Self-Supply as a means of bringing water to the people of Zimbabwe and its relation to the hand pump program.

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Introduction

The concept of “self-supply” as a means of providing water to families (who become responsible for their own supply) is becoming increasingly common in Zimbabwe. However there is nothing new in it. For well over half a century, thousands of families living in the rural areas of Zimbabwe had dug their own wells as a means of providing water for domestic and agricultural use. And many families have built tanks to catch rainwater. Rain water harvesting is another method which could fall under the concept of self-supply. A communal hand pump water supply program to support communities living in the rural areas had also begun in the 1930’s when the Bush Pump, then known as the Murgatroyd pump, after its inventor, first began to provide water in Matabeleland. The hand pump supply, supported by the governments Department of Water, subsequently spread throughout the country. In later years the on site management of the Hand Pump programme was and is still managed by the District Development Fund. For the cities and towns, water is supplied through municipal piped water supplies, largely supplied from dams and reservoirs. However many people living in the urban areas also used their own wells and boreholes excavated on their own property. And self-supply in the cities is now becoming common.

The Upgraded Family Well Program

The promotion of simple family and even small community wells had been encouraged by the Environmental Department of the Ministry of Health for some decades before 1980. After Independence in 1980, Master Plans for the rural water supply and sanitation program were drawn up, but the importance of family owned “self-supply” methods of providing water to families living in the rural areas was mentioned only in passing. However, staff at the Blair Research Laboratory, who had close contact with their colleagues in the Environmental Health Department realised the importance of these family owned wells and undertook studies (both bacteriological and technical) to improve well safety and water quality of water drawn from family owned wells. Even at this early stage government staff, particularly in the MOH recognised that a high (but unknown) percentage of water used in the rural areas was obtained from family owned facilities. The clear fact was that in Zimbabwe, the construction of family owned wells arose and became established in traditional practice together with the backing of the MOH. Using government funds the basic research, development and training of what became known as the Upgraded Family Well was undertaken by Blair Staff together with their colleagues in the Environmental Health Department.

Early pilot projects

A series of pilot studies were undertaken by Blair Staff during the period 1988 to 1992 when about 5300 upgraded family wells were built. The first were built in Makoni District in 1988 and funded by Swedish Sida. At the same time training teams from Blair were deployed throughout the country to pass on knowledge of the technique to health teams and local builders and leave a series of demonstrations, country wide. The concept was studied and debated by MOH officials during 1988 and 1989 and was officially endorsed by the MOH in 1990. This followed encouraging feedback from the users and also from MOH officials who had come into contact with pilot programmes. Notable programmes were running in both Manicaland and Mashonaland East. Blair’s own work continued in Rusike during 1990 and then in Chihota during 1991 when more effective implementation techniques were established. This early part of the program was described in the book Rural Water Supplies and Sanitation (Morgan 1990). These crucial experimental and pilot stages of the programme were supported with financial assistance from Sida, Save the Children’s Fund (UK), The Zimbabwe Trust, UNICEF, Redd Barna and Rotary of Zimbabwe. In 1991 the technique was officially endorsed by the National Action Committee of Government and introduced on a small scale at first into their National Integrated Programme. Later, this concept served a significant number of persons assisted by the integrated programme. Thus by 1991, the concept became officially accepted as part of the National Rural Supply Program. Much credit is due to the Department of Environmental Health working within the Ministry of Health for the achievement.

Subsequently, in late 1992, the small field team from the Blair Research Laboratory who had been responsible for the outreach and training programs moved to an office established by WaterAid, UK to continue their work. The NGO environment offered improved methods of the procurement of the
hardware and also vehicles required for an expanded program. The close collaboration of the staff of the WaterAid office (which subsequently became known as the Mvuramanzi Trust) and their colleagues in Government continued. In the following years a total of over 50 000 UFWs were built country wide. A number of manuals, papers were written during this era and even a government sponsored film. The advantages were clear and well described in several written works including the most detailed (Morgan 2006 and WSP 2002). These advantages included proximity to the homestead, water available for both domestic use and vegetable gardening, improved hygiene due to ease of access and more. Perhaps the most important consideration was one of home ownership, being clearly defined as a family owned asset. This addressed the crucial problem of routine upkeep and maintenance. Using wider diameter wells, equipped with a permanent access hole in the cover wide enough for entry, the well could be deepened on the spot with bucket and spade, thus following down the water table. The program was well suited to the operations of the Ministry of Health, with its extensive network of staff reaching down through provincial, district, ward and village level. Other ministries are not so well equipped to manage and service this type of program.

The exact number of people served by this Upgraded Family Well Program depended of course on the number of persons using each individual well. This could range from as little as 2 to more than 20. But with 50 000 units built at least 250 000 people had been served (using an average family size of 5 per unit). The average number of users in practice is more. Later estimates by UNICEF suggested that the actual number of UFWs had increased to over 100 000 by the year 2000 (WSP. 2002). This would suggest that at least half a million people had been served. It is now well known that the number of family owned wells has been on the increase, even after the era of donor support was withdrawn (in about 2000). The reason for this is simple. Without other sources of water, whether piped or pumped, people turned back to their well-established tradition of digging their own wells and water holes as they had done for generations if local conditions permit. In many cases this may be the result of shear desperation. The promotional work by the MOHCC (Ministry of Health and Child Care) in collaboration with the NGOs had established a huge number sites where UFWs were and still are operational. The operations of the NGO Zimbabwe Ahead, with its Community Health Club program has also assisted in training, upkeep and hygiene matters linked to UFWs as well as many other health issues. This combined effort has led to a huge number (well over 100 000) of units, spread widely over the country where conditions permitted. This has led to the concept being further copied by countless thousands of people. However, not all the wells survived due to poor construction and maintenance.

Subsidy levels
Like the Blair VIP program of this era, several donor organisations were happy to offer generous family subsidies during the 1980s and 1990s. In fact the donor contribution for the UFW consisted of 3 bags of cement, a commercially made windlass and a tin lid (current value about $88). This was somewhat higher than the subsidy level offered for the Blair VIP latrine (5 bags of cement and wire, initially, being reduced in later programs to 3 bags). In both cases the families supported by the subsidy were expected to provide bricks to line the toilet pit or well and also other local materials, like sand. They were also expected to pay a locally trained artisan. As has been noted with the Blair VIP program, this tended to favour the better-off members of the community. In the case of the wells however, the facility could be and is commonly shared by close-by neighbours, an unlikely event for family owned toilets.

Donor preference, subsidy levels and upgradeable units
It is noteworthy to mention here, that the era of donors providing large subsidies for families has passed and is unlikely to return. This led the GOZ to accept a model of the Blair VIP which could be built and upgraded in a series of steps (step by step) – the upgradeable BVIP (uBVIP). This method has been joined in more recent years by new models of a fully functional Blair VIP latrine which are more economical and easier and faster to construct. But the fact remains that donors serving the Zimbabwe Nation WASH program are unwilling, on the whole, to provide subsidies to the level of earlier times, although small subsidies in the form of a bag of cement have been found acceptable to provide an incentive. The same financial considerations also apply to the UFW, which had a higher subsidy level than the Blair VIP.
As a result of this, further work carried out by Aquamor in Epworth from 2010 to 2012 established an upgradeable series of Upgraded Family Wells (uUFW). These trials have now been operational for 5 years. A training and research programme based on this method was undertaken in 2012 (Morgan and Kanyemba, 2012). It follows the same logic as the uBVIP - start simple and upgrade. This aspect will be discussed later.

Technical issues related to earlier work

Most of the UFWs built during the productive constructional era were built with windlass supports made with upright brick columns and rubber bearings. Initially these seemed to work, but were later replaced by stronger buttressed brick supports, which were less likely to crack under the constant vibration of the windlass. The durability of these depends on the quality of construction. Also the rubber bearings used had a limited life span and required replacing periodically. Consequently in 2012 Aquamor examined and refined the method of supporting the windlass using sturdy treated gum poles and also steel supports mounted in a well cured concrete anchor. These methods which was first put into use in 2010 are still on trial. This method now forms part of an upgradeable series of UFWs.

Another issue of importance was the design and strength of the concrete headworks itself. Very often these were built with large diameters and consequently were often thin and weak. Many easily succumbed to cracking. This method of construction has also been improved in recent years - concrete headworks are smaller but much stronger – which much extends the life of the unit considerably.

It is quite possible that the combination of damaged windlass supports and poor headworks design of earlier models of the UFW led to reduced levels of hygiene when the unit was in regular use, resulting in a lowering of water quality in many wells, as they became older and well used. The work of 2012 hoped to solve this problem.

Water quality issues

Many measurements for E.coli were taken by Blair Research staff in the later 1980’s which revealed that improvements in headwork design alone could make improvements in the bacteriological quality of water. These simple improvements also improved the physical safety of the well, especially for children. Such improvements in water quality could not match the lower E. coli levels found in water delivered by completely sealed hand pumps fitted to wells and boreholes. But the important issue here remains, that family wells are much simpler and easier to maintain and are also used by relatively few people who generally remain within the same social group for years and become accustomed to their own water and its quality. Some wells used in the Epworth area have been used for many decades without causing recorded outbreaks of disease. Studies made in Epworth (Morgan 1990) reveal that there is also seasonal variation in the quality of water, with increased risk during the rainy season when headworks may become soiled if not well maintained and also the lateral movement of water within the aquifer is increased. This bacteriological drift from suspect sources like toilets can be enhanced during the rainy season. A distance of 30m was recommended between toilet and well. The importance of the sanitary survey cannot be over-emphasised when siting new wells, and this has been well described in various written works. This survey studied the area around the well site for possible locations which may cause contamination.

The Upgradeable unit (uUFW)

This aspect has already been referred to and relates to work carried out by Aquamor between 2010 and 2012 in Epworth. In this case, the design of the UFW was restyled so it could be upgraded in two stages to the level where a windlass is fitted. This greatly reduces the initial cost and complexity of construction.

The initial stage involved digging a new well or deepening an existing well. The well itself may be partly or fully lined with bricks depending on the nature of the soil. If partly lined, a step is made about one metre below ground level around the well excavation and bricks are built up to 2 courses above ground level (like a ring beam). To this is added a well cover slab made with a raised collar and
well access hole wide enough to allow access the well for deepening. A raised rim is built at the edge of the slab and a water run-off channel is also made. A lid is fitted over the raised collar and water is raised by rope and bucket. The rope and bucket rests on the concrete well slab when not in use. The slab size should be one that can accept an upgrade in the form of a windlass with windlass supports and concrete anchor (1.4m diameter used in these trials).

The second stage takes place when a windlass system is built or mounted on to the first stage well. It is possible to build brick columns, but the preferred windlass supports used in the 2012 research program were quality treated gum poles set in a well cured concrete anchor. Steel windlass supports equipped with wooden bearings were also tested. The hardwood *Eucalyptus saligna* can also be used. In this method, the windlass supports, set in a strong, reinforced and well cured concrete anchor can be added to the existing first stage uUFW at any time from the time of initial construction to a later time suitable for the families. Further upgrades beyond the windlass stage are possible.

Bacteriological studies carried out by *Aquamor* and undertaken by the Zvitambo Trust indicate no difference in the mean water quality (*E. coli*) for the first and second stages of construction (see report of 2012). Although further research is required to confirm this finding it suggests that it is the concrete headworks design with raised collar and rim together with lid and water run-off which offer the greatest protection from above. Naturally the well can be upgraded further beyond the windlass stage, but normally the windlass stage is the final one for this level of technology. What stage is reached and what level of UFW technology is chosen greatly affects complexity of construction and cost. The exact total will vary greatly depending on local circumstances and the level of upgrading performed (1st stage or 2nd stage). The average number of users in this Epworth trial was just over 30.

**Current costing for unit fitted without a windlass (first stage of uUFW)**

In the case of a family well the cost will include digging. This may be an existing well which is deepened or digging a completely new well. The well is preferably lined with fired bricks. Ideally the well should be fully lined with bricks, but in firm soils an upper lining may be adequate. This operation is normally carried out by a trained well digger. Once the well is lined and extended about two courses above ground level, the headworks is built. This requires a fully cured concrete slab (with a well access hole and a raised collar) which is mounted level on top of the well lining. Since the slab (1.4m) is wider than the diameter of the well (1m) mortared bricks are built under the protruding well slab. In the first stage uUFW the rim of the slab is raised with bricks which are extend to a water run-off channel which drains water into a seepage area (often planted with a tree or shrub). A lid is fitted to the raised collar. The cost of buying bricks and other materials and paying an artisan to dig and line the well and also make the headworks must now be considered. This cost and who bears it will vary enormously on location and willingness of the owner to pay.

**Costs Stage 1. No windlass. Part lined well.**

Labour: Digging to 10m and upper (1m) lining and completion of simple headworks $80 (Epworth)  
Hardware: Bricks (300) $30; Cement (2 bags) $28); lid ($11) total $69.  
Total (approx.) $149

*Note fired bricks are costed here at $100 per 1000. This will vary considerably and be much cheaper in the rural areas, although of variable quality. In addition the home owner may choose to dig the well or pay a well digger in kind for the work. Also the nature of the soil may determine how the well is lined. It is preferably lined from top to bottom. But in suitable stable soils can be partly lined. The owner provides the bucket and rope.*

**Costs Stage 1. No windlass. Fully lined well**

Labour: Digging to 10m and full lining and completion of simple headworks $120 (Epworth)  
Hardware: Bricks (1500) $150; Cement (2 bags) $28); lid ($11). $179  
Total (approx.) $299
Current costing for unit fitted with windlass (second stage of uUFW)

Costs with windlass. Part lined well.

Labour digging and full construction with windlass. Digging to 10m and part lining $120 (Epworth)
Hardware (fired bricks (300) $30; cement 3 bags ($42); 2 treated short poles ($10); windlass ($35); lid ($11).  = $128
Total $248

Note: Quality windlasses and lids are available from V&W Engineering. These are made in Mbare at $20 per windlass and $8 per lid, but quality not as high as the commercial product.

Costs with windlass system. Fully lined well to 10m

Labour: digging to 10m, full brick well lining and full construction $160 (Epworth sample)
Hardware (fired bricks (1500) $140; cement 3 bags ($42); windlass ($35); lid ($11). Total =$228
Total $380

Total costs per capita for UFW

This depends on the level of technology reached, the cost of local fired bricks and local labour and the number of users. In earlier programs the costs were shared by the donor who offered a generous material subsidy (cement, windlass, lid) and the owner paid for labour to dig, an artisan to construct and other material costs like bricks and sand. Bearing in mind the more recent determinants by donors, any material subsidies, if they are offered at all, are likely to remain very low for a family, as they are for the Blair VIP. The start package for the uBVIP was a single bag of PC15 cement and local bricks – to make the slab and substructure which could then be upgraded. A single bag of PC15 cement can go a long way to upgrading stage 1 of the uUFW, an option which may form the basis of future programs, with the families choosing when and how to upgrade further.

Thus we have a scale of costs per capita (approximate)

<table>
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<th>Total cost</th>
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<th>10</th>
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<td>$25.3</td>
<td>$19</td>
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</table>

Note these are costs based on Epworth findings and approximate only to levels in the rural areas. Bricks and labour are cheaper and lids and windlasses may be locally made.

Contribution by the owners

Where simple facilities like family owned wells are built, the owner may contribute a high proportion of the costs simply because it is a family owned asset. However the fact remains that that many rural families are poor and cannot afford the cost of digging and equipping a well. Fortunately family wells can be shared. And it is known that towards the end of the dry season, some family wells are more reliable than others. The question remains however, if the total cost is over $100 for an UFW, what proportion of people can afford this in the rural areas. The answer may be few. The same question has been asked in relation to the standard Blair VIP where only a relatively small number have been self-financed. In response, cruder and lower cost toilets have been built with small local funds. The concept of the uBVIP is an attempt to overcome this problem – with a step by step upgradable series. This is what often happens when houses are built – one room being followed by 2 and then 3. The uUFW also uses the same principle. For the simpler first stage uUFWs wells the costs are much less with simpler and more durable construction methods, which have the potential for further upgrading.
Relationship to the National Hand Pump Program.

The national hand pump program is considered the backbone of Zimbabwe’s rural water supply program. When the UFW was introduced in the later 1980’s it was meant to be complimentary and supportive to the hand pump program. The main issue here is that family wells can only be dug in hydro-geologically suitable areas, whereas boreholes and deep wells can penetrate the water table over much wider areas. The dryer parts of the country, which are large in extent if less densely populated require at least a hand pump supply for domestic use and also for cattle watering. Hand pumps are also required at schools and institutions in the absence of other alternatives.

Nowadays an estimated 55,000 hand pump locations have been established on boreholes and deep wells in Zimbabwe, but the records reveal that 60-70% of these are currently non-functional. This clearly is a very serious situation, and in the absence of a functional borehole, families are forced to find water for survival elsewhere. Where it is possible family wells may be dug – sometimes at great depth. In desperation, river beds and other unprotected sources will also be sought. Theoretically each hand pump is designed to serve 250 people. If all 55,000 pumps were operational, this would theoretically serve over 13 million people, the entire population of Zimbabwe. If one third were operational (which is closer to the mark) this would still serve over 4 million people. But the distribution is such that some boreholes actually serve few people and others serve many. It is a complex relationship and is a question of distributing water points over a huge area. In fact according to recent statistics the total population of Zimbabwe (2014) is 13.771 million, with 67.5% living in the rural areas (9.3 million). Thus currently functional hand pumps serve half of the rural population (theoretically).

In a manual written by the Blair Research Laboratory and the NAC in 1992, a map was produced revealing areas where UFWs were possible due to suitable hydro-geological conditions. This information was collected at the time by Ministry of Health staff working in the districts, and where family wells were used and also recording where family wells were rare or could not be used. The map reveals clearly that family wells are suitable for many areas of Zimbabwe (black), but large areas (hatched) are unsuitable where hydro-geological conditions do not permit the digging of family owned wells. It is in these areas where a hand pump supply is essential. White areas show state or commercial land. This is an old map and changes will have occurred in the status of the land. But in the main hydro-geological conditions will have remained similar. Clearly a national study revealing hydro-geological conditions is required and where evidence can be found for the changes which are taking place in water tables due to variable climatic conditions.

Map revealing areas where shallow wells can be built (1992. Blair Research Laboratory)
The importance of the hand pump program thus remains as strong as ever. Clearly priorities should lie in updating and restoring the maintenance system for the Bush Pump. This is a topic which warrants a detailed account of its own. The DDF, traditionally the custodian of the hand pump supply, deserves far more support, in terms of supplies, equipment, and the ability to train and retrain those who fit the pumps. The GOZ has already embarked on a program of improving the quality of the hardware (pump head and down the hole equipment). This requires further support in terms of retraining those response for both installation and maintenance. Technical issues also require attention. The down time (when the pump is non-operational) can be due to many factors which may include: sub-standard equipment, poor installation, aggressive water, and no on-site routine pump head maintenance schedule. One important but overlooked factor is the quality of the leather seals, which can be poor and wear out quickly requiring the entire rising main to be lifted. High quality seals are essential to reduce the frequency of lifting the pipes, which can be a tedious process. Perhaps it should also be mentioned that in line with current international trends, the use of open top cylinders should be tried again, where the piston and its seals can be lifted out through the rising main. Previous work using open top cylinders was carried in Zimbabwe during the 1990’s with 65mm GI pipes fitted together with 63.5mm open top brass cylinders. In more recent work, thick walled PVC pipes are being tested in combination with 63.5mm open top cylinders. PVC is much weaker than steel, but is lighter and cheaper. The use of such piping for rising mains and open top cylinders can reduce initial costs and also periodic maintenance costs. International trends reveal that high quality thick walled PVC can support water columns of up to 30m or even 40m. These depths are far from the full range of borehole depths used in Zimbabwe, which may descend to 60m, 80m or even 100m. Research work in this area is currently being undertaken.

The bottom line on the hand pump program is simple. If money is spent – a good proportion should be spend on reviving the maintenance and support system of existing pumps, and spending less on drilling new boreholes and equippping them with new pumps. Many existing pumps can be refurbished back into working condition. This may require, re-equipping and training district based workshops which are able to perform these tasks. Manufacturers can also work out methods of refurbishing older pumps and putting them back into service (recycling). It is known that the steel pipes and rods do have a finite life, which is shorter in aggressive waters. More detailed studies are required. Zimbabwe has a very long history of providing water in the rural areas from boreholes and hand pumps. It is a history which must not be forgotten

**Comparative installation costs**

It is possible to provide a rough estimate for the cost an installation for both boreholes and family wells (see above), but the equation is complex and variable. In the case of a borehole fitted with a pump this will include, siting, drilling, lining and fitting a pump set at 40m (an average depth) and making a headworks (a total may come to $6000). Beyond that there are maintenance costs.

**Cost per person served**

The cost per person served is complex as we have seen, as this depends on the number of people served. This applies to both boreholes and wells. If a borehole or well is served by large numbers of people, obviously the costs per capita are much reduced in both cases. Whatever the costs may be, the fact remains that in some parts of Zimbabwe the hand pump option may be the only choice, in other parts there may be two choices (UFWs and Hand Pumps). Piped schemes may also be appropriate in other situations. As we have seen the cost of the UFW depends on the level of technology reached. In the case of the borehole and pump it depends on the depth of the borehole and the pump fitted. The main cost of the Bush pump lies in the pipes used in the rising main. The cost of a borehole set at 40m is about $6000.

<table>
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<tr>
<th>Per capita costs</th>
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<tr>
<td>For 100 people</td>
<td>$60</td>
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<td>For 200</td>
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<td>For 300</td>
<td>$20</td>
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<td>For 500</td>
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</table>
Maintenance costs
Maintenance costs for Bush Pumps are high if substandard equipment is used and poorly installed. The life of the leather seal may have an important effect on down time, and also the quality of the pump and its parts. Poor quality seals can wear out fast and demand more frequent lifting of the pipes to replace seals. Also the costs of replacing pipes and rods is high and beyond the means of most rural dwellers. It is an area in which governments and donors must combine their efforts for some years to come. And also steps should be taken to ensure that down time is reduced, by various means, but this discussion lies outside the scope of this document.

Dependability and maintenance
For family owned wells there is a need for high quality initial construction and good headworks maintenance and home deepening when required. Care and upkeep are essential. Well distributed family owned wells can take the pressure off Bush Pumps thus potentially decreasing down time.

Rainfall, Ground Water and Climate Change
Good records for rainfall patterns related to water table levels in Zimbabwe are difficult to find. In the past, several drought years have occurred followed by years of above average rainfall. These have had a positive or negative effect on the water table as expected. However, during recent years it is well known that water tables in both wells and boreholes have been dropping. Such changes will have an influence on the distribution of shallow wells in relation to deeper wells and boreholes.

Predictions for a below average rainfall for the 2015/2016 season have been made for Zimbabwe, based on the relationship between El Niño and the climate of Southern Africa. El Niño-Southern Oscillation (ENSO), is a cyclical pattern involving the weather and the oceans. One of the stronger relationships is between the warm-ocean phase of the ENSO cycle (El Niño) and drought in southern Africa. Such a warming event is developing and predictions indicate a high risk of dryness for the whole of Zimbabwe for the current season.

Far more hydro-geological data is required for Zimbabwe, particularly as the effects of climate change take place. This data, if collected will greatly improve plans being made for the future water supplies of Zimbabwe.

What lies ahead?
This brief report is intended to provide some back ground information for the decision makers in Government. Formerly the UFW program was strongly backed by donors and implemented by staff of the MOHCC in close collaboration with several NGOs, notably the Mvuramanzi Trust.

In the writers view, this program warrants revival, but under rather different circumstances than were previously possible. Present government policy does not include providing support for family based water or sanitary facilities. However ground experience shows that family owned wells of varying degrees of quality are being built widely throughout many parts of the country as a means of survival where alternatives are not available. Huge numbers of people depend on them daily. For this reason alone, it is timely for government to take steps to ensure that the standards of construction are improved. This is particularly pertinent simply because the GOZ already recognises the family well and the concept of self-supply as an acceptable option in its national policy. At the same time, more data should be collected for current hydro-geological conditions which would reveal where shallow family wells are still feasible, even in conditions where the El Niño is having an influence. In previous years the MOHCC took the leading role. In the years ahead, the MOHCC may and should also take a leading role, supported by the NGOs, based on the Ministries wide network of staff which operate down to village level.

Peter Morgan
Harare
November 2015
Locally built and financed traditional family wells

Upgraded family wells built during the 1990’s. The photo on the left shows a strongly built unit using buttressed windlass supports which is being well maintained.

Wells that did not survive. Poor construction and levels of maintenance led to the collapse of the well on the left. Soil erosion can be considerable around wells, as is shown in the photo on the right.
Simple wells without a windlass

Family wells can take many forms. The centre photo taken in Mozambique shows a hygienic well with strong apron, raised collar and lid, but no windlass.

Simple first stage wells without windlass

Second stage wells. The photos on left and right have been upgraded from stage 1 wells. The centre photo shows a stage 2 well being built.

Zimbabwe Bush Pump. Standard and open top cylinder models
References

Many references related to a wide variety of subjects within the WASH sector written by the author of this document can be found on the website www.aquamor.info

A short list of useful references related to the family well program is shown below:

Morgan, Peter. 1990. Rural Water Supplies and Sanitation. MACMILLAN.


Morgan, Peter. 2011. The Upgraded Family Well – How to construct (booklet). Aquamor


WSP (2002). Upgraded Family Wells in Zimbabwe: Household-Level Water Supplies for Multiple Uses