Partners for Water and Sanitation

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Partners for Water and Sanitation

Bauchi State Small Towns Water Supply and Sanitation Project, Bauchi State

TECHNICAL REPORT
on
Dass Small Town Water Supply Scheme

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1 Executive Summary

Partners for Water and Sanitation (PAWS) is a collaboration of government, private sector and NGO organisations dedicated to solving problems associated with providing access to water and sanitation in developing countries. The initial focus of the partnership is Africa.

Due to the time constraints associated with delivery of any extension to the supply system at Dass, this report concentrates only on the Dass water supply subject. Other activities not directly related to Dass water supply will be part of a future report.

During a one week visit from the 21st to 28th of February 2009, we planned to carry out site visits to Dass and Kafin Madaki in Bauchi State. These visits were scheduled to confirm the location and condition of the assets used for water supply to the towns; to enable us to provide advice on the possible extension and enhancement of the supply areas. Unfortunately due to civil disturbance in Bauchi City on the day of our arrival in Nigeria, in the interests of safety, we changed our plans. So the BSWB and WaterAid staff from Bauchi visited us in Abuja.

With time to fully review previous reports and the available information from the Bauchi team investigation reports, in association with the Project Coordinator from BSWB, we were able to confirm a number of options together with a recommendation for extension of the Dass supply system.

2 Review of previous reports

2.1 Dass Scheme

2.1.1 Description of Dass

Dass is a small town close to Bauchi which is spread along a tarred road running North East to South West from Bauchi (to the North East of the town). Estimates of Dass' population depend on who is asked, with figures ranging from 20,000 to 40,000. Previous PAWS reports refer to the population as being between 15,000 and 18,000. We were informed by a member of the Dass WCA that the population could be as high as 90,000 people. BSWB has undertaken to confirm a best estimate of the population within the Dass supply areas.

The Dass water supply scheme consists of a number of boreholes, generators, a booster station and two reservoirs. These were rehabilitated in 1995 by a Chinese firm, and a report exists describing the situation prior to this rehabilitation (commissioned in 1995).

As previously reported in 2008 (PAWS Bauchi Report, April 2008), there are a number of "private" or independently operated schemes (such as the hospital) and WaterAid has constructed a small solar powered scheme (2004) at the northern periphery of the town. In addition to these, there are a number of "political" boreholes and privately owned and managed boreholes.

WaterAid's partner NGO in the town, WoDASS, commissioned a scheme expansion design by local consultants in 2005, after the installation of the WaterAid solar scheme. The report contains a design to connect the solar scheme to the original scheme at the south-west end of the town.

2.1.2 Dass South Water Supply Scheme (original)

A report commissioned in 1995 prior to the refurbishment of the original Dass water supply scheme contains a list and map of 9 boreholes (BSWB staff informed us that two were missing, giving a total of 11). BSWB staff also informed us that the network has some substantial leaks which prevent some of the boreholes from feeding the reservoirs.

We were informed that the generators (at the booster station) were not currently running because of lack of fuel – the local government being responsible for its purchase. On the day of the previous visit, none of the infrastructure was in operation.

2.1.3 Dass North Water Supply Scheme (WaterAid Solar Scheme)

About five years ago WaterAid Nigeria installed a small solar powered submersible pump / borehole supply scheme to the north-west of the Dass town centre. It is assumed that this scheme was installed when the main town scheme was running, and was designed to service the outlying part of town which did not have good access to the existing network.

The scheme consists of three boreholes (one of which is actually exploited), one submersible pump powered by 32 x 55 W solar panels, and a small overhead tank (estimated at 8,000 litres volume). There are 4 taps nearby connected to the overhead tank, where residents can collect water – apparently for free.

The WoDASS commissioned report indicates the yield on the three boreholes as 0.8, 0.7 and 0.6 litres per second (l/s), with the most fruitful bore being the one in operation.

It was previously reported that the submersible pump was a 1.1 kW pump, which appeared to correspond to the power provided by the solar panels. However it was calculated that a 1.1 kW pump should be able to lift around 4 l/s to a height of 20m, assuming it is operating at 70% energy efficiency.

Further details of this scheme were reported in PAWS Project No: 73-NIG report Review of Kafin Madaki and Dass Water Supply Projects dated March 2007 and April 2008.

2.1.4 BSWB plans for Dass

On the previous PAWS visit, BSWB provided us with a copy of the 2005 consultants report, commissioned by WoDASS and WaterAid. BSWB and WaterAid have asked for our technical opinion of the proposed scheme.

The scheme essentially proposes to connect the Dass South and Dass North water schemes, described above, as well as to expand the Dass North scheme to exploit the remaining 2 boreholes. The consultants carried out network deign and modelling.

Currently, BSWB has been allocated ₦22m into a project account which requires sign off from WaterAid, to spend on infrastructure in Dass. This allocation of money has been in existence since our previous report and tremendous pressure now exists to spend this sum effectively.

In the absence of sufficient detailed information the following tentative recommendations were made in the report dated April 2008:

- With the main town supply not functioning, there appears to be **no case to connect the two water schemes**.
- There also appears to be **little reason to exploit the two remaining boreholes** in the northern scheme, if the flow rates as reported in the 2005 report are to be believed.
- The case for investing in Dass itself was not very clear to us. Clearly, the inhabitants have apparently been coping with the total dysfunction of the existing system for 5 years now.
- Serious attention must be given to the sustainability of any investment carried out.
- We were made aware of a nitrate quality problem, which is potentially a subset of a wider water quality problem in the town of Dass.

2.1.5 Recommended immediate steps for the Dass Scheme

1. Establish which of the Dass south boreholes actually have working pumps. To do this it may be necessary to bring a portable 2 (to 5) kW generator and engage an electrician to connect the power supply to the portable generator for the pump test.
2. Confirm sustainable (i.e. dry season) yields of all operational boreholes in Dass. Write these down, ensure BSWB keeps a safe record of these yields. Record GPS coordinates of bore with yield information, as well as date of pumping test.
3. Locate and reinstall the missing solar panels from the Northern scheme.
4. Establish the sustainable yield of the Northern solar powered borehole.
5. Bring fuel, test all generators. Test all phases. Ensure hour meters on generators are working.

6. Nitrates: confirm the level of nitrates present in the boreholes on a seasonal basis

7. Record keeping: All flow, hours run and power meter readings should systematically be recorded daily (at every shift change over) in logbooks kept in the pump houses / generator buildings. Depth sounders (dippers) should also be used to systematically record static and dynamic water levels (daily).

2.1.6 Progress with recommended actions

It is pleasing to report that many of the recommendations made in the 2008 report have been followed up.

- The wet season yield (September 2008) of all boreholes with the Dass supply area has been established
- The GPS coordinates of boreholes, tanks and boosters have also been recorded
- A detailed GPS survey of the Dass supply area has been completed and possible routes for any extension to the system and associated distribution system have been identified
- The missing solar panels have been located, but as yet have not been reinstalled

3 Borehole Testing

In order for a network model to be created that would be representative of the available water resource, BSWB were requested to undertake yield test of all in-service boreholes – the three located at the WoDASS site and numerous other positioned around Dass.
Data for eleven boreholes was supplied and can be seen in appendix 2 and 3.

Reviewing the raw data supplied by BSWB it was clear that the test procedure employed was of the ‘constant yield’ type. The test should reveal the maximum sustainable output for the season the test was undertaken. However, the output data should be considered as representative of the condition at the time of measurement only and should not be relied upon to predict future quantity of available water.

Determining a true sustainable output figure requires extended long term testing, which is impractical in many developed applications, even more so here, where the resources, available pump and fuel etc. are limited.

Therefore, the figures supplied are to be taken as the maximum and consideration given to the success of the designed scheme should outputs be subject to seasonal variations.

4 WoDASS boreholes

The proposals from BSWB concentrate on development of the WoDASS boreholes, three existing sources with varying levels of output.

The yield test data reveals significant differential between the three boreholes, varying from little or no yield to the potential of tripling their current outputs.

4.1 WoDASS borehole 1

This borehole is currently the only serviceable source. The 2008 PAWS report considers the existing arrangements and outlines the limited utilisation of the source and that the network configuration and sizing are limiting its potential development.

Again based on supplied data, as no physical removal of the pump was possible during this or previous visits, we understand its output to be limited to circa 0.5 l/s.. The existing photovoltaic (PV) system and AC/DC pump we were informed has a maximum delivery of circa 0.5 l/s at its minimum vertical lift. This is collaborated by calculating the energy generated from PV array and cross-checking it with the reported pump type and size.

As indicated in appendix 1, the constant discharge yield test undertaken at WoDASS borehole 1 indicates that circa 1.72 l/s are potentially available – more the three times what it is currently outputting.

Therefore, the borehole does lend itself to investigating, determining the options associated with maximising the yield in conjunction with an appropriate distribution and storage system.

4.2 WoDASS borehole 2

This borehole is unemployed and offers no output to the community. The yield test indicates that a potential 1.89 l/s is available, slightly more even than the current in service WoDASS borehole 1.

Consideration was given to the options associated with utilising this source and appropriate distribution and storage systems.

4.3 WoDASS borehole 3

Again this borehole is unemployed and is of no benefit to the community. However, yield testing suggested a very limited output, circa 0.15 l/s. This might be attributed to its condition or simply that the drilling is outside of the aquifer.

Discussions with BSWB confirm a preference to employing the source as a hand pump type system; accepting the limited output, and then serving the immediate surrounding community only.

Consideration should be given to the rehabilitation of this borehole or geological investigations regarding aquifer extent and boundaries.

5 Scheme options

What is obvious from previous visits and reports is that simply expanding the existing distribution system without maximising the greater potential from the WoDASS site is pointless. The output is so low that really lends itself to its current application only – a small and discrete system with short pipe runs, to and from an adjacent high level tank, feeding a number of local standpipes only.

The existing borehole pump is the limiting factor, with a maximum delivery pressure and flow rate suitable only to its current application.

However, with an assumption that the yield test data is truly representative of the outputs available, numerous options for the expansion of the system become possible.

Common to all of the options is investment in new equipment and infrastructure.

Sustainability is of primary importance. The number of witnessed schemes where little or no water flows, all attributed to issues associated with energy deficiency, is worthy of note - whether that be as a result of NEPA power reliability or the availability of hydrocarbon based fuels to drive standalone generators.

With that in mind, we and BSWB, have a preference towards the utilisation of sustainable energy sources.

An example is that of WoDASS borehole 1. Up until a recent storm, where a number of the PV panels were damaged, the system has worked with almost no intervention or maintenance – providing a constant estimated 0.5 l/s during daylight hours.
Expansion of the existing PV system is considered the best all round option for the site.

Consideration will now be given to the options.

5.1 Option 1 – Full utilisation of WoDASS BH 2, with WoDASS BH 1 to operate as is

This option requires investment in new pumping apparatus, PV energy system and distribution system.

The proposal is to leave the existing PV systems as is, dedicated to supplying the adjacent high level tank and standpipes.

Worthy of consideration is the potential of carrying water from the existing tank to a determined point away from the site, by gravity. Hydraulic analysis confirms that appropriately sized pipes will ensure minimum head losses and facilitate the carriage of water a short distance from the tank. However, based on the limited output, circa 0.5 l/s from the existing PV pump system, this sub-option is less valued. An output of 0.5 l/s is enough only to supply multiples of standpipes.

We have not considered this sub-option further at this stage but would be pleased to assist with any future consideration.

Under Option 1, our suggestion is therefore to leave the WoDASS BH 1 system untouched, and replace the missing solar panels.

WoDASS BH 2 yield test results offer 1.89 l/s, a notable increase from current WoDASS borehole 1 output. From this source the potential for longer carriage of water is feasible.

Hydraulic analysis of the maximum flow from WoDASS borehole 2, with appropriately sized pipes, indicates the potential to carry water as far as Unguwan Zaki (UZ), where an existing but unemployed high level tank (UZ OHT2) is situated.

Calculations to determine the equipment required to transfer water from the WoDASS site to UZ were undertaken and included:

- the water level within the boreholes after its maximum draw down level was achieved at maximum output
- the elevation differential between the sites (including high level tank)
- and the head losses caused by friction from velocities in pipe

Longitudinal distances were derived from GPS data captured by BSWB (Appendix 1 and Appendix 5). It is worth noting that some differences were observed between the field measured distances supplied by BSWB and the GPS data, again supplied by BSWB.

To ensure that the head loss calculations were realistic and potentially 'worse case', we opted to use the greater of the distances, those indicated by triangulation between supplied longitude and latitude readings.

The total distance from he WoDASS site to UZ was calculated to be 2285m.

The summation of hand written distances indicated on the supplied schematic of the WoDASS to UZ proposed system (Appendix 7) is 1900m, circa 300 metres less than using the GPS data.

The maximum flow of 1.89 l/s carried from WoDASS borehole 2, and for later consideration, the combined outputs form both WoDASS boreholes 1 and 2, to UZ, through various pipe sizes are indicated in metres of head loss over the total 2285m in the table below.

Table 1: Pressure loss from WoDASS site to UZ

Detail	m
Total lift from DDL to fill level @ UZ OHT	35

Pressure loss due to friction over 2.285 km	m
100mm smooth wall pipe @1.9 l/s (WoDASS BH 2 max yield)	1.8
75mm smooth wall pipe @1.9 l/s (WoDASS BH 2 max yield)	7.1
100mm smooth wall pipe @3.6 l/s (WoDASS BH 1 and 2 max yield)	5.6
75mm smooth wall pipe @3.6 l/s (WoDASS BH 1 and 2 max yield)	22.7
150mm smooth wall pipe @3.6 l/s (WoDASS BH 1 and 2 max yield)	0.8

Head loss calculations employed a smooth wall pipe, like PVC, with an internal roughness not exceeding 0.03mm. Using pipes with greater internal roughness will, of course, adversely affect the head losses.

No factoring for rapid changes of pipe direction and pipe fittings has been included. However, as head losses are low when suitable pipe sizes are adopted, addition of the equivalent pipe lengths associated with bends and fittings make for very little additional head loss.

5.1.1 Scheme requirements

Based on the above calculations any expansion of the WoDASS system would require the procurement and installation of a new PV energy system, a new AC pump with suitable inverter and piped transmission and distribution systems.

Considering the maximum flow rate and lift requirements of employing WoDASS borehole 2 as a supply to the over head tank at UZ, some 2.2 kilometres away, any new pump must be suitable of matching the lift and flow rates indicated:

- WoDASS Bore hole 2 max yield of 1.89 l/s
- Maximum lift (inc head loses) 100mm smooth wall pipe of 45m

Such pumps are available and BSWB are aware of the supply routes for such and have existing access to on-line pump sizing software.

The WoDASS system would be configured to supply the WoDASS site, local tank and standpipes, and the existing tank at UZ. With WoDASS borehole 1 remaining as it is, to supply the local WoDASS system, and WoDASS borehole 2 to supply the new system to UZ.

Appropriate connectivity between the systems, both transmission and distribution, will facilitate the cross connecting, and therefore sharing of sources, should one element of the system fail.

Note however that the existing PV system at WoDASS borehole 1 can not supply UZ – the lift is inadequate and flows too low to be of use.

Suggested positions of cross connection are:

- at the WoDASS high level tank, to facilitate the transfer of UZ destined water into the WoDASS tank.
- on, or around, GPS position 10^{o},00',49.7" N _ 009 ^{o},31',56.8" E, where the proposed inlet and outlet pipes converge (see appendix 7 scanned copy of WoDASS/UZ schematic)

5.2 Option 2 – Full utilisation of WoDASS BH 2 and WoDASS BH 1

This option is to fully employ the reported maximum yields of WoDASS boreholes 1 and 2.

WoDASS Borehole 2 would be configured as above, with its maximum yield being pumped and piped to UZ over head tank. WoDASS BH 1 would see a similar utilisation of maximum yield, again by means of an up rated power supply and AC pump, only its increased output would be delivered to the existing over head tank at the WoDASS site.

Operating the system this way would facilitate the greater distribution of WoDASS borehole 1 water on the South side of Bauchi Road. Hydraulic consideration could be given to the distribution options. Based on a similar, but slightly lower lift from the maximum borehole drawn down level to the over head tank at WoDASS, it is realistic to see the carriage of water a similar distance as to UZ, some several kilometres.

This is the same sub-option as in Option 1 and would be design and specification driven, specifically for the piped network. Again, sub-option is not considered in any further detail within this report. Such design work could be undertaken remotely, using currently available survey data with recommendations being supplied electronically to BSWB.

Preliminary discussions between BSWB and us considered the construction of an intermediate high level tank closer to WoDASS, perhaps adjacent the Bauchi Road, North side near to UZ junction.

Construction of such a tank would mitigate the elevation differential between the WoDASS site and UZ, therefore requiring a lower lift and potentially allowing the existing PV set at WoDASS borehole 1.

However, again based on the limited output of the existing pump set, this is considered uneconomic for such a limited water source – 0.5l/s.

5.3 Option 3 – Full utilisation of WoDASS BH 2 and WoDASS BH 1 and two new boreholes at UZ

This option is as above (Option 2), for all the existing boreholes at the WoDASS site; plus the proposed drilling of two new boreholes at UZ. As these are proposed, no yield data is available. However, assuming that the potential yield would be similar to those drilled into the same aquifer in the local area (borehole 1C is stated to have a yield of 0.73 l/s), the combined yield could be as much as 5 l/s.

As with Option 2, the two WoDASS boreholes would need to employ a larger PV system and pumps to lift the borehole water into UZ over head tank.

Assuming again maximum yields are achieved from both WoDASS 2 and the new UZ 1 and 2 boreholes, the distribution system starts to become robust, with options to direct water between the two sites.

Based on the above estimate of combined outputs and using a typical eight hour daylight period, the system would have the potential to supply a volume of around 150m^3 per day, sufficient to give a population of 7500 a supply of 20 litres per head per day.

6 Conclusions

The fundamental element of any potential extension of the transmission and distribution systems from WoDASS and UZ is greater utilisation of available resources, both in terms of the measured yield from WoDASS and the potential yield from UZ.

Yield tests results clearly indicate a potential seven fold increase to current outputs from WoDASS. Of course, the utilisation of any extra available resources is not without cost.

Sustainability must feature dominantly in any solution. There is little point installing a distribution system that has no water available to be carried in it.

PV systems offer such sustainability, requiring little maintenance and working well in Dass's geographic position of abundantly clear skies.

Capital costs do however tend to be greater, with the PV cells contributing to a large percentage of the schemes total cost - in terms of cell procurement and security and installation requirements.

The technology is tried and tested, even at WoDASS itself, and does therefore, on balance, deliver the most for less and for longer.

7 Recommendations

The recommendations are subject to funding and in order of priority:

- Utilise WoDASS borehole 2 (full 1.89 l/s) by means of new PV pump system, rated to deliver quoted flow and at designed lift
- Placement of at least 100mm diameter smooth walled transmission pipe between the WoDASS site and UZ
- Placement of distribution network as will be designed by BSWB.
- Drilling two new boreholes at UZ for supply to UZ tank
- Utilise fully borehole WoDASS 1 with up-rated PV and pump system (replace existing lower output system)
- Transplanting of existing 0.5l/s PV system (PV cells, security and pump) to another current unemployed borehole elsewhere in Dass (such as existing BH 1C at UZ)

Appendix 1: Existing WoDASS and UZ borehole information (from BSWB)

BOREHOLE PUMP TEST RESULTS								COORDINATES			EXISTING SUBMERSIBLE PUMP						
S/No	Borhole No.	Location	Dia. of Casing (mm)	BH Depth (m)	SWL (m)	DWL (m)	Yield (L/s)	Northings	Eastings	Elevation ASL (m)	Make	Capacity (Kw)	Existing Solar Panels	Q (m³/hr)	H(m)	Installation Depth (m)	Operational Condition
1	Wodass BH1	Dot	127	30	4.54	15.6	1.72	10°00 '59.1 "	009°32 '14.3 "	606	Grundfos Solar pump (SP1A-28)	0.55	16 No M55 Siemens panel with 1500 Solar Tronic Inverter with Max power of (16x0.055Kw=0.88Kw).				
2	Wodass BH2	Dot	127	30	4.35	12.03	1.89	10°00 '58.7 "	009°32 '16.3 "	606	No pump		16 No. Siemen panel are provided to operate the BH and no pump installed, but 8 No panels ware removed by wind storm and are kept at the office of the NGO.				
3	Wodass BH3	Dot	127	31.37	5	28.75	0.15	10°01 '05.7 "	009°32 '20.7 "	609	No pump						
4	1C	Unguwan Zaki	150	30	8.56	23.52	0.73	10°01 '06.3 "	009°31 '48.8 "	611	Matra	0.75	There BH is operational and a Generator dedicated for the borehole is being fuel by the community	1.2	68	18	Pump in good cond. And the BH is operational , b/cos the Generator for the borehole is being fuel by the community.

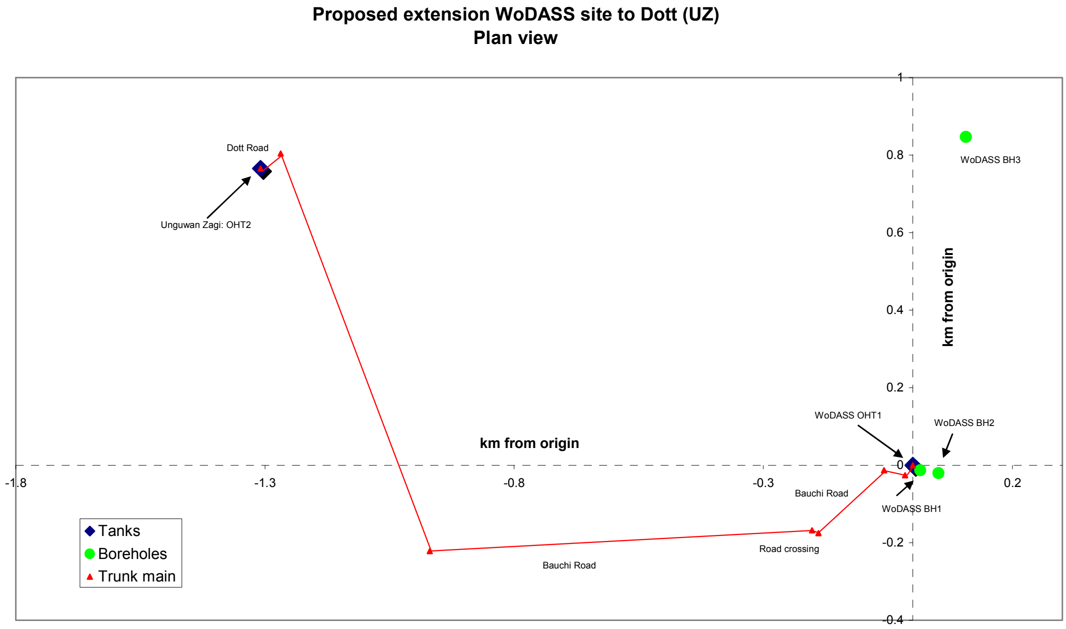
Appendix 2: Existing Dass borehole information (from BSWB)

BOREHOLE PUMP TEST RESULTS								COORDINATES			EXISTING SUBMERSIBLE PUMP					
S/No	Borhole No.	Location	Dia. of Casing (mm)	BH Depth (m)	SWL (m)	DWL (m)	Yield (L/s)	Northings	Eastings	Elevation ASL (m)	Make	Capacity (Kw)	Q (m³/hr)	H(m)	Installation Depth (m)	Operational Condition
1	2B	Tudun Wuss	150	27.00	3.74	7.12	2.12	09° 59' 02.4"	009° 31' 01.3 "	589	Astra	1.50	1.50	48.00	21.00	Pump in good cond., but BH not operational b/cos there is no power supply
2	3B	Tudun Wuss	150	30.00	4.30	18.96	5.15	09°58 '56.2"	009°30 '59.0 "	589	No Pump				21.00	Not operational
3	4B	Tudun Wuss	200	25.00	3.90	9.40	7.15	09°58 '57.1 "	009°30 '55.5 "	594	Grundfos	3.00		25.00	21.00	Not operational, b/cos the stater is burnt
4	1A	Unguwan Sarkin Bai	150	42.00	4.46	32.94	1.30	09°59 '58.0 "	009°31 '12.3 "	601	Grundfos (SP5A-25)	2.20	5.00	99.00	37.00	Pump in good cond., but BH not operational b/cos there is no pump stater
5	2A	Gindin Ayaba	150		3.05	9.42	1.00	09°59 '55.4 "	009°31 '25.3 "	604	Newmoto	0.75			12.50	Pump in good cond., but BH not operational b/cos there is no power supply
6	3A	Unguwan Sarkin Kudu	150	29.00	4.60	23.25	1.40	10°00 '10.1 "	009°31 '17.2 "	614	Grundfos (SP5A-17)	1.50	5.00	67.00	24.00	Pump in good cond., but BH not operational b/cos there is no power supply
7	4A	Generator Room	150	25.00	6.05	22.40	1.02	10°00 '03.8 "	009°31 '08.3 "	612	No Pump				24.00	The BH was filled up with sand, but bail out and pump tested, but there is no any pumping system.

Appendix 3: Proposed extension of WoDASS system (from BSWB)

PIPE NETWORKS						COORDINATES			
S/No	Location	Service provide	Dia. of Pipe (mm)	Material	length of pipe(m)	Northings	Eastings	Elevation ASL (m)	Operational Condition
1	Dabardak Road: Wodass BH3	Water Source (Borehole)				10°01 '05.7 "	009°32 '20.7 "	609	The Borehole has a very low yield. Hand Pump to be installed
2	Dabardak Road: Wodass BH1	Water Source (Borehole)	50	UPVC	86	10°00 '59.1 "	009°32 '14.3 "	606	Productive
3	Dott: Corrogated Steel Over Head Tank No.1 (15.63m³) on a 5m Steel tower	Serving the community near the tank	50	UPVC		10°00 '59.8 "	009°32 '13.8 "	607	Good
4	Dot: Wodass BH2	Water Source (Borehole)	50	UPVC		10°00 '58.7 "	009°32 '16.3 "	606	Productive
5	Dabardak Road (Borehole Site): Junction of Wodass BH1&BH2	Transmission	50	UPVC	143	10°00 '58.4 "	009°32 '12.6 "	612	Proposed
6	Bauchi Road	Transmission	75	UPVC	79	10°00 '59.1 "	009°32 '10.3 "	614	Proposed
7	Bauchi Road	Transmission	75	UPVC	363	10°00 '50.3 "	009°32 '02.8 "	612	Proposed
8	Bauchi Road (Culvert Crossing)	Transmission	75	Galvanised Iron	30	10°00 '50.7 "	009°32 '02.1"	612	Proposed
9	Bauchi Road	Transmission	75	UPVC	140	10°00 '47.8 "	009°31'59.8"	612	Proposed
10	Dott Road	Transmission	75	UPVC	431	10°01 '03.4 "	009°31'45.0"	621	Proposed
11	Unguwan Zagi: Corrogated Steel Over Head Tank No.2 (50.6m³) on a 6m Steel tower	Storage		UPVC	97	10°01'01.3 "	009°31'42.7"	623	Existing, but had never been used
				DISTRIBUTION					
12	Unguwan Zagi: Corrogated Steel Over Head Tank No.2 (50.6m³) on a 6m Steel tower	Storage				10°01'01.3 "	009°31'42.7"	623	Existing, but had never been used
13	Dott Road	Distribution	100	UPVC	97	10°01 '03.4 "	009°31'45.0"	621	Proposed
14	Unguwan Zagi	Distribution	100	UPVC	16	10°01'03.3"	009°31'44.9"	621	Proposed
15	Unguwan Zagi	Distribution	75	UPVC	132	10°01'06.3"	009°31'48.2"	619	Proposed
16	Unguwan Zagi Pri. Sch.	Distribution	75	UPVC	280	10°01'11.1"	009°31'56.1"	616	Proposed
17	Unguwan Zagi BH 1C	Borehole				10°01 '06.3 "	009°31 '48.8 "	611	Existing and productive
18	Unguwan Zagi: Corrogated Steel Over Head Tank No.3 (19.8m³) on a 6m Steel tower	Storage				10°01'06.0"	009°31'48.3"	620	Existing and in use with water supply from BH 1C
19	Interconnection of Over Head tank No3 and the distribution from the Over Head tank No2	Distribution	75	UPVC	14	10°01'06.3"	009°31'48.2"	619	Proposed
20	Dott Road	Distribution	100	UPVC	97	10°01 '03.4 "	009°31'45.0"	621	Proposed
21	Dott Road	Distribution	100	UPVC	431	10°00 '53.0 "	009°31'53.7"	616	Proposed
22	Dott Road	Distribution	75	UPVC	370	10°01'01.7"	009°32'00.0"	616	Proposed
23	Dott Road	Distribution	100	UPVC	0	10°00 '53.0 "	009°31'53.7"	616	Proposed
24	Bundott Road	Distribution	100	UPVC	345	10°00'49.7"	009°31'56.8"	612	Proposed
25	Football Field of Iliya Adamu Pri. Sch.	Distribution	100	UPVC	1142	10°00'24.7 "	009°31'28.6"	621	Proposed
26	Football Field of Iliya Adamu Pri. Sch.	Distribution	75	UPVC	201	10°0 '27.4 "	009°31'24.6"	623	Proposed
27	Sarkin Bundot Palace	Distribution	100	UPVC	225	10°00 '21.4 "	009°31'23.1"	619	Proposed
28	Sarkin Bundot Palace	Distribution	75	UPVC	200	10°00 '23.6 "	009°31'17.1"	623	Proposed
29	Bazinra Road	Distribution	100	UPVC	223	10°00'14.6 "	009°31'11.0"	615	Proposed
30	Bazinra Road	Distribution	75	UPVC	347	10°00'25.0 "	009°31'06.7"	622	Proposed
31	Proposed New Borehole 2C	Water Source	50	UPVC		10°01 '12.3"	009°31'41.2"	613	Proposed New Borehole 2C & 3C to be powered by the Generator at BH1C which would be relocated to a close location while BH1C is proposed to be powered by Solar energy
32	Proposed New Borehole 3C	Water Source	50	UPVC		10°01 '22.5"	009°31'41.7"	612	Proposed New Borehole 2C & 3C to be powered by the Generator at BH1C which would be relocated to a close location while BH1C is proposed to be powered by Solar energy
33	Dott Road	Transmission	75	UPVC	110	10°01 '21.5"	009°31'44.4"	609	Proposed
34	Dott Road	Transmission	75	UPVC	478	10°01 '05.9"	009°31'41.3"	618	Proposed
35	Dott Road	Transmission	75	UPVC	135	10°01'03.3"	009°31'44.9"	616	Proposed

Appendix 4: Proposed extension WoDASS site to Dott (UZ) - Plan view



Appendix 5: Proposed extension WoDASS site to Dott (UZ) - Altitude section