23.4	8.38	<0.05	<0.05	0	0	0	0.18	10.5	39.9	11.6	2.5	0.02	<0.01	0.48	<0.05	9.33	0.103	2.14	<0.05	0.04	<0.001	<0.002		
29216HC		24.2	7.63			1400	730	122																		
2137S		24.7	7.47	<0.05	<0.05	0	0	0	0.32	10.4	39	11.6	2.4	<0.02	<0.01	0.55	<0.05	8.64	0.102	2	<0.05	0.05	<0.001	<0.002		
2137HC		25.8	7.9			180	12	6																		
29036S		27.5	7.11	<0.05	<0.05	0	0	0	0.19	10.1	36.1	10.6	2.3	<0.02	<0.01	0.57	<0.05	8.4	0.103	2.19	<0.05	0.17	<0.001	<0.002		
29036HC		28.7	6.13			74	6	2																		
2081S	AS[2]	21.1	6.38	<0.05	<0.05	0	0	0	0.32	8.46	30.2	5.9	3.7	<0.02	<0.01	1.42	<0.05	4.5	<0.1	1.94	<0.05	<0.03	<0.001	<0.002		
2081HC		25.5	6.59			1720	, 54	0																		√
29120S		24.2	8.14	<0.05	<0.05	0	0	0	0.15	10.5	39.8	11.9	2.4	<0.02	<0.01	0.48	<0.05	8.79	<0.10	2.13	<0.05	0.04	<0.001	<0.002		
29120HC		23.4	8.26			296	14	4																		

*HD: Household diarrhoea present
OA: Overall Assessment DWAF
HC:Household Container
S: Source
AS: Alternate source pre-supply
AS[1]: Alternate source - bychoice
AS[2]: Alternate source - supply problems

Figure 15 cont: Shange Water Quality Results - Survey 5.

Shange	S*	Temp	pH	Free Cl	Tot Cl	coliforms	*E. coli.*	F. strep	Turb.	Cond.	THmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA	HD
Units		°C	mg/l	mg/l	mg/l	/100ml	/100ml	/100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	0.5	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
29161S		24.7	8.1	<0.05	<0.05	0	0	0	0.2	10.6	39.9	11.8	2.5	<0.02	<0.01	0.59	<0.05	9.58	<0.10	2.28	<0.05	0.03	<0.001	<0.002		
29161HC		23.8	8.39			2	0	0																		
29004S		24.1	8.44	<0.05	<0.05	0	0	0	0.15	10.6	39.5	11.8	2.4	<0.02	<0.01	0.5	<0.05	8.84	<0.1	2.08	<0.05	0.12	<0.001	<0.002		
29004HC		25	7.79			184	70	126																		
29005S		26.3	7.98	<0.05	<0.05	0	0	0	0.16	10.5	39.8	11.9	2.4	<0.02	<0.01	0.48	<0.05	8.87	<0.1	2.11	<0.05	0.04	<0.001			
29005HC		26.9	8.13			208	54	30																		
2083S		24.6	7.75	<0.05	<0.05	0	0	0	0.17	10.6	39.5	11.8	2.4	<0.02	<0.01	0.5	<0.05	8.62	0.13	2.12	<0.05	0.05	<0.001	<0.002		
2083HC		24.8	7.82			452	66	144																		
29023S		24.5	8.36	<0.05	<0.05	0	0	0	0.19	10.6	39.3	11.4	2.6	<0.02	<0.01	0.42	<0.05	8.53	0.114	2.1	<0.05	0.04	<0.001	<0.002		
29023HC		24.8	8.24			<1000	158	154																		
29086S	AS[2]	23.2	6.47			16	0	0	0.51	9.02	29.5	5.3	3.9	<0.02	<0.01	0.48	<0.05	3.92	0.114	4.26	<0.05	<0.03	<0.001	<0.002		
29086HC		23.8	6.77			44	8	6																		
39095S		25.7	7.42	<0.05	<0.05	720	98	46	0.28	10.2	38.2	11.3	2.4	0.14	<0.01	0.54	<0.05	8.27	0.11	2.26	<0.05	0.14	<0.001	<0.002		
39095HC		26.3	7.66			4200	368	166																		
29063S		23.4	7.88	<0.05	<0.05	0	0	0	0.53	10.6	40	12	2.4	<0.02	<0.01	0.49	<0.05	8.4	0.114	2.15	<0.05	0.07	<0.001	<0.002		
29063HC		23.3	7.99			54	8	2																		
33329S		25.6	7.93	<0.05	<0.05	0	0	0	0.18	10.6	40.2	12.1	2.4	<0.02	<0.01	0.45	<0.05	8.74	0.113	2.06	<0.05	0.04	<0.001	<0.002		
33329HC		25.6	7.99			2	0	2																		
2073S		25.3	8.27	<0.05	<0.05	0	0	0	0.17	10.7	39.3	11.4	2.6	<0.02	<0.01	0.46	<0.05	8.65	0.113	2.03	<0.05	0.04	<0.001	<0.002		
2073HC		25.9	7.02			0	0	40																		
2122S		23.4	8.28	<0.05	<0.05	0	0	0	0.18	10.7	39.1	11.3	2.6	<0.02	<0.01	0.48	<0.05	8.61	0.113	2.3	<0.05	0.1	<0.001	<0.002		
2122HC		22.6	7.9			>1000	18	0																		
2051S	AS[2]	20.9	5.75			112	36	2	0.46	6.53	11.8	1.9	1.7	0.02	<0.01	3.7	<0.05	6.79	<0.1	0.25	<0.05	<0.03	<0.001	<0.002		
2051HC		24.1	5.96			96	14	6																		
29134S	AS[2]	23.4	6.07			114	52	4	3.29	10.9	35.8	6.5	4.7	0.09	0.02	3.29	<0.05	8.65	0.104	1.3	<0.05	<0.03	<0.001	<0.002		
29134HC		23.4	5.89			548	256	124																		

Figure 16 : Mafakatini. Water Quality Results - Survey 1.

Mafakatini	S*	Temp	pH	Coliforms	*E. coli*	*F. strep*	Turb.	Cond.	THmg/l	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Jan-99																							
36988S	AS	16.6	6.84	3400	1480	112	64.2	4.63	17.08	3.5	2	2.03	0.18	0.16	3.36	<0.1		<0.05	0.07	<0.001	<0.002		
36988HC				1480	210	300																	
42626S	AS			90	18	500	64.2	4.63	17.08	3.5	2	2.03	0.18	0.16	3.36	<0.1		<0.05	0.07	<0.001	<0.002		
42626HC				12	2	114																	
36908S	AS			36	18	80	64.2	4.63	17.08	3.5	2	2.03	0.18	0.16	3.36	<0.1		<0.05	0.07	<0.001	<0.002		
36908HC				84	42	1900																	√
36978S	AS			2400	1270	58	2.53	4.44	17.08	3.5	2	2.03	0.18	0.15	3.52	<0.1		<0.05	0.07	<0.001	<0.002		
36978HC				110	60	330																	√
42525S	AS			110	80	140	64.2	4.63	17.08	3.5	2	2.03	0.18	0.16	3.36		<100	<0.05	0.07	<0.001	<0.002		
42525HC				5100	130	340																	√
42709S	AS	17.5	5.66	930	68	20	4.79	6.51	12.92	2	1.9	0.07	0.01	3.07	9.14	<0.1		<0.05	<0.03	<0.001	<0.002		
42709HC				890	700	104																	√
36984S	AS			930	68	20	4.79	6.51	12.92	2	1.9	0.07	0.01	3.07	9.14	<0.1		<0.05	<0.03	<0.001	<0.002		
36984HC				720	100																		√
36963S	AS	24.7	6.58	104	48	8	0.4	10.8	31.25	7	3.3			2.23	4.68	0.14	1.94						
36963HC				180	24	26																	√
42614S	AS			104	48	8	0.4	10.8	31.25	7	3.3			2.23	4.68	0.14	1.94						
42614HC				270	0	32																	√
4578S	AS	21.5	5.82	68	30	4	0.32	6.88	16.67	2.5	2.5	<0.02	<0.01	3.73	4.71	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
4578HC				310	68	60																	
42718S	AS	23.7	6.03	2	2	0	0.37	4.54	10.42	2	1.3	0.11	<0.01	1.36	3.14	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42718HC				2200	640	6																	
36970S	AS			2	2	0	0.37	4.54	10.42	2	1.3	0.11	<0.01	1.36	3.14	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
36970HC				14	14	0																	√
26298Stk				*0*	*0*	30	0.94	2.66	<6.67	*<1.0*	<1.0	0.09	0.02	0.58	*0.58*	<0.1	1.77	<0.05	0.03	<0.001	<0.002		
26298S	AS	20.6	6.49	18	10	144	64.2	4.63	17.08	3.5	2	2.03	0.18	0.16	3.36	<0.1		<0.05	0.07	<0.001	<0.002		
26298HC				22	20	68																	√
7253S	AS	28.6	6.24	0	0	0	0.3	8.84	30.90	4.2	2.5	0.02	<0.01	4.93	6.08	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
7253HC				320	0	12																	
25776S	AS			20	5	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		

HD*: Household Diarrhoea Present
OA: Overall assessment DWAF Guidelines
HC: Household container
S: Source
AS: Alternate source

Figure 16 cont. : Mafakatini. Water Quality Results. Survey 1.

Mafakatini	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
25776HC				820	250	26																	
24706S	AS	21.3	6.21	50	0	4	0.17	5.38	16.50	3.1	2.1	0.05	<0.01	2.07	2.85	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24706HC				50	0	4																	
25765S	AS	27.9	6.38	20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25765HC				290	140	0																	√
42021S	AS			20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42021HC				714	498	2480																	
42023S	AS			20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42023HC				296	184	0																	√
42022S	AS			20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42022HC				0	0	78																	√
25722S	AS			20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25722HC				118	2	10																	√
25797S	AS	20.1	6.64	48	26	26	1.26	4	13.42	3.7	1	0.12	<0.01	0.4	1.69	<0.1	0.36	<0.05	<0.03	<0.001			
25797HC				384	64	124																	
7395S	AS			20	0	0	0.05	<0.01	<6.67	<1.0	<1.0	0.05	<0.01	0.73	2.6	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
7395HC				354	318	140																	
25769S	AS			0	0	0	0.3	8.84	20.92	4.2	2.5	0.02	<0.01	4.93	6.08	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25769HC				6	2	0																	
4553S	AS			0	0	0	0.3	8.84	20.92	4.2	2.5	0.02	<0.01	4.93	6.08	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
4553HC					1000	110																	√

Figure 17 : *Mafakatini.* Water Quality Results - Survey 2.

Mafakatini	S*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	150	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
Apr-99																							
36988S	AS	19	7.43	100	20	36	2.62	7.15	26.08	6.1	2.6	0.13	0.01	0.22	4.6	<0.1	1.44	<0.05	<0.03	<0.001	<0.002		
36988HC				250	24	24																	
42626S	AS	20.5	7.57	180	58	40	4.3	7.27	29.42	7.1	2.8	0.1	0.01	0.22	4.75	<0.1	1.42	<0.05	<0.03	<0.001	<0.001		
42626HC				80	38	18																	
36908S	AS	19.3	7.82	10	10	4	2.78	0.17	30.17	7.9	2.5	0.17	<0.01	0.25	6.61	<0.1	1.5	<0.05	<0.03	<0.001	<0.002		
36908HC				260	14	10																	√
36978S	AS	18.6	7.35	80	24	8	0.89	6.71	24.58	5.5	2.6	0.2	<0.01	0.21	3.53	<0.1	1.38	<0.05	<0.03	<0.001	<0.002		
36978HC				50	4	0																	√
42525S	AS	20.1	7.54	220	84	26	11.4	7.04	28.50	6.9	2.7	0.12	0.01	0.24	3.85	0.15	<100	<0.05	<0.03	<0.001	<0.002		
42525HC				770	52	16																	√
42709S	AS	20.5	7.07	30	10	32	3.5	4.23	11.67	2	1.6	0.16	0.01	0.11	3.18	0.13	2.76	<0.05	<0.03	<0.001	<0.002		
42709HC				14	14	44																	√
36984S	AS	19.7	6.86	4	2	6	0.33	10.8	35.83	7.5	4.1	0.09	<0.01	2.21	5.2	0.13	1.95	<0.05	<0.03	<0.001	<0.002		
36984HC				1260	30	36																	√
36963S	AS			26	0	10	0.39	10.9	32.58	6.7	3.8	0.16	<0.01	2.54	4.95	0.15	2.09	<0.05	<0.03	<0.001	<0.002		
36963HC				680	26																		
42614S	AS	19.3	5.85	0	0	4	0.26	3.1	<6.67	<1.0	<1.0	0.05	<0.01	0.89	2.21	<0.1	0.88	<0.05	<0.03	<0.001	<0.002		
42614HC				2010	18	2																	
4578S	AS	17.9	5.81	730	522	30	0.47	6.93	15.67	2.1	2.5	0.1	<0.01	4.01	5.09	<0.1	0.22	<0.05	<0.03	<0.001	<0.002		
4578HC				760	24	14																	
42718S	AS	19.2	5.92	24	0	54	0.27	4.06	9.50	1.8	1.2	0.15	<0.01	1.24	3.87	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
42718HC				190	100	10																	
36970S	AS	20.7	5.86	0	0	54	0.27	2.89	<6.67	<1.0	<1.0	0.04	<0.01	0.92	2.74	<0.1	0.13	<0.05	<0.03	<0.001	<0.002		
36970HC				2	0	2																	
26298S	AS	19.2	7.31	120	38	10	2.03	6.69	23.08	4.9	2.6	0.18	0.02	0.26	3.33	<0.1	1.46	<0.05	<0.03	<0.001	<0.002		
26298HC		*no sample*																				ns	√
7253S	AS	19	5.85	0	0	0	0.2	8.92	21.08	4.1	2.6	0.08	<0.01	5.2	7.13	<0.1	0.36	<0.05	<0.03	<0.001	<0.002		
7253HC				12	0	0																	
25776S	AS	19.1	6.14	0	0	0	0.15	8.56	21.33	4.2	2.8	0.05	<0.01	5.26	7.36	<0.1	0.35	<0.05	<0.03	<0.001	<0.002		

HD*: Household Diarrhoea Present
OA: Overall assessment DWAF
HC: Household Container
S: Source
AS: Alternate source

Figure 17 cont. : Mafakatini. Water Quality Results - Survey 2.

Mafakatini	s*	Temp	pH	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THmg/l	Mg	Fe	Mn	NO3	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0	0	0	1	70	22-300	70	0.2	0.05	10	250	1	200	0.5	1	0.01	0.01		
25776HC				200	0	10																
24706S	AS	18	6.07	168	168	2	0.17	5.47	5.63	2.2	0.03	<0.01	2.48	3.82	<0.1	0.24	<0.05	<0.03	<0.001	<0.002		
24706HC				2000	100	2																
25765S	AS			18	2	30	0.36	2.89	2.71	<1.0	0.05	<0.01	0.86	3.92	<0.1	0.2	<0.05	<0.03	<0.001	<0.002		
25765HC				62	24	10																
42021S	AS	17.9	6.07	24	2	24	0.33	2.82	2.71	<1.0	0.05	<0.01	0.87	3.85	<0.1	0.16	<0.05	<0.03	<0.001	<0.002		
42021HC				9800	60	44																√
42023S	AS	17.9	6.07	2	0	28	0.41	2.82	2.58	<1.0	0.02	<0.01	0.89	3.87	<0.1	0.17	<0.05	<0.03	<0.001	<0.002		
42023HC				3500	54	50																√
42022S	AS	18.9	6.01	12	4	12	0.8	2.81	2.63	<1.0	0.03	<0.01	0.87	3.92	<0.1	0.15	<0.05	<0.03	<0.001	<0.002		
42022HC				4000	8	12																√
25722S	AS	19.2	6.13	50	2	2	0.48	2.98	3.08	<1.0	0.14	<0.01	0.88	4.34	<0.1	0.51	<0.05	<0.03	<0.001	<0.002		
25722HC				90	6	52																
25797S	AS			24	4	24	0.44	2.81	2.79	<1.0	0.07	<0.01	0.92	4.27	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
25797HC				4100	52	48																
7395S	AS	19.2	6.13	40	0	0	0.48	2.84	2.67	<1.0	0.04	<0.01	0.88	3.84	<0.1	0.37	<0.05	<0.03	<0.001	<0.002		
7395HC				3000	116	320																√
25769S	AS	19	5.85	0	0	0	0.37	8.41	6.75	2.6	0.06	<0.01	5.1	7.41	<0.1	0.18	<0.05	<0.03	<0.001	<0.002		
25769HC				220	18	4																
4553S	AS	17.3	6.23	0	0	0	0.18	8.49	6.67	2.6	0.04	<0.01	5.31	7.74	<0.1	0.28	<0.05	<0.03	<0.001	<0.002		
4553HC				120	28	4																

Figure 18 : Mafakatini. Water Quality Results - Survey 3.

Mafakatini	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	TH/mg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Jul-99																										
36988S	AS	10.8	8.34			8	0	2	1.49	8.4	30.58	7.9	2.6	0.04	<0.01	0.23	<0.05	6.14	<0.1	1.47	<0.05	<0.03	<0.001	<0.002		
36988HC						0	0	0																		√
42626S	AS	12	7.69			0	0	0	1.39	0.23	30.33	7.8	2.6	0.07	<0.01	0.24	0.11	6.16	<0.1	1.59	<0.05	<0.03	<0.001	<0.002		
42626HC						0	0	0																		
36908S	AS	16.9	7.73			2	0	0																		
36908HC						0	0	0																		
36978S	AS	14.3	7.99			0	0	2	0.79	8.03	28.83	7.2	2.6	0.05	<0.01	0.23	0.06	5.21	<0.1	1.45	<0.05	<0.03	<0.001	<0.002		
36978HC						0	0	0																		√
42525S		15	7.68			6	0	8	1.7	7.25	26.33	6.2	2.6	0.06	<0.01	0.28	<0.05	3.31	<0.1	1.23	<0.05	<0.03	<0.001	<0.002		
42525HC						14	0	168																		√
42709S		15.9	9.08			0	0	0	12.7	9.26	35.92	10.2	2.5	0.25	0.01	0.23	0.08	7.09	<0.1	1.54	<0.05	<0.03	<0.001	<0.002		
42709HC						0	0	0																		
36984S		15.3	9.15			0	0	0	0.77	9.29	35.42	10	2.5	0.06	<0.01	0.15	<0.05	6.95	<0.1	1.6	<0.05	<0.03	<0.001	<0.002		
36984HC						0	2	2																		
36963S		17.9	9.14	0.5	<0.1	0	0	0	0.22	9.12	34.25	9.7	2.4	<0.02	<0.01	0.17	0.08	7.03	<0.1	1.65	<0.05	<0.03	<0.001	<0.002		
36963HC						68	0	0																		
42614S	AS	19	5.84			0	0	0	0.13	2.83	<6.67	<1.0	<1.0	0.02	<0.01	0.98	<0.05	1.94	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42614HC						124	0	4																		
4578S		no sample																							ns	
4578HC						8	0	14																		
42718S	AS	19.1	6.09			0	0	0	0.12	2.83	<6.67	<1.0	<1.0	0.05	<0.01	0.95	<0.05	1.88	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42718HC						220	82	18																		
36970S	AS	18.5	5.87			0	0	0	0.17	2.87	<6.67	<1.0	<1.0	<0.02	<0.01	0.92	<0.05	2.06	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
36970HC						0	0	2																		√
26298S	AS	14.4	7.3			12	0	0	0.33	6.95	24.58	5.5	2.6	<0.02	<0.01	0.3	0.08	2.95	<0.1	1.39	<0.05	<0.03	<0.001	<0.002		
26298HC						242	138	196																		
7253S	AS	17.6	5.84			0	0	0	0.12	0.91	19.50	3.8	2.4	0.03	<0.01	4.73	<0.05	6.53	<0.1	0.26	<0.05	<0.03	<0.001	<0.002		
7253HC						2	0	12																		

HD*: Household Diarrhoea Present
OA: Overall assessment DWAF
HC: Household Container
S: Source
AS: Alternate source

Figure 18 cont. : Mafakatini. Water Quality Results - Survey 3.

Mafakatini	s*	Temp	pH	Free Cl	Tot Cl	Coliforms	E. coli	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HO*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Standard				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.005	0.005		
25776S	AS	17.6	5.84			0	0	0																		
25776HC						424	0	0																		√
24706S	AS	18.5	6.41			18	16	38	0.14	5.67						0.81	<0.05	3.24	<0.1	<0.16						
24706HC						92	54	18																		
25765S	AS	19.5	6.02			88	20	44	0.83	4.11						0.8	<0.05	3.11	<0.1	<0.16				<0.002		
25765HC						284	50	>2000																		√
42021S	AS	18.9	6.1			52	24	28	1.22	2.7	<6.67	<1.0	<1.0	0.18	<0.01	0.82	<0.05	3.06	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
42021HC						142	26	144																		√
42023S	AS	18.9	6.1			104	22	42																<0.002		
42023HC						30	2	24																		√
42022S	AS	19.5	6.02			136	16	22	0.81	2.87	<6.67	<1.0	<1.0	0.08	<0.01	0.75	<0.05	2.98	<0.1	0.75	<0.05	<0.03	<0.001	<0.002		
42022HC						40	36	58																		√
25722S	AS	19.5	6.02			52	12	56																		
25722HC						56	12	8																		
25797S	AS	17	6.06			96	18	54	2.83	2.89	<6.67	<1.0	<1.0	0.14	<0.01	0.76	<0.05	3.16	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25797HC						20	16	206																		
7395S	AS	19.5	6.02			36	18	100																		
7395HC						76	4	42																		√
25769S	AS	17.9	6.33			0	0	0	0.1	8.13	19.92	3.8	2.5	<0.02	<0.01	4.91	<0.05	6.15	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25769HC						24	6	2																		
4553S	AS	17.5	6.11			0	0	0	0.08	8.06	18.42	3.7	2.2	<0.02	<0.01	4.82	<0.05	6.32	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
4553HC						23	18	2																		

Figure 19 : Mafakatini. Water Quality Results - Survey 4.

Mafakatini	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO3	NO2	Cl	F	SO4	Cu	Zn	Cd	As	OA*	HD*
Units		°C	mg/l	mg/l	mg/l	per 100ml	per 100ml	per 100ml	NTU	mS/m	caco3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
Nov-99																										
36988S	AS1	21.4	7.21	0.5	<0.05	224	12	0	0.91	7.5	24.2	5.5	2.5	0.03	<0.01	0.09	<0.05	3.51	<0.1	1.2	<0.05	0.03	<0.001	<0.002		
36988HC		22.6	7.64			2	0	12																		
42626S		21.9	8.69	0.5	<0.05	0	0	0	0.46	9.47	32.8	9.3	2.3	0.02	<0.01	0.21	0.1	8.55	<0.1	1.71	<0.05	<0.03	<0.001	<0.002		
42626HC		22.7	7.88			0	0	0																		
36908S	AS1	no sample																							ns	
36908HC		22.5	7.36			76	22	104																		
36878S	AS1	no sample																							ns	
36878HC		21.7	7.35			96000	48	164																		
42525S		21.6	8.76	0.5	<0.05	0	0	0	0.59	9.62	34.4	9.6	2.5	0.02	<0.01	0.22	0.11	8.66	<0.1	1.82	<0.05	<0.03	<0.001	<0.002		
42525HC		22.6	8.89			130	84	14																		√
42709S		21.9	8.66	0.5	<0.05	0	0	0	0.29	9.93	34	9.6	2.4	<0.02	<0.01	0.21	0.11	8.77	<0.1	1.81	<0.05	<0.03	<0.001	<0.002		
42709HC		22.6	8.78			0	0	0																		
36984S		23.5	8.79	0.6	<0.05	0	0	0	0.26	9.56	31.4	8.9	2.2	<0.02	<0.01	0.21	0.11	8.58	<0.1	1.73	<0.05	<0.03	<0.001	<0.002		
36984HC		no sample																							ns	
36963S		21.5	8.65	0.6	<0.05	0	0	0	0.25	9.63	31.2	8.8	2.2	<0.02	<0.01	0.21	0.1	8.71	<0.1	1.82	<0.05	<0.03	<0.001	<0.002		
36963HC		22.4	7.89			172	50	8																		
42614S		18.8	8.48	0.6	<0.05	28	0	0	0.26	9.27	33.8	9.5	2.4	0.03	<0.01	0.24	0.1	8.71	<0.1	1.87	<0.05	<0.03	<0.001	<0.002		
42614HC		19.9	8.56			124	0	0																		
4578S		19.4	8.66	0.6	<0.05	0	0	0	0.58	9.44	34	9.6	2.4	<0.02	<0.01	0.21	0.1	8.67	<0.1	1.87	<0.05	<0.03	<0.001	<0.002		
4578HC		no sample																							ns	
42718S		20.2	8.75	0.6	<0.05	0	0	0	0.26	9.45	37	10.3	2.7	<0.02	<0.01	0.23	0.09	8.56	<0.1	1.91	<0.05	<0.03	<0.001	<0.002		
42718HC		19.5	8.43			24	0	2																		
36970S		19.9	8.53	0.6	<0.05	0	0	0	0.28	9.48	33.8	9.5	2.4	0.02	<0.01	0.23	0.09	8.56	<0.1	1.91	<0.05	<0.03	<0.001	<0.002		
36970HC		20.5	8.52			0	0	0																		

HD*: Household Diarrhoea Present
OA: Overall Assessment DWAF
HC: Household Container
S: Source
AS: Alternate source pre- supply
AS[1]: Alternate source - by choice
AS[2]: Alternate source - supply problems

Figure 19 cont. : Mafakatini. Water Quality Results - Survey 4.

Mafakatini	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	*F. strep*	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD*	water source
Units		°C	mg/l	mg/l	mg/l	per 100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l			
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01			
26298S	AS[1]	20.1	7.09	ns	ns	30	2	54	0.55	7	24.2	5.2	2.7	0.03	<0.01	0.14	<0.05	3.6	<0.1	1.22	<0.05	<0.03	<0.001	<0.002			M
26298HC		23.5	6.59			2	0	0																			
7253S	AS	16	5.93	ns	ns	350	240	132	0.4	9.39	17.8	3.8	2	0.04	<0.01	3.6	<0.05	5.37	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002			E
7253HC		16	5.95			178	0	60																			
25776S	AS	16	5.93	ns	ns	400	190	218	0.4	9.39	17.8	3.8	2	0.04	<0.01	3.6	<0.05	5.37	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002			E
25776HC		17.4	6.44			10	10	58																			
24706S	AS	16.6	6.21	ns	ns	120	98	116	0.57	5.52	17	3.3	2.1	<0.02	<0.01	2.18	<0.05	3.23	<0.1	0.19	<0.05	<0.03	<0.001	<0.002			D
24706HC		17.1	6.41			1420	6	246																			
25765S	AS	19.5	6.12	ns	ns	138	114	128	4.55	2.83	<6.67	<1.0	<1.0	0.14	0.02	0.67	<0.05	2.79	<0.1	0.09	<0.05	<0.03	<0.001	<0.002			H
25765HC		20.4	6.6			184000	178	28																			
42021S	AS	17.4	6.21	ns	ns	224	224	178	3.89	3.45	<6.67	<1.0	<1.0	0.12	0.01	0.6	<0.05	2.82	<0.1	0.11	<0.05	<0.03	<0.001	<0.002			G
42021HC		17.9	6.85			226	46	36																		√	
42023S	AS	17.4	6.21	ns	ns	480	224	178	3.89	3.45	<6.67	<1.0	<1.0	0.12	0.01	0.6	<0.05	2.82	<0.1	0.11	<0.05	<0.03	<0.001	<0.002			G
42023HC		18.6	6.44			46	28	32																			
42022S	AS	17.2	6.2	ns	ns	156	130	132	3.89	3.45	<6.67	<1.0	<1.0	0.12	0.01	0.6	<0.05	2.82	<0.1	0.11	<0.05	<0.03	<0.001	<0.002			G
42022HC		16.5	6.66			230	6	90																			
25722S	AS	17.2	5.97	ns	ns	156	136	124	3.8	2.77	<6.67	<1.0	<1.0	0.13	0.01	0.63	<0.05	2.85	<0.1	0.07	<0.05	<0.03	<0.001	<0.002			G
25722HC		15.7	6.22			1640	600	132																			
25797S	AS	17.2	5.97	ns	ns	128	112	122	3.8	2.77	<6.67	<1.0	<1.0	0.13	0.01	0.63	<0.05	2.85	<0.1	0.07	<0.05	<0.03	<0.001	<0.002			G
25797HC		15.9	6.26			460	102	36																			
7395S	AS	17.4	6.21	ns	ns	360	178	216	3.89	3.45	<6.67	<1.0	<1.0	0.12	0.01	0.6	<0.05	2.82	<0.1	0.11	<0.05	<0.03	<0.001	<0.002			G
7395HC		17.3	6.56			600	148	34																		√	
25769S	AS	16	5.93	ns	ns	480	270	184	0.4	9.39	17.8	3.8	2	0.04	<0.01	3.6	<0.05	5.37	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002			E
25769HC						16	8	86																			
4553S	AS	15.5	5.85	ns	ns	224	212	64	0.41	7.47	17.8	3.8	2	0.05	<0.01	4.04	<0.05	6.65	<0.1	0.48	<0.05	<0.03	<0.001	<0.002			E
4553HC		16.2	6.54			1770	30	0																			

Figure 20 : Mafakatini Water Quality Results - Survey 5.

Mafakatini	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli*	F. strep	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD
Units		°C	mg/l	mg/l	mg/l	per 100ml	/100ml	/100ml	NTU	mS/m	$caco_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
36988S	AS[1]	23.3	7.2			50	18	54	0.57	7.41	26.92	7.1	2.2	0.02	<0.01				<0.1		<0.05	<0.03	<0.001			
36988HC		23.8	7.12			288	224	120																		
42626S	AS[1]	23.6	7.12			94	42	110	0.9	6.31	21.83	5.4	2	0.05	<0.01				<0.1		<0.05	<0.03	<0.001			
42626HC		24.6	7.73			8	8	0																		
36908S	AS[1]	23.4	6.84			18	0	66	2.02	5.5	18.75	4	2.1	0.06	<0.01	0.08	<0.05	3.37	<0.1	1.32	<0.05	<0.03	<0.001	<0.002		
36908HC		24.3	7.02			64	8	28																		
36978S	AS[1]	23.1	6.99			2	0	38	1.13	6.41	21.75	5.2	2.1	0.13	0.01	0.16	<0.05	4.31	<0.1	1.1	<0.05	<0.03	<0.001	<0.002		
36978HC		23.9	6.96			10200	160	132																		
42525S	AS[1]	22.5	6.96			96	58	70	0.56	6.15	22.17	5.2	2.2	0.07	<0.01				<0.1		<0.05	0.03	<0.001			
42525HC		23.5	7.11			2500000	90000	256																		
42709S		22.6	8.55			2	0	0	0.22	10.4	40.25	12.1	2.4	0.03	<0.01				<0.1		<0.05	<0.03	<0.001			
47709HC		no sample																							ns	
36984S		21.6	8.95	0.25	<0.05	0	0	0	0.2	10.6	42.42	12.8	2.5	0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
35984HC		21.6	8.91			2	0	2																		
36963S		23.1	8.44	<0.05	<0.05	2	0	0	0.22	10.8	40.75	12.3	2.4	<0.02	<0.01	0.47	0.06	8.61	<0.1	1.89	<0.05	<0.03	<0.001	<0.002		
36963HC		no sample																							ns	
42614S		24.4	8.24	<0.05	<0.05	0	0	0	0.25	10.6	40.17	12.4	2.2	0.03	<0.01	0.58	<0.05	10.1	0.12	2.04	<0.05	<0.03	<0.001	<0.002		
42614HC		25	7.84			240	6	8																		
4576S		23.9	8.86	0.25	<0.05	0	0	0	0.41	10.5	41.00	12.4	2.4	<0.02	<0.01	0.36	0.14	8.57	0.11	1.94	<0.05	<0.03	<0.001	<0.002		
4576HC		26	6.97					800																		
42718S		22.8	8.86	0.25	<0.05	0	0	0	0.39	10.5	41.00	12.4	2.4	0.02	<0.01	0.36	0.3	8.53	0.1	1.99	<0.05	<0.03	<0.001	<0.002		
42718HC		23.7	8.74			9300	1900	88																		
36970S		23.2	8.43	0.25	<0.05	0	0	0	0.43	10.6	41.00	12.4	2.4	<0.02	<0.01	0.39	0.1	8.38	<0.1	2.24	<0.05	<0.03	<0.001	<0.002		
36970HC		23.3	8.83			2	0	0																		
26298S	AS[2]	22.2	6.76			14	6	60	3.71	5.39	17.83	3.8	2	0.19	0.01	0.07	<0.05	3.17	<0.1	1.21	0.07	<0.03	<0.001	<0.002		
26298HC		22.5	6.45			60	0	2																		
7253S	AS	17.8	5.84			0	0	0			29.33	6.9	2.9	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
7253HC		19.7	6.8			26	0	86																		

HD*: Household Diarrhoea Present
OA: Overall assessment DWAF
HC: Household Container
S: Source
AS: Alternate Source pre-supply
AS[1]: Alternate source usage - by choice
AS[2]: Alternate source usage - supply problems

Figure 20 cont: Mafakatini Water Quality Results - Survey 5.

Mafakatini	S*	Temp	pH	Free Cl	Tot Cl	Coliforms	*E. coli.*	*F. strep*	Turb.	Cond.	THRmg/l	Ca	Mg	Fe	Mn	NO_3	NO_2	Cl	F	SO_4	Cu	Zn	Cd	As	OA*	HD
Units		°C	mg/l	mg/l	mg/l	per 100ml	/100ml	/100ml	NTU	mS/m	$CaCO_3$	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
Std				0.05-2.5	0.1-2.5	0	0	0	1	70	22-300	150	70	0.2	0.05	10	1	250	1	200	0.5	1	0.01	0.01		
25776S	as	17.8	5.84			0	0	0			29.33	6.9	2.9	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
25776HC		18.7	5.94			17000	376	640																		
24706S	as	20.6	6.09			38	38	4	1.4	0.23	17.50	3.5	2.1	0.06	<0.01	2.02	<0.05	2.96	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
24706HC		22.3	6.25			6300	116	2																		
25765S	as	20.4	6.14			6	6	20	0.23	3.01	<6.6667	<1.0	<1.0	<0.02	<0.01	1.15	<0.05	3.07	<0.1	<0.16	<0.05	<0.03	<0.001	<0.002		
25765HC		21.2	6.13			82	28	18																		
42021S	as	19	6.03			20	10	10			28.67	9.8	<1.0	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
42021HC		21.9	6.72			3000	160	172																		√
42023S	as	19	6.03			50	6	16			28.67	9.8	<1.0	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
42023HC		21.5	6.53			19800	2420	10																		√
42022S	as	26.5	6.01			6	0	4	0.18	2.97	<6.67	<1.0	<1.0	<0.02	<0.01	5.73	<0.05	6.33	<0.1	0.33	<0.05	<0.03	<0.001			
42022HC		24.7	6.12			7900	110	12																		√
25722S	as	21.5	6.01			4	0	0	0.18	2.97	<6.67	<1.0	<1.0	<0.02	<0.01	5.73	<0.05	6.33	<0.1	0.33	<0.05	<0.03	<0.001			
25722HC		25.1	6.07			92000	92000	960																		
25797S	as	19	6.03			28	10	18			28.67	9.8	<1.0	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
25797HC		21.9	5.89			15000	15000	216																		
7395S	as	19	6.03			14	6	48			28.67	9.8	<1.0	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
7395HC		20.1	5.96			32	2	2																		
25769S	as	21.4	5.82			0	0	0	0.11	8.9	22.75	4.6	2.7	<0.02	<0.01	5.73	<0.05	6.33	<0.1	0.33	<0.05	<0.03	<0.001	<0.002		
25769HC		23.1	6.73			3	0	224																		
4553S	as	17.8	5.84			0	0	0			29.33	6.9	2.9	<0.02	<0.01				<0.1		<0.05	<0.03	<0.001	<0.002		
4553HC		19.1	6.77			5800	2410	306																		

APPENDIX 3
Ethics Committee Approval

0045138

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UMGENI
19 APR 2000
WATER AMANZI

13 April 2000

Dear Mr Bailey

PROTOCOL: An evaluation of the impact of RDP levels of Water Supply on community and environmental health. I Bailey. Analytical Services/Public Health/Umgeni Water. Ref E122/99

Thank you for submitting the Zulu translation of section E9 of the research application form. Full ethical approval is given as of this day.

I would mention that there is no record of having received this document previously. The only version of E9 in our files is the English one, amended in response to queries raised by members of the Ethics Committee.

Yours sincerely

Anita Walker

Anita Walker
Postgraduate Administration
Aw/ethics/bailey.5

Copy: Dr M Colvin, MRC

Other related WRC reports available:

An assessment of common problems associated with drinking water disinfection in the developing areas

I Pearson and G Idema

The aims of the project were to assess the problems with present disinfection systems in the developing areas, most of which are chlorine-based systems. The resulting health implications with respect to intermittent disinfection could be serious, and give rise to severe criticism of local authorities.

The results showed that, in many of the water treatment plants and small water supply schemes, existing disinfection practices are unreliable and often not monitored. In a number of systems no chlorination is practised at all. Failure of disinfection is essentially not due to technology problems with equipment (although equipment did fail - after which the alternative of hand addition of chlorine was mostly practised). The reasons for failure and unreliability of disinfection include:

- Lack of chlorine chemicals
- Lack of operator attention
- No provision made for chlorine addition
- Lack of funds for purchasing chlorine
- No monitoring of chlorine residuals to detect chlorine levels.

Probably the most important aspect derived from this study is that the operators controlling the plant do not have the knowledge and understanding of the background of water disinfection, the importance thereof and the possible consequences to the community they are serving. Proper training was, therefore, deemed as being absolutely essential.

Report Number: 649/1/98 **ISBN: 1 86845 376 6**

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