Project Well Guidelines

Created by

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Acknowledgments

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Contents

1.Background and Overview

1.1. Arsenic and its health effects

Arsenic poisoning through drinking contaminated groundwater is a slow, chronic process. With long-term exposure, high mortality risks from many serious diseases—such as skin, lung, kidney, bladder, and liver cancers—may develop (National Research Council 2001). Diseases of the vascular system including peripheral vascular disease, Blackfoot disease and cerebrovascular disease are other consequences (Tseng 1989; Tseng et al. 1996). Cardiovascular diseases, lung diseases, and diabetes mellitus are some other risks associated with chronic exposure (Smith et al. 2006; Smith et al. 2011a; Tsai et al. 1999; Tseng 2008; von Ehrenstein et al. 2005; Wang et al. 2003; Yuan et al. 2007), as are reproductive effects (von Ehrenstein et al. 2006). Recently, it's been shown that exposure to arsenic in drinking water as a child or before birth can cause not only childhood health and cognitive problems, but even illness and death as an adult (Dauphine et al. 2010; Liaw et al. 2008; Smith et al. 2011b; von Ehrenstein et al. 2007). Although there exist a few options for symptomatic treatments, there is no effective overall treatment to combat arsenic health effects. Therefore, the only solution is to not drink contaminated water.

Arsenic in water is a colorless, odorless, and tasteless naturally-occurring metalloid released from soil and rocks. The behavior of arsenic in groundwater is difficult to predict because it easily changes valence state and reacts to form various species that range in toxicity and mobility. Concentrations can change drastically over a few meters in lateral space and depth, so that one tubewell containing safe water may be only a few meters away from another tubewell that is severely contaminated. Because arsenic contamination is not consistent over a given region, mitigation is very difficult.

1.2. Extent of Problem in India

Water contaminated with arsenic can be found in over 70 countries throughout the world. India, Nepal, and Bangladesh are three countries of the Gangetic delta that have certain regions with high concentrations of arsenic in groundwater. In India, the problem is found in five states, including West Bengal, Bihar, Jharkhand, Assam and Uttar Pradesh. In fact, nine of 19 districts in West Bengal have reported contaminated groundwater, potentially affecting a total population of over 42 million. Of this, over 6 million people are drinking water with arsenic concentrations above 0.05 mg/L (50 µg/L) and over 300,000 people have developed skin lesions resulting from ingesting the metalloid. These numbers continue to grow (Chakraborti et al. 2003; Sengupta et al. 2003).

The permissible limit of arsenic in drinking water set by the Bureau of Indian Standard is 0.05 mg/L, while the permissible limit set by WHO is 0.01 mg/L. Epidemiological findings indicate that 1 in 10 people would die from arsenic-caused illness if the concentration of arsenic in drinking water was 0.5 mg/L and 1 in 50 would die if the concentration was 0.1 mg/L, a typical amount found in the village shallow tubewells where dugwells programs are being implemented.

1.3. Options for Arsenic-Safe Water

There are several strategies available to provide arsenic-safe water at the community or household level, some that are based on physical or chemical removal processes of contaminated water and others that promote alternative water sources. Arsenic removal units (filters) based on adsorption, ion-exchange, or coagulation/precipitation processes have been implemented in West Bengal, with some negative outcome reports (Hossain et al. 2005). Some alternative sources include water from deep aquifer tubewells, rainwater harvesting, and dugwells.

There is no overall "best" method: depending on the community, and various hydrological, geological, geographical, and social considerations, some options are more feasible and/or desirable than others (for example, in shallow aquifer areas confined by hard bedrock, it would be impossible to install deep tubewells). Although the ideal long-term approach may be for every family to get water through pipelines, this solution will be a long time coming in many areas. For now, community-based supplies are the fastest and most equitable ways to address the emergency.

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Project Well

2.1. Project Well Objective

Project Well, a non-profit organization, provides safe drinking water to arsenic-contaminated areas of India, and makes these water sources sustainable by developing community-based programs. Project Well also educates communities on proper sanitation and personal hygiene practices.

2.2. History of Project Well

Project Well founder Dr. Meera M Hira-Smith grew up in West Bengal and is familiar with the culture and communities of the region, which has proved invaluable in creating and running Project Well. Beginning in 1996, Dr. Hira-Smith began investigating methods of arsenic mitigation for some villages in the N24 Parganas district of West Bengal. She conducted surveys in the villages and consulted with scientific and engineering experts, coming to the conclusion that the best method would have to be easily adaptable and cheap. Dr. Hira-Smith developed a program centered around the traditional dugwell, a method that fulfilled the above criteria and was also familiar to the villagers. Dr. Timir Hore, a hydrogeologist, provided the design (interior) for a modified version of the traditional shallow dugwell, using concrete rings one meter in diameter and an attached handpump to extract water. Over the years, the design has been further modified to a bore-dugwell design, discussed in chapter 4.

Project Well officially began in 2000, when the first donation was made to begin the program. Mr. Protap Chakarborti, geologist and ex-director of the Geological Survey of India, together with non-government organizations Loka Kalyan Parishad of Kolkata and Aikya Sammelani Club of Simulpur, constructed the first dugwell in Simulpur in May 2001; this dugwell was treated with potassium permanganate to control bacterial growth.

Project Well instituted a program to record bacterial counts and note technical problems prior to program expansion. One year later, in May 2002, five additional dugwells were constructed in Kamdebkhati, Bamondanga, and Simulpur. Initial reports on dugwell water quality showed very low levels of arsenic but some elevated coliform counts (Hira Smith et al. 2003). Users did not like the tint that potassium permanganate added to the water. Project Well replaced potassium permanganate with a chlorine-based disinfectant (5-10% available chlorine) and initially dosed the water once a month.

Twenty more dugwells were constructed in 2003, extending coverage into the villages of Chondipur and Kolsur; the monitoring program for five dugwells was also extended. In 2004, an additional eight dugwells were constructed in the villages of Ranidanga, Chandalati, and Ranihati. The monitoring program has continued until today.

In 2004, Project Well registered as a non-profit organization in California, with Professor Allan Smith, director of the Arsenic Health Effects Research Group (ASRG) at UC Berkeley, as President and Dr. Hira-Smith, a long-time research specialist at ASRG, as treasurer. Dr. Timir Hore, *Vice President of C&H Environmental*, Inc., of New Jersey, was brought on as the technical advisor. Ms. Cynthia Green was the initial Secretary, a position now held by Ms. Jane Liaw, also of ASRG.

For transparency and management purposes, Project Well created an India-incorporated NGO in 2005 called Aqua Welfare Society (AWS), which became the sister organization of Project Well. Founding members were local experts with arsenic mitigation interests, including geologists Mr. Protap Chakraborti, Mr. Saumen Banerjee and Mr. Uday Mukherjee (secretary) and Mrs. Alpana Hira-Davidson, geographer (treasurer). The first President of AWS was Mr. Amal Ghosh, a practicing lawyer. The current President is Mr. Ashok Paul. The other board members and advisors are Dr. Xavier Savarimuthu, environmental scientist, Mr. Punardan Dutta, technician and social worker, and Mr. Suprio Das, chartered engineer. AWS now comprises thirteen staff, ten of whom were hired from the arsenic-contaminated villages.

Project Well bore-dugwells have gradually expanded over the districts of North 24 Parganas, Nadia and Murshidabad. Growth is cautious, as Project Well researches and surveys before construction to make sure this traditional method is acceptable to villagers at the selected sites. Through 2004, 36 shallow dugwells were constructed; since partnering with AWS in 2005 until 2011, 181 more sources have been added, bringing the total up to 217 sources.

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3. Site Selection for a Well Program

3.1. Different types of wells and the history of dugwells (known locally as "kua")

Dugwells and tubewells are the two types of wells in this part of India.

Dugwells are excavated manually and may be shallow, about 3- 10 meters in depth, or deep, about 10-60 meters in depth, with narrow or broad diameters. Dugwells as big as 5 meters wide are called 'indara' and are constructed with bricks and concrete instead of concrete rings.

Tubewells draw water through narrow pipes (iron or poly vinyl chloride, PVC) usually with the help of handpump but sometimes with an electric pump. Tubewells can also be shallow or deep. Shallow tubewells generally tap water from the second aquifer, at depths of 15-30 m (50-100 feet). Deep tubewells are more than 30 m (100 feet) deep.

Hand-dug wells ("dugwells" or "kua") have been used in India for several hundred years and, until fairly recently, were a ubiquitous feature across West Bengal and other parts of India. In fact, dugwells are still used in other states of India, such as Tamilnadu, Rajasthan, Gujarat, and Karnataka. However, in West Bengal, NGOs began installing tubewells about 40 years ago due to concerns about waterborne diseases attributed to drinking bacterially-contaminated, untreated near-surface and surface water. Unfortunately, the tubewell water that came from deep, confined aquifers was never tested for arsenic, and millions of people have since been exposed to elevated arsenic concentrations from contaminated tubewells.

Project Well initially provided alternative safe water sources in the form of traditional dugwells after assessing potential alternative methods of providing arsenic-free water to villages of West Bengal, India (Hira Smith 2000). Dugwells tap into unconfined near-surface aquifers where arsenic concentrations are characteristically low. Dugwell water is treated to prevent bacterial contamination under a rigorous but simple maintenance program run by the community. Because dugwells are a familiar water source, communities easily learned how to properly use and maintain the dugwells.

After eight years of monitoring and testing, Project Well decided that bore-dugwells are a better well design than traditional dugwells in terms of providing water year-round. Project Well bore-dugwells are shallow, at only 8 meters (27 feet) deep, and tap water from the same unconfined aquifers as dugwells. Detailed bore-dugwell specifications and construction methods are discussed in detail in Section 4. The design of the Project Well bore-dugwell has been modified to minimize contamination and promote ease of use.

3.2. Criteria for site selection for bore- dugwells

(Mr. Protap Chakraverty, geological advisor to Aqua Welfare Society, contributed text in this section regarding geological expertise and satellite imagery.)

3.2.1. Setting up a dugwell program requires coordination between several groups, namely local government bodies, Block Development Offices (BDO), panchayet offices and other NGOs working in the area. These groups need to be informed about the program. The government office may be able to provide detailed reports on existing arsenic-affected villages, including information about contaminated wells. Sometimes the government already has plans to bring pipelines or other water sources to the area. This information would make it easier to select sites.

3.2.2. Villages with arsenic patients are given first priority.

3.2.3. Record the latitude and longitude coordinates of about four of the suggested (by the BDO or panchayet) sites on a handheld global positioning system (GPS) device (Figure 1).

3.2.4. Plot and label the coordinates on Google Earth Mapping software (free download from the internet) and save it using 'Save Place As' feature. This feature allows the use of Google Earth 'Saved Places' without internet connection.

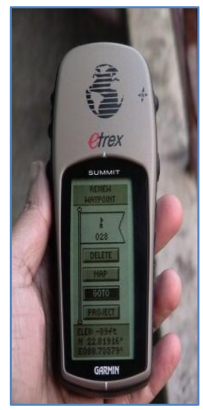

Figure 1: Garmin GPS device

Consult with a geologist specializing in satellite image interpretation, fluvial geomorphology and geo-hydrology, to select geologically suitable sites for construction in the vicinity of villages where patients with symptoms caused by arsenic ingestion have been identified. To be geologically suitable, a site must satisfy the following criteria:

The soil profile should contain sandy silt or silt toward the top and groundwater-bearing sandy layers at the bottom. There should be no clay layers within the profile as well as on the surface around the site.

The depth of the sand layer below the ground should be less than the depth to which air can penetrate below the ground through pore spaces in the overlying soils (the depth of oxidation). The depth of oxidation is generally high in sandy soils (up to 8 m) and shallow within clay soils (up to 0.5 m). The depth of sand layers can be broadly predicted from satellite imagery and can be measured at the proposed site by sinking galvanized iron pipes using a "hand jigging with water pouring" method as a pilot test, while the depth of oxidation has to be assessed in the field on the basis of soil type, texture and structure. For the pilot testing, two 3 m (10 foot)- and one 1.5 m (5 foot)-iron pipes of 3.8 cm (1.5 inches) diameter are used to drill down to a depth of approximately 8 m (25 feet). Initially, a small hole is hand-dug up to 60 cm (2 feet) to position the iron pipe; beside it, a bigger hole is dug to accumulate water that flows in through the side of the pipe and outflows through the interior of the pipe as hand jigging (thumping with the palm) continues. This way, drilling is done and the quality of sediment is noted simultaneously. If sandy soil is not available at 8 m, the site is cancelled and workers move on to the next proposed site, where the same method is repeated. This full process takes 1.5 to 2 hours and is executed by three drilling/boring laborers. The cost for each pilot test is about Rs. 400.

a) The size of the sand grains within the sand layer should be large.

b) The depth of the groundwater table, measured from the surface, should be less than the depth of oxidation, especially during the pre-monsoon period. The depth to groundwater table can be measured from local tanks/ponds/natural standing water bodies.

3.2.5. The geologist will locate such sites from geocoded satellite imagery (refer to section 3.2.3) by detecting geologically old (Holocene age), fluvial geomorphic landforms, whose inherent sediment composition and internal structures satisfy the aforementioned geological criteria. The Holocene river system comprised high energy, sand-transporting streams and produced suitable groundwater-bearing landforms. In contrast, present day river/streams transport mainly clay and do not produce such landforms.

3.2.6. The specific fluvial geomorphic landforms which can be detected and interpreted from satellite imagery, (refer to Figure 2) and the geologically suitable sites associated with such landforms, have been tabulated below:

Fluvial geomorphic landforms	Suitable dugwell sites
Paleo channel fill deposits	Areas along both the channel banks as well as within filled-up (aggraded) channel deposits
Paleo oxbow lakes	• Areas along the convex bank of oxbow lakes not completely filled up (aggraded) and still containing standing water • Areas within the fill deposits of oxbow lakes, especially those produced by the fluvial process of chute cut-off.
Point bar deposits within meander loops of paleochannels	Areas over entire length of arcuate ridge deposits, which form a part of ridge and swale topography of point bar deposits. The Paleo point bars can range in size from 1 to 100 square km, and village areas usually located on top of the ridges.

Notes:

- Fluvial geomorphic landforms mentioned in the table cannot be detected or mapped from ground observations.
- The geological and remote sensing protocol, discussed in section 3.2.4, is applicable to alluvial sedimentary terrains of the early Holocene age, extending from Malda and South 24-Parganas districts of West Bengal and similar geological/geomorphic terrains elsewhere.

3.2.7. It is advisable to find any historical dugwells in the area and analyze the water for arsenic concentrations. If the water is found to be within maximum permissible limits (0.05 mg/L), efforts should be made to revive the dugwell by sanitizing it—constructing housing (refer to pg. 15 for housing), connecting a handpump to extract water, and disinfecting the water weekly.

Figure 2: : Appearance of paleo channels as seen on satellite images via Google Earth

3.2.8. If the geologists believe bore-dugwells are feasible for the site, the next step is to meet with villagers to discuss donating a plot of land. Land donation follows the criteria below:

a. the land should be on HIGHER GROUND than the surrounding area;

b. the land should preferably be OUT IN THE OPEN where there is plenty of sunshine;

c. Arsenic-CONTAMINATED TUBEWELLS <u>(Figure 3)</u> are PRESENT near the selected site.

d. The NEAREST SOURCE of arsenic-free drinking water is at least 700 m (1200 feet) away, so there is no overlap and the dugwell will be fully utilized.

e. The well should be UPGRADIENT and at least 30 m (100 feet) AWAY from toilets, septic systems, abandoned pits (doba), stagnant water in small ponds, cow sheds (khatal) and animal shelters housing pigs, goats and poultry, slaughterhouses, burial grounds, markets, and agricultural fields. This is to minimize the potential for bacterial and chemical contamination.

f. There is a potential USER POPULATION of at least 100-150 people.

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4. Well Construction

4.1 Design of Dugwell

Dugwells and bore-dugwells are common in different parts of India, but the challenges in constructing such wells in West Bengal or the Indo-Gangetic Plain are:

1) the area is contaminated with arsenic at various unknown depths below 15 m (50ft).
2) within short distances—as little as 1000 m—the geological composition of sand and clay also varies (Figure 4).
3) transport of heavy excavation machinery is not possible because the sites are in interior and remote areas where vehicles cannot traverse, so skilled laborers (drillers and diggers) construct manually; this slows the construction process.

Figure 3: Contaminated tubewell

Figure 4: Fine sand (light grey) and clay (brown)

After several years of experience with dugwells of various depths, Project Well has modified the well design to that of a bore-dugwell (Figure 5), with specifications discussed below.

Figure 5: Bore-dugwell with handpump

The original dugwell design created by Dr. Hore in 2000 was improved upon each successive season as more data became available. Initially, the depth of the dugwells varied from site to site due to the width of clay and sand layers. The water was extracted with a handpump attached to the concrete well; the well was covered with a tin frame to prevent any debris like leaves, stones or birds droppings from falling in. The mouth of the cylinder was covered with a net to prevent insects and reptiles from entering.

However, some of these shallow wells were not getting enough water in the dry, summer seasons and about 15% dried up, instigating further changes in the bore-dugwell design. In

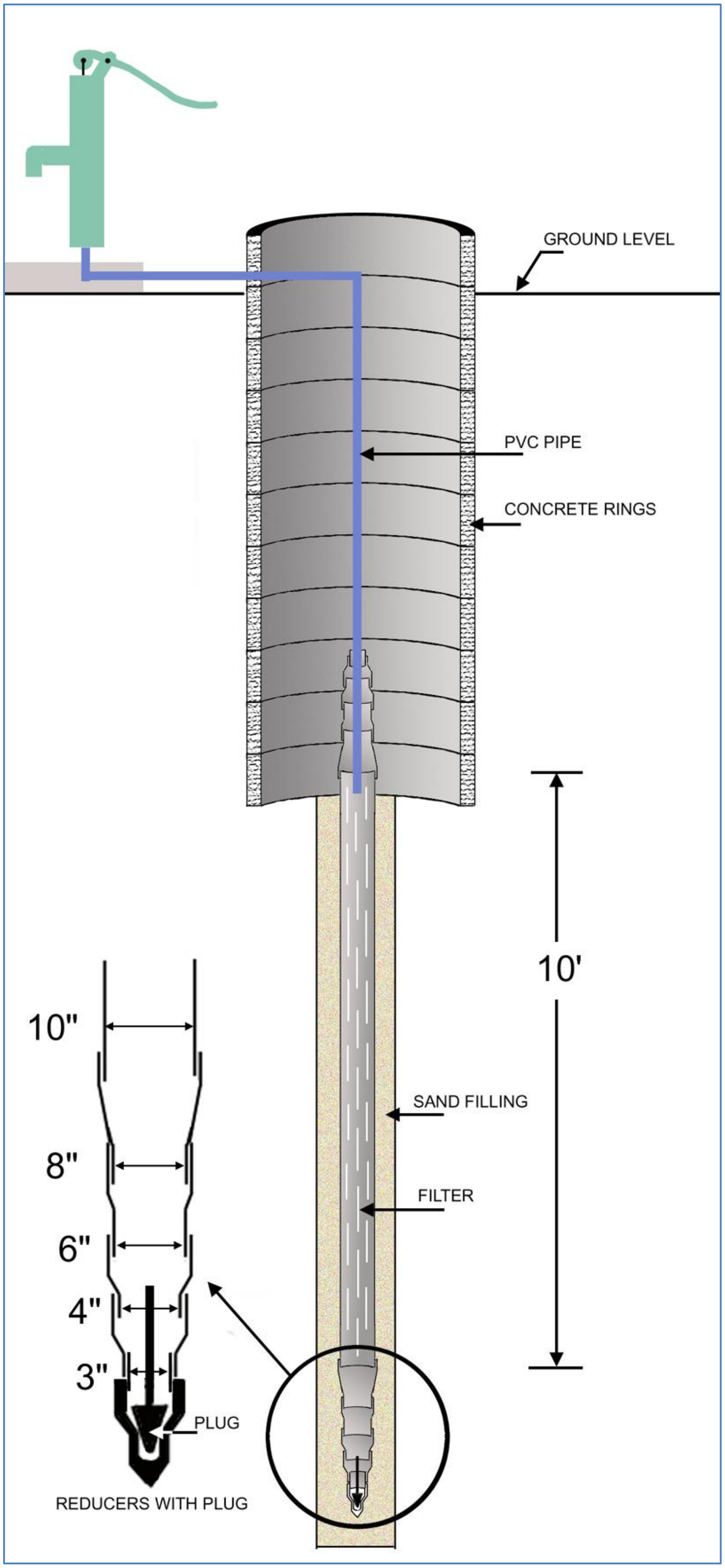


Figure 6: The longitudinal section of a bore-dugwell

2011, the modified bore-dugwell was made the standard Project Well design. A longitudinal section of a bore-dugwell is shown in Figure 6. The depth of the well is now 8 meters (27 feet). The bore-dugwell is 4.8 m (16 feet) below ground level and 1.2 m (4 feet) above ground level, with a 3 m (10-foot)-PVC pipe insert. Reducers are added that bring the total depth to 8 meters (27 feet). (The materials used and their specifications are described in the next section).

4.2 Procedures of Construction

(Descriptions and specifications are contributed by Mr. Suprio Das, technical advisor, and Mr. Dennis Baroi, technical manager of Aqua Welfare Society.)

The bore-dugwell construction process is divided into three sections:

1. Drilling the borewell,
2. Digging the dugwell and
3. Housing.

Construction can be done year-round except during the rainy season and one month after the rain retreats. It is important to consider the depth of the water table that varies from place to place even in the same district.

Drilling:

Generally, drilling up to a depth of 9m (30 ft) takes about 3-4 hours. Early in the morning, six laborers set up the bamboo scaffolding (Figure 7). They begin drilling using a 46cm (18 inches) drill bit (Figure 8) to insert the 25cm (10 inch)-diameter PVC pipe (Figure 9).

Figure 7: Bamboo scaffolding

Figure 8: The 46 cm drill bit

The drill bit is screwed on to the end of a 10cm (approx)-diameter metal pipe that is open at both ends. While the pipe with the drill bit at the lower end is rotated manually, water is pumped in to the pipe from the top end. This water pressure pushes out the excavated mud from the hole that is formed. The drilling is done up to a depth of 9m (30 ft). A diesel engine with an irrigation pump is generally used, with the nearest source of water feeding it. Next, a 25cm-diameter PVC pipe with wall thickness of 8mm and length of 3m is pushed down by the metal pipe used for drilling to the bottom of the hole. The PVC pipe is perforated with a longitudinal slit and covered by a fine nylon mesh. The mesh is held to the PVC pipe by thin steel wire stitched to the edges of the mesh. The ends of the PVC pipe are fitted with reducers (Figures 10 & 11) in three or four

Figure 9: Lowering of the assembled 3m by 25cm PVC pipe into the 46cm by 9m hole

Figure 10: The assembled reducer

stages so that the top end can be screwed to the metal pipe. The bottom end, also fitted with reducers, is fixed with a 'plug cutter' (local term).

As shown in Figure 11, the plug cutter is a small steel cylinder with a narrow opening at one end and a wider threaded opening at the other end. The end with the narrow hole has an arrowhead. The wider hole matches the reduced diameter of the PVC pipe. The bottom end of the PVC pipe attached with the 'plug cutter' (Figure 12) has to be kept open while the assembly is lowered in to the excavated hole. The open end allows the water in the flooded hole to enter the PVC pipe and prevent it from floating up. Water is again pumped in to the pipe to empty it of any clay/slit that may have entered while the pipe was being lowered. Once

Figure 11: The 3m - pvc pipe with reducers at either end. The coarse sand in the foreground will be used to fill up the annular space around the pipe once the pipe is inserted

the PVC pipe has been lowered to the bottom of the hole, a plug is dropped from the top so that it blocks the hole of the 'plug cutter'. The plug is a conical piece of steel with a long and narrow tail attached to its base (Figure 13). The plug is dropped with the tail upward so that it goes down and fits into the hole of the plug cutter. This seals the bottom end of the pipe by sealing the plug cutter and prevents mud/sand from entering the pipe in the future. The height of the cone is 8 inches and the tail is about 12 inches long. The long tail helps the plug go down vertically without tilting. A final cleaning of the inside of the plugged PVC pipe is done.

The annular space between the pipe and the hole is next filled up with coarse yellow sand.

Figure 12: The plug cutter

Figure 13. The plug fitted to close the hole of the plug cutter

Digging:

Four or five local skilled well diggers (at approximately Rs. 400 each) are usually employed following the drilling. They expand the 18-inch hole radially to about 110cm (3.5 feet), just the right size to fit the 100cm (3.3 foot)-diameter concrete rings (specifications are available in the material section). Starting from the top (Figure 14), the diggers carefully cut around the inserted pipe up to a level exposing 91cm (3 feet) of the pipe, including the reducer that overlaps with the dugwell. The larger diameter pipe is exposed to a depth of 91cm to avoid sand entering the pipe from the bottom of the dugwell during rainy or flood seasons. This method is derived from past experience of pipes being clogged with sand.

Figure 14: Digging from the top cutting around the inserted pipe

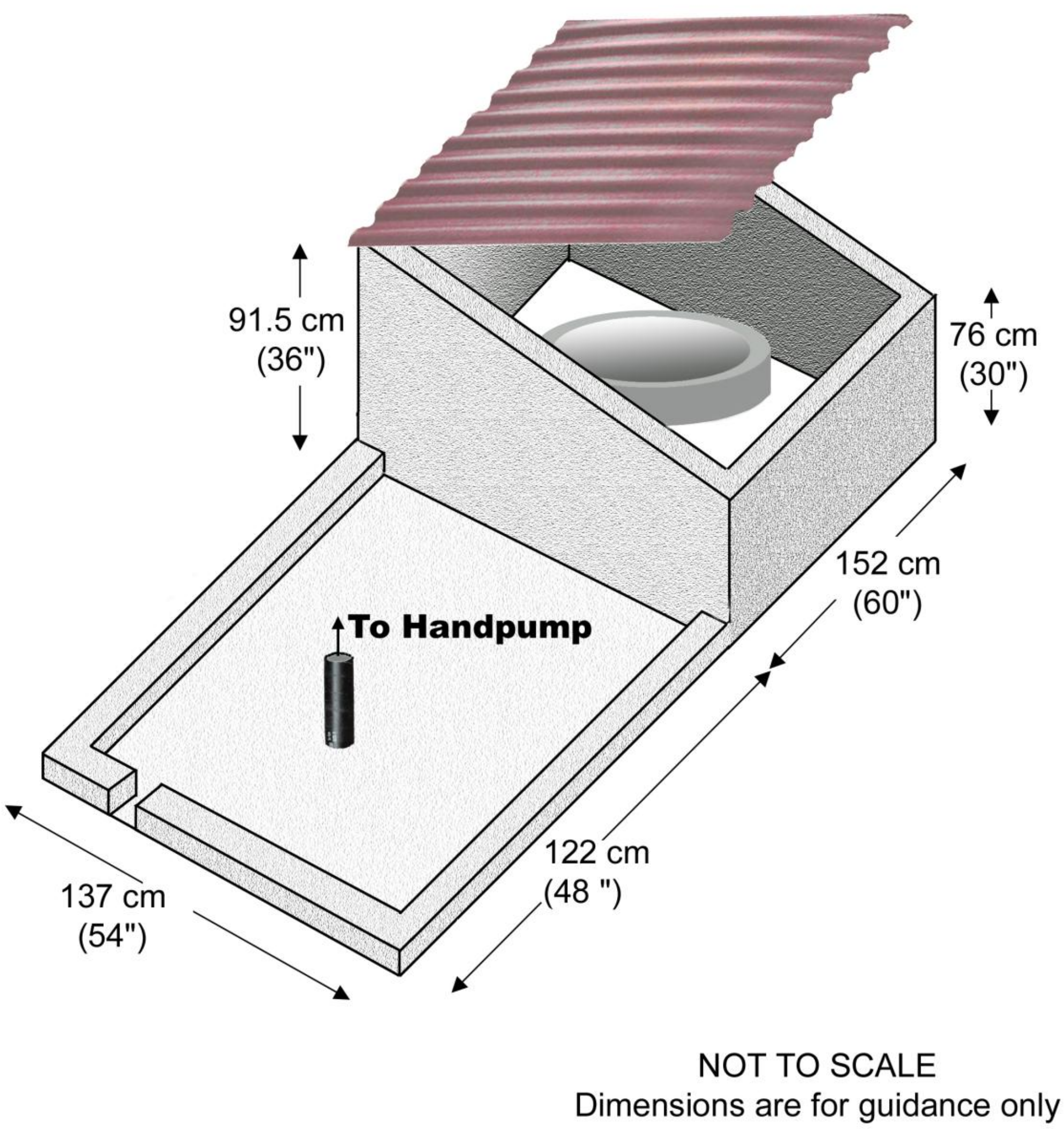
This set-up, with 2.4m (8 feet) of the larger pipe plus the reducer, extends the bore-dugwell to a total depth of 8m (27 feet).

The concentric rings are stacked on top of one another until the total height of the cylinder reaches approximately 5m (17feet) with 60-90 cm (2-3 feet) above ground level, or 2-3 rings above the surface, depending on whether the site is prone to flooding. To join two concrete rings, mortar (mixture of cement, sand and water) is used. The height of the inner cylinder (including the height above the surface) is 5.8-6m (19-20 feet).

Housing:

Local masons are employed for brickwork and to construct the apron/ platform surrounding the well. Masonry work takes about 2-3 days and requires 2 workers (Figure 15, with specifications).

Figure 15: Housing - the exterior portion of the bore-dugwell



Well platform/ apron:

A handpump is attached to the dugwell and connected via a delivery pipe (Figure 16). These pumps provide a maximum output of 40 liters of water per minute, depending on the efficiency of the handpump and the person pumping (young child versus an adult). Handpumps are used, rather than a bucket-rope system, as they are less prone to contamination.

Materials are described and also listed in the table below.

Finally, a marble tile is embedded on the wall at the site acknowledging the donors, implementers and the year of construction (Figure 17).

Following well construction, the water in the well should be pumped out, preferably with a small irrigation pump, to remove the finer residue until the water is clear and sediment-free.

4.3 Disinfecting

Prior to use, the well water should be treated with Theoline, a locally-available disinfectant that contains 8-10 % chlorine. Project Well follows a dosing regimen recommended by the USEPA of 24 ounces of chlorine to 100 gallons of water, which works out to approximately 75 ml of Theoline to 100 liters of water. To help users, Project Well developed an easy-to-read chart (Appendix 1 and described in section 5.1 - Maintenance) and distributes it to the community-based groups. Monthly treatments of Theoline can result in a strong chlorine smell, so instead, the dose is divided into four parts and users apply Theoline weekly.

The implementers send the water to a nationally certified laboratory (Appendix 2: Protocol for water analysis for arsenic and bacteria) after well disinfection, to analyze total coliform and E. coli counts and verify potability. Arsenic concentrations are measured at the same time.

4.4 Other Materials and Tips

Good quality construction materials are crucial to the success of a well. Care should be taken in manufacturing the concrete rings, using the specifications given below.

The following description is a list of materials and cost of the main items needed to build an 8m (27-foot) bore-dugwell in West Bengal, India. More details are available in Appendix 5, table 5.2.

1. Materials like bamboo and ropes to build the scaffold, as well as materials to drill; these are transported on flat-surface rickshaws, driven manually so that they can go through the narrow, unpaved paths in the villages. (Tip: make a contract with the drilling team to provide all the materials.)

2. Pipes: Poly Vinyl Chloride (PVC) pipes are readily available throughout India, but be careful to install good quality pipes. Check that there is an 'ISI' trademark (issued by the Indian government to denote good quality) on the body of the pipes before placing the order. There are four kinds of pipes of various diameters used in the bore-dugwell and handpump.

i) 25.4cm (10-inch)-diameter PVC pipe of length approximately 3m (10 feet). (Tip: make sure to get estimates from several dealers for this specific pipe, because it makes up 1/3rd of the total cost of the bore-dugwell.)

ii) Delivery pipe: The diameter of the PVC delivery pipe is 3.8cm (1.5 inch) and the length is 7.3 m (24 feet). It is inserted into the borewell, the larger diameter pipe.

iii) The filter pipe is also 3.8cm (1.5 inch) in diameter and 1.2m (4 feet) long.

iv) Galvanized iron pipe of 160 cm (5.2 feet) length used for connecting the vertical PVC delivery pipe to the handpump with elbows (1.5 inch) and sockets (1 inch x 4 inch).

3. Reducer: 3 to 5 PVC reducers to gradually narrow the 8-inch diameter to 3 inches.

4. Monoblock pump: It is more economical to purchase an irrigation pump than to rent one.

5. Concrete rings: The diameter of the inner cylinder (concentric rings) is 100 cm (3.3 feet), height is 28 cm (11 inch), and thickness is 2.5 cm (1 inch). The rings are made of cement, stonechip, sand, and net, with a cement:sand ratio of 5:1. For an 8 m (27-foot) bore-dugwell, 20 to 22 rings are needed. Cost of each ring is approximately Rs. 140/- (West Bengal, 2011).

Rings should be properly cured and uniform in size and material. Rings with uneven surfaces should not be used. Cement plaster should be applied between rings for better binding. The edges of the rings may not be enough to make the joints impermeable to sand and silt, so jute rags are placed in between the rings at the joints, to prevent sand around it from flowing into the well.

6. Coarse Sand: Approximately thirty 20-cft bags are needed to fill the gaps around the 10-foot PVC pipe. Sand size should be as uniform possible, with a uniformity coefficient between 2 and 3.

7. Concrete mix to make the apron: the upper 60cm (2 feet) needs to be sealed with concrete mixture so contaminated surface water does not migrate down into the well.

8. Handpump: cost of a handpump is Rs. 1200/-

9. Other plumbing materials include: washer, clamp, checkvalve, 3 inch plug cutter, foot valve, elbow.

10. Well cover:

    i) A nylon net (thread count of 120x120) with an area of 1.5 m^2 and cost of Rs. 40 per square meter is fitted over the mouth of the well (Figure 18).

Figure 16: The delivery pipe

Figure 17: The sponsor plate on the housing

Figure 18: Fitted Nylon net

    ii) Tin cover: A corrugated tin sheet of approximately 160cm x 182 cm (5 feet x 6 feet) x 1.5 mm in thickness covers the well. Approximate cost of the wood frame, tin sheet and labor charge is Rs. 1200/- .

    iii) Lock: A lock is used to secure the tin cover to the well and prevents vandalism and contamination. A sturdy lock will cost around Rs. 22 to Rs. 40.

Detailed costs of building one bore-dugwell with a total depth of 27 feet and a dugwell depth of 16 feet is provided in Appendix 5.

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5. Maintenance

To ensure water is safe to drink, it is important to get physical and chemical reports on the water, including fluoride, arsenic, mercury, manganese, nitrites and pesticide measurements from the Central Ground Water Board or a similar agency. If such data cannot be obtained, then it is essential to test the potability of water from two bore-dugwells at a reliable laboratory. Water should be carefully collected using the sample collection protocol documented in Appendix 2.

When a new bore-dugwell is constructed, the water is treated with Theoline (described in section 5.1) once a week for one month before it is analyzed. After the first month, water samples are to be collected following the sampling protocol. At the laboratory, the samples should be measured for arsenic concentrations and counts of total coliform and E.coli (E.coli, or Escherichia coli, is a fecal coliform bacteria found in animal and human intestines. It causes diarrhea and other “food poisoning” symptoms, and can sometimes be fatal).

Ideally, both coliform counts should be ‘0’ or ‘undetected’ but total coliform is often present in water; total coliform includes harmful and harmless bacteria, and total coliform numbers are less important. Fecal coliform counts or E.coli counts are more important—in 2009, for example, among 20 Project Well dugwells measured for fecal coliform, 44% had undetected levels, 50% had less than 50 cfu/100ml and 5% (1 sample) had 50-500 cfu/100ml and in 2010 E.coli counts of all 48 dugwells were found to be undetected. Water from two dugwells was not analyzed.

The maximum permissible limit for arsenic in drinking water set by the Bureau of Indian Standards is 0.05 mg/L (50 ppb). 42 percent of Project Well water has <0.01 mg/L arsenic, and 42% has 0.01-0.05 mg/L, while 16% contains arsenic levels above 0.05mg/L and the highest being 0.162 mg/L. Wells with arsenic >0.05mg/L are marked as ‘O & M’ (‘under observation and maintenance’) so that arsenic tests are definitely done for three consecutive years and, if possible, three times a year (seasonally). If arsenic levels do not come down to acceptable levels by the end of that time, the well will be closed.

As soon as reports show the tested water is arsenic-safe, with undetected levels of E. coli and undetected or low levels of total coliform, the well water is ready for consumption. However, to ensure the water continues to be safe to drink, the community must follow stringent monthly maintenance procedures. At village meetings, mothers are advised to give boiled water to their children below five years of age.

Maintenance includes:

5.1. Application of the chlorine-based disinfectant on a weekly basis.

Project Well uses a chlorine-based product with the local trade name 'Theoline'. Theoline contains sodium hypochlorite (liquid bleach) that consists of 8-10% available chlorine, 0.2% free alkali and water. A user-friendly dosage chart, developed based on US Environmental Protection Agency standards, is given to every CBG and the field workers. Twenty-four ounces of Theoline can disinfect 100 gallons of water. The chart is in Appendix 1.

To calculate the weekly dose of Theoline, the depth of well water must first be measured, since dose is based on volume of water (the wells are built to a standard circumference, so the depth is all that is needed to calculate the volume). There are two ways to measure water height: a) directly from a measuring tape or b) using a rope and tying two knots. In both methods, a heavy solid object—a pebble or a piece of metal—is tied on the end that touches the bottom of the dugwell. One should be careful to drop the weight to the bottom of the dugwell and not into the borewell.

If using a rope, one knot is tied at the top edge of the first ring and the second knot is tied at the level that touches the water. These two knots are read as the depth of the well and the depth to water level respectively with a regular measuring tape. Height of water column = depth of dugwell – depth to water level (dry column). The volume of water and corresponding dose of Theoline is read off the Theoline chart.

Disinfectant should also be applied immediately after (1) new construction, (2) any repair or maintenance to the well, (3) flooding, or (4) a period of non-use.

There is some concern about exposure to chlorine-based disinfection by-products (DBP). Balancing the microbial and DBP risks is certainly an issue that should be addressed when determining appropriate disinfection measures. At the recommended PW dosage levels, the benefits of safe low-arsenic and low-coliform water far outweighs any risks associated with the ingestion of DBP. According to the WHO Guidelines (1993):

> *"The estimated risks to health from disinfectants and their by-products are extremely small in comparison to the real risks associated with inadequate disinfection, and it is important that disinfection should not be compromised in attempting to control such by-products. The destruction of microbial pathogens through the use of disinfectants is essential for the protection of human health."*

5.2 Cleanliness:

The area around the well should be kept clear of any unwanted vegetation so sunlight is not blocked from the well. Wells not blocked by vegetation are more easily accessible, and give an impression of cleanliness (some Project Well sites in shaded areas were abandoned). Plants that absorb arsenic from the soil, like arum (kochu), can be planted near the site, *BUT* measures should be taken to warn villagers not to eat any part of these plants.

5.3. Maintenance Report:

As part of the bi-annual maintenance report on all the water sources, the following steps should be taken:

a) Check that the hand pump and delivery pipes are functioning properly. If not, organize a meeting with community members and discuss the problem and how to fix it. Most repair work is minor and can be done by the community. CBGs are often reluctant to work on their own, pay for any repairs or hire experts.

b) Check well water for turbidity, especially after the rainy season. If there is any turbidity and/or unpleasant odor, then examine the integrity of the well. The presence of turbidity indicates that there is a leak from the surface to the well that must be repaired. (Tip: If a well becomes non-functional and is no longer monitored, community members may misuse or take parts of the hand pump. They may also start contaminating the site by tying pigs, goats or cows nearby that smell and pollute the water. It's important to monitor the wells, keep them in working condition, and prevent disrepair from happening.)

5.4 Dredging:

The bore-dugwell does not require dredging, but it is advisable to clean or dredge (Figure 19) about one foot of sediment, which may contain impurities, from the bottom of the dugwell at least every 2-3 years. If possible, dredging can be done every other year during the dry season, when the water is low or not present. Water in the larger-diameter bore pipe need not be

Figure 19: Dredging in progress

Figure 20: Repairing an old dugwell

disturbed. Dredging provides employment to the same laborers hired for new well construction. (Tip: Dugwell dredging costs approximately Rs. 400 per well.)

In addition to dredging, periodic renovation is necessary if wells are heavily used. For example, the handpump may need repair, the joints between rings might need cement plastering (Figure 20) to prevent water leakage, broken cemented parts of the apron might need fixing and the delivery pipe might need replacing.

5.5 Monitoring of well water:

Project Well conducts annual testing for arsenic every March or April. Annual bacteria testing is NOT required unless there are reports of stomach illnesses related to the dugwell water from more than one user family.

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6. Surveillance Program

Surveillance is essential for a successful water program. Only long-term monitoring gives a true sense of how many people are using the water sources, and allows for adjustments over time. If user numbers drop suddenly, monitoring will capture this and give the program a chance to course-correct. Without tracking, we cannot know and deal with problems that cause communities to stop using wells, especially if the reasons are unrelated to the physical condition of the well but instead are due to social factors.

A comprehensive surveillance program comprises a user registry and demographic information on each user. Information, such as georeferences of user households, is geocoded using a global positioning system device and a tracking geographical information systems (GIS) database. The GIS database is used to monitor the growth of the CBG over time.

Field workers are employed by Project Well at program startup until members of the community are trained to take on the responsibility of maintaining wells independently. They are recruited from the user communities and thus are trusted by users and familiar with social dynamics in their communities. Field workers often serve as liaison between the community and AWS administrators.

Field worker responsibilities include: (1) maintaining wells, (2) surveying of the user community, (3) well registry and record-keeping, (4) well usage monitoring, and (5) collecting fees for well maintenance at the initial stage.

Field workers are also responsible for training community members to take care of their well and to collect and manage maintenance fees; after the first year, the community pays for repair work and purchases the disinfectant. Our experts train the field staff on proper monitoring procedures, including disinfectant application. In turn, salaried field workers have begun to train one or two members of each CBG on disinfection practices during monthly visits. If the well is not used by at least 20 families, then additional (sometimes more than once per year) awareness health programs are held. Training continues until users assume full responsibility.

6.1 Forming Community-Based Groups (CBGs)

Project Well aims for each well to serve at least 20 families, and these user families form community-based groups (CBGs). CBGs are another essential component of the Project Well program. The cost of running the beneficiary committee program is included in the cost of maintaining a field worker and the awareness program. Field workers are already members of the local community and therefore serve as a critical link between users and Project Well. Although very little cost is involved in the implementation of these programs, maintaining strong relations with the community requires an ongoing time commitment.

CBGs eventually take over “ownership” of the dugwell. They

1. Collect maintenance funds
2. Disinfect the wells
3. Manage well maintenance

And Project Well continues updating the registers and collecting water samples for annual water analyses of arsenic.

6.2 Record-keeping

Keeping records is necessary to gauge user needs and ensure the program is running efficiently. Without regular surveys, organizations cannot know if people are really using the wells. Sometimes there are social or other reasons people are reluctant to switch water sources, and these cannot be uncovered by simply making sure wells are in working order.

COMPUTER FORMATS

Spreadsheet programs like Microsoft Excel or databases like Microsoft Access are used. Records are used to produce monthly field reports.

MONTHLY REPORTS:

Project Well has instituted a dugwell tracking system comprising monthly follow-up reports prepared by the field supervisor with assistance from field workers. The reports contain information on the number of consumers, volume of water in the well, physical quality of water including taste, color, and odor. The detailed format is available in Appendix 4.

WATER TABLE LOGS:

In the monthly report, geological logs for each well are recorded to compare quality and quantity of water from well to well if needed. Well conditions vary due to factors such as seasonal fluctuation of water table, volume of water available during dry periods, concentrations of arsenic and the presence of any odor or tastes.

ANNUAL ANALYSIS:

Project Well measures arsenic once a year during the dry season, and total coliform and E.coli 3-4 months after constructing a new well. These measurements are discussed in more detail in the Maintenance section.

6.3 Awareness Programs

Awareness programs educate the community on the serious consequences of arsenic exposure, the specifics of the dugwell program and the need for community self-reliance. The awareness program presenters try to make the information accessible and entertaining, using various methods like films and live theater, diagrams on charts, newsletters and pamphlets, and Powerpoint talks. After each presentation, villagers are given the opportunity to ask questions.

There are four types of village meetings or awareness programs held by the field workers:

1. Before construction of the dugwell, during site selection.

2. After construction of the dugwell, mainly to discuss well maintenance, the benefits of chlorination and the consequences of not chlorinating.

3. Health meetings to discuss issues like proper sanitation, personal hygiene practices and prevailing seasonal illnesses, and to refresh users' memories on the effects of drinking arsenic-contaminated water. This type of meeting is repeated in communities that are reluctant to use the well water.

4. Awareness meetings held in schools and colleges, also to discuss the arsenic health effects and the benefits of drinking arsenic-safe water, and to teach personal hygiene practices.

Field workers publicize the programs and get the community to attend. Apart from educational institutions, programs are held at community centers and in outdoor public areas, convenient locations in the immediate user area (Figures 21 & 22).

Figure 21: A street show in the midst of a cluster of houses/hamlets or at the weekly market

Figure 22: Village meeting at Parui para of Kolsur, in the district of North 24 Parganas

6.3 Making data public

Project Well strongly believes in documenting our work and sharing it publicly on our website www.projectwellusa.org, where annual newsletters containing details on past and future projects are published together with information on each newly constructed well. Several reports have also been posted that discuss ongoing construction progress, women's education, and awareness programs. A booklet of stories with accompanying photos taken by professional photographers is also available online. Additionally, Project Well participates in the program Peer Water Exchange, discussed in the next section.

6.4 Peer Water Exchange

For the past two years, 2010 and 2011, reports on Project Well's activities have been uploaded onto the Peer Water Exchange website www.peerwater.org. Through this online platform, organizations working on water issues can share their experiences and learn from one another, improving water management throughout the world. Organizations submit proposals for funding and review their peers' proposals for the funding body.

PWX is a scalable, web-based crowdsourcing tool used by water organizations not only for the proposal process but also to track past and present projects. A large component of funding criteria is good follow-up and record-keeping (and thus transparency and accountability) on past projects. Project Well is one of 86 partner organizations that upload updates on projects at least once a year.

The Project Well program model is straightforward to implement; if any organization is interested in implementing a similar program and need additional information not found in these guidelines, please contact Project Well.

References

Chakraborti D, Sengupta MK, Rahman MM, Chowdhury UK, Lodh D, Ahamed S et al. 2003. Groundwater arsenic exposure in India. In: Arsenic Exposure and Health Effects V (Chappell WR, Abernathy CO, Calderon RL, Thomas DJ, eds.). San Diego: Elsevier, 3-24.

Dauphine DC, Ferreccio C, Guntur S, Yuan Y, Hammond SK, Balmes J, et al. 2011. Lung function in adults following in utero and childhood exposure to arsenic in drinking water: preliminary findings. Int Arch Occup Environ Health 84:591-600.

Hira Smith MM, Hore T, Chakraborty P, Chakraborty DK, Savarimuthu X, Smith AH. 2003. A dugwell program to provide arsenic-safe water in West Bengal, India: preliminary results. J Environ Sci Health Part A 38(1):289-99.

Hira Smith MM. 2000. An Assessment of Alternative Methods of Providing Arsenic Free Water in Villages of North 24 Parganas, West Bengal, India. Proceedings of the International Seminar of Changing Environmental Scenario of India and Adjacent Countries Since Independence and XII Annual Conference of Indian Institute of Geomorphologists (IGI). [In April 2007, the same article, slightly updated, was published as a chapter entitled “Arsenic Catastrophe And A Safer Tradition” in the book “Economic Studies of Indigenous & Traditional Knowledge," published by the Indian Economic Association Trust for Research and Development.]

Hossain MA, Sengupta MK, Ahamed S, Rahman MM, Mondal D, Lodh D et al. 2005. Ineffectiveness and poor reliability of arsenic removal plants in West Bengal, India. Environ Sci & Tech 39: 4300-4306. [Featured in the news section of Nature Magazine, July 21, 2005: "Arsenic-free water still a pipedream." Nature 436: 313.]

Liaw J, Marshall G, Yuan Y, Ferreccio C, Steinmaus C, Smith AH. 2008. Increased childhood liver cancer mortality and arsenic in drinking water in northern Chile. Cancer Epidemiol Biomarkers Prev 17(8): 1982-1987.

National Research Council. 2001. Arsenic in drinking water: 2001 update. Washington, D.C.: National Academy Press.

Sengupta MK, Mukherjee A, Hossain MA, Ahamed S, Rahman MM, Lodh D, et al. 2003. Groundwater arsenic contamination in the Ganga-Padma-Meghna-Brahmaputra plain of India and Bangladesh. Arch Environ Health 58(11): 701-702.

Smith AH, Marshall G, Yuan Y, Ferreccio C, Liaw J, von Ehrenstein O, et al. 2006. Increased mortality from lung cancer and bronchiectasis in young adults after exposure to arsenic in utero and in early childhood. Environ Health Perspect 114(8): 1293-1296.

Smith AH, Marshall G, Yuan Y, Liaw J, Ferreccio C, Steinmaus C. 2011a. Evidence from Chile that arsenic in drinking water may increase mortality from pulmonary tuberculosis. Am J Epidemiol 173(4): 414-420.

Smith AH, Yunus M, Khan A, Yuan Y, Liaw J, Alam DS, et al. 2011b. Pulmonary effects among children exposed to arsenic in utero in Matlab. In: 23rd Congress of International Society for Environmental Epidemiology. Barcelona, Spain: Environmental Health Perspectives.

Tsai SM, Wang TN, Ko YC. 1999. Mortality for certain diseases in areas with high levels of arsenic in drinking water. Arch Environ Health 54(3): 186-193.

Tseng CH, Chong CK, Chen CJ, Tai TY. 1996. Dose-response relationship between peripheral vascular disease and ingested inorganic arsenic among residents in blackfoot disease endemic villages in Taiwan. Atherosclerosis 120(1-2): 125-133.

Tseng CH. 2008. Cardiovascular disease in arsenic-exposed subjects living in the arseniasis-hyperendemic areas in Taiwan. Atherosclerosis 199(1): 12-18.

Tseng WP. 1989. Blackfoot disease in Taiwan: a 30-year follow-up study. Angiology 40(6): 547-558.

von Ehrenstein OS, Mazumder DN, Yuan Y, Samanta S, Balmes J, Sil A, et al. 2005. Decrements in lung function related to arsenic in drinking water in West Bengal, India. Am J Epidemiol 162(6): 533-541.

von Ehrenstein OS, Guha Mazumder DN, Hira-Smith M, Ghosh N, Yuan Y, Windham G, et al. 2006. Pregnancy outcomes, infant mortality, and arsenic in drinking water in West Bengal, India. Am J Epidemiol 163(7): 662-669.

von Ehrenstein OS, Poddar S, Yuan Y, Mazumder DG, Eskenazi B, Basu A, et al. 2007. Children's intellectual function in relation to arsenic exposure. Epidemiology 18(1): 44-51.

Wang SL, Chiou JM, Chen CJ, Tseng CH, Chou WL, Wang CC, et al. 2003. Prevalence of non-insulin-dependent diabetes mellitus and related vascular diseases in southwestern arseniasis-endemic and nonendemic areas in Taiwan. Environ Health Perspect 111(2): 155-159.

Yuan Y, Marshall G, Ferreccio C, Steinmaus C, Selvin S, Liaw J, et al. 2007. Acute myocardial infarction mortality in comparison with lung and bladder cancer mortality in arsenic-exposed region II of Chile from 1950 to 2000. Am J Epidemiol 166(12): 1381-1391.

Appendix No. 1

Theoline Chart

	THEOLINE CHART				
Number of rings under water	**Volume of water**	**Monthly Theoline Dose**		**Weekly Theoline Dose**	
or height of water column	**in the well in litre**	**10 % chlorine in ml**	**10 % chlorine in litre**	**10 % chlorine in ml**	**10 % chlorine in litre**
1 or 11"	148.78	111.64	0.11	27.91	0.03
2 or 22"	297.56	223.28	0.22	55.82	0.06
3 or 33"	446.35	334.92	0.33	83.73	0.08
4 or 44"	595.13	446.55	0.45	111.64	0.11
5 or 55"	743.91	558.19	0.56	139.55	0.14
6 or 66"	892.69	669.83	0.67	167.46	0.17
7 or 77"	1041.47	781.47	0.78	195.37	0.20
8 or 88"	1190.25	893.11	0.89	223.28	0.22
9 or 99"	1339.04	1004.75	1.00	251.19	0.25
10 or 110"	1487.82	1116.38	1.12	279.10	0.28
11 or 121"	1636.60	1228.02	1.23	307.01	0.31
12 or 132"	1785.38	1339.66	1.34	334.92	0.33
13 or 143"	1934.16	1451.30	1.45	362.82	0.36
14 or 154"	2082.95	1562.94	1.56	390.73	0.39
15 or 165"	2231.73	1674.58	1.67	418.64	0.42
16 or 176"	2380.51	1786.21	1.79	446.55	0.45
borewell	36.19	15.00	0.02	3.75	0.00

Caution: USE GLOVES DURING HANDLING OF THEOLINE.

Appendix No. 2

Water Sampling and Analysis protocol followed by Project Well-Aqua Welfare Society.

Arsenic and bacteria analysis are done in **duplicate** and water samples are submitted to the **reliable** laboratories by the staff so the laboratory is **blind** to the coded samples. A **copy** of the **codes only** is submitted with the samples.

Things needed for <u>Arsenic</u> analysis:

1. 100 ml plastic bottles
2. gloves
3. nitric acid
4. dropper
5. label stickers
6. list of codes.

Procedure:

1. Collect clean bottles from the laboratory where the analysis will be performed.
2. Wash bottles with water.
3. Collect water as a user would collect water for consumption. No need to pump extra.
4. Add one drop of nitric acid or as instructed by the laboratory.
5. Stick coded label to the bottle. Use non-smudge pens (Tips: Use a Sharpie marker.)
6. Submit collected samples to the laboratory using flow-injection hydride generation atomic absorption spectrometry (AAS) for analysis. The detection limit is <0.003 mg/L.

(Tips: The cost of one sample to be tested for arsenic is Rs. 50 – Rs. 300.)

Things needed for <u>bacteria</u> (Total Coliform and E.coli) analysis:

1. 500 ml plastic bottles
2. Gloves
3. Label stickers
4. List of codes

Procedure:

1. Collect sterilized bottles from the laboratory where the analysis will be executed.
2. Do not open the bottles until water collection.
3. Wash hands with soap and water before wearing the gloves for water collection. Do NOT come in contact with anything or person after wearing the gloves.

4. Collect water as a user would collect water for self-consumption. No need to pump extra.
5. Secure the lid immediately after collecting the water sample.
6. Stick on coded label.
7. Submit to the lab within **six hours** of collection. (Tips: collect the first water sample six hours before placing it in the refrigerator unless using ice box during collection).
8. Make sure the laboratory will give the actual counts as most probable number (MPN) or colony forming number (cfu).

(Tips: The cost of each bacteria sample (TC or E. coli) is Rs. 500.)

Appendix No. 3

Table 3: Chain of Custody for water analysis

Bore dugwell ID No.
Sample ID No.
Contaminant
Name of the Collector
Date of Collection
Method of Collection
Laboratory for Analysis
Name of the Analyst
Time of Analysis: from/to
Date of Analysis
Result
Date of Report
Signature of Supervisor

Appendix No. 4

Record of individual bore-dugwells (Table 4.1) & records maintained as part of the surveillance program (Table 4.2)

Table 4.1 Information on new bore-dugwells

Serial Number	Serial number of projects.
Bore-dugwell Identity Number	PW001/KDK1-the first number signifies number of dugwells implemented by the NGO and the second number signifies the serial number in the village or panchayet.
Owner name	The name of the person who donated the land for the bore-dugwell
Name of the contact person	
Contact phone number	Phone number of any member of the community.
Month/Year of construction	
Latitude	
Longitude	
Para	
Village	
Panchayet	
Block	
District	
Sponsor	Fund provider.
Uploaded on PWX: yes/no	To manage projects on Peer Water Exchange (PWX)
Application identity number	For PWX
Project identity number	For PWX
Photo taken: yes/no	For PWX
Demography: yes/No	For PWX

Table 4.2 - Monthly status of bore-dugwells

Serial Number
Dugwell Identity Number
Construction year
Owner
Month/Year of construction
Village
Beneficiary Families_month & year
Persons_month & year
Column of water in feet_month & year
Date of Theoline_month & year
Amount of Theoline given in ml_month & year
Cost of Theoline in Rs._month & year
Colour_month & year
Odour_month & year
Taste_month & year
Maintenance report & Problems_month & year
Date_month & year
What is needed_month & year
Paid by NGO_month & year
Paid by community_month & year
Notes_month & year
Follow Up_month & year

Appendix No. 5

Budget and Cost of one bore-dugwell

Project Well budget for 50 bore-dugwells in 2012. The depth of the bore-dugwell is 27 feet. The breakdown of the bore-dugwell costs is given in Table 5.2.

Table 5.1 – Budget

Items	Rate in INR	UNITS	TOTAL INR	USD (X44)	Sub Total USD
Total cost per bore-dugwell construction	30972	50	1548600	35195	35195
Water analysis: arsenic test	300	100	30000	682	
Bacteria: total coliform and e.coli	500	200	100000	2273	
Water analysis				2955	2955
Transport and Information Technology	10000	12	120000	2727	2727
Service fees of 13 staff	58000	12	696000	15818	15818
Maintenance of dugwells, awareness program,	5000	12	60000	1364	
Rent: Primary Office in the village	800	12	9600	218	
Stationary, paper, printing etc	1000	12	12000	273	
Auditing Fee	1	1	15000	341	
Maintenance and overheads				2195	2195
8% for inflation (except item 4,6,8)=$42597	149941	1	149941	3408	3408
Total expenses					62298

Table 5.2: Bore-dugwell of depth=27 feet.

PARTS or Description	**QTY**	**RATE**	**RS**	sub total
Boring charge for pilot test: (average)	1	160	160	
10"dia perforated pvc pipe, length10 feet	1	9360	9360	
Transport of 10 feet pvc pipe (delivered with other pipes)	1	10	10	
1.5" pvc pipe	24	14	294	
1.5" pvc filter pipe - 4 feet	1	50	50	
10"x3" Reducer	2	1250	2500	
labour for 18"dia boring for 10"x10' pvc pipe	1	2400	2400	
rental charge of shallow pump (per well)	1	250	250	
Borewell				*15024*
Rings with transport	20	140	2800	
Transport of rings for one bore-dugwell	1	500	500	
Dugwell digger labour charge (day)	1	1700	1700	
Hand pump	1	1190	1190	
Hand pump fitting labour charge (per dugwell)	1	480	480	
Iron pipe (see specification)	5.5	75	412.5	
Washer/bucket	1	40		
Checkvalve	1	25		
3" plug cutter	1	220	220	
Others - approximately (for eg - Clamp Rs.40, elbow Rs.65, adhesive Rs.20, wire to bind the filter Rs.50, well washing after construction average Rs.400 etc)	1	700	700	
net (meter)	3	40	120	
rope to bind the rings (kg)	1	60	60	
Dugwell				*8243.5*
Mason (day)	3	300	900	
Sand (bag)	35	30	1050	
Brick	300	5.6	1680	
cement (bags)	4	326	1304	
Stone chip (bags)	2	70	140	
van fare brick, sand, cement, stone chips	1	1100	1100	
Tin sheet + wood for frame and the labor	1	1200	1200	
Sponsor name marble plaque	1	550	550	
Housing& Finishing				*7924*
Total expense for one bore-dugwell				***31191.5***

List of Figures