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Ethiopia: CCTV well field review 2009

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Zeyede (driver and pump removal team member).

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Summary

- This report covers data collection and field work for the technical aspects of the World Bank-funded Joint Governance Assessment and Measurement Initiative (JGAM) in Ethiopia. The work comprised a survey on rural borehole drilling in Ethiopia, in support of the Water Sector Diagnostic. It was carried out as part of an initiative to assess the degree of corruption within the water sector in the country.
- The objective of the technical aspect of the work was to compare the variables of location, depth, diameter, construction across the contract specification, completion report, invoice and actual field data.
- A total of 26 boreholes were visited in order to gather information. These boreholes were funded by a variety of funding agencies and all were constructed within the past 3 years. A borehole CCTV camera was used to measure well screen and casing lengths, plus borehole depth.
- Out of the sample, 20 boreholes had both documentation available and a CCTV survey undertaken successfully. Of these, 12 had depths within 90% of those stated in the documentation. A further 6 were between 79% and 90% and were considered to have suffered from silting-up. Only two boreholes had surveyed depths less than 70% of those originally documented and were considered to be outside the range of normal silting.
- Overall, the standard of reporting and borehole construction for shallow boreholes fitted with hand pumps is very good. It was found that there were some issues with poor well head completion where concrete plinths had cracked, or where inadequate drainage channels had been installed.

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1 Introduction

For many years the water sector in Ethiopia has been the recipient of many schemes designed to alleviate chronic deficiencies in the country's water supply chain. A significant proportion of this funding has been invested in the construction of groundwater abstraction sources. Many of the latter have comprised shallow (<60 m depth) boreholes fitted with hand pumps and located close to villages in rural areas. In spite of the large number of installations completed over the years, relatively little is known about the quality of the constructed boreholes or even the processes involved in locating sites for them.

The current review has been funded by the World Bank with a view to assessing the extent of corruption in the water sector. The Bank commissioned the British Geological Survey to undertake the survey work and interpret the results. The work covered by this report is restricted to measuring the technical aspects of borehole construction (depth, diameter, materials used) in the field and comparing them to completion reports and invoices. In addition to the technical assessment, a study of local stakeholder perceptions at each site was undertaken.

The field work was carried out between 26 May and 16 June 2009 in two main areas: Oromia, to the west of Addis, and Southern Nations, Nationalities and People's Region (SNNPR), to the south and west of the capital.

1.1 PROJECT OBJECTIVES

- To provide evidence of the relationship between drilling specifications and the installed infrastructure by carrying out a post construction survey of mainly shallow (<50 m depth) water abstraction boreholes, equipped with hand pumps.
- Undertake the multi-component study of a sample of boreholes constructed within the past 3 years and drawn from 2 regions (SNNPR and Oromia) to the west and south of Addis Ababa.
- Make comparisons between project completion reports and the work actually carried out.
- Assess the degree of corruption in the water well construction industry in Ethiopia.
- Train selected personnel from the MoWRD and FEAC in the use of the CCTV equipment and the methodology and reporting used to measure borehole variables.
- Donate the CTV equipment to FEACC in Addis.

1.2 TERMS OF REFERENCE

The work was carried out according to the Bank Terms of Reference, which are listed below:

1. Develop the survey instruments, and pilot test them.
2. Select a sample of up to 50 boreholes within two Regions of Ethiopia. The sample sites to be chosen from a range of projects funded by various agencies and constructed by a range of drilling contractors (Figure 1).
3. Review all technical documentation of each borehole.
4. Develop the study design, data collection methods, the analysis and draft and final reports.

5. Undertake a physical inspection of each borehole, including use of CCTV equipment to make observations of down-the-hole components (depth, width, type and amount of different casings, gravel packs etc).
6. Supply the CCTV equipment and all ancillary equipment necessary for the study.
7. Supervise and give on-site training to a small team in the Anti-Corruption section of Ethiopian Government (FEACC) and Ministry of Water Resources (MoWRD) technical staff who will accompany the consultant (though the consultant is independently responsible for the analysis and delivery of the study)
8. Assess the quality of drilling and procedures followed in the sampled boreholes, including costs and water quality, and make recommendations on how drilling practices could be improved.
9. Assess the functioning of borehole and pumps and analyze the causes of any breakdowns.
10. Compare the inspection results with commissioned specifications to determine whether these were carried out as required and analyze the causes of ay gaps.
11. Interview local stakeholders to develop a clear picture of how the contractor carried out the drilling and build up a history and analysis of the approach followed in each borehole development.
12. Upon completion of the study hand over the CCTV and any other study equipment to a suitable unit in the Government of Ethiopia (GoE) for use in future borehole inspection work.
13. Give a demonstration to senior MOWRD and GoE officers in the capability, use and upkeep of the equipment.

1.3 THE QUESTIONING FRAMEWORK

Prior to commencing data collection in the field and in Addis, a questioning framework was devised in order to properly structure the work and ensure the correct information was being gathered. In addition to the technical information gathered from the site visits, focus group discussions were carried out at each locality in order to obtain information from local people on perceptions. This aspect is the work is reported elsewhere.

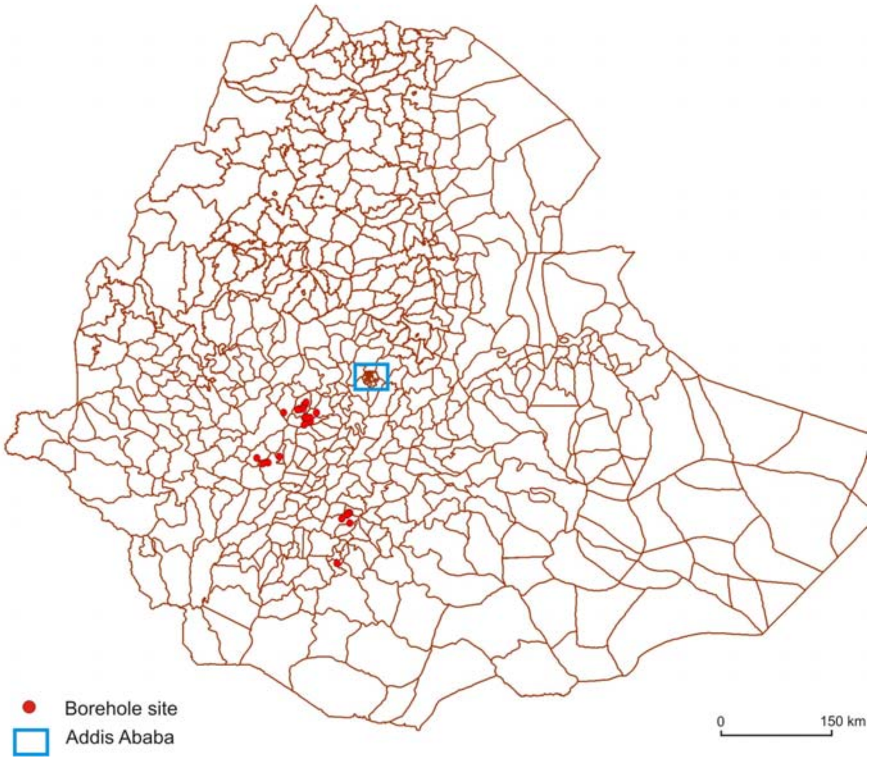

Figure 1. Ethiopia, showing site locations

Table 1. Boreholes: a questioning framework.

	PRIMARY SET			SECONDARY SET				TERTIARY SET
	CONSTRUCTION	**DESIGN / SPEC**	**PAYMENT (SUPERVISION)**	**OUTCOMES**	**PROCESS**	**TENDERING AND PROCUREMENT**	**VILLAGE CHARACT.**	**VILLAGE PERCEPTIONS**
QUESTION TO BE ANSWERED	**What was built?** **Location variable?**	**What was designed/ specified?** **What was reported in the Completion Report?**	**What was paid?** **What should have been paid?**	**Did the borehole meet prescribed objectives?**	**Was good development practice followed?**	**How was the borehole procured?**	**What are the characteristics of the village?**	**What do people perceive was built and paid for**
HOW TO ANSWER IT	ON-SITE MEASURE **Size** - depth - diameter **Materials** - Casing - screen **Equipment** - Pump type	TENDER DOCUMENTS **Size** - depth - diameter **Materials** - Casing - screen **Equipment** - Pump type	COMPLETION REPORT / INVOICE **Size** - depth - diameter **Materials** - Casing - screen **Equipment** - Pump type	COMPLETION REPORT & SURVEY **1. Water quantity** - yield/sufficiency - reliability **2. Water quality** - meet prescribed standard (sample test) - user satisfaction **3. Water access** - Average distance/time for users (dry season). - restrictions?	SURVEY **1. Level of participation and engagement** - in WASH plan **2. Management arrangements** - womens rep. - rules and regs - training provided **3. Contribution arrangements** - process - level/type	TENDER DOCS **1. Type of Contract** **2. Procure. method** - single source - competitive tender **3. Eval. method** - no. of evaluators - independence of evaluators - transparency of evaluation **3. Payment method** - fixed price vs actuals **4. Payment relationship**	KEBELE DATA & SURVEY (& extension workers) **1. Population** **2. Ethnic mix** **(3. Educational level)** - years **4. Social participation** - presence of other committees/structures (e.g. Idder, Maheber coops)	SURVEY (& woreda water office) **(1. Location)** Why do some villages have improved sources and others not? **2. Design** Do you think the design is correct? **3. Construction** Do you think the borehole was built properly (and in the way it was designed)? **3. Payment** Do you think the payment was as it should be?

2 Methodology

In order to assess the degree of corruption in the water sector within the area of shallow groundwater sources a work plan was devised that involved selecting suitable boreholes, gathering relevant documentation and carrying out a site survey using, amongst other equipment, a CCTV camera. The results from the site visit were then compared to the documentation to compare the Primary Set variables described in Table 1 for depth, diameter, materials, location and pump type. The general order of the technical phase was:

- Sample selection
- Data collection
- Site visit
- Reporting

2.1 SELECTION OF SAMPLE

Two Regions of Ethiopia were selected for the study: Oromia and SNNPR. These Regions were chosen because of their proximity to Addis Ababa and for the number of rural water supply projects undertaken. Over the 17 or so days allotted for the field work phase of the study, it was thought that up to 50 sites could be visited, although a more realistic figure was thought to be nearer 30.

The site selection process included the following provisos:

- The number of boreholes to be visited should be equally divided between Oromia and SNNPR.
- Sample sites to be located reasonably close together in order to minimise travel times between sites.
- Completion reports and invoice information for the sample set must be available.
- Boreholes should ideally be located in villages, be less than 50 m deep and be equipped with hand pumps.

2.2 DATA COLLECTION

Documentation for the sample set was acquired from several sources. Within Oromia region, many reports and invoices were sourced in Addis, with the remainder found at MoWRD Zone offices at Waliso and Jimma. For SNNPR Region, Awasa and Walkite Zone offices provided most documentation. Data collection was carried out by Yemarshet Yemane, a consultant engineer with experience in the Ethiopian water sector. The documentation types comprised tender, contract specification, completion reports and invoices. Of these, the field work phase concentrated on obtaining the completion reports and invoices. The main features of these reports are:

- **Completion reports**: Generally very detailed accounts of the drilling process, equipment used, depths, diameters, materials used. Occasional reports gave GPS coordinates for the various sites. Usually, a village name was the only location information supplied. Some reports gave data on the time spent at each borehole site and the hours of work for the rig and compressor. Mostly, borehole graphic logs were very well presented. Information reported on water yields from individual boreholes showed that only the most basic form of assessment was generally carried out. This normally comprised a visual estimate of yield from a short air-lift flushing session. Pumping tests were rare, but, on a positive side, this type of work is expensive and can be over-used.

- **Invoices**: Details of the metres drilled and invoiced, plus the type of casing and screen installed were normally available in the invoices. It was possible, in most cases, to compare the invoice details with the completion reports and the CCTV survey data.

2.3 SITE SURVEYS

Each borehole location was visited in order to inspect the installations, measure borehole parameters, establish the actual location and carry out focus group discussions for the social survey. The procedure used by the project team for site visits comprised the following:

- ***Site visits***: Organise sites into geographical groups for the following one or two days field work.
- ***Local assistance***: a visit was always made to the appropriate Zone or Woreda MoWRD office prior to the site visits. This was done in order to obtain further documentation and to employ the services of the local pump technician for route-finding and help on site.
- ***Site work***: The project team comprised:
    - Derek Ball (BGS), Elizabeth Mekonnen (social studies consultant), Yemarshet Yemane (consultant engineer), Ali Aman (MoWRD – engineer), Michael Tekeste (MoWRD – engineer), Ato Ayalew Wube (MoWRD main contact for the project), Zeleke Ashenafi (FEACC representative for the project), Behrane (MoWRD driver), Zeyede (driver and pump removal team member). A further BGS team member, Roger Calow, was the social study specialist who provided interview training to Yemarshet and Elizabeth.
    - A visit to a village borehole normally involved the following:
    - *Contact with village water committee members* to establish whether we had arrived at the correct place.
    - *Take a borehole water sample* for measurement of specific electrical conductivity (SEC). This is not essential, but enabled a quick assessment of borehole salinity to be made, which could be compared with values presented in some of the completion reports.
    - *Remove pump installation*. For the Afridev type, this comprised an inner set of stainless steel pump rods and lower valve assembly, inside a 50 mm diameter PVC rising main.
        - It was found that, in order to lower the 37 mm diameter CCTV camera down the boreholes, the hand pump assembly first had to be removed. Most boreholes were complete using 141 or 150 mm diameter uPVC casing and well screen. Inside this, a 50 mm PVC rising main was installed, along with centralisers and supporting ropes. Removing the 50 mm PVC rising main meant that it had to be cut into 6 m lengths. After the CCTV survey, re-installation of the pump equipment involved cementing the pipes back together with PVC glues and either the use of new lengths of pipe or new collars for joining existing pipe work. In total, the removal and installation of the pumps took approximately 3 hours per site.
        - At two sites, India Mk II pumps were present. These were too heavy to remove by hand, and a clamp borrowed from a Zone office, designed for the purpose of removing the heavy 18 mm diameter GI piping, proved to be ineffective. For these boreholes, the camera was lowered down between the

casing and the riser, but became lodged at depths of 25 m and 30 m below surface.

    - Three borehole sites did not have pumps, but were waiting for them to be installed. These sites had welded steel caps fitted, which were removed by chiselling. The camera was then lowered inside.

  - The **CCTV camera** used for the field work had the following specification:
    - Manufacturer: Well-Vu of Minnesota, USA. Model: WV-C500SDC.
    - Camera: battery-powered, 37 mm diameter, downward-viewing, colour (PAL system), with LED lighting assemblage. A fully-charged battery lasted about 10 hours. A 45^{o} mirror was attached to the camera to enable horizontal viewing of the casing and screen to take place.
    - Cable length: 150 m, with electronic depth display. Spare 150 m cable and camera provided.
    - Recording system: SD 2 GB memory card, with transfer of site videos to a laptop each evening.
    - Total weight: approximately 37 kgs. Custom-built storage trunk also provided.
  - *Carry out CCTV survey*, after a 30 minute wait to let the water inside the borehole clear. Turbid water after disturbance from the pump removal was a problem. Video from the CCTV scan was recorded on to a 2 GB SD card for later transfer to a laptop.
  - *Measure casing diameter and note the condition of the concrete well head plinth.*
  - *Take a GPS reading of the borehole location. Both latitude-longitude and UTM* coordinates were noted.

- ***Reporting***: all information relating to each site was recorded on a paper form. This included a graphic log of the CCTV survey, with a comparison made between the completion report log and the CCTV log.

During the study, it became clear that boreholes fitted with Afridev hand pumps were preferable to those equipped with India Mk II pumps. This is because the latter………….

A methodology was developed to measure borehole parameter variables within information sources in the Primary Set (Table 1). These data were then compared in order to highlight any differences.

Figure 2. Water sampling

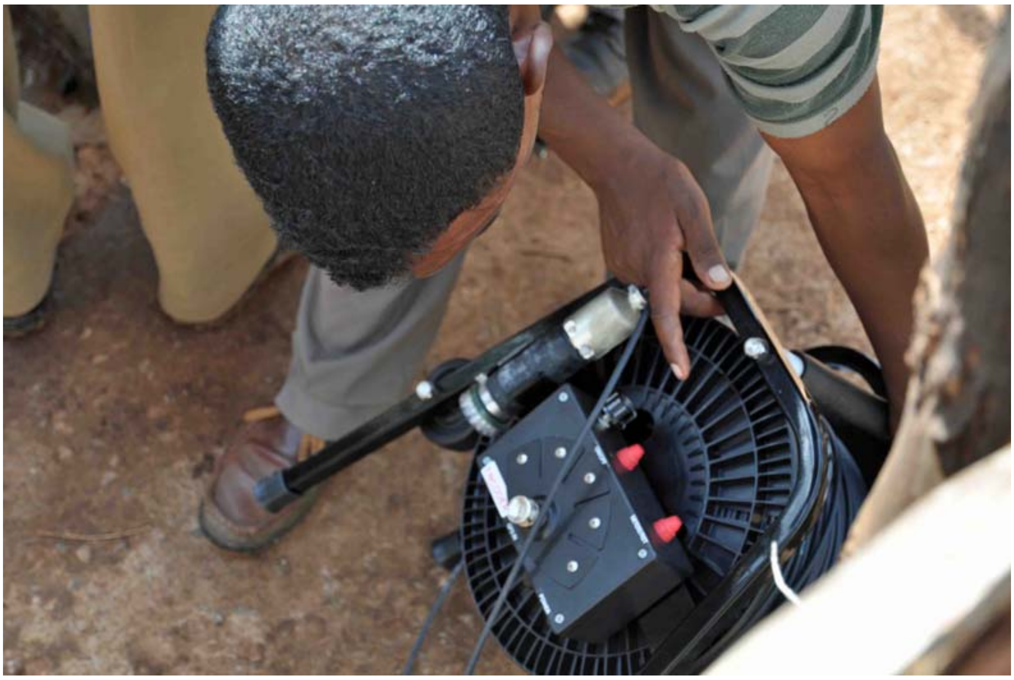

Figure 3. The CCTV camera

Figure 4. Tripod and camera

3 Results of the field work

Field work was carried out between 26 May and 17 June 2009. Table 2 provides a summary of the boreholes visited.

Table 2. Site summary

SITE	DATE VISITED	UTM East	UTM North	KEBELE	WOREDA	ZONE	REGION	FUNDER
Digo	27/05/2009	288537	844538		Omo Nada	Jimma	Oromia	WB
Toli Sebeta	27/05/2009	298220	845669		Omo Nada	Jimma	Oromia	
Birbisa	28/05/2009	277909	853801	Serbo	Kersa	Jimma	Oromia	PLAN
Liban	29/05/2009	317418	856496	Liban Bole	Sokoro	Jimma	Oromia	WB
Oddo	31/05/2009	354892	939234	Gamboro	Amaya	SW Shoa	Oromia	UNICEF
Atnafo	31/05/2009	352231	940018	Chekesie	Amaya	SW Shoa	Oromia	Glimm of Hope
Waguta	01/06/2009	361150	947419	Abado Hole	Amaya	SW Shoa	Oromia	UNICEF
Haro/Hole	01/06/2009	363351	947412	Abado Hole	Amaya	SW Shoa	Oromia	WASH
Gololle	02/06/2009	325352	933660	Gulale	Nanno	W Shoa	Oromia	NGO
Taramesa School	04/06/2009	440491	757686	Taramesa	Shebedino	Sidama	SNNPR	UNICEF
Shemeta	06/06/2009	439108	755477	Sedeka	Shebedino	Sidama	SNNPR	UNICEF
Gya	06/06/2009	438241	757702	Fura	Shebedino	Sidama	SNNPR	PLAN
Sasamo Dela	06/06/2009	440312	39325		Dale	Sidama	SNNPR	WASH
Adoshe	07/06/2009	440783	753000	Degamo	Dale	Sidama	SNNPR	Action Faim
Wangela	07/06/2009	426171	746985	Kuna	Dale	Sidama	SNNPR	WASH
Jejeba	08/06/2009	417895	668968	Gishe	Gedebe	Gedio	SNNPR	UNICEF
Gayo	10/06/2009	361922	924439	Dire Laffo	Abeshgehu	Gurage	SNNPR	WASH
Lencha	10/06/2009	372149	917602	Layegnano	Abeshgehu	Gurage	SNNPR	WASH
Gasory	12/06/2009	360904	912057	Gasory	Abeshgehu	Gurage	SNNPR	
Bukasa	12/06/2009	364111	926825	Abado Bukasa	Goru	SW Shoa	Oromia	WASH
Aroji	13/06/2009	364561	951794	Dere Aroji	Amaya	SW Shoa	Oromia	UNICEF
Korbessa	13/06/2009	360019	939942	Bereda Chelo	Amaya	SW Shoa	Oromia	UNICEF
Kekewie	14/06/2009	350050	938741	Chaksie Kessie	Amaya	SW Shoa	Oromia	Glimm of Hope
Chebo	15/06/2009	372230	924267	Chinifer	Goru	SW Shoa	Oromia	R WASH
Chitu	15/06/2009	380823	933183	Leman Abu	Goru	SW Shoa	Oromia	R WASH
Wayou	16/06/2009	365469	924394	Wayou	Goru	SW Shoa	Oromia	R WASH

Table 2 shows that 16 boreholes were located on Oromia with the remaining 10 in SNNPR, with seven funding sources. Out of the 26 sites visited, 20 had both documentation available and a CCTV survey carried out. Of the remaining 6 sites, the Gololle and Gasory boreholes contained India Mk II pumps which could not be removed. Here, the camera could not be lowered all the way to the bottom of the borehole because of the lack of space between the steel riser pipe and the casing. The remaining four: Digo, Birbisa, Gya and Adoshe still had no Completion report available at the time of writing. The 26 sites were visited over 21 days full field work. The rate of 1.2 sites per day reflects the conditions encountered during the survey due to the following factors:

- Site locations: Accurate map coordinates were rarely available. The team had to be guided to each borehole by local technicians from the MoWRD office. Access to boreholes was frequently difficult, with only rough tracks present in most cases. The distances between each site and the time taken for travel was a major limiting factor.
- Identification of boreholes: there were instances where two boreholes were found in the area around a village. Further inquiries were necessary to establish the correct site.
- Pump installations: Where hand pumps were installed, they had to be removed before the CCTV camera could be lowered into the boreholes. Removal and re-installation of the pumps would take over 3 hours in most cases.

Table 3 shows details of surveyed borehole depths and compares them to the completion reports (CR). Entries coloured red have strong discrepancies, those in yellow are borderline.

Table 3. Borehole depth details

SITE	DRILLER	CCTV SURVEY	PUMP PRESENT	CR DEPTH (m)	SURVEY DEPTH (m)	RATIO SURVEY DEPTH TO CR DEPTH	COMMENT	CONCLUSION
Digo	KSR	No	Yes	N/A	N/A	N/A	No depth confirmation	Probably OK
Toli Sebeta	KLR	Yes	No	70	70	1	Still original depth	Probably OK
Birbisa	WWCE	Yes	No	150	146	N/A	No depth confirmation	Unknown
Liban	KSR	Yes	Yes	60.4	52.5	0.87	Likely to be silting	Probably OK
Oddo	Osho	Yes	Yes	55	18.5	0.34	Discrepancy	Suspect
Atnafo	Nile	Yes	Yes	60	52	0.87	Likely to be silting	Probably OK
Waguta	Osho	Yes	Yes	54	44.8	0.83	Likely to be silting	Probably OK
Haro/Hole	KSR	Yes	Yes	57	47.4	0.83	Likely to be silting	Probably OK
Gololle		Yes	Yes	N/A	N/A	N/A	No depth confirmation	Unknown
Taramesa	MoWRD	Yes	Yes	52	53	1	Still original depth	Probably OK
Shemeta	MoWRD	Yes	Yes	44	42.7	0.97	Almost orig. depth	Probably OK
Gya	Royal+Raj	Yes	No	N/A	121.5	N/A	No depth confirmation	Probably OK
Sasamo Dela	KLR	Yes	No	99	95	0.96	Almost orig. depth	Probably OK
Adoshe		Yes	Yes	N/A	50.4	N/A	No depth confirmation	Unknown
Wangela	KLR	Yes	No	174	145+	0.9	Likely to be near original depth	Probably OK
Jejeba		Yes	Yes	49	48.4	0.99	Almost orig. depth	Probably OK
Gayo	Royal+Raj	Yes	Yes	59.8	60.6	1	Still original depth	OK
Lencha	Royal+Raj	Yes	Yes	82.8	84.1	1	Still original depth	OK
Gasory	Nanwash	Part	Yes	86.2	N/A	N/A	No depth confirmation	

SITE	DRILLER	CCTV SURVEY	PUMP PRESENT	CR DEPTH (m)	SURVEY DEPTH (m)	RATIO SURVEY DEPTH TO CR DEPTH	COMMENT	CONCLUSION
Bukasa	KSR	Yes	Yes	60	58	1	Still original depth	OK
Aroji	Osho	Yes	Yes	47	32.4	0.69	Discrepancy	Suspect
Korbessa	Osho	Yes	Yes	50	42.9	0.86	Likely to be silting	Probably OK
Kekewie	Nile	Yes	Yes	54	52.3	0.99	Still original depth	OK
Chebo	KSR	Yes	Yes	50	46.5	0.93	Almost orig. depth	OK
Chitu	KSR	Yes	Yes	53	51.5	0.97	Almost orig. depth	OK
Wayou	KSR	Yes	Yes	60	47.6	0.79	Likely to be silting	Probably OK

3.1 BOREHOLE DEPTH

From Table 3, any borehole showing a ratio of survey depth to the CR depth of 0.8 or thereabouts was considered to have been drilled to the stated depth. Twelve sites returned a ration of more than 0.9. A further six boreholes (highlighted in yellow) were between 0.79 and 0.9: their reduction in depth is also assumed to be due to silting-up inside the well screen and casing, although they are more extreme cases.

Only two boreholes, Oddo and Aroji, had ratios less than 0.7 (survey depth is 70% or less than CR depth), with the former returning a very low ratio of 0.34 (34%). Unless there has been a misidentification of the sites, these two are clearly at odds with the CR and invoice data. Oddo was invoiced for 55 m of drilling, but had a survey depth of only 18.5 m, with a short section of well screen from 11 to 14 m below ground level (bgl). The Aroji borehole, found to be 32.4 m deep, was invoiced for 47 m. Unless silting was particularly severe at this site, or misidentification has occurred, there is clearly a mis-match between field results and the paperwork. It should be noted that supervision of drilling is normal in Ethiopia, but is often undertaken by junior hydrogeologists.

Table 4 shows the broad agreement between CR and invoice depths. Entries coloured red have strong discrepancies, those in yellow are borderline.

Table 4. Comparison of invoice, completion report and survey depths

SITE	INVOICE DEPTH (m)	CR DEPTH (m)	SURVEY DEPTH (m)	RATIO SURVEY DEPTH TO CR DEPTH
Digo	60	N/A	N/A	N/A
Toli Sebeta	70	70	70	1
Birbisa	148	150	146	0.97
Liban	61.4	60.4	52.5	0.87
Oddo	55	55	18.5	0.34
Atnafu	60	60	52	0.87
Waguta	54	54	44.8	0.83
Haro/Hole	57	57	47.4	0.83
Gololle		N/A	N/A	N/A
Taramesa School	52	52	53	1

SITE	INVOICE DEPTH (m)	CR DEPTH (m)	SURVEY DEPTH (m)	RATIO SURVEY DEPTH TO CR DEPTH
Shemeta	44	44	42.7	0.97
Gya		N/A	121.5	N/A
Sasamo Dela	99	99	95	0.96
Adoshe		N/A	50.4	N/A
Wangela	174	174	145+	0.9
Jejeba	49	49	48.4	0.99
Gayo	64.4	59.8	60.6	1
Lencha	81.55	82.8	84.1	1
Gasory		86.2	N/A	N/A
Bukasa	60	60	58	0.97
Aroji	47	47	32.4	0.69
Korbessa	50	50	42.9	0.86
Kekewie	53	54	52.3	0.99
Chebo	50	50	46.5	0.93
Chitu	53.14	53	51.5	0.97
Wayou	60	60	47.6	0.79

3.2 SCREEN LENGTH AND DIAMETER

Table 5 shows a comparison between CR and survey screen lengths and diameters, where available. The Oddo and Aroji sites have unacceptable ratios for reported and surveyed sceen lengths.

Table 5. CR and survey screen length ratios

SITE	CR SCREEN LENGTH (m)	SURVEY SCREEN LENGTH (m)	RATIO SURVEY SCREEN LENGTH TO CR SCREEN LENGTH	CR to SURVEY DIAMETER RATIO	WELLHEAD CONSTRUCTION
Digo	N/A	N/A	N/A	1.0	Good
Toli Sebeta	18	Not seen	N/A	1.0	Not complete
Birbisa	N/A	Not seen	N/A	1.0	Not complete
Liban	14.15	Not seen	N/A	1.0	Good
Oddo	11.4	3.0	0.26	1.0	Acceptable
Atnafu	17	Not seen	N/A	1.0	Good
Waguta	11.4	11.2	0.99	1.0	Good
Haro/Hole	14.25	Not seen	N/A	1.0	Good
Gololle	N/A	Not seen	N/A	1.0	Acceptable
Taramesa School	N/A	Not seen	N/A	1.0	Acceptable

SITE	CR SCREEN LENGTH (m)	SURVEY SCREEN LENGTH (m)	RATIO SURVEY SCREEN LENGTH TO CR SCREEN LENGTH	CR to SURVEY DIAMETER RATIO	WELLHEAD CONSTRUCTION
Shemeta	11.2	10.6	0.95	1.0	Good
Gya	N/A	24	N/A	1.0	Not complete
Sasamo Dela	N/A	Not seen	N/A	1.0	Not complete
Adoshe	N/A	8.6	N/A	1.0	Good
Wangela	40	N/A	N/A	1.0	Not complete
Jejeba	8.5	N/A	N/A	1.0	Good
Gayo	8.8	13.0	1.00	1.0	Good
Lencha	21.6	20.0	0.93	1.0	Good
Gasory	N/A	N/A	N/A	1.0	Good
Bukasa	21.0	20.0	0.95	1.0	Poor
Aroji	11.4	4.2	0.37	1.0	Acceptable. Drainage poor
Korbessa	11.4	9.7	0.85	1.0	Acceptable
Kekewie	16.3	13.8	0.85	1.0	Poor
Chebo	16.0	16.0	1.00	1.0	Acceptable. Drainage poor
Chitu	20.0	20.0	1.00	1.0	Acceptable. Drainage poor
Wayou	15+	12.8	0.85	1.0	Poor

Absence of CR information, turbid water, preventing a view of the screen during the CCTV survey or snagging on riser pipes meant that only 12 screen length ratios could be calculated. Of these, the previously highlighted boreholes at Oddo and Aroji had ratios of 0.26 and 0.37 respectively. The remainder had ratios of at least 0.85, which were considered acceptable.

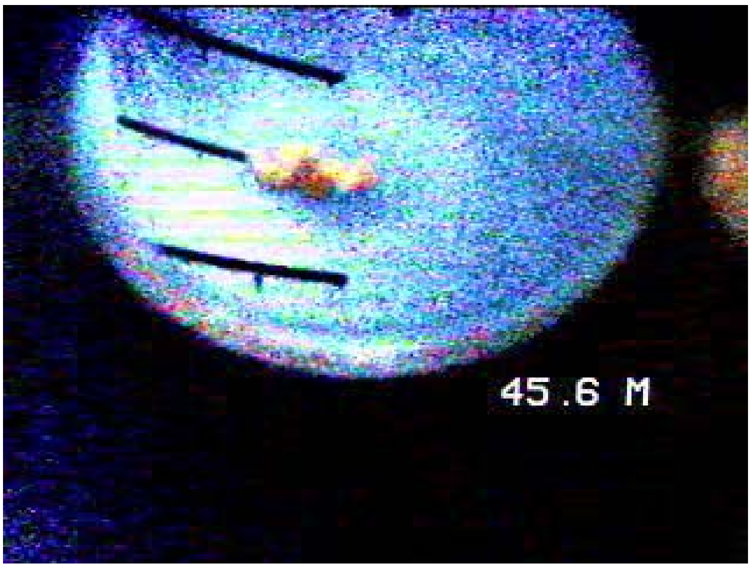

Figure 5. Screen slots and iron bacteria in the Gayo borehole

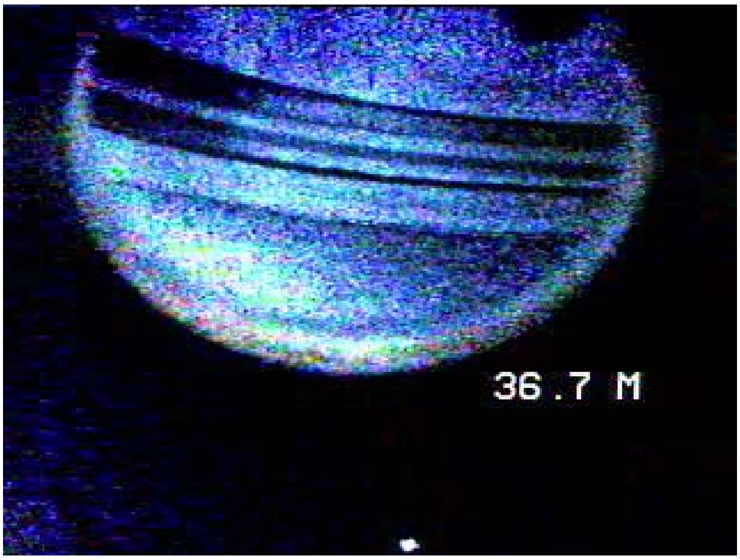

Figure 6. Partly-threaded PVC casing in the Gayo borehole

Figure 7. Steel rising main in the Gasory borehole

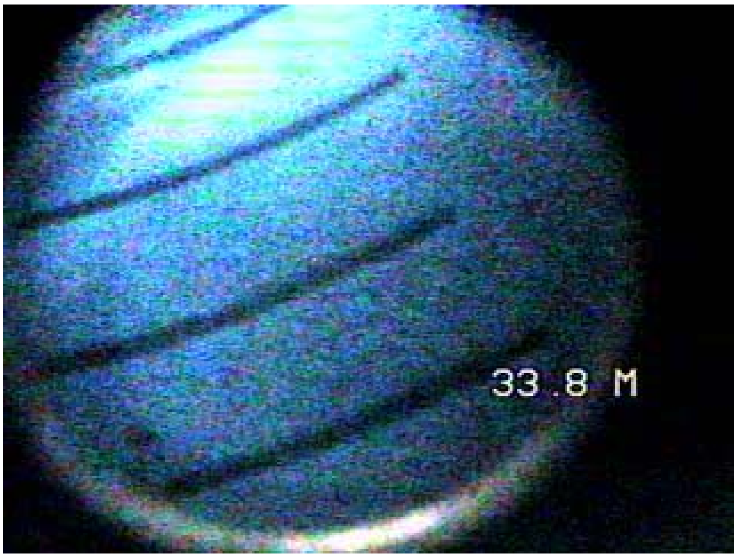

Figure 8. Wayou borehole at 33.8 m below surface

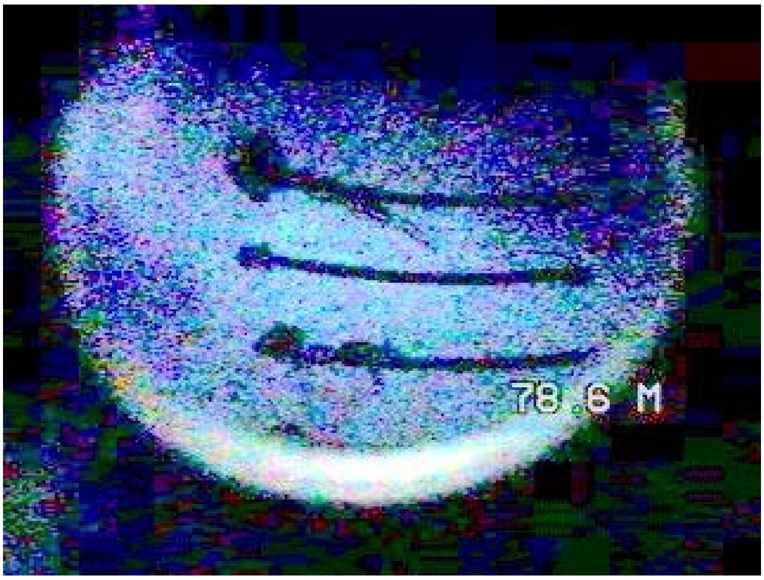

Figure 9. Partially-blocked screen in the Tatesa borehole at 78 m bgl

Casing and screen diameters were all as per specification and invoices. The diameters of the casing were standard for hand pump installation.

3.3 BOREHOLE CONSTRUCTION

Table 5 provides comments on borehole and well head construction. Most sites were either well constructed or were still waiting for completion (pump installation and plinth construction. However, the boreholes at Bukasa, Kekewie and Wayou had poor concrete plinths which were unacceptable for use. These plinths were constructed with a layer of concrete too thin to bear the weight of the people using the well and had, as a consequence, partly collapsed and cracked. This could allow waste water to infiltrate below the plinth and find its way back into the borehole. Boreholes at Aroji, Chebo and Chitu had good plinths, but did not have adequate drainage channels to lead waste water away from the well head. As a consequence, standing water had formed a swampy area adjacent to the borehole where ponded water could eventually leak back into the borehole.

4 Lessons learned

The data collation and field survey have highlighted several issues that may be relevant to any future work of a similar kind.

4.1 PLANNING AND TIME ALLOCATION

4.1.1 Data collation

The project confirmed that completion reports, contract specifications and invoices are located in many offices across the Regions. It can take a significant period of time to establish exactly which office they are in and who is responsible for their storage. For a project of this scale, at least 10 days should be allocated at the start of the project for data gathering.

4.1.2 Site locations

It is essential to have as good an idea as possible prior to the field work stage of where the sites are located. Only a few completion reports contained coordinate information and most just had a village name. In practical terms, many sites can only be located within a 5 km radius prior to travel. A reconnaissance of all the sites prior to the arrival of the survey team would have led to a larger number of sites visited, as planning daily journeys would have been more effective.

4.1.3 Time of survey

The survey was carried out at the end of the dry season, in late May and early June. This made travel to sites relatively easy. However, towards the end of the field work, periods of thundery rain caused rivers to rise and fields, underlain by black volcanic soil, to become very heavy and impassable. If rainy weather had occurred throughout the field work phase, then progress would have been much slower.

4.2 FIELD SURVEYS

4.2.1 Local help

It is essential to have a local MoWRD technician as part of the team at all sites. He can liaise with local water committees and provide technical expertise when removing pumps. Daily per diem payments are expected.

4.2.2 Borehole identification

There were occasions when identification of the borehole was uncertain where two or more hand pumps were in use within a small area. Extra time taken to establish the correct site was taken at several sites.

4.2.3 Pump removal

In order to insert the camera into the borehole it is necessary to remove the hand pump from the borehole, including the riser. In the case of the Afridev pump, removal by hand is straightforward, as the riser I made of lightweight PVC. However, it is necessary to cut the 50 mm PVC riser into 6 m sections for ease of handling. Additional costs are therefore incurred when gluing the pipes back together. The time taken for pump removal and re-installation averaged 3 hours.

Figure 10. Removing the PVC riser

4.2.4 CCTV survey

Removing pumps causes disturbance of sediment within boreholes which results in turbid water conditions. This can obscure the view of the well screen when lowering the camera down the borehole. A period of up to two hours should be allowed in order to let the sediment settle.

4.3 INTERPRETATION OF RESULTS

4.3.1 Depth

Six boreholes were confirmed to have depths of 79% to 87% of the original, depth reported in the completion reports. This was interpreted as being due to silting because of the nature of the bedrock across much of the Oromia and SNNPR Regions. Layers of volcanic basalt commonly weather to clay minerals and this material can often be found when drilling boreholes. Once constructed, clay minerals can infiltrate the gravel pack and well screen to form a layer at the base of the borehole. This layer can be significantly thick in certain boreholes and can lead to a complete silting-up almost to the water table surface in some cases.

In general terms, the original depths of the surveyed boreholes were reasonable for the intended use involving hand pumps or submersible installations.

4.3.2 Borehole construction

Overall, the standard of construction of the surveyed boreholes was good. Hand pumps were correctly installed and depths/diameters of boreholes were as expected. However, in some cases, the well head concrete plinths were substandard and not fit for purpose. Also, for certain sites, more thought could have gone into designing effective drainage systems for waste water.

One aspect of borehole construction found in the sample should be discussed. The initial drilling diameters of between 10 and 12 inches (300 to 350 mm) and final depth diameter of 200 mm were reasonable for the eventual installation of 140 mm diameter uPVC casing and well screen, with gravel pack. However, it could be beneficial for future installations to modify construction techniques.

In some instances, drilling diameters may be reduced, and therefore costs lowered, where boreholes are constructed in hard rock aquifers. However, the survey area was located within exposures of volcanic lava flows, which have partly weathered to clay minerals which form clay and silt. This leads, in many cases, to the presence of loose silt and clay in boreholes. The problem can be reduced by increasing the thickness, but reducing the grading size of the gravel pack surrounding the well screen. Increasing the thickness of the gravel pack means that the diameter of original drilled borehole would have to be larger at, say, 250 mm to final depth, leading to increased drilling costs. However, a gravel pack of 50 mm thickness could then be installed, which should be more effective in keeping clay and silt out of the borehole. Using a gravel pack grading of up to 2.5 mm diameter would be preferable to the apparently standard Ethiopian use of up to 9 mm gravel.

A reduction in the slot size of the screen could also be beneficial. In all cases in the survey, a slot size of 2.5 mm width was found. This is quite large for areas of weathered rock formations and could be reduced to 1 or 1.5 mm for future boreholes.

4.3.3 Borehole location

In almost every case, the location of the boreholes was determined by technical issues relating to the geology and hydrogeology, but also bearing in mind the needs of the local community, the eventual users. The survey found that boreholes were located in reasonable locations from a technical viewpoint and there was no evidence of any variations due to other reasons.

5 Conclusions

- For 24 of the 26 boreholes sampled for the survey, no evidence of deliberate altering of reports or invoices was found.
- Two boreholes which were considerably shallower than reported in the documentation, if correctly identified, showed evidence of a mis-match between the completion reports and the survey data.
- Overall, the standard of borehole construction was high for shallow wells fitted with hand pumps.
- Certain sites suffered from poor plinth construction or a lack of waste water drainage facilities.
- For the future, the problem of silting in boreholes located within areas of weathered basalt may be reduced by increasing the drilled diameter and using a different gravel pack.