AN ABSTRACT OF THE THESIS OF

Denise H. Costello for the degree of Master of Science in Geography presented on June 5, 2013.

Title: An Evaluation of a Water, Sanitation, and Hygiene (WASH) Program for Rural Communities in Northern Afghanistan

Abstract approved:

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The Water, Sanitation and Hygiene (WASH) sector of international development works to increase access to sustainable, safe water and improved sanitation. Currently, at least 780 million people live without clean drinking water and 2.5 billion without access to improved sanitation (UNICEF & World Health Organization, 2012). Lack of access to these human rights is a major cause of diarrheal disease, which annually kills nearly 760,000 children under the age of five. Many institutions, including the United Nations (UN), non-governmental organizations (NGOs), and local governments are working to resolve this inequality by increasing safe water access, providing sanitation facilities, and improving knowledge and practice of healthy hygiene behaviors. Implementing agencies often self-monitor their efforts and, due to funding challenges, only through the life of the project. This study attempts to evaluate the longer-term effectiveness of an NGO's WASH program in Balkh Province, Afghanistan by investigating five questions, post program 1) was access to safe drinking water improved; 2) how is the spatial distribution of households relative to water sources related to safety of stored drinking

water; 3) was there an increase in WASH knowledge; 4) was there an increase in WASH practices; 5) was stored household drinking water safe for consumption?

In August to September 2012, an evaluation was conducted of the longer-term effectiveness of a 2009 WASH program in northern Afghanistan. A total of 59 households from four villages took part in the follow-up survey that collected information regarding drinking water, sanitation, health behaviors, and storage or treatment of drinking water. With permission of the participants, drinking water samples were collected and tested for any presence of E. coli, an indicator of fecal contamination. Additionally, samples were taken and analyzed from 15 drinking water sources, 13 of which were public boreholes. Lastly, a Garmin GPS device was used to collect latitude and longitude location of important points during the field research. This information was used to conduct a spatial analysis of well distribution throughout the villages.

Survey results showed increases in several beneficial health behaviors, such as using boreholes as the main source of household drinking water, having a specific place to wash hands after using toilet facilities, and having soap in that specific area. Also, based on results of the spatial analysis, access to improved water sources was increased. The practice of treating water in the home dropped significantly. Biosand Filter technology introduced during the WASH program had been adopted by only a small percentage of households. Of the 54 surveyed households that gave permission to sample, 40 had drinking water that tested positive for presence of *E. coli*. In contrast, a majority of borehole samples provided water that was free of *E. coli*. Lastly, by examining the spatial distribution of households, it was found that all households beyond 300m from a borehole had drinking water with a presence of *E coli*.

These outcomes make two suggestions. One is that using “1000m from an improved source” as an indicator of accessibility may be too great a distance for households that must collect and carry water, especially when a closer, though contaminated, water option exists. The second is a need for longer term follow-up, especially as behavior change is one of the main goals of the program. More investigation into why families have not adopted handwashing and in home water treatment to a greater extent would be beneficial in creating a stronger WASH program that has greater health impacts. Extended programming is challenging when NGOs are reliant on external funding for program costs. Advocating to funders the importance of longer term monitoring and evaluation as well as reoccurring education programs, could be a vital next step.

An Evaluation of a Water, Sanitation, and Hygiene (WASH) Program for Rural Communities in Northern Afghanistan

by
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Denise H. Costello, Author

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For Ryan, an amazing husband. I could not have done this without your love and support.

An Evaluation of a Water, Sanitation, and Hygiene (WASH) Program for Rural Communities in Northern Afghanistan

1 INTRODUCTION

1.1 Context

Water scarcity is a growing concern across the globe as human populations increase and the finite resource becomes stretched. Water is an essential part of life on our planet. It is essential for healthy ecosystems and societies, yet is becoming increasingly more contaminated and scarce (Brooks, 2002; Gleick, 2009). It affects rich, industrialized nations as well as those struggling to improve economic and social well-being, which is where the over 780 million people without access to safe drinking water live (UNICEF & World Health Organization, 2012). From 1977 global efforts have been made to promote the rights of all to safe, accessible drinking water (United Nations, 1977). Unfortunately, there is still uneven access to safe drinking water globally and challenges in managing freshwater resources at national and regional levels (Brooks, 2002; World Health Organization, 2010; Gleick, 2011). Recently, there has even been suggestion that the global number of 780 million people without access to safe drinking water is severely underestimated (Bain et al., 2012). There is also uneven distribution of access to safe sanitation, 36% of the world's population (2.5 billion people) lack adequate facilities (World Health Organization, 2010). This proves not only challenging for daily living, but also detrimental to human health. Diarrheal disease, caused predominately by unsafe water and poor sanitation, effects 1.7 billion people annually and is the second largest killer of children under five years of age (Kosek et al., 2003; UNICEF & World Health Organization, 2009; World Health Organization, 2010, 2013).

As a result many institutions, including the United Nations (UN), non-governmental organizations (NGOs), and local governments are working to resolve this uneven access through Water, Sanitation, and Hygiene (WASH) programs. These programs typically target increasing safe water access, providing sanitation facilities, and improving knowledge and practice of healthy hygiene behaviors. Implementing agencies often self-monitor their efforts, which lasts only through the current funding cycle, and face challenges sharing their results widely (Lockwood, 2013). This is an issue as longer-term monitoring and evaluation of projects is essential for sustainable WASH outcomes.

1.2 Study Purpose

This study attempts to evaluate the longer-term effectiveness of one US-based NGO's WASH program in Balkh Province, Afghanistan. Eighteen months after completion, the researcher examined the outcomes of the NGO's interventions to increase use of safe water and improve beneficial WASH knowledge and practices. The researcher also explored potential health impacts of the program. The evaluation addresses five research questions:

Q1. Post program, was access to safe drinking water improved within the study area?

Q2 How is the spatial distribution of households relative to water sources related to safety of stored drinking water?

Q3. Was there an increase in WASH knowledge within the study area?

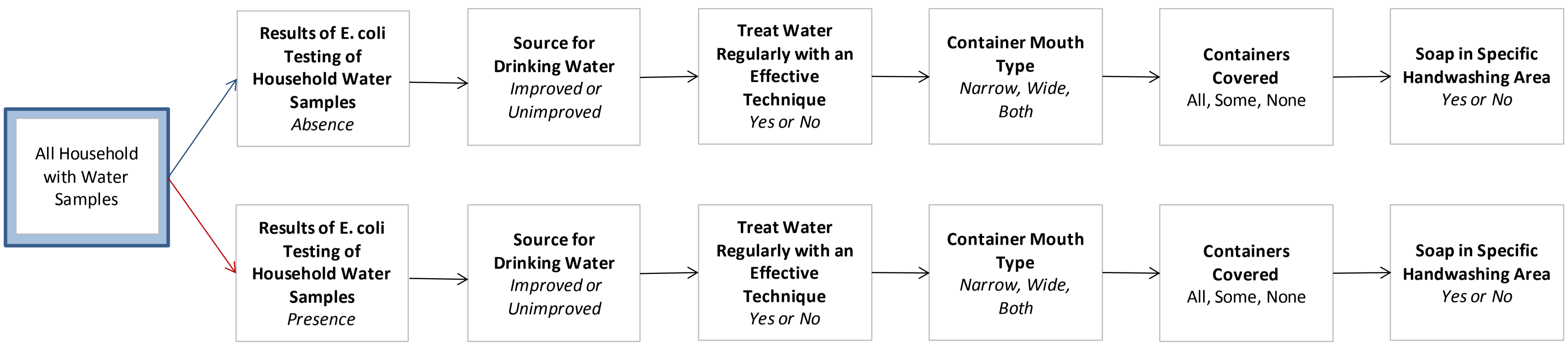
Q4. Was there an increase in WASH practices within the study area?

Q5. Was stored household drinking water safe for consumption?

To explore the relationships between the last three research questions, a flowchart was created to display the connections between outcomes of water sample tests and decisions households made in collecting, treating, and storing drinking water and handwashing with soap (Figure 1.1). The flowchart will indicate areas of break down in the chain of safe water storage and handling and indicate where increased support by WASH programs can be applied.

The results of this study will inform future program planning for the NGO as it continues to help communities increase access to safe water and sanitation and reduce incidence of diarrheal disease. They will also increase knowledge regarding effective WASH interventions for rural populations in northern Afghanistan, an area that has minimal published research. A recent search found only one published article focused on WASH in Afghanistan. In helping to fill knowledge gaps, this study aims to help increase long term human development for rural Afghans.

Figure 1.1: A conceptual flowchart of water collection, treatment, and storage by presence or absence of *E. coli* , as well as proxy information about handwashing with soap.



2 BACKGROUND

2.1 Global WASH Sector

WASH is a sector within the larger international development field. Present goals of the sector are stated in the United Nations' Millennium Development Goal (MDG) 7: "halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation" (United Nations General Assembly, 2003). Currently, at least 780 million people live without clean drinking water and 2.5 billion without access to improved sanitation (UNICEF & World Health Organization, 2012). A lack of these basic human needs creates a significant burden, especially for women and children who are often the primary water collectors if a household does not have piped water. Time and energy that could be spent on education or other tasks is instead used to collect water on a daily basis. Lack of access to these requirements also creates unsanitary conditions and is a major cause of diarrheal disease (UNICEF & World Health Organization, 2009). Diarrhea, due mainly to contaminated food and water, affects 1.7 billion people annually and is the second largest killer of children under five years old (UNICEF & World Health Organization, 2009; World Health Organization, 2010, 2013). These rates could be greatly reduced with improvements in WASH technology and practices (Cairncross et al., 2010; Clasen et al., 2007; Fewtrell et al., 2005).

In 2010, the UN General Assembly in its 64th session declared access to safe, clean drinking water and improved sanitation a universal human right (United Nations General

Assembly, 2010). In doing this, the General Assembly reinforced the commitment made in MDG 7 and created a requirement for complete access for all people, not simply a fractional increase. By definition, a UN recognized human right is one that member States have pledged to achieve whether for their citizens or for others by providing financial, technological, or capacity-building support. This sets the stage for post-2015 in which MDG 7 looks to be replaced by a universal coverage goal (Biran et al., 2012a).

2.2 Common Program Interventions

2.2.1 Hard Path Approaches

The MDG goal 7 does not explicitly state a definition for safe water, though this addition is being discussed for post-2015 targets (World Health Organization & UNICEF, 2012a). Instead, the agreed upon proxy indicator for safe drinking water is an "improved" source that inhibits microbial contamination. Water quality testing for the variety of disease causing pathogens can be costly and challenging, especially at the national scale, for this reason an appropriate proxy had to be identified (Edberg et al., 2000; World Health Organization & UNICEF, 2006). Sources are considered improved if "by the nature of their construction or through active intervention, [they] are protected from outside contamination, particularly faecal matter" (World Health Organization, 2010, 2012). Below, Table 2.1 lists sources that meet the definition for "improved" as defined by the World Health Organization & UNICEF (2006). As more improved sources are created, the hope is that individuals gain access to greater quantities of better quality water.

Table 2.1: List of Water Sources by Category

Water Sources	
Improved	**Unimproved**
Piped water into dwelling	Unprotected spring
Piped water to yard/plot	Unprotected dug well
Public tap or Standpipe	Cart with small tank/drum
Borehole	Tanker-truck
Protected dug well	Surface Water
Protected Spring	
Collected rainwater	

If an individual, agency or government does want to test microbial drinking water quality from improved or other sources, the current recommendation is to test for *Escherichia coli* (*E. coli)*. *E. coli* is used as indicator to detect fecal contamination in water systems throughout the world (Environmental Protection Agency, 2012; World Health Organization, 2011). There are many disease causing pathogens that enter water through fecal contamination; testing for each is costly and impractical, especially in areas lacking electricity for labs (Edberg et al., 2000; World Health Organization, 2011). *E. coli* is only found in human and other mammal feces thus it is a strong indicator of fecal contamination and the potential presence of disease causing pathogens (Edberg et al., 2000; World Health Organization & UNICEF, 2012b; Wright et al., 2004). The World Health Organization states a complete absence of *E. coli* in any 100mL sample as the ideal standard for safe drinking water and the suggestion for post-2015 WASH goals is fewer than 10 CFU *E. coli*/100 mL (Biran et al., 2008; World Health Organization, 2011).

In several studies, improved sources do indeed provide water that is free, or very nearly free, from *E. coli* (Arnold et al., 2013; Dalu et al., 2011; Leiter et al., 2012; Parker et al., 2010; Trevett et al., 2004). Other studies, though, detected *E. coli* in improved sources like boreholes, exemplifying that proxies are not perfect indicators (Abdelrahman & Eltahir, 2011; Mwabi et al., 2012). Improved sources can become contaminated through, for example, a lack of proper lining or sealing of wells thus allowing surface water to contaminate (Parker et al., 2010). Recently, researchers investigated the reliability of this proxy in five countries with over 1,500 improved sources tested for water quality in each country. They found that counting improved sources as safe greatly overestimated access due to many not meeting water quality standards (Bain et al., 2012).

Another infrastructure component to WASH programs is building or helping to build improved sanitation facilities. These facilities help separate human waste from water, food, and general human contact, especially when used by only one household (World Health Organization & UNICEF, 2006). Improved facilities, such as flush/pour flush toilets that deposit waste into a piped system or tank, keep feces separated better than other types of facilities (World Health Organization, 2010). Ventilated pit latrines are another type of improved sanitation facility. They do not require water to be used for waste disposal which is beneficial for households with a limited water supply. Common unimproved options are a simple pit latrine or open-defecation in fields or near roads.

Sanitation improvements have been shown to have health impacts in several literature reviews, presumably through feces containment that helps keep water contamination-free (Cairncross et al., 2010; Esrey et al., 1991; Esrey & Habicht, 1985; Fewtrell et al., 2005). Several of these reviews found that the evidence for a relationship was very weak, mainly due to a lack of high quality research in the area (Cairncross et al., 2010; Clasen et al., 2007; Fewtrell et al., 2005).

2.2.2 Soft Path Approaches

Another component of WASH sector programming is hygiene promotion, the "H" in WASH. Hygiene was added as component of water and sanitation programs due to an acknowledgment that providing safe water sources alone would not guarantee a reduction in diarrheal disease (Black & Talbot, 2005). Often, the goal of hygiene promotion is to increase handwashing with soap and sanitary feces disposal through improved knowledge of the health benefits of such practices (Biran et al., 2012a; Curtis et al., 2011; Luby et al., 2009a). Safe water handling and storage as well as overall education in disease transmission are also vital components to WASH programs (Fewtrell et al., 2005; Halvorson, 2004; Opryszko et al., 2010; Wright et al., 2004). Studies suggest that even when no improvements are made to infrastructure, increasing hygiene practices in these areas greatly improves health (Curtis et al., 2011).

Water Handling, Treatment and Storage

One soft path strategy of WASH programs is encouraging proper water handling, treatment and storage in the home, often via education and promotion of certain practices. An understanding of these strategies is essential as water that is clean at the source can easily become contaminated in transport or storage (Fewtrell et al., 2005; Fisher et al., 2011; Rufener et al., 2010; Wright et al., 2004). When effective water storage and treatment strategies are done regularly, diarrheal disease is reduced (World Health Organization & UNICEF, 2012b). Effective methods for water treatment in the home are: boiling, filtration, chlorination, flocculation, and solar disinfection (Arnold & Colford, 2007; Luoto et al., 2011; World Health Organization & UNICEF, 2006, 2012b). These strategies need to be implemented each and every time new drinking water is collected and stored in order for disease reduction to be realized. Along with promoting water treatment, certain safe storage practices are also promoted: using narrow-mouthed containers, covering storage containers, and keeping hands out of contact with stored water (Mazengia et al., 2002; Wright et al., 2004).

One type of low cost filter is growing in popularity, the Biosand Filter (BSF). These are slow sand filtration systems that can produce up to 1 liter per minute of filtered water. Biosand Filters have the potential for long term use, especially as they require only a one-time financial investment and have low maintenance requirements (Sobsey et al., 2008). In the lab, BSFs can reduce bacteria content up to 99% (Buzunis, 1995; Elliott et al., 2008; Stauber et al., 2012). Follow-up surveys by researchers from the University of North Carolina - Chapel Hill found 90% of households were still using BSFs 1 year after they were introduced in Bonao, Dominican Republic (Aiken et al., 2011). Another study in Cambodia found households using BSFs up to eight years after introduction and that the BSFs reduced *E. coli* in drinking water by 95% (Liang et al., 2010).

Safe water handling and storage is essential for homes that collect water from sources outside of the household. Eschol et al. (2009) found, after studying drinking water from 50 households in Hyderabad, India, that water collected from an improved source then stored in the home for 20-36 hours had increased in contamination by 36%. This led researchers to conclude that until all households have water pumped directly into their homes via water pipes and faucets, in-home storage practices need to be the crucial area of focus. In a similar study in Honduras, Trevett et al. (2004) found significant deterioration in microbial water quality from source to home. This study, lasting two years, conducted routine visits to homes in three communities and found the same level of deterioration on a regular basis. Storage containers were covered, but water was often exposed to human hands and no treatment was documented. Lastly, in their reviews of literature, Fewtrell et al. (2005) and Clasen et al. (2007) found that treating water just before consumption was strongly related to a reduction in diarrhea. Education in water storage and handling, as well as treatment, must be a major component of WASH interventions.

Handwashing with Soap

Another increasingly common WASH strategy is promoting the practice of handwashing with soap, especially at critical times such as after defecating, before preparing food, before feeding a baby, and before eating. Promotion of hand washing with soap is often done in conjunction with increasing water access. Water quantity is important for many hygiene practices, especially handwashing with soap (Cairncross et al., 2010). If a household lacks water, risky hygiene behaviors such as not washing hands at critical times are likely to develop (Biran et al., 2012b; Curtis et al., 2011). Despite challenges, hand washing with soap is a critical WASH practice that reduces diarrheal disease up to 53% (Fan & Mahal, 2011; Luby et al., 2004; Mattioli et al., 2013). Luby et al. (2011) boldly state that it is the key hygiene behavior to promote and create an environment for, due to its power to interrupt the disease cycle. In both developed and developing world settings, washing with soap, for as little as 14 seconds, dramatically reduced the presence of fecal indicator bacteria on individuals' hands (Burton et al., 2011; Pickering et al., 2011).

Handwashing prevalence is challenging to assess. Structured observation, which requires an observer to sit for hours within a household, has been shown to have the most accurate results, but also the greatest cost and limited potential for scaling up (Biran et al., 2008; Luby et al., 2011). Asking individuals when they washed their hands in the previous day is a common assessment tool, but individuals tend to over report especially if they have knowledge of “proper” handwashing times (Halder et al. 2010; Luby, 2009b). Several proxies have been shown to be, at least somewhat, viable indicators of practice: surveyor observation of clean finger pads, moms of children under five using soap when asked to demonstrate how they wash their hands, the presence of soap in a specific handwashing area, and the presence of water in a specific handwashing area (Biran et al., 2008; Halder et al., 2010; Luby et al., 2009b). These proxies are quick and less intrusive than structured observation and can provide, if not exact information, at least a trend in the impact of the promotion interventions of a program.

In the WASH sector, educational programs promote behavior change and are linked to a reduction of diarrheal disease. Fisher et al. (2011) conducted a study in Bangladesh investigating the link between knowledge, attitude, and practices, asking whether or not education can change behavior. The education program lasted two years and presented water, sanitation, and hygiene lessons. Based on follow-up household survey results, the program interventions positively affected attitudes and increased knowledge among primary caretakers for children under five years old. The change in attitude and increase in knowledge were then statistically linked to an increase in beneficial hygiene behavior. Lastly, based on the follow-up survey, which was conducted after the WASH program had ended the beneficial hygiene behaviors were statistically linked to a decrease in under-five diarrhea incidence as compared with control group participants.

Sanitation Behavior

One sanitation behavior addressed in this study and promoted by many WASH education programs is the safe disposal of child feces. One of the core questions for WASH surveys, created by the WHO and UNICEF, assesses respondents' practices in disposing of child feces safely (World Health Organization & UNICEF, 2006). The child using a latrine/toilet, an adult putting child feces into a latrine/toilet, or burying the feces are sanitary disposal tactics.

Overall

As described above, WASH programs are designed around researched based strategies to reach the goals of increasing access to safe water and sanitation, while also reducing diarrheal disease. Hygiene interventions create outputs (such as classes taught) that will lead to an increase in knowledge and ideally impact behavior - with an eventual impact on health, Figure 2.1.

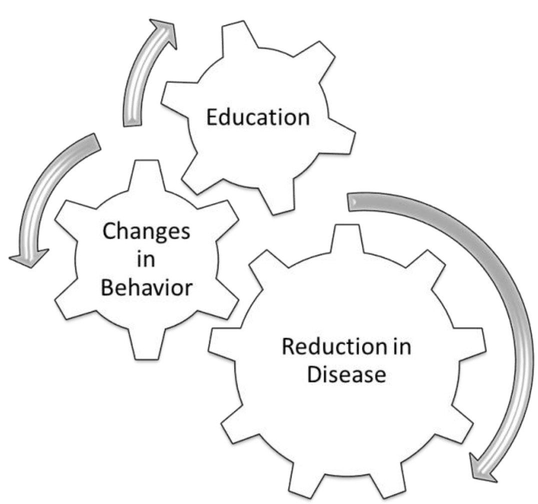


Figure 2.1: A model of the components of a hygiene program. Denise Costello

2.3 WASH Sector in Afghanistan

Access to sustainable safe drinking water and basic sanitation is increasing globally as governments and international agencies work to achieve and surpass MDG 7. Despite the improvements, disparity exits between and within countries. The least developed countries tend to have the lowest access to safe water and sanitation and rural communities have less access than urban dwellers. At the global scale, there are nine countries with access to safe drinking water at less than 50% for its citizens: Mauritania, Niger, Chad, Ethiopia, Somalia, DR Congo, Mozambique, Madagascar, Papua New Guinea, and Afghanistan (World Health Organization & UNICEF, 2013). Afghanistan's citizens also have low access to improved sanitation facilities, under 50% on average.

In 2012 the Joint Monitoring Programme for Water and Sanitation (JMP) reported that 42% of the rural population in Afghanistan had access to improved drinking water sources, while 11% still used surface water (UNICEF & World Health Organization, 2012). This is a dramatic jump from the 1990 figure of 1% using improved sources, but leaves Afghanistan far from reaching the water target of MGD 7 (RECA, 2012). Even fewer rural residents, 30%, have access to improved sanitation, exactly half that of the urban population. Using raw data from the most recent MEASURE DHS (2010) survey conducted in Afghanistan, the researcher created Figures 2.2 and 2.3 to show the spatial distribution of household access at the provincial level. These maps highlight trends of high and low access.

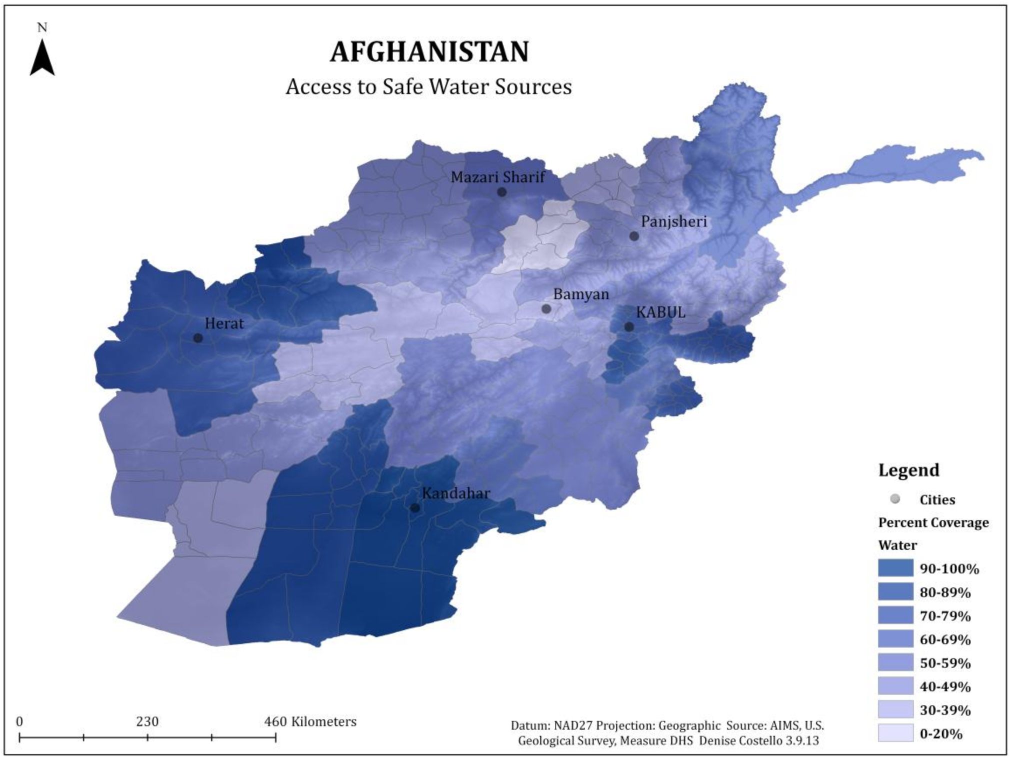


Figure 2.2: Distribution of access to safe water sources by province.

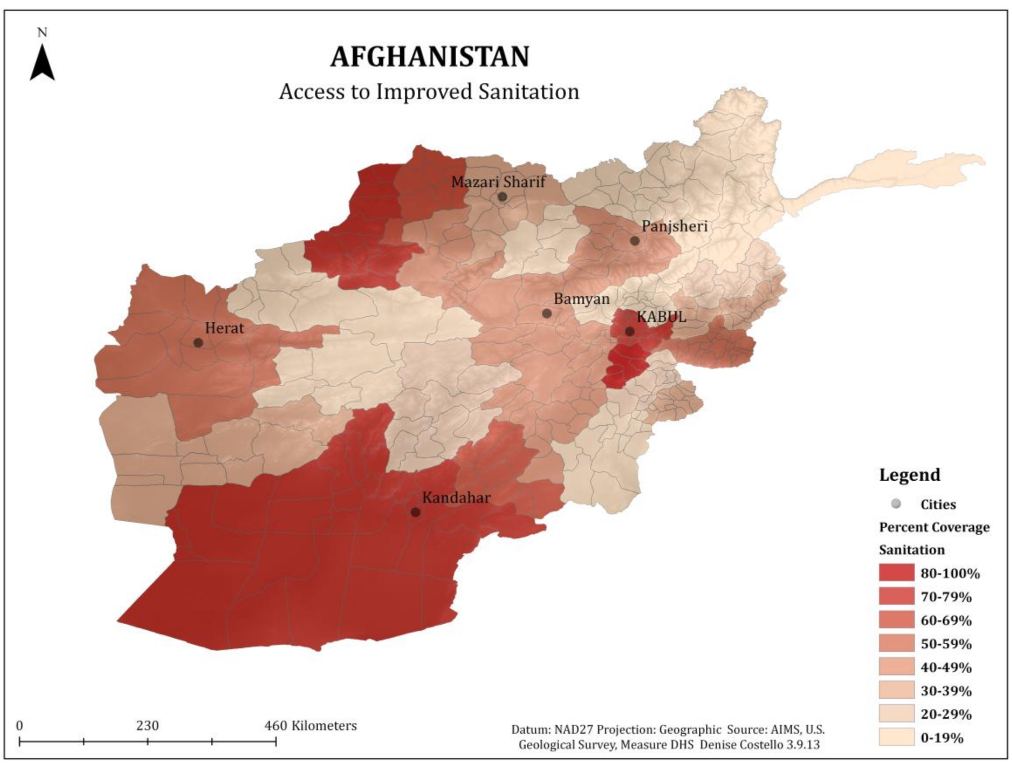


Figure 2.3: Distribution of access to improved sanitation by province.

Connected to the low access rates are high rates of diarrheal disease and low life expectancy. A 2006 UN study found that diarrhea was the leading cause of illness among children under five years old - 47% of all reported illnesses (Center for Policy and Human Development, 2011). Life expectancy has been improving over time, but is still less than 50 years on average (49.1) (United Nations Development Program, 2013).

In response to these and other human development challenges, the Afghan government created the Afghanistan National Development Strategy (Islamic Republic, 2008). Increasing the WASH standards set by the MDG's, the Afghan goal is for 90% of rural villages to have access to safe drinking water and 50% to have access to improved sanitation by the end of 2013. As the UN human rights declaration recognizes, the Afghan strategy emphasized the need for support from the international community in reaching these targets.

2.4 NGO: Specific Program Goals and Interventions

Many international nonprofits and for profit agencies have partnered with the Afghan government and people to increase access to safe water and improved sanitation. This study evaluates one such project run by an international nonprofit, non-governmental organization (NGO) in Balkh Province.

The NGO chose an integrated strategy, rather than implementing a single WASH intervention. Several studies have shown that programs with a comprehensive approach with a goal of long term change have longer lasting outcomes (Luby et al., 2009a; Opryszko et al., 2010). In an 18 month WASH program in 10 villages, the NGO implemented four main interventions: drilling wells, repairing and teaching other to repair hand pumps, training hand-pump repair technicians, teaching hygiene education classes, and introducing biosand filter (BSF) technology. At least one well was drilled, with several repair technicians trained, in each village.

The BSF technology was introduced for household treatment of stored water. The goal was to provide a low-cost tool for water treatment as well as a small business opportunity for the BSF supplier. Hygiene classes were open to all women in each village. Village elders and their wives took the lead in promoting the event within their community. They also identified homes in which to host the classes. The classes met two times per week for two hours and lasted a total of two months. The topics were: 1) Good and Bad Hygiene Behaviors; 2) Health Problems in Our Community; 3) Chain of Infection; 4) F-diagram – Disease Transmission; 5) F-diagram – Blocking Disease Transmission; 6) Cycle of Diarrhea; 7) Safe Water Chain; 8) Sanitation Ladder; and 9) Hand Washing and Tippy-Tap Making. (The F-diagram is a generic visual aid used to demonstrate how vectors such as fingers and fluids transport fecal contamination and potentially dangerous pathogens to foods and future hosts. The typical diagram also shows ways to block the contamination routes.) All lessons facilitated by female WASH staff were interactive and used a variety of visual aids.

The NGO had five program outcome goals, to increase: 1) access to safe water; 2) use of BSF; 3) use of safe water; 4) sanitary behaviors; and 5) handwashing behaviors. Increasing handwashing behavior was the most promoted behavioral goal of the program. All goals were included due to the established relationship between them and decreased diarrheal disease, the ultimate impact goal of the study (Cairncross et al., 2010; Clasen et al., 2007; Fan & Mahal, 2011; Fewtrell et al., 2005).

3 METHODS

3.1 Study Area

Balkh Province, the fifth most populous province, is located in northern Afghanistan at the borders of Turkmenistan, Uzbekistan and Tajikistan (Figure 3.1). It is a mountainous region with over half the province having steep terrain. It consists of 15 districts with an estimated total population of 1.12 million residents (Kamal, 2004). The population is 61.3% rural, with the urban population located in five major cities. Just over half of the population (55.5%) uses improved drinking water sources; 35.5% of the population uses improved sanitation facilities (MEASURE DHS, 2010).

Figure 3.1: Map of the study area in northern Afghanistan.

The province is located in the northern river basin, a region with variable water supplies highly dependent on precipitation (Gohar, Ward, & Amer, 2013). The five prominent rivers in this basin - Murghab, Shirin Tagab, Sarepul, Balkh and Khulm - head in the northern slopes of the Hindu Kush. They flow northward towards the Amu Darya River, which forms part of the northern border of Afghanistan, but end in irrigation canals or the desert before ever reaching the border (Kamal, 2004). The water from these canals is used for agriculture, but also for domestic purposes such as washing clothes, bathing, preparing food, and drinking.

The villages that participated in this study are located in a central district in the lowlands of the province. There is an average of 200 households per village, with the majority being Dari and Pashtu speakers. The villages consist of people from the Tajik, Pashtu, and Hazara ethnicities. Each village has a mosque, a shared school, a small market area, and tree-lined, unpaved roads (Figure 3.2 and Appendix A). The villages are also connected to a system of irrigation canals, mentioned above, that had flowing water at the time of the survey. In some years, the water dries up due to lack of precipitation and other sources must be found. Improved sources for domestic water are public pumps (boreholes) located along the streets (Figure 3.3).

Figure 3.2: A village street.

Figure 3.3: A public pump.

3.2 Description of Baseline Survey

Starting September 2009, the NGO facilitated 18 month long WASH programs in ten villages in Balkh Province, Afghanistan. Some villages had slightly shorter program periods due to security threats that interrupted services during the time of implementation. The WASH program was designed for service to the community, not as a formal research study.

The villages, ranging from 170 to 500 households, were selected for proximity to an agricultural research station run by the NGO. Before the program was implemented, NGO staff visited each village to conduct a baseline survey assessing knowledge and practices of beneficial health behaviors, access to safe drinking water sources, and access to improved sanitation. In each village, 19 households were randomly selected via systematic sampling. The households were selected from detailed maps that had been created by driving or walking down every street in the villages, since no formal list of household addresses existed. The only eligibility criterion for participation was voluntary consent of the female head of household. Female head of households were surveyed using a questionnaire that included questions from the World Health Organization's (2006) "Core Questions on Drinking-water and Sanitation for Household Survey". The "Core Questions" document was created to encourage WASH organizations in collecting standardized information that can be compared from region to region and over time. The NGO questionnaire consisted of 29 questions and 6 surveyor observations regarding: incidence of under-five child diarrhea, types of water and sanitation technologies, knowledge of diarrheal disease, and practices of household water storage, sanitation, and hygiene. The surveys were conducted orally and in person by Afghan WASH staff with responses written by hand. After analysis of the survey, WASH programs were started in each of the ten villages. Based on the results of the surveys as well as funding conditions, the programs consisted of four main components: drilling wells, training hand-pump repair technicians, teaching hygiene education classes, and introducing biosand filter (BSF) technology. The programs lasted about a year and half with intermittent follow-up on BSF use and hand-pump repairs.

From August 2012 to September 2012, this researcher and two WASH staff from the NGO conducted follow-up surveys in four of the ten villages. The research described in this study attempts to assess the efficacy of the WASH interventions a year and a half after implementation.

3.3 Household Survey

3.3.1 Data Collection

To assess the effectiveness of the WASH programs, follow-up surveys were carried out using similar procedures to the baseline, with systematic sampling of 15 households from each village. Due to time constraints, only four out of the ten villages were included in this research. The selection of the four villages was primarily based on security information stating which were the safest. The Afghanistan NGO Safety Office (ANSO) was frequently contacted to confirm that the selected villages were free of overt security threats to foreign and Afghan workers. The researcher and translators also met with the village elders preceding the start of surveying in their village to discuss how long the survey would last and the type of information that would be gathered. Consenting female heads of households were interviewed due to their roles as primary care-givers to children and overall household managers (Halvorson et al., 2011; Halvorson, 2004; Opryszko et al., 2010). Often, all the women of the household, along with children, were present during the survey. In only one home were male members of the household present. The head of household either answered the questions or assigned the duty to another woman of the household who had participated in the NGO hygiene classes.

Surveys were conducted orally due to low literacy rates. An estimated 83% of the female population in rural Afghanistan have little to no formal education (Afghan Public Health Institute, 2011). The researcher was conversational in Dari, an official language of Afghanistan, but limited in the in-depth vocabulary needed for the survey. For this reason, two translators were hired to assist in the research. The translators were Afghan woman who worked in the NGO's WASH program and were familiar with the survey process. It was important to have only female translators, since survey participants were women.

The questionnaire used at baseline was adapted for the follow-up study by reducing it to 23 questions (Appendix B). All of the previous surveyor observations were kept. With guidance from a professional WASH consultant, questions were cut to make a more exact and efficient questionnaire that focused only on concepts that fit the research questions being explored. An open-ended question was added asking the participants to comment on their perceptions of the past program. One reason for this response opportunity was to collect qualitative information that may not have been captured in the other questions. Another reason was to investigate word-of-mouth dissemination of hygiene concepts to woman who had not participated in the classes.

In total, 59 questionnaires were completed with 15 from each village. In village 3, one survey was cut short due to being asked to leave before the survey was finished and the final survey was not conducted due to security concerns. Overall, the response rate was 98% (59/60=98.3%).

3.3.2 Survey Variables

Water and Sanitation Technologies

The water and sanitation technologies available to each household were assessed by questions such as, “What is the main source of drinking water for members of your household?”, “In the last two weeks has the water from this source been unavailable for at least one whole day?” and “Where is the sanitation facility located?” Observations such as sanitation facility type (Figure 3.4) and water storage container type (Figure 3.5) were also used to assess technology.

Figure 3.4: The inside of a ventilated pit latrine.

Figure 3.5: Storage containers for drinking water.

Knowledge about transmission of diarrhea and handwashing

Three survey variables were designed to assess participant knowledge of diarrhea cause and prevention as well as critical times to wash hands. The first knowledge question was, “What do you think can cause diarrhea in young children?” The second question was similar asking participants how they thought diarrhea could be prevented. Finally, respondents were asked to state times throughout the day when it is important to wash your hands. The answers were marked on the questionnaire and later recoded into accurate or inaccurate responses for causes and preventions of diarrhea. Handwashing responses were recoded into times that where either critical or noncritical. Critical times in this survey were: after defecation, after cleaning a young child after defecation, before preparing food, before eating, and before feeding a child.

Water Treatment, Water Storage, and Hygiene Practices

WASH practices were also assessed using a mix of questions and surveyor observations. Questions such as, “Do you treat your water in any way to make it safer for drinking?” and “If yes, what do you usually do to the water to make it safer to drink?” were asked to assess treatment practices. Participants were asked to recall why they had used soap either today or yesterday. These answers were later recoded into participants that had recalled washing their hands at critical handwashing times. Also, participants were asked where the youngest child had last gone to the bathroom and where feces had been disposed of if he/she had not gone in the latrine. The answers were later recoded into households that did and did not practice safe feces disposal. Latrines were observed for type as mentioned above, but also for any presence of fecal matter on the floor or walls. Lastly, water storage practices were assessed by surveyor observation noting whether or not containers were covered (Figure 3.6).

Figure 3.6: Drinking water storage containers that are both covered and uncovered.

Incidence of Diarrheal Disease

Assessing incidents of diarrhea for children five years of age or younger was done through self-report of the caregivers. First, participants were asked how many children five and under live in the household. Later in the questionnaire, the participants were asked, “Regarding children age 5 and under, how many have had diarrhea in the past 2 weeks?” Following the design of the baseline survey, a definition for diarrhea was not given to the participants. The reported count was documented on the survey form and later recoded as the percentage of children in the household who had had diarrhea in the last two weeks.

Perspective on the Program

The final question on the survey was open-ended allowing the participants to give their feedback, if any, on the WASH program that had been conducted by the NGO. The responses to this question appear in Appendix C.

3.3.3 Analysis

After data collection was finished, the responses from the paper questionnaires for both baseline and follow-up surveys were entered into Microsoft Excel. The data entry for the follow-up survey was double checked by printing out the Excel files and comparing to the hard copies. Additionally, the results were transferred to the social science statistical software "IBM SPSS Statistics" (SPSS). The frequency counts of how each participant answered for each variable were calculated in Excel and SPSS, by village and total. The counts from SPSS and Excel were verified against each other as an additional step to check for data entry error. In Excel, frequencies were turned into the percentage of participant who answered a certain way for all questionnaire variables. The percent difference from baseline to follow-up was then calculated for each village. The percent differences of all four villages were averaged and the standard deviation determined. Mean differences were considered statistically significant if they were more than two times the standard deviation from zero.

3.4 Water Testing

3.4.1 Data Collection

To supplement the questionnaire information and further investigate outcomes of the NGO interventions, water samples were collected and analyzed from source and stored household drinking water. Source samples were taken from boreholes drilled by the NGO as well as other organizations and from surface water sources known as JUIs.

Permission was sought from each household respondent to collect a 100 mL sample of drinking water. Bottled water was also sampled to serve as a control for each day's tests. These samples were used to assess the presence, if any, of bacterial contamination.

The samples were analyzed using the EPA approved IDEXX Colilert product, testing for presence/absence of *E. coli* as well as with 3M™'s Petrifilm™ *E. coli*/Coliform Count Plates product (Eschol et al., 2009; Halvorson et al., 2011; Metcalf & Stordal, 2010). Due to a lack of consistent electricity, both tests were "pocket incubated" for 24 hours using a method designed by Dr. Robert Metcalf and promoted by the World Health Organization (Metcalf & Stordal, 2010). The pocket incubation method relies on body heat to incubate the water samples at a relatively constant temperature of 35 (+/- .5)°C. The samples must be in small enough testing containers to be wearable by the researcher and warmed by the body's heat. This requires the researcher to wear Colilert's 10mL test tubes and 3M™'s 1 mL count plates next to the body for 24 hours before reading the results (Figure 3.7).

Figure 3.7: Pocket incubation using a money belt.

This researcher along with two assistants took samples in sterile, 100mL plastic bags, stored them on ice, and prepared them for analysis within 6 hours. Water from the original 100 mL sample was sterilely transferred into two 10 mL Colilert test tubes, for a total of 20 mL of water from each sample being tested. The manufacturer stated that only a 10 mL is necessary for presence/absence testing. The second 10 mL was used for verification of results. The 3M™'s count plates were used as additional verification of presence or absence, but due to a limited supply were used on only 46 out of 67 total samples.

3.4.2 Analysis

For Idexx's Colilert test, results are read as follows: clear = absence of coliform/*E. coli*; yellow = presence of coliform; florescent under black light = presence of *E. coli* (Figures

3.8 a, b & c). The 3M™'s Petrifilm™ is read by counting bacterial colonies, if any, that are visible at the 24 hour mark. Red colonies represent environmental coliforms. Blue colonies represent *E. coli* coliforms (Figure 3.8b). A clear plate (Figure 3.8a) shows that the 1 mL sample is free from coliforms and *E. coli.* Pictures were taken of all results. The results of the water tests were written on paper forms (Appendix D) and later transferred into Excel. Counts and percentages for all positive and negative samples were calculated, broken down by village.

Figure 3.8 a, b & c: Outcomes of water tests for coliforms/*E. coli.*

3.5 Geographic Information System (GIS)

3.5.1 Data Collection

A Garmin GPS device was used to mark the latitude and longitude location of important points throughout the field research. The datum was set to WGS 84, as recommended by UNICEF Afghanistan. Every morning, at least three calibration points were collected in the same spot at the NGO main office. The device was then used to collect locational information for several key items. Points were collected along the roads in to order to create maps of general village boundaries. Significant points in the villages were marked, such as mosques and schools. Points were also taken on roads near each of the surveyed households as well as next to each borehole. Coordinate information was stored in the device and recorded on a paper form (Appendix E). Data points were also marked, as soon as collected, on a hand drawn map of the village. All points were within six meter accuracy according to the GPS device.

3.5.2 Analysis

Upon returning to the United States, data was downloaded from the Garmin and uploaded into ARC. The data points were projected into UTM zone 42N. Then, information from the data sheets was added to the attribute table for each point. Outlines of the villages were digitized from satellite images and confirmed with the GPS points. Also, multi-ring buffers were created around working wells at 250, 500, 750, and 1000 meter increments. Lastly, straight line distances from each household to its nearest working borehole were calculated. These distances were compared to water test results and reported incidence of diarrheal disease.

Ethics Approval

The study protocol was approved by the Institutional Review Board, Oregon State University, Oregon USA.

4 RESULTS

In this section of the paper results from the household survey, water tests, and spatial analysis will be presented. It will begin with the demographics of the survey participants. Descriptive statistics will be given for the survey results, followed by a change over time analysis. Descriptive statistics will also be given for water test results and the distance measurements from the spatial analysis. Lastly, maps displaying patterns of interest will be presented.

4.1 Survey Results

From four villages, a total of 76 randomly selected households participated in the baseline survey, while another 59 randomly selected households participated in the follow-up survey. Both surveys were conducted in the fall, three years apart (2009 and 2012). Respondents were women who were responsible for care of the household and children. Many households consist of extended families all living within one walled compound. In the surveys, the number of adults living within a household ranged from 1 to 23 (Table 4.1a). The number of children five or under living within a household ranged from 0 to 8 (Table 4.1b). The number of children older than five years ranged from 0 to 13 (Table 4.1c). In most households, the children over the age of 15 were counted as adults (a decision made by the respondent).

Tables 4.1 a, b, & c: Number of household members by age category.

# of Adults	# of Households in each category	
	Baseline	Follow-Up
0	0	0
1 - 5	48	30
6 - 10	19	19
11 - 15	7	7
16 - 20	2	2
21 - 25	0	1
Total	76	59

# of Children <= 5yrs	# of Households in each category	
	Baseline	Follow-Up
0	16	11
1 - 2	30	28
3 - 4	21	15
5 - 6	7	4
7 - 8	2	1
9 - 10+	0	0
Total	76	59

# of Children >5yrs	# of Households in each category	
	Baseline	Follow-Up
0	10	7
1 - 2	18	22
3 - 4	30	12
5 - 6	14	12
7 - 8	3	4
9 - 10+	1	2
Total	76	59

Baseline Survey Results- Technology

As shown in Table 4.2, 25% of households reported using improved drinking water sources, while 75% stated they collect water from either unprotected dug wells (30.3%) or surface water (44.7%) which are considered unsafe by WHO/UNICEF standards (2012b). No households had piped water running into their home. Respondents reported water collection taking an average of 8.24 minutes. A majority (60.5%) also reported that the source had been unavailable for at least one whole day. Based on surveyor observation, 13.2% of households used narrow mouthed containers for drinking water storage, 23.7% used wide mouthed containers, and 56.6% used a combination of the two. Improved sanitation facilities, either a ventilated pit latrine (4%) or a pit latrine with a slab (5.3%) were used by 9.3% of the surveyed population. A majority of the households (90.7%) either used a pit latrine without a protective slab (86.7%) or did not have a facility in their compound (4.0%). Sanitation facilities were used by an average of 1.96 households, yet many households (48.7%) reported having a private facility.

Follow-Up Survey Results - Technology

In contrast to baseline, most households reported using an improved drinking water source (Figure 4.1). Consistent with baseline, no surveyed household was connected to a working piped water scheme, but 71.2% stated that they used boreholes for their main source of drinking water (Table 4.2). Surface water was being used as the main source of drinking water by 15.3% of respondents. The surface water is collected from small irrigation canals, “JUIs”, that run along the main roads in each village as seen in Figure 4.2. At the time of the follow-up survey, the canals were being used for water collection, swimming, and watering animals.

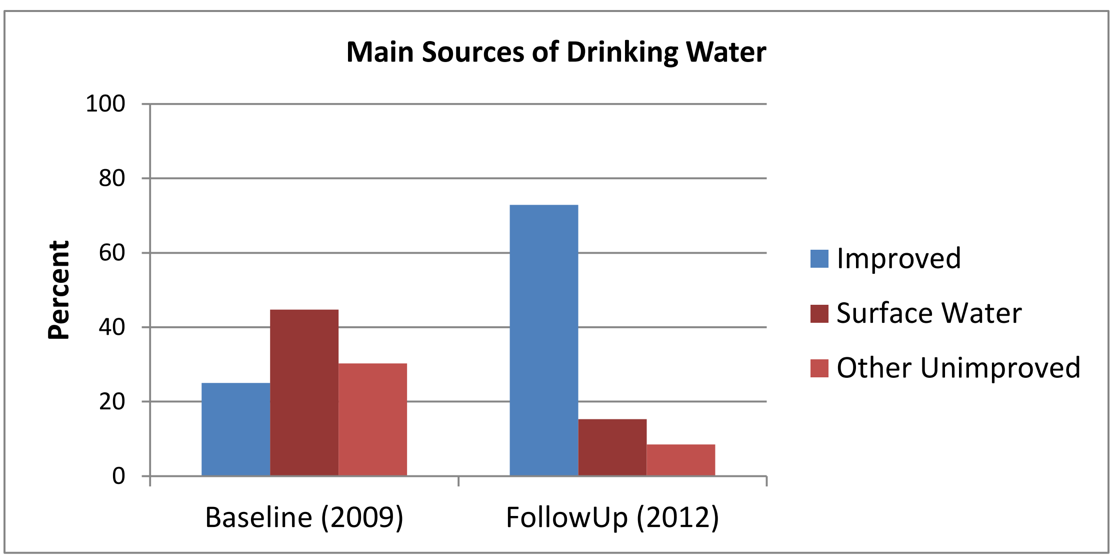


Figure 4.1: Comparison of main sources of household drinking water at baseline and follow-up.

Figure 4.2: Surface water source in Village 4, “JUI”.

In village 2, some households diverted the canals to run through their walled compounds providing very easy access to water for a variety of domestic purposes (Figure 4.3). The surveyor noted that dishes and clothes were being washed directly in some of these diverted waterways, but was also specifically told in one household that the water was not used for drinking.

Figure 4.3: A JUI diverted through a household compound.

The average time for collecting water was 11.06 minutes, with a reported range from under five minutes to 30 minutes. The percentage of households whose water source had been unavailable for at least one whole day was 50.9%. Observation data showed that the majority of water collectors were children that either carried or used wheel barrows to transport containers. Storage water containers used by households were narrow mouthed (26.3%), wide mouthed (43.9%) or a combination of both container types (29.8%). Based on surveyor observation, it was noted that many of the wide mouthed containers had screw top covers and spigots for accessing the water and were not wide mouthed pails open to the environment. The lids and spigots allowed access without dipping hands or a collection device into the water. Unimproved sanitation facilities were used by 82.5% of survey households. Households that had no sanitation facility available within their compound, using either a neighbor's facility or bare earth at the corner of the compound, made up 17.6% of the survey population. One household had an inside bathroom with a flushable commode. On average, sanitation facilities were shared by 2.07 households.

A unique situation was observed in Village 2. This village had a piped water scheme running to about half of the village households. A large, elevated water tank located in the garden of the mosque was connected to a gravity fed system that piped water to the household standpipes. The system was not functioning though, due to a reported lack of funding for petrol to run the generator which pumps water from a well into the holding tank. It was reported to the surveyor that the system had been set up prior to the baseline survey, but was not functioning at that time either because the generator was broken. After the baseline survey, the village leadership negotiated with the NGO to help with the purchase of a new generator rather than have additional boreholes drilled. The NGO agreed and split the cost of a new generator with the village. But as stated previously, the system was not being used at the time of the follow-up survey.

Table 4.2: Outcomes by variable between villages in baseline and follow-up surveys for "technology" variables.

	Baseline					Follow Up				
Variables[1]	1	2	3	4	**Total**	1	2	3	4	**Total**
Technology in Use Variables										
Main source of drinking water for household										
Public Tap	0.0	0.0	0.0	0.0	**0.0**	0.0	6.7	0.0	0.0	**1.7**
Borehole	57.9	5.3	0.0	36.8	**25.0**	86.7	33.3	64.3	100	**71.2**
Protected Dug Well	0.0	0.0	0.0	0.0	**0.0**	0.0	6.7	7.1	0.0	**3.4**
Unprotected Dug Well	0.0	21.1	52.6	47.4	**30.3**	0.0	20.0	14.3	0.0	**8.5**
Surface Water	42.1	73.7	47.4	15.8	**44.7**	13.3	33.3	14.3	0.0	**15.3**
Type of Water Source										
Improved (Safe)	57.9	5.3	0.0	36.8	**25.0**	86.7	46.70	71.40	100	**76.3**
Unimproved (Unsafe)	42.1	94.7	100.0	63.2	**75.0**	13.30	53.30	28.60	0.0	**23.7**
Length of time to collect water										
Average Time in Minutes	10.26	8.37	6.21	8.11	**8.24**	11.93	10.40	10.64	11.27	**11.06**
In the last 2 weeks has the water from this source been unavailable for at least 1 whole day?										
Yes	84.2	68.4	47.4	42.1	**60.5**	80.0	33.3	21.4	66.7	**50.9**
No	15.8	31.6	52.6	57.9	**39.5**	20.0	66.7	78.6	33.3	**49.2**
Type of water storage container										
Narrow Mouthed	10.5	10.5	10.5	21.1	**13.2**	20.0	20.0	28.6	38.5	**26.3**
Wide Mouthed	36.8	36.8	15.8	5.3	**23.7**	46.7	46.7	35.7	46.2	**43.9**
Both	47.4	31.6	73.7	73.7	**56.6**	33.3	33.3	35.7	15.4	**29.8**
No Stored Water	5.3	21.1	0.0	0.0	**6.6**	0.0	0.0	0.0	0.0	**0.0**
Sanitation facility										
Commode	0.0	0.0	0.0	0.0	**0.0**	7.7	0.0	0.0	0.0	**1.8**
Ventilated Pit Latrine (VIP)	5.3	11.1	0.0	0.0	**4.0**	0.0	0.0	14.3	0.0	**3.5**
Simple Pit Latrine w/ Slab	0.0	0.0	21.1	0.0	**5.3**	23.1	0.0	7.1	20.0	**12.3**
Pit Latrine w/o Slab	94.7	88.9	79.0	84.2	**86.7**	61.5	80.0	57.1	60.0	**64.9**
No Facility	0.0	0.0	0.0	15.8	**4.0**	7.7	6.7	21.4	13.3	**12.3**
Outside Yard - Can't Access	0.0	0.0	0.0	0.0	**0.0**	0.0	13.3	0.0	6.7	**5.3**
Type of Sanitation Facility										
Improved	5.3	11.1	21.1	0.0	**9.3**	30.8	0.0	21.4	20.0	**17.5**
Unimproved	94.7	88.9	79.0	100.0	**90.7**	69.2	100.0	78.6	80.0	**82.5**
Location of HH sanitation facility										
Inside or Attached to Dwelling	11.1	10.5	0.0	0.0	**5.3**	6.7	0.0	0.0	0.0	**1.7**
Elsewhere Inside Yard	72.2	47.4	89.5	79.0	**72.0**	80.0	80.0	78.6	80.0	**79.7**
Outside Yard	16.7	36.8	10.5	5.3	**17.3**	6.7	13.3	0.0	6.7	**6.8**
No Facility	0.0	5.3	0.0	15.8	**5.3**	6.7	6.7	21.4	13.3	**11.9**
Shared sanitation facility										
Average Number	1.89	1.95	1.95	2.06	**1.96**	1.79	2.20	2.23	2.07	**2.07**
Shared the sanitation facility										
Yes	52.6	42.1	52.6	57.9	**51.3**	50.0	66.7	69.2	53.3	**59.7**
No	47.4	57.9	47.4	42.1	**48.7**	50.0	33.3	30.8	46.7	**40.4**

[1]Catogorical responses are shown as percent of total. Continuous responses are shown as averages.

Survey Results- Knowledge

Two questions were asked by the surveyor in order to assess the respondents' knowledge of causes and preventions for diarrhea. Another question was asked to assess knowledge about critical times for washing hands in order to disrupt disease transmission, with "after defecation" as the most critical time. Each of these questions was open ended and the surveyor checked off the responses given from a list of common responses (see questionnaire, Appendix B). Later, the answers were recoded and put into categories of those respondents who did or did not name at least three causes of diarrhea, name at least three ways to prevent diarrhea, name the most critical time for washing hands, and name at least two other critical handwashing times. As Table 4.3 displays, 11.8% of respondents could name three causes for diarrhea at baseline while 55.9% could at follow-up. At baseline, 4.0% of respondents could name three ways to prevent diarrhea which changed to 42.4% at follow-up. When asked about important times to "wash your hands" 75% of respondents at baseline named the most critical hand washing time as well as 75% naming two other critical times. Results of the follow-up survey differed slightly with 72.9% of respondents stating the most critical handwashing time and 62.7% stating two other critical times.

Table 4.3: Outcomes by variable between villages in baseline and follow-up surveys for "knowledge" variables.

	Baseline					Follow Up				
Variables[1]	1	2	3	4	**Total**	1	2	3	4	**Total**
Knowledge Variables										
Named at least 3 causes of diarrhea										
Yes	10.5	26.3	5.3	5.3	**11.8**	60.0	66.7	50.0	46.7	**55.9**
No	89.5	73.7	94.7	94.7	**88.2**	40.0	33.3	50.0	53.3	**44.1**
Named at least 3 ways that diarrhea can be prevented										
Yes	5.3	5.3	5.3	0.0	**4.0**	33.3	26.7	50.0	60.0	**42.4**
No	94.7	94.7	94.7	100.0	**96.1**	66.7	73.3	50.0	40.0	**57.6**
Named the MOST critical hand washing time										
Yes	42.1	84.2	89.5	84.2	**75.0**	80.0	93.3	64.3	53.3	**72.9**
No	57.9	15.8	10.5	15.8	**25.0**	20.0	6.7	35.7	46.7	**27.1**
Named at least two other critical hand washing times.										
Yes	63.2	57.9	100.0	79.0	**75.0**	53.3	60.0	64.3	73.3	**62.7**
No	36.8	42.1	0.0	21.1	**25.0**	46.7	40.0	35.7	26.7	**37.3**

[1]Responses are shown as percent of total.

Survey Results- Practices

Another set of questions on the household survey was designed to assess WASH practices within the household, see Table 4.4. Respondents were asked if they treated their water in any way to make it safer for drinking. The percentage of respondents who answered affirmatively was 40.8% at baseline and 22.0% at follow-up. Responses to questions asking about the method and frequency of water treatment were recoded into the percent of households that stated treating water effectively and the percent that stated treating water effectively and regularly. According to self-report, 11.8% of households treated water with an effective method and on a regular basis at baseline and 15.3% did so at follow-up. Effective treatments used were: boiling, adding chlorine, or using a BSF. Despite being promoted during the WASH program, BSFs were found in only 10.2% of surveyed households at follow-up. Upon observation of the filters, it was questionable as to whether or not they were being used effectively by the small percentage of households that had them. Based on surveyor observation, 9.2% of water storage containers were covered at baseline, while 57.4% were at follow-up. Lastly, the practice of handwashing was assessed by self-report was well as by the proxy indicators of having a specific area to wash hands after using the latrine and having soap in that area. The reported frequency of washing hands at the most critical time increased from 11.8% to 37.3%. There was also an increase in respondents that recalled washing their hands at at least two other critical times, 18.4% to 42.4%. Just over 90% of household did not have a specific place to wash their hands at baseline, while 71.4% had a specific place at follow-up. The presence of soap as observed by the surveyor changed from 0% at baseline to 19.0% at follow-up.

The overall pattern of treating water declined from baseline to follow-up. When the question of treating drinking water was asked three participants gave an answer of “no”, but added that they didn’t need to because they were collecting if from a borehole. Four others stated a financial or distance barrier to purchasing treatment tools, such as chlorine. This can be confirmed by researcher observation that chlorine for water treatment was not available in the village stores which would require it being purchased in the closest city.

Table 4.4: Outcomes by variable between villages in baseline and follow-up surveys for "practices" variables.

	Baseline					Follow Up				
Variables[1]	1	2	3	4	**Total**	1	2	3	4	**Total**
Household Practices Variables										
Treat water in any way to make it safer for drinking										
Yes	42.1	31.6	52.6	36.8	**40.8**	20.0	13.3	28.6	26.7	**22.0**
No	57.9	68.4	47.4	63.2	**59.2**	80.0	86.7	71.4	73.3	**78.0**
Treat Drinking Water Effectively										
Yes	31.6	10.5	21.1	21.1	**21.1**	20.0	13.3	28.6	26.7	**22.0**
No	68.4	89.5	79.0	79.0	**79.0**	80.0	86.7	71.4	73.3	**78.0**
Treat Drinking Water Effectively AND Regularly										
Yes	21.1	0.0	10.5	15.8	**11.8**	20.0	0.0	28.6	13.3	**15.3**
No	79.0	100.0	89.5	84.2	**88.2**	80.0	100.0	71.4	86.7	**84.8**
Use Biosand Filter for Treating Drinking Water										
Yes	0.0	0.0	0.0	0.0	**0.0**	6.7	0.0	21.4	13.3	**10.2**
No	100	100	100	100	**100.0**	93.3	100.0	78.6	86.7	**89.8**
Recalled Washing Hands during Most Critical HW Time										
Yes	0.0	15.8	26.3	5.3	**11.8**	26.7	40.0	28.6	53.3	**37.3**
No	100.0	84.2	73.7	94.7	**88.2**	73.3	60.0	71.4	46.7	**62.7**
Recalled Washing Hands for at least one other critical HW Time										
Yes	5.3	26.3	26.3	15.8	**18.4**	46.7	33.3	42.9	46.7	**42.4**
No	94.7	73.7	73.7	84.2	**81.6**	53.3	66.7	57.1	53.3	**57.6**
Covered Water Storage Containers										
All Are	26.3	10.5	0.0	0.0	**9.2**	71.4	53.8	42.9	53.3	**57.4**
Some Are	63.2	52.6	73.7	42.1	**57.9**	28.6	30.8	14.3	20.0	**24.1**
None Are	5.3	15.8	26.3	57.9	**26.3**	0.0	15.4	42.9	13.3	**18.5**
No Stored Water	5.3	21.1	0.0	0.0	**6.6**	0.0	0.0	0.0	0.0	**0.0**
Fecal Matter Present Inside Sanitation Facility										
Yes	47.4	38.9	36.8	52.6	**44.0**	20.0	6.7	7.7	6.7	**10.3**
No	52.6	61.1	63.2	31.6	**52.0**	60.0	66.7	69.2	66.7	**65.5**
No Facility	0.0	0.0	0.0	15.8	**4.0**	6.7	6.7	23.1	13.3	**12.1**
Cannot Access (No Permission)	0.0	0.0	0.0	0.0	**0.0**	13.3	20.0	0.0	13.3	**12.1**
Practiced Safe Disposal of Child Feces										
Yes	42.1	26.3	42.1	36.8	**36.8**	20.0	40.0	28.6	60.0	**37.3**
No	57.9	73.7	57.9	63.2	**63.2**	80.0	60.0	71.4	40.0	**62.7**
Location for Washing Hands after going to the Toilet										
Inside/Near Sanitation Facility	0.0	0.0	0.0	0.0	**0.0**	14.3	13.3	23.1	7.1	**14.3**
Inside/Near Kitchen/Cooking Area	10.5	15.8	0.0	0.0	**6.6**	7.1	13.3	0.0	7.1	**7.1**
Elsewhere Inside Yard	0.0	5.3	0.0	0.0	**1.3**	42.9	53.3	53.8	50.0	**50.0**
Outside Yard	0.0	0.0	0.0	5.3	**1.3**	0.0	0.0	0.0	7.1	**1.8**
No Specific Place	89.5	79.0	100	94.7	**90.8**	35.7	20.0	23.1	28.6	**26.8**
Soap Observed										
Yes	0.0	0.0	0.0	0.0	**0.0**	26.7	6.7	23.1	20.0	**19.0**
No	100	100	100	100	**100**	73.3	93.3	76.9	80.0	**81.0**

[1]Responses are shown as percent of total

Change Over Time

For the survey responses the percent difference from baseline to follow-up was calculated for each village. The percent differences were then averaged and the standard deviation determined. Mean differences were considered statistically significant if they were more than two times the standard deviation from zero. Twelve variables, summarized in Tables 4.5 and 4.6, were found to have responses that were significantly different, either an increase or decrease, between baseline and follow-up. In two instances, an increase in one response seemed to be directly related to a decrease in a different response to a single variable. For example, there was a significant increase in respondents who stated using a borehole as their main source of drinking water while at the same time there was a significant decrease in respondents who stated using surface water. This was also true for the variable investigating where people washed their hands after using the latrine. There was a significant increase in those households that had a designated handwashing area and a significant decrease in those that had no specific place. Five variables responses had mean percent differences of over 40%. These are described in detail below in Figures 4.4, 4.5, 4.6, and 4.7.

Table 4.5: Variables with significant change between baseline and follow-up surveys.

Variables with a Significant Increase[1]	Village1[2]	Village2[2]	Village3[2]	Village4[2]	Mean Difference	Standard Deviation
Technology						
Main source of drinking water for household						
Borehole	28.8	28.0	64.3	63.2	**46.1**	**20.4**
Type of water storage container						
Narrow Mouthed	9.5	9.5	18.1	17.4	**13.6**	**4.8**
Knowledge						
Named at least 3 causes of diarrhea						
Yes	49.5	40.4	44.7	41.4	**44.0**	**4.1**
Named at least 3 ways that diarrhea can be prevented						
Yes	28.0	21.4	44.7	60.0	**38.5**	**17.4**
Practices						
Covered water storage containers						
All Are	45.1	43.3	42.9	53.3	**46.2**	**4.9**
Recalled Washing Hands for at least two critical HW Times						
Yes	20.0	21.4	35.7	28.0	**26.3**	**7.2**
Where hands are usually washed after going to the toilet						
Inside Yard, Kitchen, or Sanitation Facility	53.8	58.8	76.9	64.2	**63.4**	**9.9**
Soap was observed in handwashing area						
Yes	26.7	6.7	23.1	20.0	**19.1**	**8.7**

[1]The percent difference is considered significant if it is more than two times the standard deviation from 0.

[2]Cell Values are the difference in percent between baseline and follow-up surveys. Follow-up percent- Baseline percent = percent difference

Table 4.6: Variables with significant change between baseline and follow-up surveys.

Variables with a Significant Decrease[1]	V1[2]	V2[2]	V3[2]	V4[2]	Mean Difference	Standard Deviation
Technology						
Main source of drinking water for household						
Surface Water	-28.8	-40.4	-33.1	-15.8	**-29.5**	**10.3**
Practices						
Treat water in any way to make it safer for drinking						
Yes	-22.1	-18.3	-24.0	-10.1	**-18.6**	**6.2**
Where hands are usually washed after going to the toilet						
No Specific Place	-53.8	-59.0	-76.9	-66.1	**-64.0**	**10.0**
Fecal matter present inside sanitation facility						
Yes	-27.4	-30.1	-29.1	-45.9	**-33.1**	**8.6**

[1]The percent difference is considered significant if it is more than two times the standard deviation from 0.

[2]Cell Values are the difference in percent between baseline and follow-up surveys. Follow-up percent- Baseline percent = percent difference

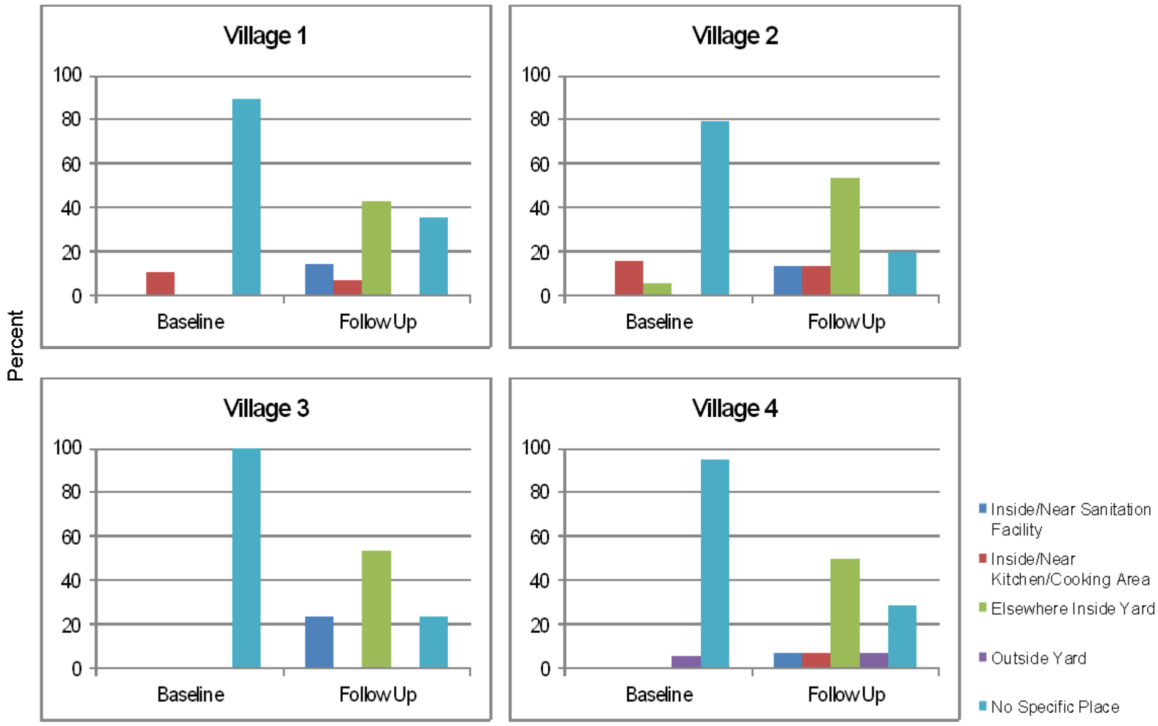


Figure 4.4: The change between baseline and follow-up surveys of where participants usually wash their hands after using the toilet.

In order to increase handwashing, the WASH hygiene classes contained lessons on the importance of having a specific place to wash hands after using the toilet. During the survey, the respondents were asked where they usually washed their hands after using the latrine. Figure 4.4 displays, by percentage, how respondents answered the question. Overall, the trend is an increase in having a specific place inside the yard, kitchen, or sanitation facility to wash hands. In Village 1 there was a 53.8% difference (10.5% to 64.3%) between “having a specific place” at baseline and follow-up. There was a 58.8% difference (21.1% to 79.9%) in Village 2, a 76.9% difference (0% to 76.9%) in Village 3, and a 64.2% difference (0% to 64.2%) in Village 4. For all villages combined, the mean difference is 63.4% with a standard deviation of 9.9%. This suggests a significant increase in percentage of households that had a specific place to wash their hands. Complementing the increase in having a specific place for handwashing is a decrease in having a "no specific place." The percentage of respondents that did not have a specific place either in their yard, kitchen or sanitation facility decreased from baseline to follow-up in all villages. The mean difference is 64.0% with a standard deviation of 10.0%, suggesting a significant decrease.

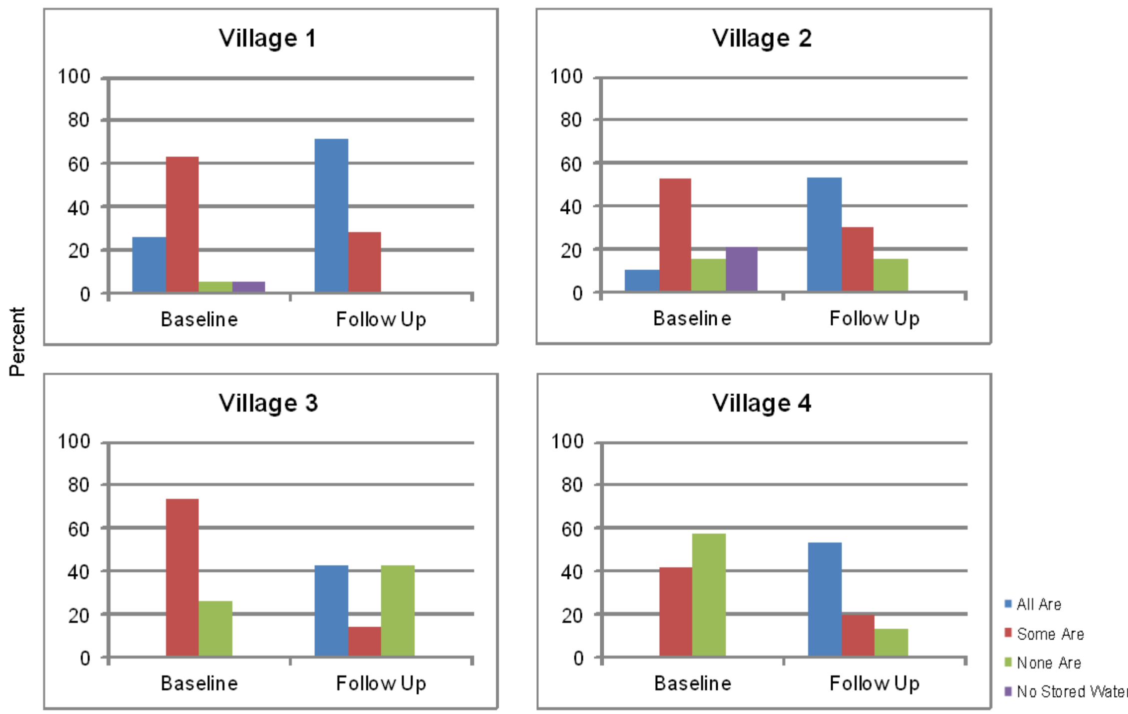


Figure 4.5: The change between baseline and follow-up surveys of the question, "Are water storage containers covered?"

Surveyors observed storage containers used for household drinking water. The goal is for all containers to be covered. Covering containers, similar to using narrow mouthed containers, has been shown to inhibit contamination of stored drinking water by limiting the ability of hands or other objects to enter the water (Brown & Sobsey, 2012; World Health Organization & UNICEF, 2012b; Wright et al., 2004). Figure 4.5 displays the percentage, by village, of households that had covered water storage containers at baseline and follow-up. Overall, the trend is an increase in covered containers. In Village 1 there was a 45.1% difference (26.3% to 71.4%) between baseline and follow-up. There was a 43.3% difference (10.5% to 53.8%) in Village 2, a 42.9% difference (0% to 42.9%) in Village 3, and a 53.3% difference (0% to 53.3%) in Village 4. For all villages combined, the mean difference is 46.2% with a standard deviation of 4.9%. This suggests a significant increase in covered water containers across all villages.

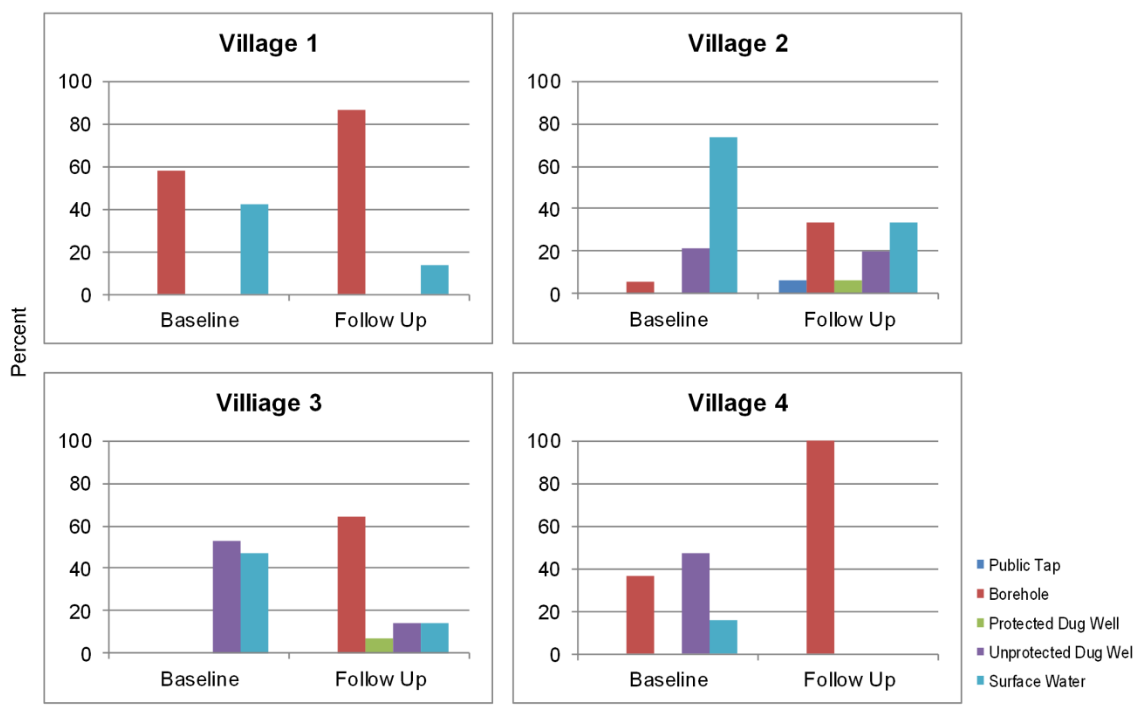


Figure 4.6: The change between baseline and follow-up surveys of the main source of drinking water for the household.

Figure 4.6 displays, by percent, the stated source of drinking water for surveyed households at baseline and follow-up. Across all villages there was a trend of increased use of boreholes and decreased use of surface water. In Village 1 borehole use increased from 57.9% to 86.7%, a difference of 28.8%. It increased from 5.3% to 33.3% (28.0% difference) in Village 2, 0% to 64.3% (64.3% difference) in Village 3, and 36.8% to 100% (63.2% difference) in Village 4. For all villages combined, the mean difference between baseline and follow-up is 46.1% with a standard deviation of 20.4%. This suggests a significant increase in borehole use. Complementing the increase in borehole use is the decrease in surface water use. The percentage of respondents stating that they used surface water decreased from baseline to follow-up (42.1% to 13.3%) in Village 1, a 28.8% difference. It also decreased 73.7% to 33.3% (difference of 40.4%) in Village 2, 47.4% to 14.3% (difference of 33.1%) in Village 3 and 15.8% to 0.0% (difference of 15.8%) in Village 4. The mean difference overall was 29.5% with a standard deviation of 10.3%. This suggests a significant decrease in surface water use.

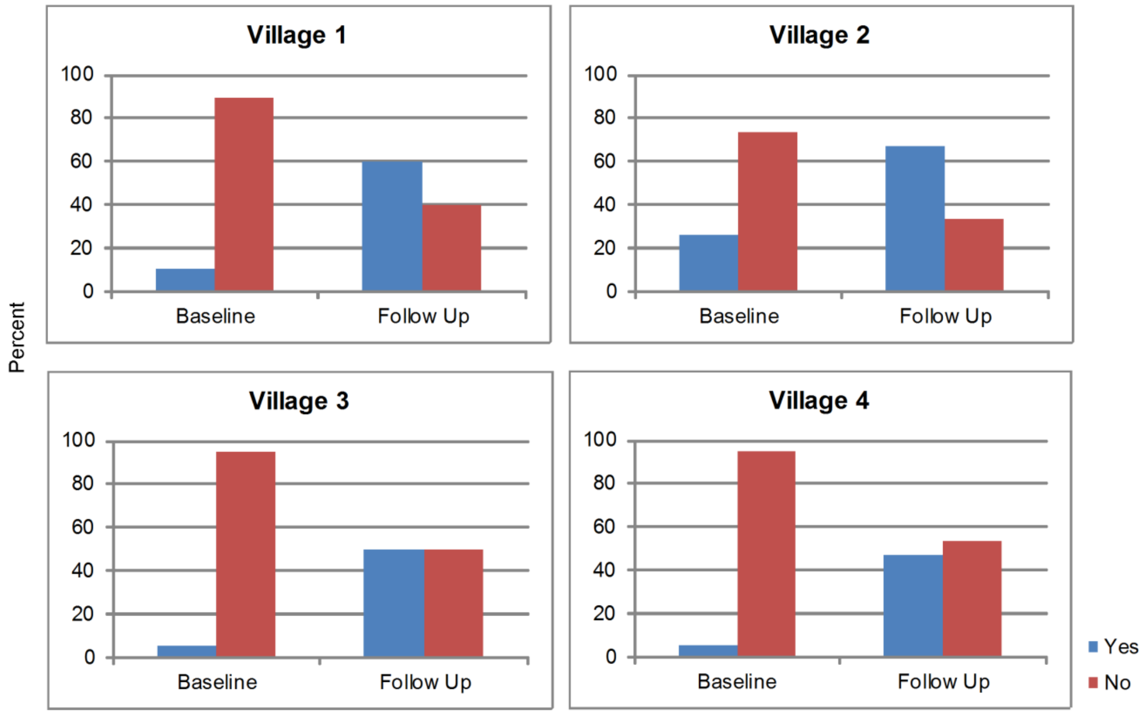


Figure 4.7: The change between baseline and follow-up surveys for the percentage of participants that named three causes for diarrhea.

Figure 4.7 shows, by village, the percentage of respondents who were able to name at least three causes of diarrhea at baseline and follow-up. Overall, the trend is an increase in the ability to name causes for diarrhea. In Village 1 there was a 49.5% difference (10.5% to 60.0%) between "yes" (able to identify at least three causes) at baseline and follow-up. There was a 40.4% difference (26.3% to 66.7%) in Village 2, a 44.7% difference (5.3% to 50.0%) in Village 3, and a 41.4% difference (5.3% to 46.7%) in Village 4. For all villages combined, the mean difference is 44.0% with a standard deviation of 4.1%. This suggests a significant increase across all villages.

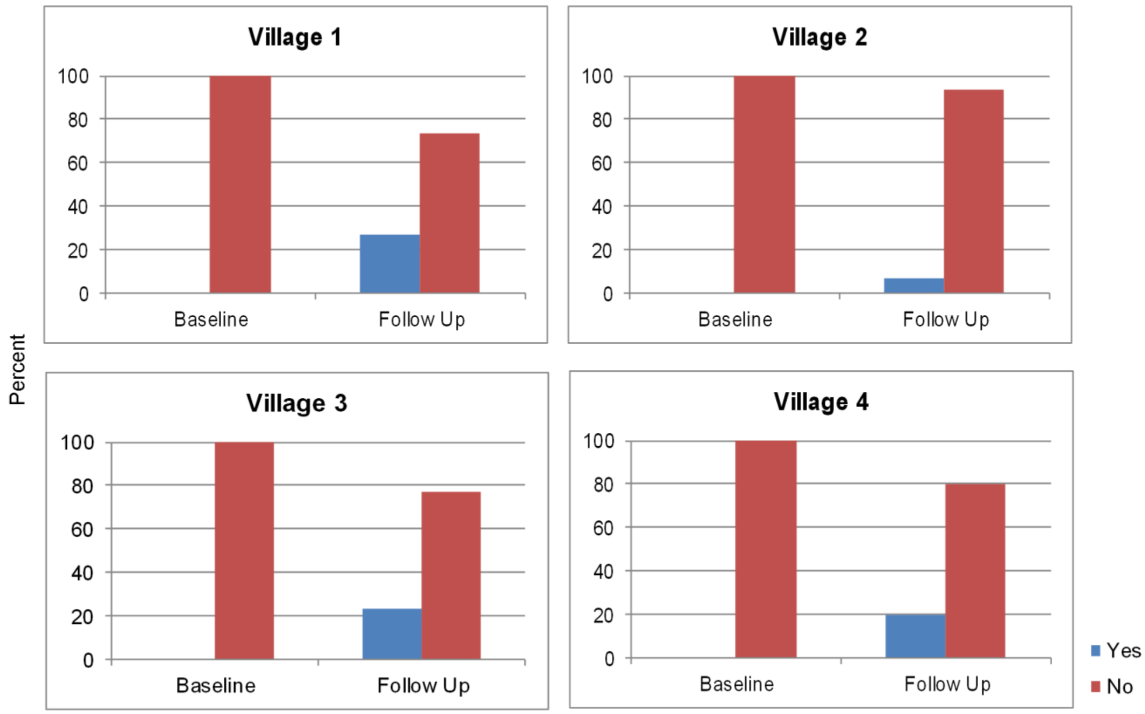


Figure 4.8: The change between baseline and follow-up surveys of the presence of soap in handwashing area.

Another variable, though not having a difference greater than 40%, is important to describe with more detail because it is the only variable that was zero percent at baseline in all villages with an increase in every village at follow-up. Figure 4.8 displays the percentage of households at baseline and follow-up that had soap in their specific handwashing area. In Village 1 there was a 26.7% difference (0% to 26.7%) between baseline and follow-up. There was a 6.7% difference (0.0% to 6.7%) in Village 2, a 23.1% difference (0% to 23.1%) in Village 3, and a 20.0% difference (0% to 20.0%) in Village 4. For all villages combined, the mean difference is 19.1% with a standard deviation of 8.7%. This suggests a significant increase in respondents that had soap in their handwashing area.

Survey Results - Reported Diarrheal Disease

Figure 4.9 displays the percentage of children five years of age and under in surveyed households that reportedly had diarrhea in the previous two weeks. The responses were averaged by village. The respondents were asked, "Regarding children age 5 and under, how many have had diarrhea in the past 2 weeks?" In Village 1 there was a 12.8% difference (58.8% to 46.0%) between baseline and follow-up. There was a 20.6% difference (49.2% to 28.7%) in Village 2, a 5.1% difference (40.8% to 35.7%) in Village 3, and a 7.5% difference (41.4% to 33.9%) in Village 4. For all villages combined, the mean difference is 11.5% with a standard deviation of 6.9%. Though it appears that the percentage of children with diarrhea dropped in all villages, there is no suggestion of a significant difference. This means that the reductions could be attributed to chance as much as to the NGO interventions.

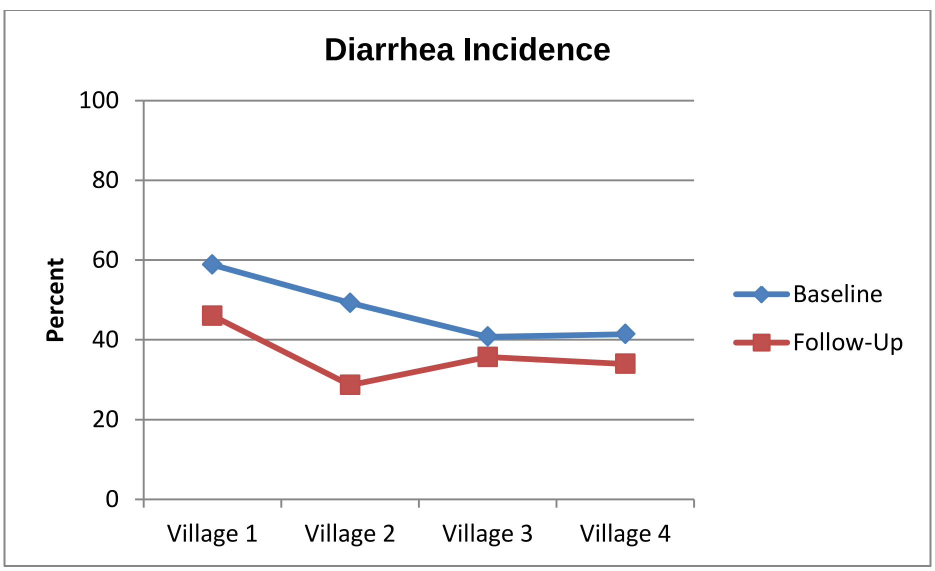


Figure 4.9: Percentage of children 5 and under in surveyed households that reportedly had diarrhea in the previous two weeks.

There was a significant increase in participants who were able to name the causes and preventions of diarrhea, but when compared to percentages of children suffering from diarrheal disease the knowledge does not appear to have a relationship with disease incidence (Table 4.7).

Table 4.7: A comparison of respondents who named causes or preventions for diarrhea and reported occurrences of diarrhea in children under five years old in the same household.

	Percent Reporting		
	Child(ren) Did Not Have Diarrhea[1]	Child(ren) Had Diarrhea[1]	Total
Named 3 Causes of Diarrhea	44.5	55.5	100
Named 3 Ways to Prevent Diarrhea	50.0	50.0	100

[1] Cells show percentage of respondents in each category

4.2 Water Test Results:

Sources of Drinking Water

Samples from both improved and unimproved sources of drinking water were taken for analysis. Of the 13 samples taken from safe sources (boreholes), only 1 (7.7%) showed a presence of *E. coli* (Figure 4.10a). This borehole was located in Village 3 along a main road next to a JUI. All of the remaining samples (12, 92.3%) were free of *E. coli* and a low risk for disease if the water was consumed straight from these sources. Two samples were taken from surface water sources. Both samples resulted in a presence of *E. coli* (one had 13 *E. coli* colonies formed on the 3M™ petrifilm) and a high risk of disease if water was consumed directly from these sources (Figure 4.10b).

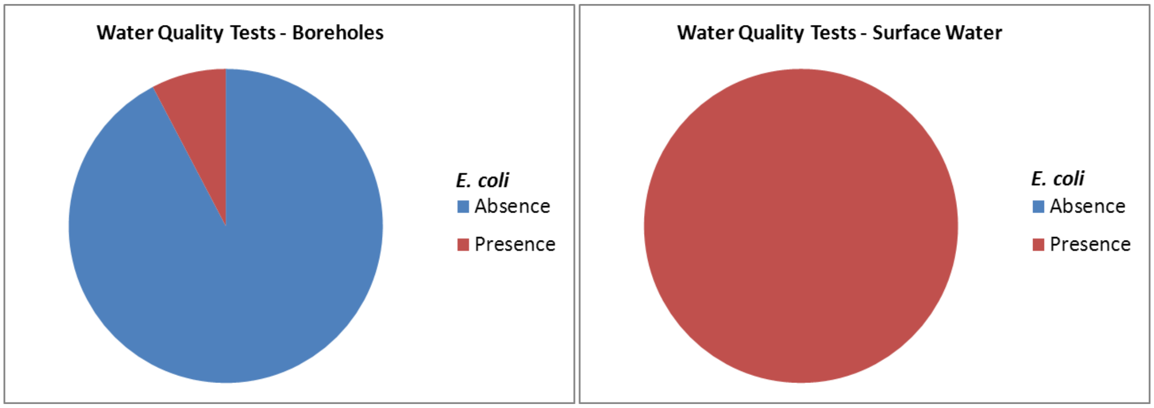


Figure 4.10a & b: Results of microbial water quality tests for boreholes (a) and surface water (b).

Stored Household Drinking Water

A total of 54 out of 59 households provided samples of their drinking water. Three households did not have drinking water on site, while two denied permission to sample. Samples from 40 out of 54 (74.1%) households tested positive for presence of *E. coli*, while 14 (25.9%) showed an absence (low risk of disease) as displayed in Figure 4.11. Village 2 had the highest number of households that had drinking water test positive for the presence of *E. coli*, 13 out of 14 (92.9%). Village 3 had similar results, 11 out of 13 (84.6%) samples showed a presence of *E. coli.* Villages 1 and 4 each had 8 samples test positive.

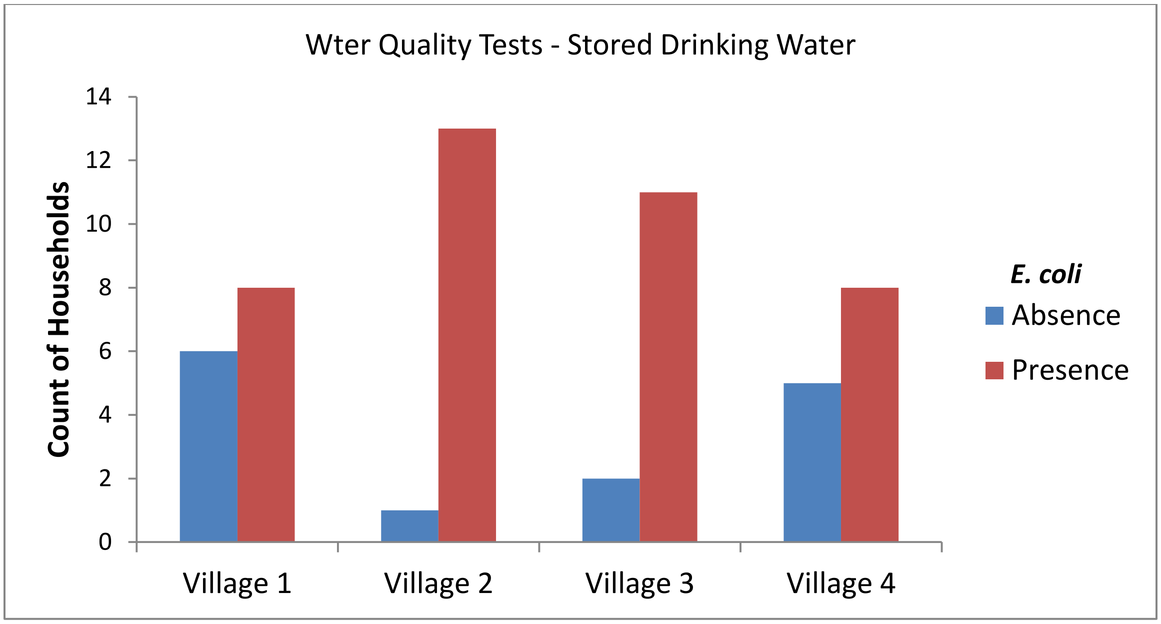


Figure 4.11: Results of microbial water quality tests for stored household drinking water.

Comparing the survey variables that are considered to have an association with safe water for the 14 households whose water tested free of *E. coli*, showed that there was only one variable response that all had in common. Each of the 14 survey respondents stated using a borehole as their main drinking water source (Table 4.8). There were three other variables in which 71% or more of the households shared the same practices: 1) covering water containers, 2) keeping the latrine free of fecal matter, and 3) having a specific place for handwashing. A comparison of the 40 households whose drinking water sample tested positive for *E. coli* showed no variable responses 100% in common (Table 4.9).

Table 4.8: Comparison of survey variables for households with water samples testing free of *E. coli.*

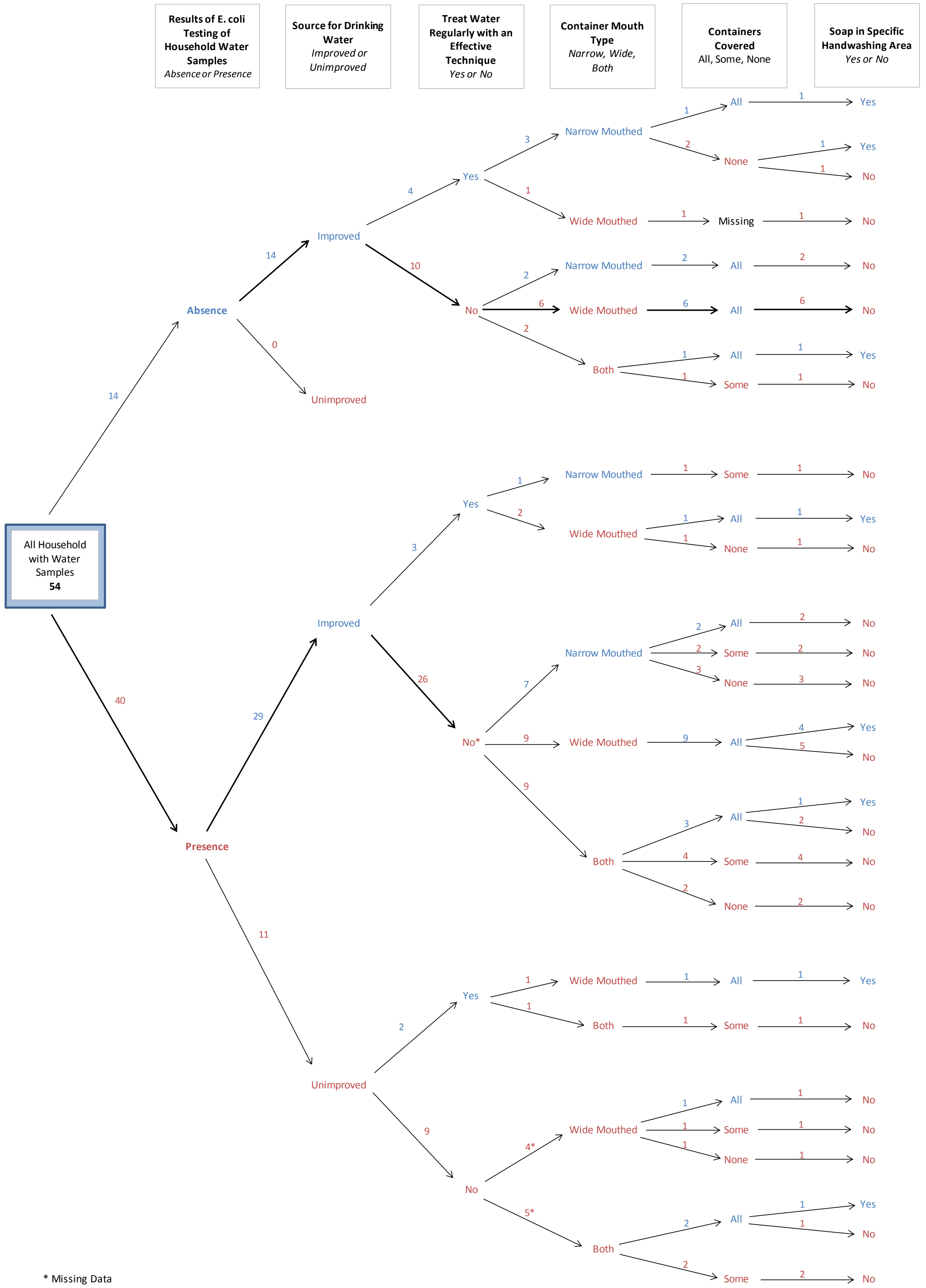
	Counts of Households															
	E. coli Absence	Borehole as Water Source	Water was Available All Days in the Last Week	Narrow Mouthed Container	All Containers Covered	Treat Water Effectively	Treat Water Effectively & Regularly	Use Biosand Filter	Named Diarrhea Causes	Named Diarrhea Preventions	Soap Present	Recalled Washing at 2+ critical times	Improved Toilet	Fecal Matter Absent Inside of Latrine	Practice Safe Disposal of Child Feces	No Children 5 or under with Diarrhea in Last Two Weeks	Had a Specific Place for Hand Washing
Village 1	6	6	0	1	4	2	2	0	3	1	2	3	3	5	2	2	3
Village 2	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Village 3	2	2	2	1	1	1	1	0	1	1	0	0	0	1	0	0	2
Village 4	5	5	2	2	4	2	1	2	3	3	0	1	1	4	3	2	5
Total	**14**	**14**	5	5	10	5	4	2	7	5	2	4	4	11	5	4	10

Table 4.9: Comparison of survey variables for households with water samples testing positive for a presence of *E. coli.*

	Counts of Households													
	E. coli Presence	Unimproved Water Source	Water was Unavailable at Least One Whole Day in the Last Week	Mixed Container Types	Containers Uncovered	Do Not Treat Water	Did Not Name 3 Diarrhea Causes	Did Not Name 3 Diarrhea Preventions	Soap Was Not Present	Did Not Recall Washing at 2+ critical times	Unimproved Toilet	Fecal Matter Present Inside of Latrine	Did Not Practice Safe Disposal of Child Feces	No Specific Place for Hand Washing
Village 1	8	1	6	3	3	7	2	4	6	8	6	2	7	2
Village 2	13	7	5	5	8	11	4	10	12	10	13	1	7	2
Village 3	11	3	3	5	6	8	5	5	8	6	8	1	7	3
Village 4	8	0	6	2	3	6	5	4	5	6	7	5	3	4
Total	40	11	20	15	20	32	16	23	31	30	34	9	24	11

Using the conceptual flowchart presented in the introduction to display survey data, it is shown that only one household practiced all of the safe water collection, treatment, and storage strategies introduced by the NGO (Figure 4.12). This household also had a specific handwashing area with soap and drinking water that was free of *E. coli*. At the time of the survey, two household were not practicing any of the safe water strategies nor did they have soap present in a specific handwashing area. These households also both had a presence of *E. coli* in their drinking water. The darker arrows display pathways where a majority of respondents had similar practices.

Figure 4.12: A flowchart of survey data for water collection, treatment, and storage by presence or absence of E. coli, as well as proxy information about handwashing with soap.



Controls for Water Tests

All control water samples were free of *E. coli*. Controls were taken either from small bottles of water purchased from local vendors or from the researcher's stored household water. The household water was transported to the field lab in reusable plastic bottles, cleaned in chlorine water each night.

Biosand filter test results

The water quality tests for the six households that reported using a biosand filter were extracted from the overall results. Tests showed a presence of *E. coli* in four (67%) of the samples (Figure 4.13). The two samples that showed an absence of *E. coli* were both located in Village 4. Based on surveyor observation, four of the BSFs did not have the container type and/or placement recommended to prevent recontamination of drinking water once it passed through the filter.

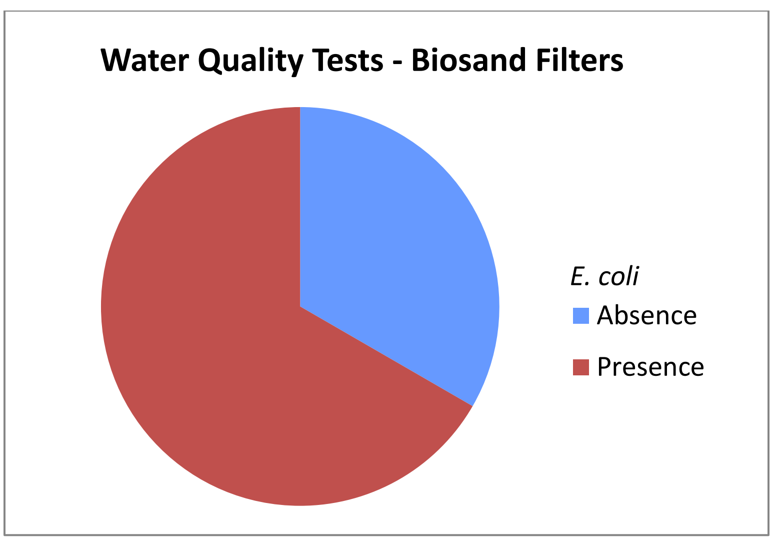


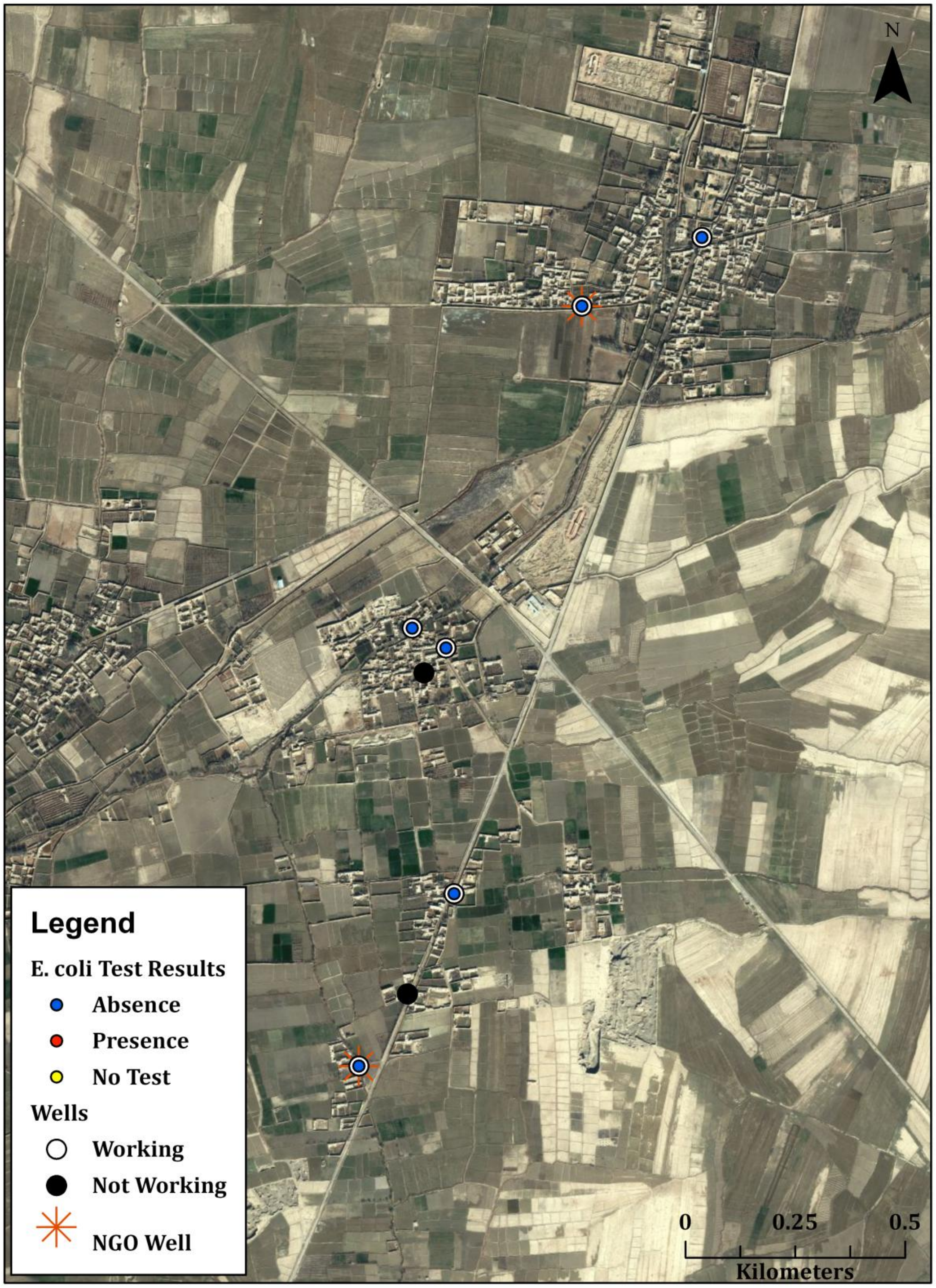
Figure 4.13: Results of microbial water quality tests for household biosand filters.

4.3 Spatial Analysis Results

Well Distribution

During the follow-up survey locational information was collected for all observed wells (boreholes) in each village and is displayed in Figures 4.14 and 4.15. No such information existed for the baseline survey. Based on surveyor observation, there were a total of six wells in Village 1, two in Village 2 (Figure 4.14), seven in Village 3, and ten in Village 4 (Figure 4.15). Of the six wells in Village 1, only four were working at the time of the follow-up survey; both were working in Village 2. Villages 3 and 4 both had two non-functioning wells. Village 3 had the only borehole that resulted in a positive test for the presence of *E. coli*. Village 4 had the greatest number of observed boreholes and also had several outlying areas that were considered part of the village. The NGO drilled one well with a hand-pump in each village, identified on the maps with an asterisk symbol.

Boreholes - Villages 1 and 2



Datum: WGS84 Projection: UTM 42N Degrees Source: Denise Costello March 16, 2013 Denise Costelllo

Figure 4.14: Distribution of boreholes in Villages 1 and 2.

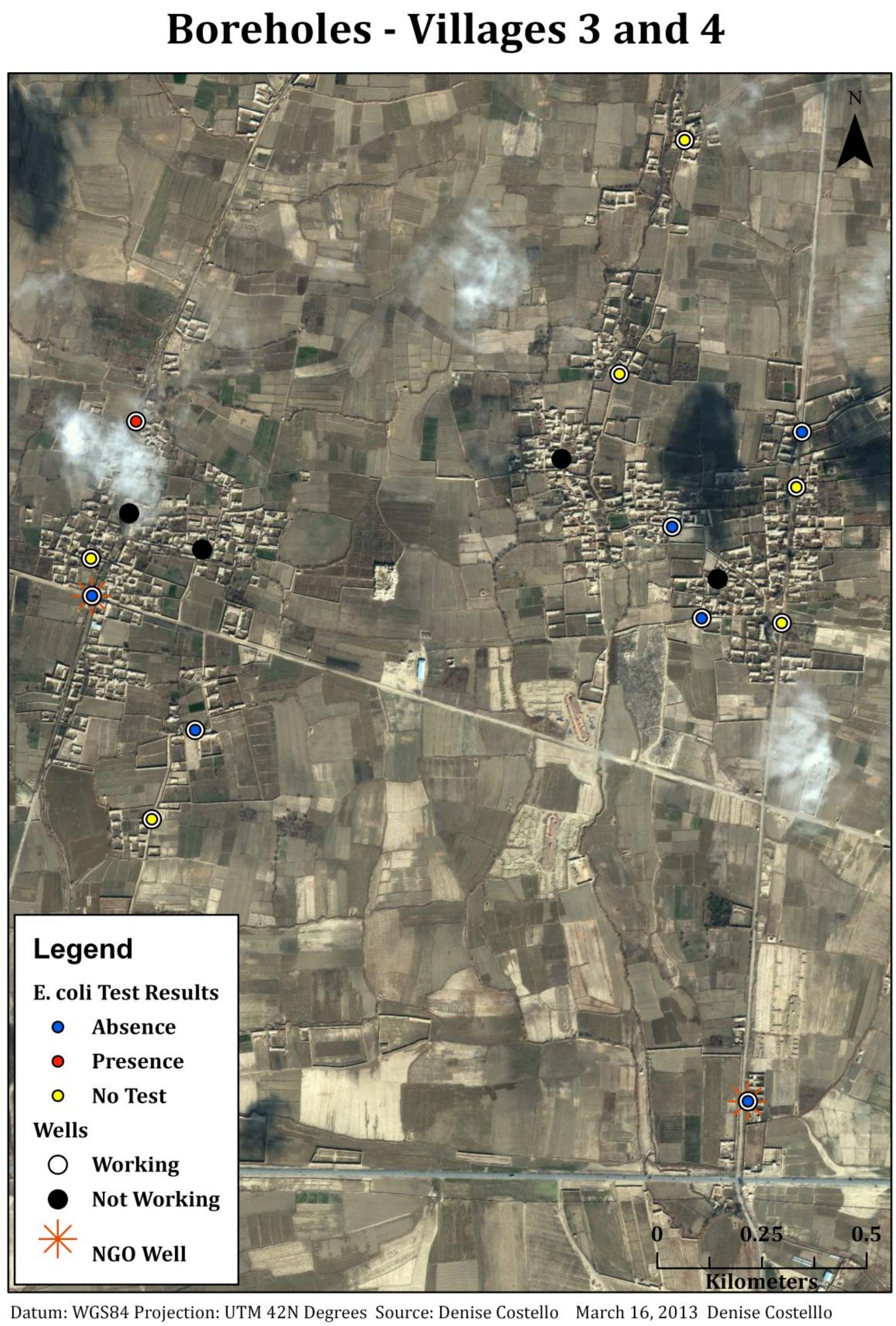


Figure 4.15: Distribution of boreholes in Villages 3 and 4.

Distance Investigation

Once the well locations were identified, multi-ring buffers were used to investigate how the NGO wells added to the overall coverage of the villages. To be considered accessible by WHO standards, an improved drinking water source needs to be within 1000m of a household. Figure 4.16 displays the coverage level without the NGO wells for villages 1 and 2. The outlines of each village are displayed with shaded black. Buffers extend from working wells that were not drilled by the NGO at 250m increments up to 1000m. Most of the village areas are within 750m of an improved source, with parts extending beyond 750m but less than 1000m. Figure 4.17 displays buffering of 1000m for all wells, including the wells drilled by the NGO. The villages are now covered entirely within the 750m ring, with much of the village areas within 500m of an improved source.

In Figure 4.18, the display is similar to 4.16, except that it is showing well coverage of Villages 3 and 4. The area of Village 3 is almost entirely within 500m of an improved source. Village 4 has an elongated shape running north to south. The northern, slightly wider portion of the village is all within 500m of an improved source, but the most southern portion is completely outside of the 1000m buffer. This means that households living in the southern part of the village do not have access to safe drinking water unless they have a private, protected dug well. The NGO wells were added to the buffer (Figure 4.19) and coverage increased dramatically for Village 4. The NGO well is located at the southern end of the village; therefore the area that was previously without coverage is now within 250m of an improved, safe drinking water source. No part of the village is beyond 750m from an improved source. Village 3's access to safe water sources was relatively unchanged by adding the NGO well. An important attribute of the Village 3 well is that it was installed at the village mosque, which is a central meeting place for the community.

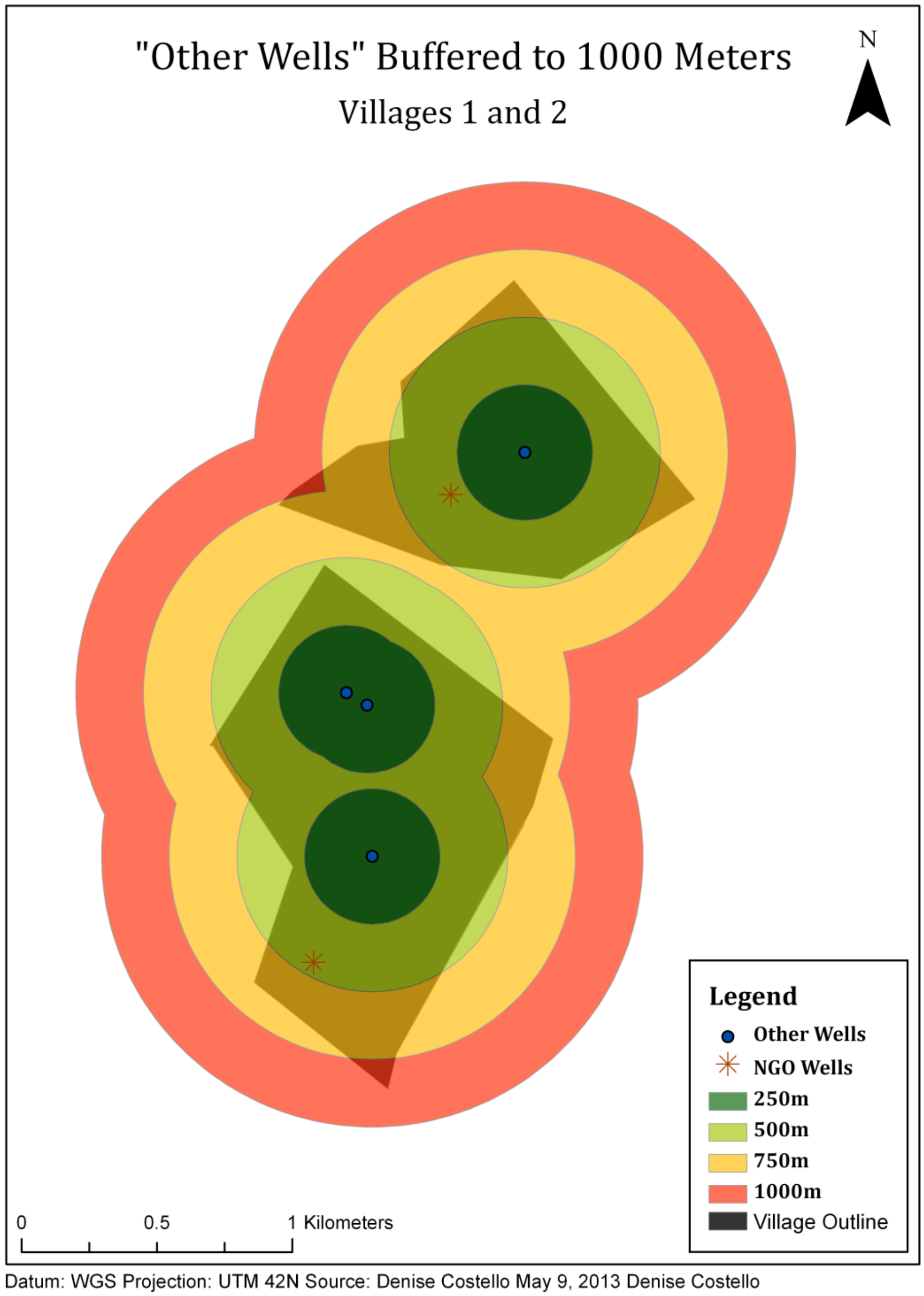


Figure 4.16: Working wells not constructed by the NGO buffered to 1000m in Villages 1 and 2.

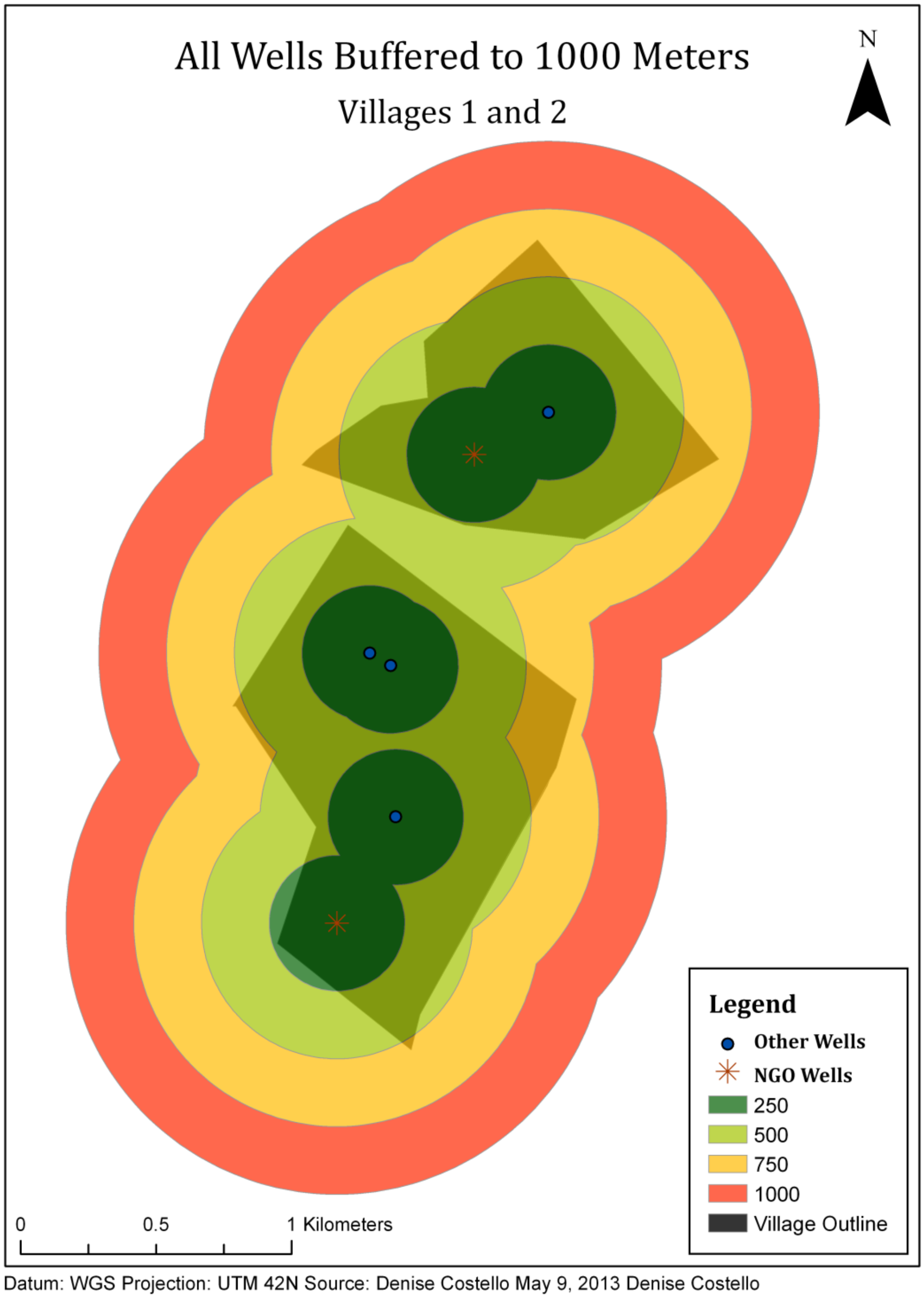


Figure 4.17: All working wells buffered to 1000m in Villages 1 and 2.

Datum: WGS Projection: UTM 42N Source: Denise Costello May 9, 2013 Denise Costello

Figure 4.18: Working wells not constructed by the NGO buffered to 1000m in Villages 3 and 4.

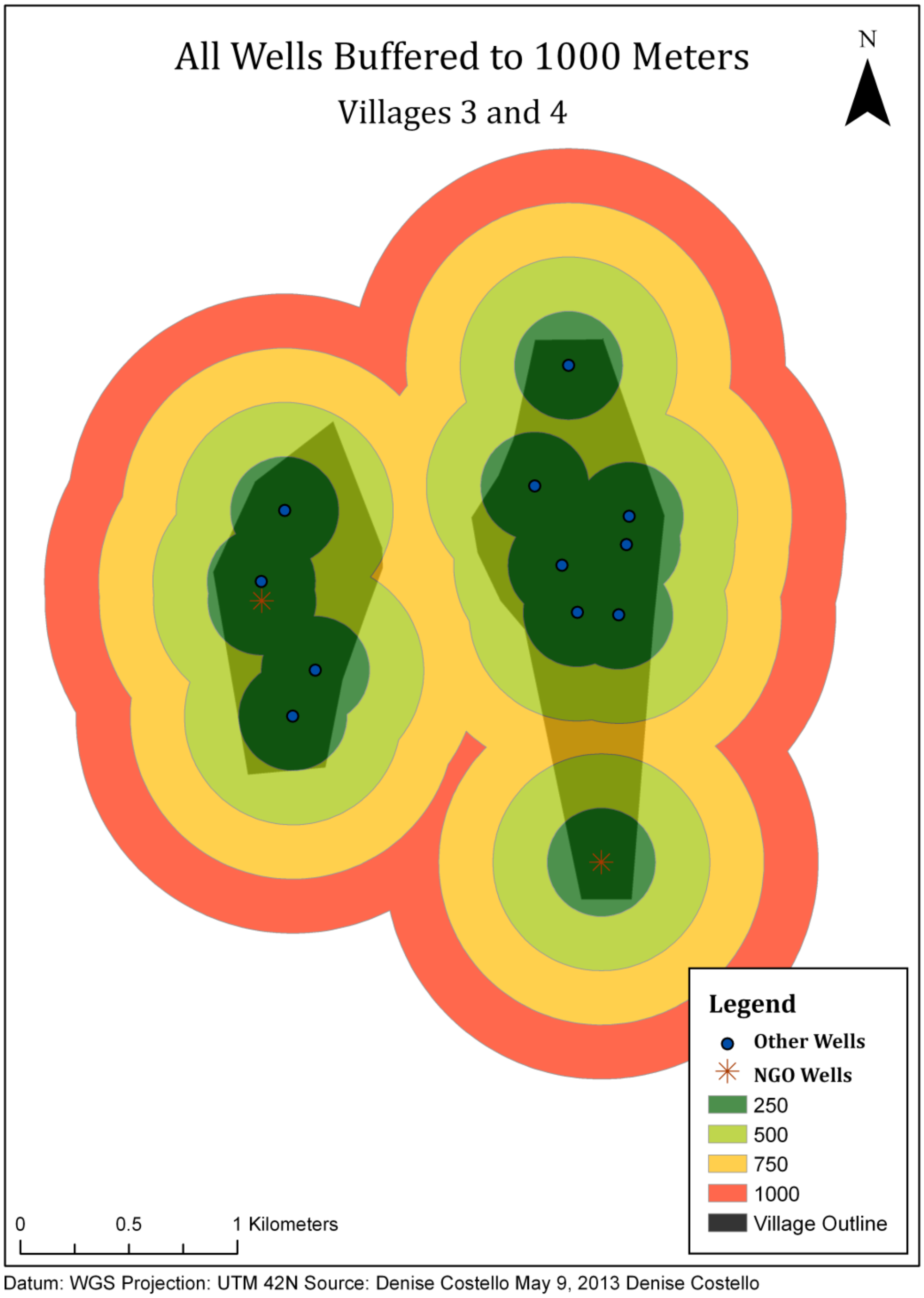


Figure 4.19: All working wells buffered to 1000m in Villages 3 and 4.

Below, Figure 4.20 displays the straight line distances in meters of surveyed households to their nearest well. Respondents may not necessarily use the closest borehole as their main source of drinking water, but this measurement was calculated to investigate more closely each household's access to safe drinking water. All households in the survey are within 1000m of a borehole and nine are fewer than 50m from a borehole. Village 4, with eight working boreholes, has the shortest mean (122.82m) and median (112.22m) distances. Village 1 has the largest median distance (180.09m) and Village 2 has the largest mean distance (229.66m). The two households that are over 500m from the closest borehole, located in Village 2, both reported using surface water as their main source of drinking water with a round trip travel time of fewer than 15 minutes.

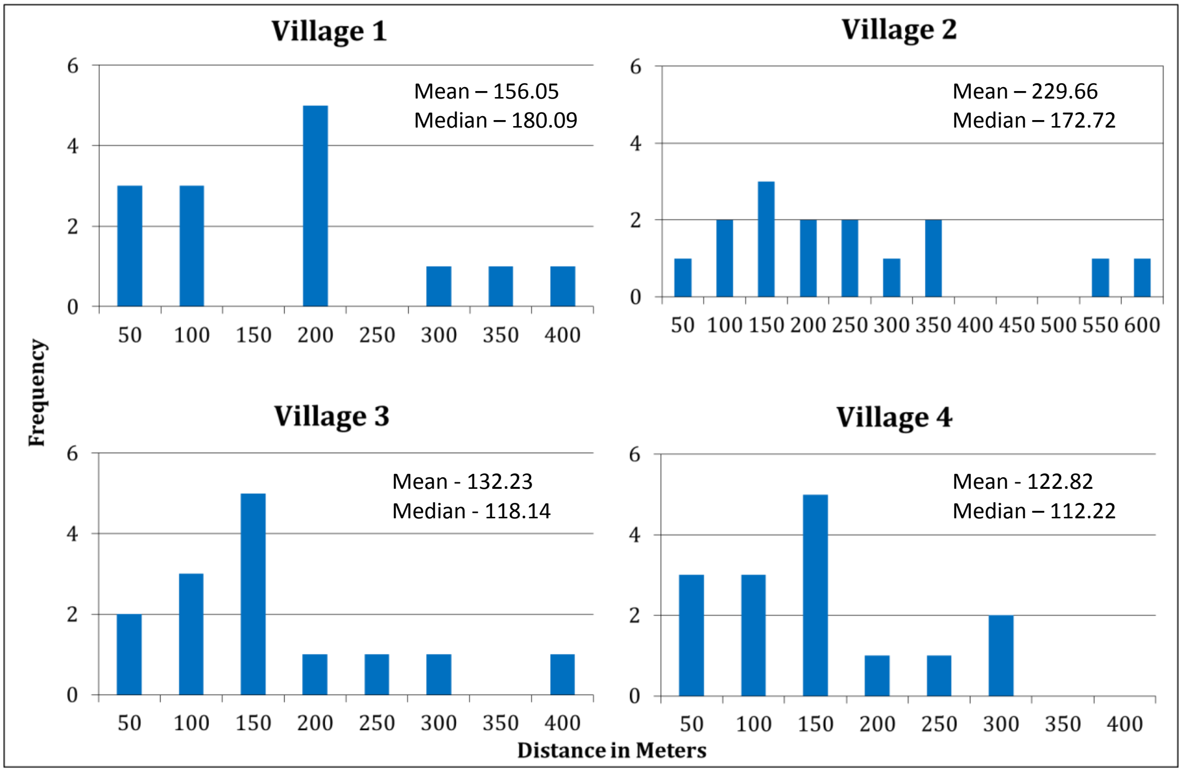


Figure 4.20: Distance from surveyed households to the nearest working borehole.

After calculating the distance of each household from the nearest borehole, a histogram of the number of households at each 50m distance bin that had provided water samples from all villages was created. These households were then coded by the outcomes of their water quality tests, Figure 4.21. Two patterns emerge from the messy distribution: 1) households over 300m from a borehole all showed a presence of *E. coli* in their drinking water and 2) households 50m or less from a borehole had the greatest number of drinking water samples free from *E. coli*.

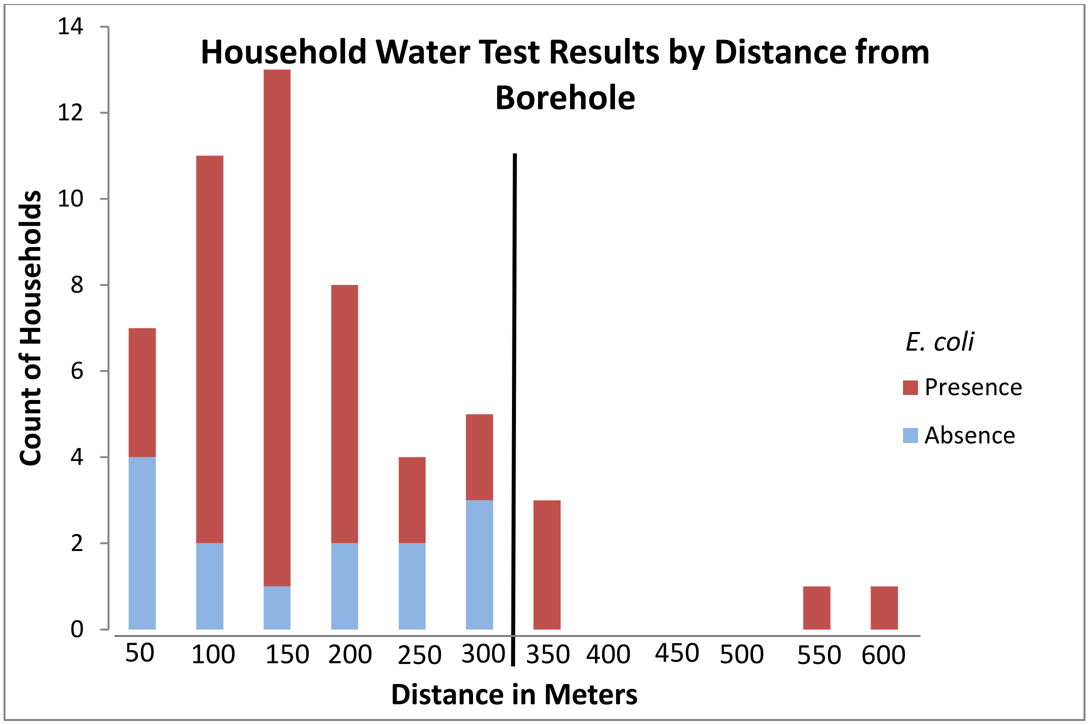


Figure 4.21: The counts of positive and negative household water tests results at each distance bin.

In pattern 1, there were five households out of the total of 54 (9%) that were between 300m – 600m from the nearest borehole. All five of these households had a presence of *E. coli* in their drinking water samples. There were two other households beyond 300m, but neither provided drinking water samples thus were not included in the the histogram. Of the seven total households beyond 300 meters from the nearest borehole, all reported collecting water from an unimproved, unsafe source. Five households stated using surface water sources and two stated using unprotected dug wells.

As seen in pattern 2, of the 49 households within 300m of the nearest borehole, 14 (29%) had drinking water free from *E. coli* with the highest number (4) being within 50m of the measured source. Overall, 91% of surveyed households with water samples were within 300m of a borehole. Based on visual inspection of satellite imagery for each village, it appears that the spatial pattern of a majority of homes being within 300m of a borehole holds true for all households and is not limited to only the surveyed households.

Again using the distance measurements, a scatter plot was made for each village. The plots graph a household's distance to its nearest borehole and the reported number of children five years old or younger that reportedly had diarrhea in the previous two weeks (Figure 4.22). Based on these scatter plots, there does not seem to be a relationship between distance and diarrhea. The households with the highest counts of diarrhea range from less than 100 meters to over 500 meters from a borehole. In Villages 2, 3, and 4, the households farthest from the nearest borehole all reported zero children having diarrhea in the previous two weeks.

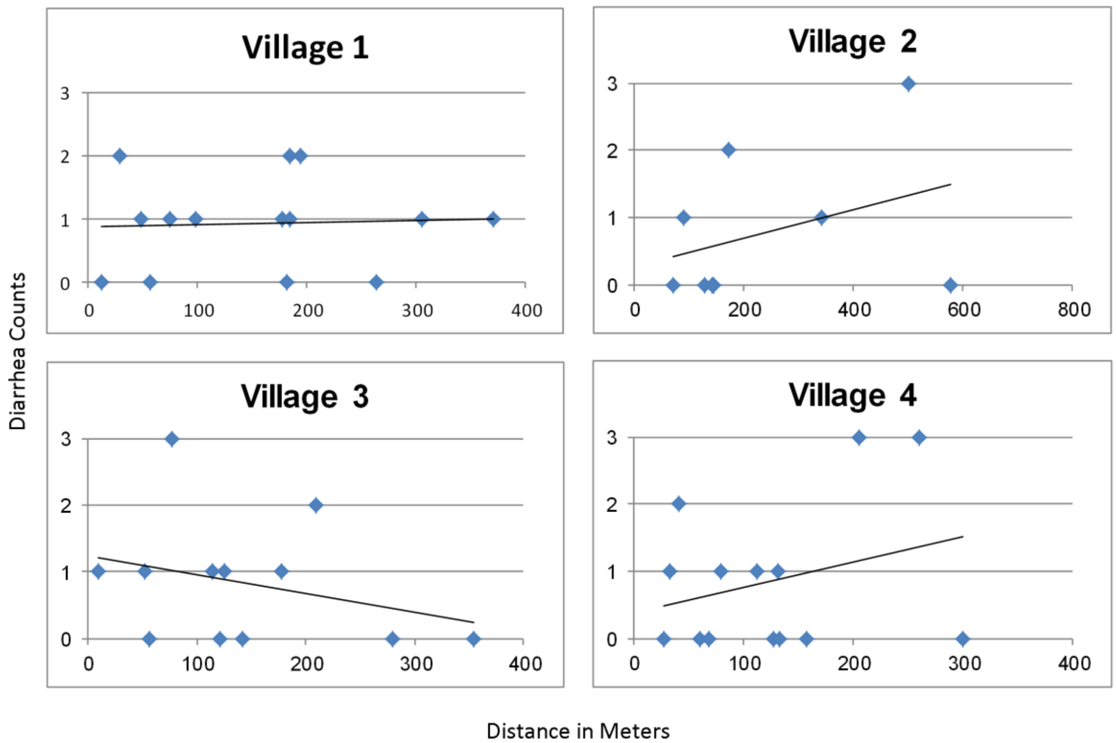


Figure 4.22: Stated counts of children that had diarrhea in the previous two weeks versus distance to the nearest borehole for each household.

5 DISCUSSION

5.1 Overall

The results of the study show many positive outcomes to the NGO's WASH program as well as areas for improvement if interventions are resumed in the surveyed villages. Boreholes drilled by the NGO in each village increased access to water, 11 variables from the survey showed significant, beneficial change between baseline and follow-up, and 13 out of 14 boreholes tested free from the presence of *E. coli* (including all four drilled by the NGO). The survey had 15 other tested variables that did not show significant increase or decrease between baseline and follow-up, including the percentage of children per household suffering from diarrheal disease. It was found that 74.1% of homes had stored drinking water that had a presence of *E. coli*, an indicator of fecal contamination and other disease causing pathogens.

5.2 - Q1. Post program, was access to safe drinking water improved within the study area?

Drinking water access did seem to be improved based on spatial data giving the locations of each well the NGO built, the general locations of homes, and the extents of the villages. Not all survey respondents use improved sources for drinking water, but every surveyed household is within 1000 meters of one. The World Health Organization guidelines state that being within 100 to 1000 meters of an improved source is considered "basic access" (Howard & Bartram, 2003). In fact, based on GIS measurements, the maximum distance of any household from an improved source was 576.6 meters. As presented in the maps of buffered wells, if the NGO's wells were not present some households would not be covered. This is true in Village 4, where the NGO's well provided access to households that are on the outskirts of the area of central development. In all villages, many homes that were already within 1000 meters of a well were able to travel shorter distances due to the wells the NGO drilled. It is unclear if shorter distances translated into direct health impact. Unlike a study in Nicaragua, this study found that homes farthest from boreholes were not necessarily more likely to report higher incidents of diarrhea, Figure 4.22 (Gorter, Sandiford, Smith, & Pauw, 1991). These findings may be more related to the difficulty in accurately assessing diarrhea rates through self-reporting than diarrhea incidents and distance from the nearest borehole having a negative relationship with each other.

The boreholes were not only accessible by global WASH standards, but as found in several other studies, also provided drinking water that had a low risk for disease (Dalu et al., 2011; Leiter et al., 2012; Parker et al., 2010). The one exception to borehole water being uncontaminated was in Village 3 where one borehole tested positive for a presence of *E. coli*. The outcome demonstrates that in this area of northern Afghanistan, similar to other studies, counting boreholes only will not necessarily give accurate information about *safe* water access (Bain et al., 2012).

Lastly, Village 2 had an additional component to consider when assessing safe water accessibility for residents. The piped water scheme that reportedly ran to about half of the village households was not being used. If the system was in use there would have been periodic running water, via standpipes, inside households' walled compounds. This would have provided better access to homes in the village with a potential for better quality water than surface sources. At the time of the follow-up survey, residents of the village had only two public wells and one was located inside the yard of the local primary school. In conjunction, Village 2 had the highest percentage (33%) of people using surface water as their main source for drinking, Table 4.2. It also had the highest percentage of stored water contaminated by *E. coli*. This suggests that source water may be related to contamination levels in stored water. The NGO's money may have been better spent and the community better served by investment in additional boreholes. Boreholes require manual labor, unlike a gravity fed scheme, but overall are cheaper for communities to operate.

5.3 – Q2. How is the spatial distribution of households relative to water sources related to safety of stored drinking water?

In analyzing the spatial distribution of boreholes to homes, it was found that all households over 300 meters from the nearest borehole had stored drinking water contaminated with *E. coli*, Figure 4.21. Additionally, the results of this study suggest that using "1000m from an improved source" as an indicator of accessibility may be too great a distance for households that must collect and transport water; especially when a closer, though contaminated, water option exists. The burden of transporting water from the nearest borehole for households beyond 300m proved too great and they chose to use unsafe water sources instead. This is fully 700m less than the distance deemed “accessible” by the UN and WHO and the distance used to evaluate progress of all people having the UN declared “human right” of safe water.

5.4 – Q3. Was there an increase in WASH knowledge within the study area?

The questionnaire only specifically asked about three pieces of knowledge: when appropriate times are to wash hands throughout the day, causes of diarrheal disease, and preventions for diarrheal disease. Based on the results of the follow-up survey, there were two areas of knowledge that had significant increase - causes of diarrhea and preventions for diarrhea. Respondents had better knowledge of the illness, but this improved knowledge did not seem to lead to an absence of diarrheal disease as Table 4.7 displays.   This is not entirely unexpected as Fisher et al. (2011) also found that an increase in knowledge does not necessarily lead to an increase in practice or, as in this example, and eventual impact on health.

The results of the question asking participants to recall when they had washed their hands with soap in the previous day showed a significant increase between baseline and

follow-up. Interestingly, the more general knowledge question asked later in the survey "When is it important to wash your hands?" did not have a similar increase.
When looking more closely at the responses for the knowledge question, it should be noted that a very high percentage of respondents at baseline (75%) were able to state important handwashing times. There was very little room for significant improvement of this variable. Responses remained high, with no significant decrease in the percentage of respondents able to name critical handwashing times. The recall of practice question suggests that more people seemed to be applying the handwashing knowledge at follow-up than they were at baseline. Or, as found in other studies, with the reminder of the knowledge about handwashing that the NGO classes provided, respondents may have over reported handwashing activities in a response bias versus actually increasing practice (Biran et al., 2008; Halder et al., 2010; Luby et al., 2011).

Lastly, when observing the responses of the final, open-ended question of the survey, a wealth of knowledge is found that directly links to the WASH lessons taught by the NGO (Appendix C). Participants recalled learning that pump water is cleaner than JUI water, that clean water is beneficial for your health, that it is important to keep latrines clean, that it is necessary to cover stored water, that toilets can make well water dirty, and that washing hands with soap is important. One woman specifically talked about the knowledge versus practice paradox. After listing several things she learned from the class she paused, looked around her house, and then admitted to not always putting these beneficial ideas into practice. The opened ended question was helpful in assessing additional knowledge gained by survey participants that had attended the NGO classes.

5.5 – Q4. Was there an increase in WASH practices within the study area?

A majority of the questionnaire focused on practices within the household. As Figure 2.1 models, WASH programs invest in hygiene education with the belief that increasing knowledge will affect behavior and ultimately impact health. Conducting robust health impact assessments is often beyond the scope of many WASH programs. For this reason, based on the relationships that have been scientifically determined between certain practices and reduction of diarrheal disease, they monitor and evaluate outcomes such as observable practices instead.

This survey had several sets of related practices that were investigated. The first was a set of practices around treating water. Treating stored drinking water prior to consumption is highly effective in reducing microbial contamination, but, as in this research, the practice is often not continued after the WASH program ends (Brown & Sobsey, 2012; Luoto et al., 2011). Similarly, Opryszko et al. (2010), who also conducted a study in Afghanistan, were told that chlorine treatment provided at no cost during research would be impossible for participants to purchase at full price later. Thus the practice of treating with chlorine, though known to be beneficial, would be stopped due to the financial burden. The questionnaire for this study had in-depth questions about how people treated their water, but no specific questions asking why the participants did not treat their water. The only information the researcher has is anecdotal. Four respondents, when answering whether or not they treated their water, commented that lack of resources kept them from treating their water. Two others stated that it was not necessary because water was collected from a borehole.

The BSF technology introduced by the NGO during the program was not widely adopted. The majority of homes that did have the filters were households that had been given them in order to demonstrate their use to others. It did not seem to be a technology that households were willing to spend their limited income on. The BSFs were in use in the households that had them, but it was unclear if they were being used consistently or effectively. In one household, it appeared that water had been poured into the filter just before the researcher observed the room where it was located. The majority of water samples taken from households with BSFs showed a presence of *E. coli*, which is inconsistent with many documented field trials (Aiken et al., 2011; Stauber et al., 2012; Tiwari et al., 2009). But these observations are similar to a long-term assessment of BSFs that was conducted in Haiti in which 47% of filters were no longer in use (Sisson et al., 2013).

Three indicators for the practice of handwashing with soap increased, suggesting that handwashing itself may have increased. The reported handwashing at critical times significantly increased from baseline in which the highest reported village average was only 26%. At the time of the follow-up survey two villages had an average of 47% of participants reporting washing at critical times. This reported handwashing is not necessarily backed up to the same degree by the proxy indicator of having soap at a specific handwashing area. A majority of households (78%) had a specific place to wash their hands, but only 19% had soap in that place. Luby et al. (2009b) found that having a specific place for washing hands was not as strong an indicator of behavior as having soap in that same place. In this study, having a specific place to wash increased dramatically which could indicate an intention to wash hands. Yet, the indicator that has been significantly linked to handwashing with soap (soap in the handwashing area) did not have as dramatic of an increase. The percentage of households with soap in the handwashing area may be a truer picture of the percentage of households that regularly wash with soap rather than self-reports of the practice. The relatively small percentage of surveyed households with soap in the handwashing area may be one reason why this study, unlike others where handwashing improved, did not see a significant reduction in diarrhea incidents (Cairncross et al., 2010; Fewtrell et al., 2005; Luby et al., 2004). Figure 4.12 gives a visual display of this same information and provides a picture of points (such as treating water or having soap) where further increase in practices could be encouraged.

5.6 – Q5. Was stored household drinking water safe for consumption?

Similar to several other studies, this research found that stored drinking water had *E. coli* present in a majority of homes, despite improvements in several key storage practices (Eschol et al., 2009; Leiter et al., 2012; Trevett et al., 2004). This means that either clean source water was getting contaminated on the way to or in the home or source water was contaminated from the beginning. Either way, contamination could have been reduced or completely destroyed by consistent, effective point of use drinking water treatment, as reported by several studies (Arnold & Colford, 2007; Luoto et al., 2011; Mwabi et al., 2012). A very low number of participants reported treating their water in the home. Treatment significantly reduced between baseline and follow-up and overall was low even at baseline. The low level of water treatment is a similar to the findings of Luoto et al. (2011) and Parker-Fiebelkorn et al. (2012). Several survey participants stated that they do not treat their water because the “water is clean” due to being accessed from the boreholes. Another, more challenging reason as to why people do not treat their water is the reported lack of financial resources. Opryszko et al. (2010) found that households with lower economic status were less likely to use water treatment interventions, which is supported by the World Health Organization and UNICEF (2012b). This is a challenging constraint that requires more investigation into how to make water treatment less of a financial burden.

High contamination may also be related to the ease of collecting water from JUIs. A majority of participants reported using boreholes as their main source of drinking water, but the researcher noticed many children collecting water from JUIs. It cannot be determined whether the water being collected was being used for drinking. This observation does lead to questioning whether drinking water was as consistently collected from boreholes as reported; especially as children were most often the collectors, not the survey participants. Even though boreholes are within 1000 meters of every home, JUIs, in almost all cases, are closer. If JUI water is being used for drinking water, this makes the practice of point of use treatment even more important.

Fourteen households had drinking water that was free from *E. coli* at the time of sampling. All of these households reported using boreholes as their source of household drinking water; this suggests a similar relationship to that found by Trevett et al. (2004) in which the quality of stored water from boreholes was found to be significantly better than from other sources. If this could be further researched and a significant relationship established, it would give even more importance to collecting drinking water from an improved source.

5.7 Limitations and Suggestions for Further Research

There are several ways that this study was limited and could be expanded in the future. For a clearer understanding of the patterns of water contamination, repeated testing of household stored water and source water would be necessary. Water testing was only conducted once per household and per source. One borehole, the NGO borehole in Village 1, was tested on two different days to verify non-contamination, but due to the researcher being restricted to pocket incubation (a limit of 22 test tubes per 24 hours); more robust testing did not take place.

The survey could be adapted to provide more detailed, reliable information in the future. Firstly, this survey had a relatively small sample size. To gain more information a larger sample size could be collected, if feasible in regards to time, money, and safety. The questionnaire could be improved by adding the description of diarrhea defined by the World Health Organization. Adding a definition would give participants clarity on what the surveyor means by the word “diarrhea.” Also, the question about diarrhea should either be expanded to include all members of the household or the survey design should be limited to only include households with at least one child five years old and under. Lastly, to better understand the contamination found in households using BSFs, it would be beneficial for two water samples to be taken. Taking one sample directly from the output of the BSF and one from the container that the filtered water is stored in would help determine whether or not the filter was working properly.

One vital area for further research is investigating ways to promote consistent, effective, and socially acceptable forms of household water treatment. Water treatment is effective in reducing microbial contamination and incidents of diarrhea. High levels of adoption of a water treatment strategy could have a significant health impact on the residents of these villages.

6 CONCLUSIONS

The WASH program implemented by the NGO met several of their desired goals. Notable outcomes were a significant increase in households having a specific place to wash hands after using the toilet, soap present in the handwashing area, improved water storage practices, and an increase in knowledge of the causes and preventions of diarrhea. Access to improved drinking water sources was also increased by the wells the NGO drilled. Despite these successes, there was a high percentage of households with contaminated drinking water and the percentage of children with diarrhea per household was not significantly reduced. This may have been related to the small overall percentage of respondents that treated their water and the small, though significantly larger than baseline, percentage of participants that regularly washed with soap at critical times. Biosand Filter technology was introduced and promoted by the NGO, but uptake of the technology was low. For those households that did use BSFs, several had drinking water samples that showed a presence of *E. coli*, suggesting that either the water was getting re-contaminated after filtration or the filters were not being used in an effective way. Also, the findings suggest that using “1000m from an improved source” as an indicator of accessibility may be too great a distance for households that must collect and carry water, especially when a closer, though contaminated, water option exists.

These outcomes add to the growing list of studies that show the need for longer term follow-up, especially when behavior change is one of the main goals of the program. Longer programs would allow for a better understanding of particular cultural norms of the community as well as time for repeated classes, as was requested by one the survey participants. Extended programming is challenging when NGOs are reliant on external funding for program costs. Advocating to funders the importance of longer term monitoring and evaluation as well as reoccurring education programs, could be a vital next step.

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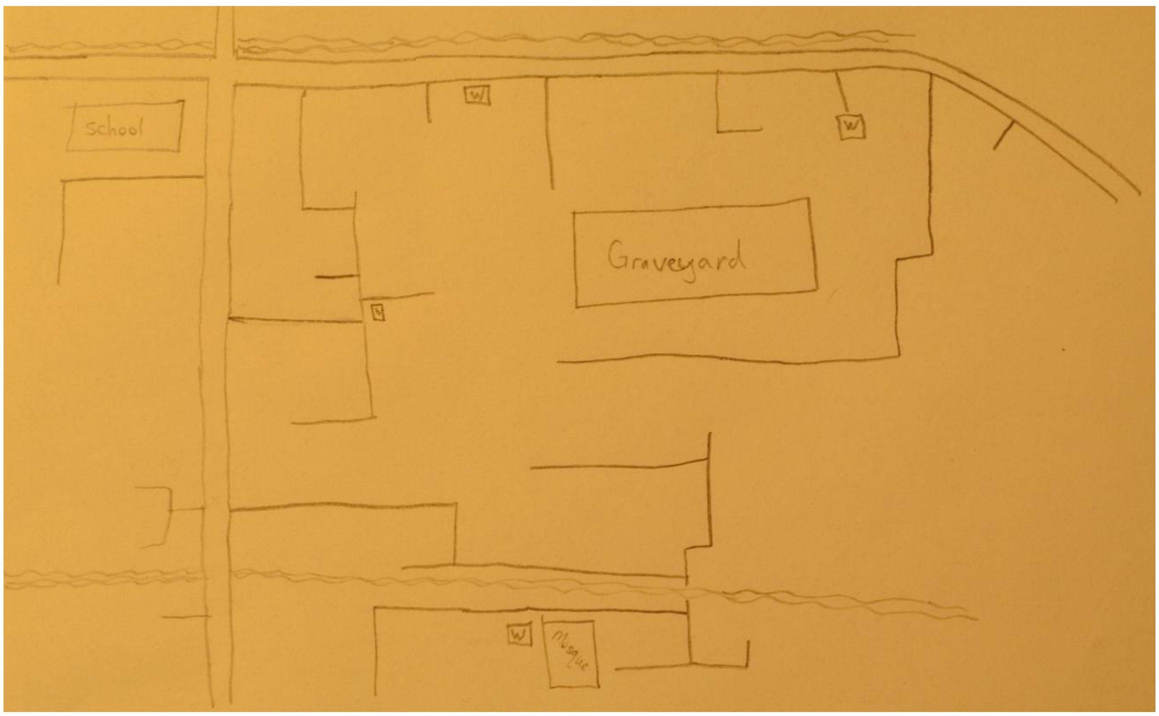
APPENDICES

Appendix A: Map of the Layout of the Villages



Appendix B: Follow-Up Survey Questionnaire

SURVEY: WATER SUPPLY, SANITATION, AND HYGIENE (Revised: April 2012)

IDENTIFICATION	
CODE:	
DATE OF SURVEY:	
WATER SAMPLE: Y N	
# PEOPLE IN HH: ADULTS ☐☐ CHILDREN UNDER 5 ☐☐ CHILDREN 5+ ☐☐	

HOUSEHOLD WATER SUPPLY, SANITATION, AND HYGIENE

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
1	What is the main source of drinking water for members of your household? (CHECK ONE)	PUBLIC TAP/STANDPIPE .... 13 ☐ BOREHOLE .... 14 ☐ PROTECTED DUG WELL .... 15 ☐ UNPROTECTED DUG WELL .... 16 ☐ PROTECTED SPRING .... 17 ☐ UNPROTECTED SPRING .... 18 ☐ RAINWATER COLLECTION .... 19 ☐ SURFACE WATER (RIVER/POND/LAKE/DAM/ STREAM) .... 23 ☐ OTHER ________ 96 ☐ (SPECIFY)	
2	How long does it take you to fetch water from this source; to go there, get water, and come back? (CHECK ONE)	MINUTES ☐☐☐ ON PREMISES .... 996 ☐ DON'T KNOW .... 998 ☐	
3	In the last 2 weeks has the water from this source been unavailable for at least 1 whole day?	YES .... 1 ☐ NO .... 2 ☐ DON'T KNOW .... 8 ☐	
4	Do you treat your water in any way to make it safer for drinking?	YES .... 1 ☐ NO .... 2 ☐	→7
5	IF YES, what do you usually do to the water to make it safer to drink? (ONLY CHECK MORE THAN ONE RESPONSE, IF SEVERAL METHODS ARE USUALLY USED TOGETHER, FOREXAMPLE, CLOTH FILTRATION AND CHLORINE)	LET IT STAND AND SETTLE/SEDIMENTATION ...... A ☐ STRAIN IT THROUGH CLOTH .... B ☐ BOIL .... C ☐ ADD CHLORINE/WATERGUARD/PUR .... D ☐ BIOSAND FILTER .... E ☐ SOLAR DISINFECTION (SODIS) .... F ☐ OTHER ________ X ☐ (SPECIFY) DON'T KNOW .... Z ☐	→7
6	When did you treat your drinking water the last time using this method?	TODAY .... 1 ☐ YESTERDAY .... 2 ☐ OVER ONE DAY AGO/LESS THAN ONE WEEK ...... 3 ☐ ONE WEEK AGO OR LESS THAN A MONTH .... 4 ☐ ONE MONTH AGO OR MORE .... 5 ☐ DON'T REMEMBER .... 8 ☐	
7	Have you used soap today or yesterday?	YES .... 1 ☐ NO .... 2 ☐	→9
8	When you used soap today or yesterday, what did you use it for? (DO NOT READ THE ANSWERS, ASK TO BE SPECIFIC, ENCOURAGE "WHAT ELSE" UNTIL NOTHING FURTHER IS MENTIONED AND **CHECK ALL THAT APPLY.**) IF FOR WASHING MY OR MY CHILDREN'S HANDS IS MENTIONED, PROBE WHAT WAS THE OCCASION, BUT DO NOT READ THE ANSWERS.	WASHING CLOTHES .... A ☐ WASHING MY BODY .... B ☐ WASHING MY CHILDREN .... C ☐ WASHING CHILD'S BOTTOM .... D ☐ WASHING MY CHILDREN'S HANDS .... E ☐ WASHING HANDS AFTER DEFECATING .... F ☐ WASHING HANDS AFTER CLEANING CHILD .... G ☐ WASHING HANDS BEFORE FEEDING CHILD .... H ☐ WASHING HANDS BEFORE PREPARING FOOD ..... I ☐ WASHING HANDS BEFORE EATING .... J ☐ OTHER ________ X ☐ (SPECIFY)	
9	Regarding children age 5 and under: How many children have had diarrhea in the past 2 weeks?	☐☐	

FOR USE BY WASH SURVEY STAFF
REFERENCE: DHC2012 WASH BASELINE SURVEY

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
10	What do you think can cause diarrhea in young children? (DO NOT READ THE ANSWERS, ENCOURAGE BY ASKING IF THERE IS ANYTHING ELSE UNTIL S/HE SAYS THERE IS NOTHING ELSE AND CHECK ALL MENTIONED) NOTE: FOOD INCLUDES MILK, YOGURT, ETC.	BAD/DIRTY WATER .... A ☐ BAD/DIRTY FOOD .... B ☐ POOR HYGIENE .... C ☐ FECES/DEFECATING IN THE OPEN .... D ☐ DIRTY HANDS .... E ☐ GERMS .... F ☐ FLIES .... G ☐ OTHER ______ X ☐ (SPECIFY) DON'T KNOW .... Z ☐	
11	Do you think diarrhea can be prevented?	YES .... 1 ☐ NO .... 2 ☐ DON'T KNOW .... 8 ☐	 →13
12	If yes, how do you think diarrhea can be prevented? (DO NOT READ THE ANSWERS, ENCOURAGE BY ASKING IF THERE IS ANYTHING ELSE UNTIL S/HE SAYS THERE IS NOTHING ELSE AND CHECK ALL MENTIONED)	WASH HANDS .... A ☐ USE SOAP .... B ☐ USE TOILET FACILITY TO DEFECATE .... C ☐ DISPOSE CHILDREN'S FECES IN TOILET .... D ☐ BURY FECES .... E ☐ DRINK CLEAN WATER .... F ☐ STORE WATER SAFELY .... G ☐ TREAT WATER (BOIL, FILTER, CHLORINATE) .... H ☐ PREPARE FOOD HYGIENICALLY/PROTECT .... I ☐ DISPOSE OF GARBAGE IN A PIT .... J ☐ BREAST FEEDING IN GENERAL .... K ☐ BREAST FEEDING ONLY UNTIL 6 MONTHS .... L ☐ NO OTHER FOOD/DRINK BEFORE 6 MONTHS ..... M ☐ MEASLES VACCINATION .... N ☐ VITAMIN A .... O ☐ GOOD NUTRITION .... P ☐ OTHER ______ X ☐ (SPECIFY) DON'T KNOW .... Z ☐	
13	When is it important to wash your hands? (DO NOT READ THE ANSWERS, ENCOURAGE BY ASKING IF THERE IS ANYTHING ELSE UNTIL S/HE SAYS THERE IS NOTHING ELSE AND CHECK ALL MENTIONED)	BEFORE PREPARING FOOD OR COOKING .... A ☐ BEFORE EATING .... B ☐ BEFORE FEEDING CHILDREN .... C ☐ AFTER CLEANING/CHANGING BABY .... D ☐ AFTER DEFECATING .... E ☐ AFTER EATING .... F ☐ OTHER ______ X ☐ (SPECIFY) DON'T KNOW .... Z ☐	
14	The last time [*name of child*] passed stool, where did he/she defecate?	USED LATRINE .... 11 ☐ USED POTTY .... 12 ☐ USED NAPPIES .... 13 ☐ WENT IN HOUSE/YARD .... 15 ☐ WENT OUTSIDE THE PREMISES .... 16 ☐ WENT IN HIS/HER CLOTHES .... 17 ☐ OTHER ______ 96 ☐ (SPECIFY) DON'T KNOW .... 98 ☐	→17
15	The last time [*name of child*] passed stools, where were the feces disposed of? (IF "WASHED OR RINSED AWAY", PROBE WHERE THE WASTE WATER WAS DISPOSED OF. IF "DISPOSED", PROBE WHERE IT WAS DISPOSED OF SPECIFICALLY.)	DROPPED INTO LATRINE .... 11 ☐ RINSED/WASHED AWAY WATER DISCARDED INTO LATRINE .... 21 ☐ WATER DISCARDED OUTSIDE .... 23 ☐ DISPOSED INTO SOLID WASTE/TRASH .... 31 ☐ SOME WHERE IN YARD .... 32 ☐ OUTSIDE PREMISES .... 33 ☐ BURIED .... 41 ☐ DID NOTHING/LEFT IT THERE .... 51 ☐ OTHER ______ 96 ☐ (SPECIFY) DON'T KNOW .... 98 ☐	
16	How do you store drinking water?	IN CONTAINERS (BUCKET, JERRY CAN, POT, BOTTLE, DRUM, ETC.) .... 1 ☐ ROOF TANK OR CISTERN .... 2 ☐ NO WATER STORED .... 3 ☐	 →20 →20
17	IF IN CONTAINERS, may I see the containers, please?	YES .... 1 ☐ NO .... 2 ☐	 →20
18	OBSERVATION ONLY: WHAT TYPE OF CONTAINERS ARE THESE? (CHECK ALL THAT APPLY) Narrow mouthed: opening is 3 cm or less (interviewers use template)	NARROW MOUTHED .... 1 ☐ WIDE MOUTHED .... 2 ☐ OF BOTH TYPES .... 3 ☐	

SURVEY: WATER SUPPLY, SANITATION, AND HYGIENE (Revised: April 2012)

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
19	ARE THE CONTAINERS COVERED? (OBSERVE AND CHECK)	ALL ARE .... 1 ☐ SOME ARE .... 2 ☐ NONE ARE .... 3 ☐	
20	Where is the sanitation facility located?	INSIDE OR ATTACHED TO DWELLING........ 1 ☐ ELSEWHERE INSIDE YARD .... 2 ☐ OUTSIDE YARD .... 3 ☐ NO FACILITY, FIELD, BUSH, PLASTIC BAG .... 27 ☐	 →25
21	May I see the sanitation facility?	YES........ 1 ☐ NO .... 2 ☐	 →25
22	OBSERVATION ONLY: What kind of sanitation facility does this household use? (CHECK ONE):	COMMODE .... 13 ☐ VENTILATED IMPROVED PIT LATRINE (VIP)........ 21 ☐ SIMPLE PIT LATRINE WITH SLAB........22 ☐ PIT LATRINE WITHOUT SLAB/OPEN PIT........ 23 ☐ NO FACILITY, FIELD, BUSH, PLASTIC BAG .... 27 ☐	 →25
23	How many households share this sanitation facility? (ASK REGARDLESS OF LOCATION)	Number ☐☐ NOT SHARED........ 1 ☐ 10 OR MORE .... 10 ☐ DON'T KNOW .... 98 ☐	
24	SANITATION FACILITY OBSERVATION: IS THERE FECAL MATTER PRESENT INSIDE THE FACILITY - ON SEAT, FLOOR, DOOR OR WALLS (HUMAN OR ANIMAL)?	YES........ 1 ☐ NO .... 2 ☐ CANNOT ASSESS........ 8 ☐	
25	Can you show me where you usually wash your hands and what you use to wash hands? ASK TO SEE AND OBSERVE INSIDE/NEAR SANITATION FACILITY	INSIDE/NEAR SANITATION FACILITY........ 1 ☐ INSIDE/NEAR KITCHEN/COKING PLACE........ 2 ☐ ELSEWHERE IN YARD........ 3 ☐ OUTSIDE YARD .... 4 ☐ NO SPECIFIC PLACE........ 5 ☐ NO PERMISSION TO SEE........ 8 ☐	 →30 →30
26	OBSERVATION ONLY: IS THERE SOAP OR DETERGENT OR LOCALLY USED CLEANSING AGENT? THIS ITEM SHOULD BE EITHER IN PLACE OR BROUGHT BY THE INTERVIEWEE WITHIN ONE MINUTE. IF THE ITEM IS NOT PRESENT WITHIN ONE MINUTE CHECK NONE, EVEN IF BROUGHT OUT LATER.	SOAP........ 1 ☐ DETERGENT........ 2 ☐ ASH........ 3 ☐ SAND........ 4 ☐ NONE........ 5 ☐ OTHER ________ 6 ☐ (SPECIFY)	
27	OBSERVATION ONLY: IS THERE WATER? INTERVIEWER: TURN ON TAP AND/OR A CHECK CONTAINER AND NOTE IF WATER IS PRESENT THIS ITEM SHOULD BE EITHER IN PLACE OR BROUGHT BY THE INTERVIEWEE WITHIN ONE MINUTE. IF THE ITEM IS NOT PRESENT WITHIN ONE MINUTE CHECK NO, EVEN IF BROUGHT OUT LATER.	YES........ 1 ☐ NO .... 2 ☐	
28	May I take a sample of your drinking water?	YES........ 1 ☐ NO .... 2 ☐	 →30
29	OBSERVATION ONLY: IS THERE A HANDWASHING DEVICE SUCH AS A TAP, BASIN, BUCKET, SINK, OR TIPPY TAP? THIS ITEM SHOULD BE EITHER IN PLACE OR BROUGHT BY THE INTERVIEWEE WITHIN ONE MINUTE. IF THE ITEM IS NOT PRESENT WITHIN ONE MINUTE CHECK NO, EVEN IF BROUGHT OUT LATER.	YES........ 1 ☐ NO .... 2 ☐	
30	ARE THERE ANY COMMENTS YOU WOULD LIKE TO MAKE ABOUT THE WASH PROGRAM OR WHAT YOU LEARNED FROM THE PROGRAM?		

Appendix C: Qualitative Responses to Question 30

Appendix Table: Qualitative data describing respondents perspective on the WASH program

Survey Respondents	
Village	Paraphrased Comments
1	Didn't participate, hadn't heard about the program
1	Didn't participate, hadn't heard about the program
1	Good lessons; learned about washing dishes and clothes, cleaning and how to keep children from getting sick
1	Everything was beneficial. We learned that cleaning helps from getting sick.
1	Good class; good for everyone; now our village knows about good hygiene practices; in the past we didn't know/practice good hygiene
1	Her neighbors went; heard that they learned about all sorts of things and that it was a good class ;learned to keep flies them away from food and how to keep things clean
1	Neighbors went, they didn't; it was a long time ago (last year) don't remember what neighbors said about it
1	Went to classes; Why aren't there more?; Another organization gives women 250afs for each class attended
1	Good class; received filter; filter works well; From the lessons, I learned that we should separate our drinking water from the animals'; In the past we drank from the same buckets as the cows; We learned the importance of cleaning ourselves
1	My daughter went, but didn't tell me anything; It was good for them; daughter got gifts - chlorine
1	Good because woman who can't read could learn (with pictures); learned how to keep the house clean
1	Didn't participate; didn't really hear anything about it
2	Neighbor went and told them in this household about it; now we take garbage out of the yard; we are careful what food we give children; cover food from flies and dust
2	neither woman had participated
2	It was good; after program, cleaned up toilet area
2	Good course. It helps our life; We learned that many diseases are caused by germs; We now take better care of our houses, keep them clean; keep children clean
2	Good course
2	Didn't attend classes; Didn't hear about them; They don't get news of things on this street
2	Lessons were good; If we follow the lessons it will be good for us, if not bad for us
2	Didn't participate
2	Use chlorine to treat water, but have to get chlorine from city because it isn't sold in village; went to class; All the lessons were good
2	Everything was good; received biosand filter as gift (hosted a class); learned to cover food and water
2	Used to use chlorine from the hygiene class, but it's finished; knows about boiling, but doesn't do it; the toilet lesson was new for us; after the lesson we made our toilet better
2	Didn't participate; no comments
2	All the lessons were very good, interesting, new and kept our attention; especially the lessons about keeping the latrine hole closed and keeping the food safe and covered to keep from getting sick. Also boiling water, chlorine, and bio-sand filters were new subjects for us. We also learned the importance of washing our hands and our children's hands after the latrine, before eating, and after home chores. We are all happy because of everything that we have learned. The lessons were useful for out health.

Appendix Table cont.

Survey Respondents

Village	Paraphrased Comments
2	My daughter participated in your lessons and when she returned home she repeated the lessons to me. She was so happy. I am also happy because I learned new things. The lessons we have learned were great, especially the subjects related to cleanliness in our home, yard, dishes and ourselves. The other interesting lesson was about bio-sand filters, chlorine, and the "Three - Bucket Method". Quite new. Anytime the well is "collapsed" and "crumbled", we can get water from the stream and use the Three-bucket method.
2	The lessons were very good, especially handwashing after latrine, drinking safe and healthy water, utilizing chlorine, cleaning of our rooms and yards; We did our cleaning, but not in the proper way, now we have learned the proper way of how to keep our children, rooms, and yards clean.
3	They were good lessons.; We learned about microbes, which was very good information.; We learned about toilets, which types are better and how to keep the latrine clean.; We also learned how to keep the water safe and how to use the bio-sand filter, which is a new thing for us.; Overall the lessons were good and we learned many things.
3	Didn't participate in classes but heard about them; We heard they were a couple of hours.; We only heard a little bit about it.; We heard about washing hands with soap; washing after going to the toilet, keeping ourselves clean, and how to keep water clean.
3	It was a good class, beneficial for our health.; We learned how to take care of our drinking water, to keep edibles clean, and to [store] food carefully in order not to get sick.; We learned all of this with your help. We hope to have more lessons in the future.
3	The lessons were all new material.; The lessons were very good, cleanliness is a part of faith.; Since the lessons, we (adults and children) are regularly washing our hands.; Also we built our latrine a far distance from water wells and our home.; We also built a [chicken] birdhouse.; We bought a biosand filter which was totally new for us.; We learned many things.
3	The classes were very good.; We are very happy to have been encouraged towards cleanliness.; We are also happy to apply cleaning practices in the appropriate way.; We have learned that microbes are dangerous substances and have to keep them away from ourselves.; We would be very happy to have similar lessons again.
3	We learned to wash our hands after doing certain things like cleaning and going to the toilet.
3	I liked the Fly movie. It was good.; We learned why to keep flies away and the importance of covering food.
3	We learned about putting vegetables/fruit in chlorine to clean. We also learned that pump water is clean, but not JUI water.; We also learned to wash our hands and that toilets can me well water dirty.
3	Woman didn't attend classes, but her daughter did. She forgot what daughter told her about the class.; The woman also stated that "It was dangerous to go" because the men sat near the mosque and said things when women walked by on the way to the class.
3	No one from household attened the classes. We heard about them, but didn't ask people what they had learned.
3	Good class.; They taught about washing hands after going to the toilet.; We have been practicing good hygiene this last year.
3	Didn't go to the class; No one told her anything about it.; She's new to the village.
3	They didn't attend the classes.
3	The classes were good, but I've forgotten everything.
4	Lessons 1 & 2 were good.; We learned about cleaning and washing our hands.; We also learned about being careful about their children when going to the toilet.;We should cover our water containers.
4	We learned about the filter.; We learned a lot [from the classes].

Appendix Table cont.
Survey Respondents

Village	Paraphrased Comments
4	Very good class.; Very good teaching.; I learned something every time.; I learned about and how to use the biosand filter, which was new information.; We remind our children to wash their hands after going to the toilet.; We alos learned about the "Three Bucket" method which was new to us.
4	Didn't attend classes
4	Didn't attend classes, didn't hear about them
4	It was very good; We have learned several things such as cleanliness and hand washing with soap.; Also, the prevalence of illness is becoming less.
4	We learned to wash our hands, clean our homes, and not let flies in the house.
4	We didn't go because we didn't have permission from the men in the family to go.; We didn't hear anything about it from neighbors.; We don't like these programs.
4	No one from HH went to classes.; They hadn't heard anything about the classes from neighbors.
4	They didn't participate in the classes and hadn't heard about it from their neighbors.; They are busy at the house with lots of work.
4	Ddin't attend classes.
4	Didn't attend class and no one knew anything about the classes.
4	I heard about it, but didn't go.
4	No one in this yard attended the classes
4	I liked the classes.; The lessons were very good especially subjects such as learning that drinking clean water is beneficial to our health.; We learned to drink water from the well, not the JUI.; We also learned the importance of keeping our children's hands clean after they go to the latrine.; We learned about keeping our latrine clean, covering our water and food and keeping our water and food in a safe place.; We also learned about washing our hands with soap and clean water.; What we learned was useful.

Appendix D: Water Tests Data Sheet

Test #	Date/time	Location	Water source	Colilert yellow/clear	Colilert Did tube fluoresce?	Petrifilm # blue & gas on	Risk of Disease
Ex. 1	23.03.2008	Central Market	Spring (improved)	yellow	yes	8	High

From: UN Habitat - A Practical Method for Rapid Assessment of the Bacterial Quality of Water.

Appendix E: GPS Data Sheet

Water Project
August - September 2012
Afghanistan
WGS84

Date/Time	ID #	Latitude	Longitude	Elevation	Accuracy(m)	Attribute Information: Water Point (WP)*, Household (HH), Road (RD), Boundary (B)

*WPS = WP Surface; WPW = WP Well; WPHH = WP HH Storage

Adapted from GEO 565 - Geographic Information Systems and Science course, Oregon State University