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## Lessons Learnt on borehole water supply during the first two BSF rounds

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## Welcome and Introduction

- WELCOME by Kate
- BSF team Juba involved in Lessons Learnt study:
  - Kate Louwes (Team Leader)
  - Geerte van der Meijden (M&E)
  - Serena Bossi (Financial administrator)
  - Simon Ngida (Administrative Assistant)
  - Sarah Baba (Office Manager)
- Consultant: Clarissa Mulders –
  - expertise: geophysical siting and drilling contract management in sub-saharan Africa
- Introductory round of participants





18 days assignment included

- collection and desk study of available siting and drilling documents, drilling contracts
- Analysis of NGO budgets and expenditures
- Interviews with BSF Contract management, grant recipients with base in Juba, sector Lead
- Field trip to AMREF/Aquafund project area in Eastern Equatoria
- Preparation of Lessons learnt report, and presentation

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## Agenda

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1. Introduction
2. Presentation:
  - Background info on water sector in S Sudan
  - Analysis of water project results 1<sup>st</sup> and 2<sup>nd</sup> round
  - Discussion of steps in the borehole construction process (actual vs. optimum) to evaluate actual performance
  - Lessons learnt / Best practices
3. Way forward
4. AOB

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## The water sector in S Sudan (1) – working environment of NGOs

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### HISTORY

The second civil war (1983 – 2005) has displaced 4 million southerners, a lost generation with no access to basic services.

In 1989 Operation Lifeline Sudan was established. OLS, run alongside UNICEF, coordinated work of most NGOs and UN agencies and ran up to 2003. By Jan 2004, rural water coverage was estimated at 25-30% (JAM aims at 60-60% by 2011; MDG 7).

### DATA

UNICEF developed a WES database and standard borehole completion logs for submission by implementers, currently being managed by DRWS. Backlog of data, and actual coverage unknown.

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## The water sector in S Sudan (2)

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**CAPACITY RURAL WATER DEPARTMENT**  
One staff per county -> no proper supervision feasible

### CONTRACTS

No standardised siting and drilling contracts, no standard designs/specifications

### O&M

According to Water Policy, O&M is to be carried out by end users. However, spare part supply chain and O&M structures are weak. UNICEF currently provides spare parts free of charge.

% of non-functional BHs unknown, but estimated high.

### DRILLING LOGISTICS

Incompetent and too few drilling contractors (in country).  
In dry season (Nov-May) all BHs need to be drilled.

## Summary of water supply project results - numbers



Organisation	Area of operation (States)	Through / drilling company	PLANNED water sources					ACTUAL water sources				
			New boreholes	Rehabilitated boreholes	New shallow wells	Rehabilitated shallow wells	New boreholes	Attempts	Rehabilitated boreholes	Shallow wells	Rehabilitated shallow wells	
1	Oxfam	Upper Nile, Unity	own rig	80	20	0	0	74	74	24	0	0
2	Medair	Upper Nile	own rig	10	5	5	0	10	10	0	5	0
3	AMREF/Aquafund	Central Equatoria	Aquafund International	20	10	0	0	19	26	10	0	0
4	Caritas-Switzerland	Eastern Equatoria	New Sudan Service & Delivery; Mango Camp	20	30	0	0	17	19	no data	0	0
5	Merlin/AVSI	Eastern Equatoria	AVSI / Draco Ltd.	10	0	0	0	10	10	0	0	0
6	IRC	N. Bahr el Ghazal	Geotechnical Drilling Company Ltd.	35	19	0	19	35	35	14	0	0
7	Save The Children - US	Upper Nile	no data	20	0	0	0	4	0	0	0	0
				195	84	5	15	169	171	48	5	0



## Summary of water supply project results – water quality

### Boreholes with technical information:

	Organisation	No. of boreholes drilled	Of which dry/low yielding	unfit for human consumption [No.]*	high mineral content (salty)	turbid	Boreholes installed
1	Oxfam	74	0	25	5	20	74
2	Medair	10	0	no data	9	no data	9
3	Amref/Aquafund	26	7	3	0	no data	19
4	Caritas	19	2	no data	no data	no data	no data
5	Merlin/AVSI	10	1	0	0	0	10
6	IRC***	20	0	0	0	1	20
7	Save The Children - US	4	no data	no data	no data	no data	no data

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\*Oxfam: based on test results of first 47 boreholes

\*\*Amref: Aquafund carried out E.coli tests. Of the 9 submitted well reports, four E.coli tests were reported, of which 1 had 2 cfu/100 ml., and 2 had more than 10 cfu/100 ml

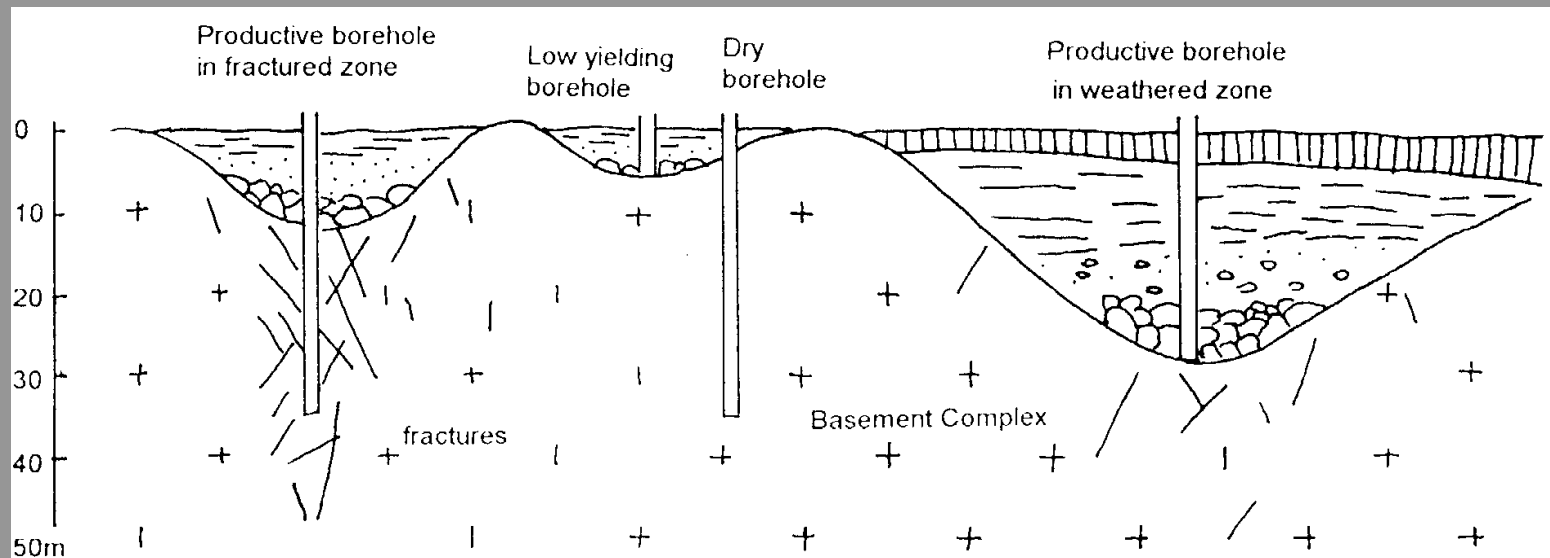
\*\*\* No. of boreholes drilled based on report of 1st 20 boreholes, and water quality based on records 2nd of 10 boreholes sampled.

*Section is intended to bring people with different professional background to similar level of understanding concepts*

## Theory

Water encountered in aquifers of which type depends on geology. In S Sudan basement rocks and sedimentary formations.

## Basement rocks:



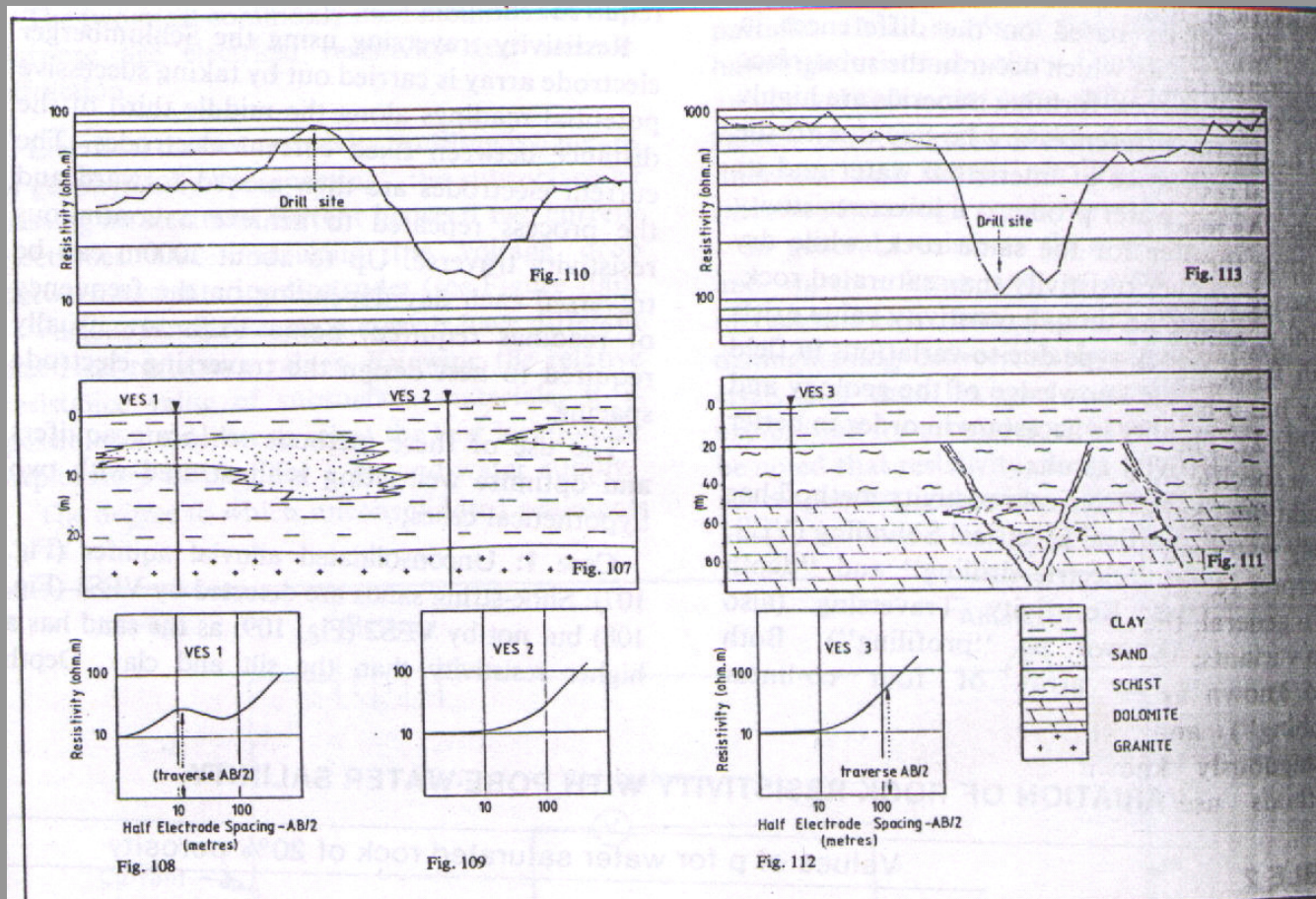
## Geophysical siting of boreholes (2)

Geophysical siting to locate aquifers - increases borehole success-rate (but certain failure rate remains following adverse hydrogeological conditions)

Mostly used is geo-electrical method: lower resistivity indicating water / fractures

- In Basement rocks siting aims to pinpoint water-bearing fractures and thicker overburden, -> localised / discontinuous aquifers
  - Method: through combination of Aerial photograph analysis, profiling and VES
- In Sedimentary formations siting aims to find sandy/gravelly layers, and avoid clay and saline water, -> (sub-) continuous aquifers
  - Method: (if any..) only VES and data existing boreholes
- Task of hydrogeologist rather than drilling company

# Geophysical siting of boreholes (3)



Sedimentary formation

Basement formation

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## Siting of boreholes (4)

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...and actual practice in BSF project:

Only Medair and Oxfam issued separate siting contracts, and have siting results, rest assumed drilling company would do it. Aquafund mentioned siting for 2 sites, but failed to produce siting results.

All boreholes drilled in sedimentary formation during BSF project (according to limited info) are yielding.. No siting required...?

Only AMREF/Aquafund drilled partly in Basement, of which 80% of boreholes were dry. Siting is expected to increase this success-rate.

## Drilling and drilling supervision (1)



- Oxfam and Medair use own rig, rest subcontracts to private sector drilling contractors.

Project aims at successful boreholes. Definition?  
Providing water of good quality and sufficient quantity  
throughout the year at the right location

How can quality be safeguarded?

1. Standards for successful boreholes are set, and agreed upon through binding contract / agreement
2. Supervision by hydrogeologist / experienced drilling supervisor is a **must** to ensure minimum specifications are followed, and water quantity and quality are appropriate

## Drilling and drilling supervision (2)



### Actual practice:

- No contract / technical specifications given (IRC exception)
- No full-time supervision
- Visits to drill sites are sometimes made by non-qualified staff
- Borehole completion reports are largely absent (apart from IRC and Merlin/AVSI)

### Result:

- Database at BSF has huge gaps and is inconsistent.
- Actual numbers of successful boreholes is unknown
- Some boreholes installed are substandard

## Drilling specifications (1)



Recommended for:

- borehole design
- Materials (screens, gravel pack etc.)
- minimum quality / quantity of water
- development
- test-pumping



## Drilling specifications (2): Water QUALITY

### Results

#### parameters reported on:

- Amref/Aquafund: Only E. Coli (for some)
- Caritas Suisse: none
- IRC: 12 parameters
- Merlin/AVSI: 16 parameters
- Medair: chloride, sodium, TDS\*
- Oxfam: 14 parameters

Discussion.. only installation when no health risks /  
no objection by users?

- Oxfam installed all 74, whereas 25 were unfit for consumption using own standards. Other NGOs did not / hardly test

->minimum standards

## Drilling specifications (3): Water QUANTITY



### General:

1. minimum yield for
  - installation of handpump: 0.7 m<sup>3</sup>/hr
  - E.g., standard in Uganda: supply a village of 300 people with 20 litres/day = 6 m<sup>3</sup>/day (or 0.7 m<sup>3</sup>/hr with 8.5 hrs pumping)
  - Sphere standards: 500 people/borehole (providing 12 litres/person with 8.5 hrs pumping)
2. sustainable yield versus airlift yield
3. Minimum test-pumping requirements to determine sustainable yield and intake pump:
  - 3 hrs pumping at minimum yield followed by recovery readings



- discussion of results
- standard designs for platform, type of hand pump, fencing, drainage/soak-away pit
- backup system: maintenance of the handpump, availability of trained handpump mechanics, spare parts supply chain

## Data



- Need for constant updates on water supply coverage, also data on dry boreholes very useful
- Who has supplied data to BSF Secretariat? And to DRWS (formerly UNICEF)? Who is responsible?



### Water Well Report

PROJECT DRAINING BORHOLE FOR AMPPE

Location  
 State CALIFORNIA Borough ID \_\_\_\_\_  
 County TEHAMA  
 Payson TRU Long E 2039'19.52"  
 Range \_\_\_\_\_ Lat N 6207'19.41"  
 Village \_\_\_\_\_ Elevation \_\_\_\_\_  
 Site TRU HWY ROAD

Use  
 Community water supply  
 Domestic water supply  
 Community center  
 Private compound  
 Health facility  
 Education facility  
 Test well  
 Property or handed over to \_\_\_\_\_  
 Setting  
 Geophysics  
 Other \_\_\_\_\_

Drilling data  
 Start date 6/14/2008 End date 7/11/2008  
 Total depth 50 [m] SWL 25 [m]  
 Main water table \_\_\_\_\_ [m] Yield 7,2500 [m<sup>3</sup>]  
 Dynamic water level \_\_\_\_\_ [m]

Drilling operation  
 Drilling diameter  inch  mm  
 0-8" From 0 [m] To 4 [m] Method Air Rotary  
 0-5.75" From 4 [m] To 50 [m] Method DR  
 Method of drilling  
 Percussion  Hand drilled  
 Air rotary  Mud rotary  
 DRH  Rig make FAT 401

Casing type  
 uPVC  
 Fiberglass  
 Bottom plug Height above/below ground level 0.5 [m]  
 Filter pack (gravel) a  
 Composition \_\_\_\_\_  
 Units  bags [kg]  
 Amount used \_\_\_\_\_  
 Drift casing & screen installation  inch  mm  
 PLAIN Type E From [m] To [m]  
 0- Type From [m] To [m] Slot Type From \_\_\_\_\_  
 0- Type From [m] To [m] Slot Type From \_\_\_\_\_  
 0- Type From [m] To [m] Slot Type From \_\_\_\_\_

Development  
 Air lift  Over-pumping  Surging  Backwashing  Jetting   
 Duration \_\_\_\_\_ [hr] Water:  Limpid  Turbid  Other \_\_\_\_\_  
 Comment \_\_\_\_\_

Water level  
 \*Magl = negative ground level  
 Measurement from \_\_\_\_\_ H.a.g. = \_\_\_\_\_ [m] Static water level (SWL) \_\_\_\_\_ [m] Date \_\_\_\_\_  
 Test pumping  
 Air-lift cap. evaluation  Step Drawdown Test  Constant Rate Test (CRT)  Short CRT  
 Duration \_\_\_\_\_ [hr] Discharge \_\_\_\_\_ [ ] Dynamic water level (first drawdown) \_\_\_\_\_ [m]

Pump  
 IMI  Akkiover  Submersible Date installed \_\_\_\_\_  
 IMI x-deep  Mono Depth of pump intake \_\_\_\_\_ [m]  
 Dubs Type of pipes \_\_\_\_\_  
 Make \_\_\_\_\_ of pipes \_\_\_\_\_  
 Comment \_\_\_\_\_

Well head and platform completion  
 Pump stand  Welded on casing  Filled around casing   
 Apron  Concrete slab  Drainage  Sock-away pit  Fence  
 Comment \_\_\_\_\_

Physical quality  
 Color \_\_\_\_\_ Taste \_\_\_\_\_ Turbidity \_\_\_\_\_ [NTU]  
 T \_\_\_\_\_ [°C] TDS \_\_\_\_\_ [mg/l] CE \_\_\_\_\_ [p/Stone] E. coli total \_\_\_\_\_ cfu per 100 ml  
 Sample taken  Yes  No Date \_\_\_\_\_ Lab \_\_\_\_\_  
 Comment \_\_\_\_\_  
 Bacteriological quality  
 Fecal coliform \_\_\_\_\_ cfu per 100 ml  
 E. coli total \_\_\_\_\_ cfu per 100 ml  
 Disinfection  
 Chemical used \_\_\_\_\_ Volume \_\_\_\_\_  
 Nearest sources of possible contamination  
 Type \_\_\_\_\_ Distance \_\_\_\_\_  
 Remarks \_\_\_\_\_

Borehole completion date \_\_\_\_\_  
 Comments \_\_\_\_\_

Borehole log and construction details		
From	To	Lithology
0	2	LT. dk. V-F sil. clay brownish
2	4	in colours CRM's
4	8	
8	8	
8	10	
10	12	
12	14	lt. clay V-F sil. white clay
14	18	soft CRM
18	18	
18	20	
20	22	
22	24	
24	26	
26	28	
28	30	
30	32	F. sil. clay soft, a bit hard
32	34	band of CRM growth in colours
34	36	
36	38	
38	40	
40	42	Pure fine sand yellowish
42	44	pebbles colours CRM
44	46	
46	48	clay a bit of coarse sand
48	50	water yellowish
50	52	
52	54	
54	56	
56	58	

Log = Lithology drawing

## Rehabilitation of boreholes



- Many boreholes non-functioning in S Sudan, with relatively little costs quick result, but....
- Maintenance versus rehabilitation
  - How were BSF boreholes selected ? why abandoned/out of order? -> Location, low yield, no O&M structure?
  - Determine required works (analysis of required works – desilting, replacement of pump parts, platform and pump head works) before works are carried out
  - Costs
  - Supervision
  - Actual situation: fixed costs, no flushing done, no reporting



1. In 2.5 years, with BSF 169 boreholes were installed, and 48 boreholes rehabilitated, meaning 65,100 people gained access to safe water, assuming one borehole covers 300 people (or 108,500 with 500 p/BH). Achievement is due to NGOs already operational in the area
2. Some of these boreholes are however of questionable standards, esp. water quality (turbidity, iron, hardness, manganese, or highly mineralised (salty))



3. In sedimentary formations all boreholes appear successful, and therefore no siting is required. Based on the limited geophysical siting data, it is concluded that saline aquifers do not show up as distinctly different resistivities, and therefore siting in these formations is also not warranted to discern saline aquifers from fresh aquifers. In Basement formations, geophysical siting will increase success-rates, and is therefore cost-efficient.



4. Direct drilling costs vary widely from 7,280 US\$ (by IRC in Northern Bahr-El-Ghazal) to 15,500 US\$ (by AMREF/Aquafund in Central Equatoria) per successful borehole.

Costs logically vary depending on the type of drilling contract, depth and installation details of boreholes, and mobilisation costs as a result of remoteness of an area. However, interestingly IRC's relatively cheap boreholes were drilled in a far more remote area than AMREF/Aquafund's boreholes.



5. Drilling supervision / management has been inadequate at all three levels:
  - BSF Secretariat / Management Consultant
  - Grant recipient (NGOs)
  - Drilling contractors
  
6. The available borehole database as well as hydrogeological map have not been used in the planning of new / rehabilitated boreholes.

1. BSF Secretariat to specify
  - Which water quality standards to apply – WHO, neighbouring countries' standards
  - Water quality parameters to analyse
  - Minimum yield
  - Borehole design specifications
  - Contract quality



Why contracts? To know rights and obligations of client and contractor, to avoid issues with the contractor, and to ensure high quality output

## 2. Contract between BSF and Grant recipient (NGO):

- Payment terms
  - LS for successful boreholes only – payment upon submission of test-pumping results proving minimum yield and adequate water quality
  - BOQ based – Payment upon submission of completion records and completion certificate signed by supervisor



2. Contract between BSF and NGO (c'td)
- Installation terms – minimum sustainable yield, water quality
  - Reporting details
  - Appointment of fulltime borehole drilling supervisor
  - No payment for technical failures

3. Contract between grant recipient and contractor, supervisor
  - Contracts for siting, drilling, and drilling supervision
  - Finances:
    - Type of contract: LS vs BOQ -> BOQ preferred
    - payment terms, incl. retention
    - advance payment, performance bonds
  - ToR: hydrogeological information, designs, timeschedule, techn. specifications for development, test-pumping, minimum water quality etc.
  - data collection / submission

## Description of best practices (5) DRILLING AND INSTALLATION



4. Introduce standards for design, development, test-pumping, minimum water quality and quantity
5. In sediments: analyse groundwater level fluctuations over the year, to establish appropriate borehole depths and pump intake levels.
6. In Basement area: insist on geophysical siting including profiling and soundings



## Description of best practices (6) SUPERVISION



7. Drilling always fulltime supervised by experienced drilling supervisor.

- Even if the contract is a lump sum contract for successful boreholes only ! Client needs proof that the borehole has sufficient water with the pump intake placed at the correct depth (so has been test-pumped appropriately), and that the water is of good quality (water analyses of relevant parameters carried out).

8. The DRWS WES database update is responsibility of the grant recipient; BSF secretariat receives copy for their files

# What is the way forward...?



# Discussion points

1. Are standards necessary?
2. Does siting, supervision pay back?
3. Are contracts practical?
4. Who is responsible for:
  - a) Quality of boreholes
  - b) Success-rate of boreholes
  - c) Drawing up contracts
5. Action points for boreholes done in 1<sup>st</sup> two rounds
6. Action points for boreholes planned for 3<sup>rd</sup> round