

Report on Completion of Training for Borehole Rehabilitation

1. Outline of the Training

1-1. Name of Panelist: Tadao SUZUMURA

1-2. Specialty: Borehole Rehabilitation

1-3. Period of training From: 24 November To: 7 December 2006

1-4. Outline of the Contents

This training course aims to transfer of rehabilitation technology of borehole which has been used for many years to Ethiopian engineers of mostly hydrogeologists. In Ethiopia, 6 inches diameter borehole of iron pipes installed is common. Needs for rehabilitation of boreholes might be increased in future. Through the groundwater development training course, drilling and groundwater investigation technology has been introduced in considerably in high and deep level. On the other hand, borehole rehabilitation technology had started since 2004. A basic information of borehole to be rehabilitated are sometimes lacks of geological log, borehole structure, electrical logging data and screen location, pumping test data, water quality data and operation records etc., and replaced a person in charge for such works. When borehole rehabilitation is needed urgently, rehabilitation method should be properly selected and carried out. In this situation, the training course is executed to explain main borehole troubles and damaged causes with overseas examples of rehabilitation, and manufacture rehabilitation tools and explain their operation methods.

To rehabilitate borehole, camera or TV set is necessary, however, it has high technology of optical and micro electrical technology plus water proof of the apparatus to put into deep groundwater depth. Only three borehole TV camera sets are available in Ethiopia. Though one set exists in this center, the borehole TV camera set was out of order unfortunately. Due to difficult to find a necessary spare parts to be repaired, the camera TV is under way to send back to manufacturer.

This training course made efforts so that the engineers start borehole rehabilitation in each Region by manufacturing necessary rehabilitation tools by using local materials as much as possible including borehole camera. All other materials with except of digital camera and timer set can be found at local market. The timer set brought from Japan is an example to be manufactured in Ethiopia by using available electrical parts in local market. Though Kodak film camera is still popular in local area in Ethiopia, its mechanical shutter system and automatic power off system are hard to clear for borehole camera use. In future, digital camera will be popular in Ethiopia, then, this training course applied to use digital camera. Other necessary rehabilitation tools such as brush, swabbing, double packers are introduced how to manufacture

them by using local materials.

2. Contents of the Training Course

1-1. Field: Borehole Rehabilitation

1-2. Period: From: 7 November 2006 To: 30 November 2006

1-3. Participants of the Training Course

The participants are listed below Table;

Table List of the Participants

No.	NAME	AGE	Office	Position	Graduated
1	Ato. Elias Shumiye	23	Ministry of Water Resources	Geologist	Bsc. Geology
2	Ato. Seiyfu Tadesse	24	Arba Minch W/R/D Office	Geologist	Bsc. Geology
3	Ato. Emiru Wadajo	48	Oromia Water Resource Bureau	Electrical Engineer	Bsc. Electrical Engineering
4	Ato. MekonnenTiginen	27	Siltie Zone W/R/D Office	Geologist	Bsc. Geology
5	Ato. Gezahegn Deme	32	Oromia Water Resource Bureau	Geologist	Bsc. Geology
6	Ato. Ermiyas Wondwosen	25	Oromia Zone, T/T/W/A/R/D	Geologist	Bsc. Geology
7	Ato. Jarso Kabeto	31	Oromia Water Resource Bureau	Geologist	Bsc. Geology
8	Ato. Tadesse Shewakena	29	Oromia Zone,T/T/W/A/R/D	Geologist	Bsc. Geology

1-4. Available Existing References in the Center

The following references documents are available in this center for borehole rehabilitation;

- Report on Completion of Training for Borehole TV Survey, October 2004
- Training Plan on Borehole TV Survey Technology (BTV), September 2004
- Quick Reference Manual on the R-2000 Dual TV Camera, October 2004
- Operations Manual by LAVAL Co., Ltd.
- Training Manual for Borehole Maintenance & Rehabilitation; Metaferia Consulting Engineers, February 2001

1-5. Training Course

The following training has been introduced by the lecturer

- Explanation of the seven water natures (water molecule is the smallest in nature condition, keeping temperature, dissolution, buoyancy, flowing power, hydropower, ultra water and magnetism of water)
- Cause of borehole pipe damage, and iron pipes corrosion by groundwater quality in Ethiopia
- Rehabilitation Case-1 in overseas: Patch method and flexible ring place method
- Rehabilitation Case-2 in overseas: Double casing pipe installation
- Rehabilitation Case-3 in overseas: Removal of plugged materials in packed gravels and aquifers by using CO₂ liquid gas

- (6) Rehabilitation Case-4 in overseas: Re-drilling of the borehole
- (7) Borehole camera arrangement by using digital camera
- (8) Manufacturing of timer set to be installed to digital camera set
- (9) Rehabilitation tools-1: Manufacturing of brush and its field use, and manufacturing of swabbing tool
- (10) Rehabilitation tools-2: Manufacturing of double packer for partial water jetting and rapid cementing
- (11) Rehabilitation tools-3: Manufacturing of swabbing tool
- (12) Flow chart and reporting of rehabilitation work
 - ◇ Mapping of boreholes locations to be rehabilitated by using GPS
 - ◇ Field work flow
 - ◇ Compilation of photos taken from borehole
 - ◇ Judge of rehabilitation effects from groundwater drawdown amount (S_w), comparison of well loss (B) and aquifer loss (C) coefficients before and after the work

GPS data arrangement and photo compilation are used free soft wares and/or popular software such as Kashmir and GPS Utility, Photo Shop, Photo Editor and Excel so as to use by Ethiopian engineers easily.

Above training items from (1) to (6) are shown in Attached documents. For the items from (7) to (11) shall be explained below. The item of (12) is shown in the next chapter based on the field survey work in this training period.

(7) **Borehole Camera Arrangement by Using Digital Camera**

Camera Model-1: Fujifilm Co., Ltd, FinePix1400. The 1 MB pixel. The 128 pictures can be taken by 128 MB smart media of former type. Non-automatic switch off. “AAA” size batteries: 4 pieces.

As shown in below right photo, shutter button will be opened and the two terminals of front and centre, out of the three terminals, shall be connected to electric wire to extend to timer set or electric wire for manual switch on. This model camera is enough large size shutter button to modify. By the six screws loosening, main parts can be separated easily, then, the same electric circuit board can be replaced when it is out of order. It can be installed to the diameter of 100mm container, and possible to take photos for six inches borehole.



Left: Shutter button connection



Right: Under drying due to water intrusion

Camera Model-2: Fujifilm Co., Ltd, FinePix A303. The 3.2 MB pixel. The 48 photos can be taken by 16 MB smart media. Two minutes of auto power off. “AAA” size batteries: 2 pieces

Shutter button can be opened and two terminals shall be connected by electrical wire. It is too small to dismantle and re-assemble to repair. It can put container size of diameter 70 mm and possible to use for four inches diameter borehole.

At present, FinePix A303 only is usable. Out of two sets of FinePix1400, one set is out of order by water intruded. The other one set is possible to “power on” but not working. These three cameras are possible to close-up to 3 to 5 cm in distance. Power source is by commercial base dry battery of 1.5 V which is convenient to procure in any local market. Pictures taken from borehole shall be downloaded to computer through memory card or accessory cable with Fujifilm soft ware. After downloading pictures to computer, color, brightness and gamma adjustment can be done by Phot Shop or Photo Editor soft wares.

(8) Manufacturing of Timer Set

Above digital cameras can take 128 pictures by 128 smart media (Fine Pix 1400) and/or 384 pictures by 128MB memory (Fine Pix A303) with the shutter intervals of every seven seconds. In order to more smooth and easy operation, automatic self timer system are manufactured and tested at Yiruba borehole to the depth of 120 m. After its test, three kinds of timer system are manufactured;

Timer-1: Altered Radio Cassette Deck Part

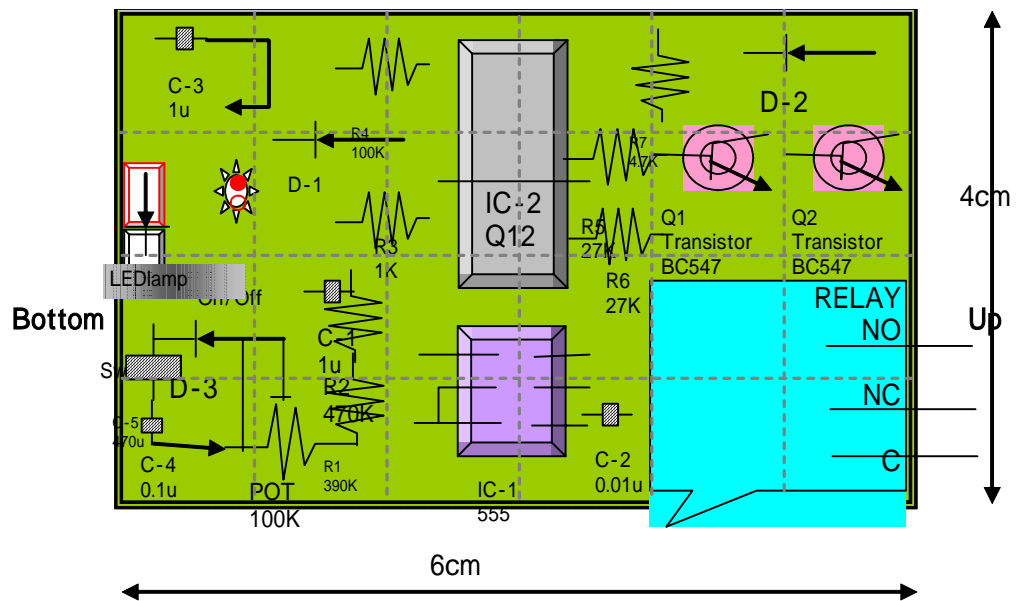
DC 12V motor is replaced with 6V motor to reduce necessary battery volume.



Left: Timer set by Radio Deck and E-K Japan (PU-2705)
 Right: Tested depth: 120m (battery is in plastic bag)

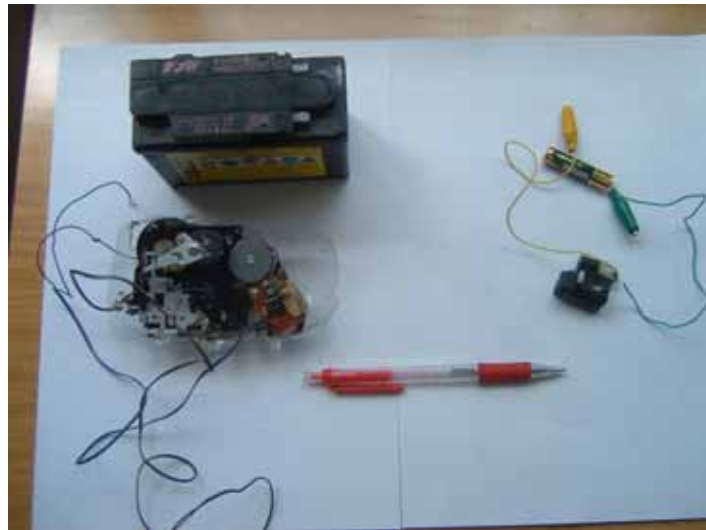
Timer-2: E-K Japan (PU-2705)

The timer set brought from Japan has the size of 5 x 6 cm. In order to put into available smaller size container, the electrical circuit was designed as shown below drawing of 4 x 6 cm in size;



Timer-3: Recycled Motor from Digital Camera Parts

To minimize the timer space, the small motor from water intruded Fine Pix 1400 camera was recycled. This system is under preparing. The size is smallest among the three types of timer systems, then, smaller container can use with more strong durability by smaller size effect against water pressure. In next stage, the system shall be planned to use up to the depth of 120m or 150m below water level. The below left picture shows that timer-1 system used in this field work with large battery and the right side picture shows the Timer-3 under preparing with necessary battery of “4A size”. Timer-3 system can set in the same container of camera in next stage.



(9) Manufacturing of Rehabilitation Tools (Brush and Swabbing)

These rehabilitation tools are of consumable one. Therefore, all materials are made by using local available materials. Brushing tool was confirmed its effectiveness at site. Swabbing tool shall be confirmed in near future by the participants.



Just before brushing



After brushing used

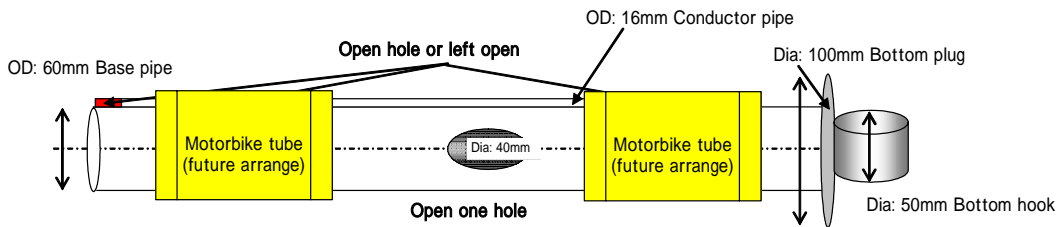


Swabbing tool under manufacturing by using wasted old tire and wooden materials

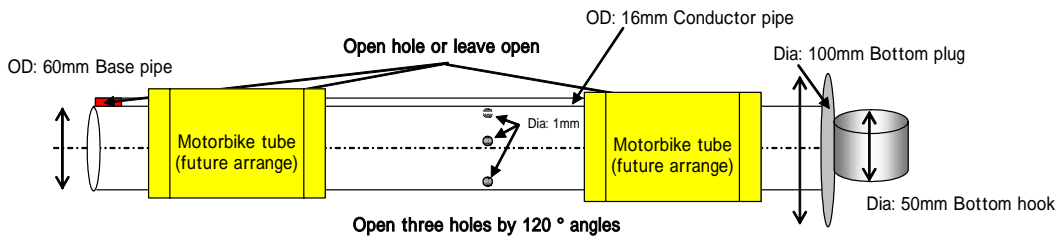
(10) Manufacturing of Double Packer System

In general, air packer system is common. However, high pressure nitrogen bomb, air pressure regulator, and high pressure air hose are not available in Ethiopia. Therefore, water pressured packer system is adopted. The system is tested at Yiruba village borehole at the depth of 100 m. The result shows that electric wire to be inserted in water hose is necessary to detect hose water level to adjust water pressure of packer, and water leakage counter measurement in and around the packer is necessary.

Type-A: Double packer rapid cementing device



Type-B: Double packer water jetting device



Design Drawing of Packer



Above: Cutting work of wasted pipes



Right: Packer Test



Insert of water level wire into water hose



Water injection to the hose

3. Comments from the Participants

The participants are attended to the period from 7 Nov to 30 Nov for the course.

Table List of the Attendants Participated

Name & Date	7	8	9	10	13	14	15	16-21	22	23	24	27	28	29	30
Ato. Elias Shumiye	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Seiyfu Tadesse	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Emiru Wadajo	F	F	F	F	F	F	F	F	F	F	F	F	F	-	
Ato. MekonnenTiginen	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Gezahegn Deme	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Ermiyas Wondwosen	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Jarso Kabeto	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Ato. Tadesse Shewakena	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Note: "F": Full attendant, "-": Urgent leave, **Bold portion: Field activity**

The seven participants submitted us the inquiry. The result is shown below;

Table: Participants Comments and Evaluated Achievement Result by Each Participant

ITEMS	A	B	C	Total	Remarks
Lecture					
L1: Water nature & cause of borehole pipe damages	6	1	-	7	The participant of "B" commented is requesting more detail for L2 (his evaluated achievement result is the lowest) Most of highly evaluated participants show their opinions as follows; - one participant complained for inconvenient of useless of damaged camera in the center, and expressed thanks for the alternative digital camera method by manufacturing
L2: Introduction of overseas case for the rehabilitation method	6	1	-	7	
L3: Manufacturing of borehole camera in Ethiopia	6	-	1	7	
L4: Manufacturing of rehabilitation tools	6	1	-	7	
Field Activity					
F1: Acquisition of borehole photos	5	1	1	7	- one participant complained for English communication difficulty - one participant explained the difficulty of timer set manufacturing
F2: Brushing work	5	1	1	7	
F3: Check of manufactured double packers	5	1	1	7	
F4: Data compilation (GPS & photos)	5	1	1	7	
F5: Presentation by using computer soft wares	6	-	1	7	
Evaluated Achievement Result	3	2	1	6	One participant is not submitted

Note: A: "Excellent", B: "Fair", C: "Disappointed"

For the evaluated achievement result by each participant A: 90-81%, B: 75-71%, C:60%

4. Comment from the Lecturer

In general, the participants' evaluation for their achievement on the course is satisfactory result. However, some participants complained for useless of the borehole camera in the center under repairing. On the other hand, the introduced alternative manufacturing and using method by digital camera is appreciated by them for its cost performance and possibility to apply even in local area.

Through the course of the field survey, the lecturer tried to apply "Kodak film camera", which is the most economic and the most convenient method in remote area for borehole photos. It is regretted that no one had interested for this idea. It seems that the participants expect to use the latest and modern system of high price. When a high priced borehole camera is broken, it should be understood by the participants that high repair cost and its careful operation and maintenance are required. It is important to recognize that borehole rehabilitation tools and instrument shall be manufactured by using local materials as much as possible to minimize cost and to be able to have necessary tools in any places.

It seems that many engineers engaged in local area are under an inconvenient condition to use a computer at present. They have not much chance to use the latest and modernist apparatus and instrument. In this situation, transfer technology for such equipment or instrument is important to explain its basic mechanical structures, how to modify them to use in site, their applying methods and how to repair them. A transfer of knowledge of simple switch panel operation for such equipment and instrument will be hard to understand its mechanism and how to repair it.

The most of participants are introvert. Whenever the lecturer asked any question in each lecture time, their opinions are not responded in most of cases. For more communication in each other, it is recommendable to make close contact each other by using out of service hours.

5. Recommendations and Request for Next Training Program

For borehole rehabilitation, manufacturing of necessary tools and acquiring of practical rehabilitation method is necessary. The participants in this stage are mostly of hydrogeologists. However, drilling experts and electrical engineers are needed to cooperate for the work. Various kinds of engineers are recommended to participate. Also, the work will use the following equipment and tools. Therefore, arrangement of necessary equipment and tools are needed in next stage.

1. Pumping test of the two step drawdown at least before rehabilitation
2. Borehole camera observation to find problem location, and selection of suitable rehabilitation method
3. Brushing (when the above-2 taken “pictures” are not clear, re-picturing work is necessary)
4. Rehabilitation (swabbing, partial water jetting, rapid cementing etc)
5. Bailing to remove dirty groundwater by brushing and swabbing
6. Pumping test of the two step drawdown at least after rehabilitation
7. Borehole camera observation to confirm the effect of the work
8. Reporting

Note: Necessary equipments for the above under line are to be prepared.

6. Output from This Training Course

The three (3) sites borehole camera observation and brushing, packer effect are tested in this stage. The location is Ziway town water supply borehole, Awassa town shallow dug well and Yiruba village deep tube well. As one crane car was available at Ziway town, brushing work only carried out for the town water supply borehole. The brushing depth is up to the depth of 60m because that the pre-information was 50m long borehole and arranged pipe was 60m only. The following output was resulted;

- ◇ Brushing effect was confirmed by the photos taken before and after brushing
- ◇ Photos for dug well in Awassa town was taken by the method of every forty five degrees from magnetic north by clock wise for each one meter depth up to the depth of 10 m. Actual outcrop of basaltic lava condition was visually observed.
- ◇ Camera observation up to the depth of 80m in Yiruba village deep tube well was tested to confirm its water proof. The timer set was tested its reliability up to the depth of 120 m. The double packer was set at 100m in depth to test its efficiency. The problem was found by packer check test that water tightness (=leakage) is not sufficient and electrical wire is not suitable (=too large) to insert into the water hose to detect water level.

Attachment-1: Site information with location map and GPS data; page 12-14

Attachment-2: Photos before and after brushing; page-15

Attachment-3: Photos of shallow dug well; page-16

Attachment-4: Photos to the depth of 80m in Yiruba village; page-17-18