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Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

# BGS Consultancy: UNICEF IWASH Project, Northern Ghana. Visit Report 25/10-5/11/2010

Groundwater Science Programme

Internal Report IR/11/048





BRITISH GEOLOGICAL SURVEY

GROUNDWATER SCIENCE PROGRAMME

INTERNAL REPORT IR/11/048

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Handpumped borehole at Sung in Bunya Sandstone, northern Voltaian Basin, Northern Region, Ghana.

## *Bibliographical reference*

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# 1 Introduction

BGS have been commissioned to investigate the low drilling success rates encountered by the UNICEF IWASH programme in the Northern region of Ghana. The work is split into three phases: (1) situation analysis and information collation on current methods of groundwater development; (2) the development of a preliminary groundwater development map and suggestions for improving siting methods; and (3) a workshop and training course on groundwater development in N region.

The project started on October 15<sup>th</sup> 2010 and is scheduled to finish by February 28<sup>th</sup>, 2011. Phase 1 involves a visit to Ghana, Phase 2 will occur mainly in the UK; and Phase 3 is scheduled to take place in Ghana during February 2011. This short note reports on the data collection visit 25<sup>th</sup> October – 5<sup>th</sup> November 2010. An itinerary, list of contacts and summary of data collected is given in the Appendices.

## 2 Available Data

Various information and data were pursued: detailed information from the IWASH project; information on the general distribution of successful and unsuccessful boreholes in the northern region; final reports for previous large drilling projects in the region (e.g. AFD and EU); any other detailed information from projects; information and data from the HAP project in the Northern Region, and general data on the geology of the area.

### 2.1 IWASH

Information from the IWASH project proved difficult to access. Reports were not in one place but were distributed between UNICEF, the various contractors, and CWSA. Specific information from each borehole drilled under the IWASH project was required: a GPS location, geophysical surveys, drilling log, pumping tests (or yield) and chemistry. Some of the reports only available in hardcopy were scanned, others were on computers that were not working, and therefore lost.

**Table 1 IWASH reports collected during visit**

<b>Contractor</b>	<b>No of BHs</b>	<b>Geophysics</b>	<b>Drill logs</b>	<b>Pumping tests</b>	<b>Chemistry</b>	<b>GPS</b>
Terrahydro 2009	20	Y	Y	Y	Y	Y
Watersites 2009	20	Y	N	Y	Y	N
Watersites 2010	35	Y	Y	Y	Y	Y
Terrex 2010	20	Y	Y	Y	Y	Y
Prohydro	20?	Y	Y	N	N	Y
Church of Christ	30?	Y	Y	N	N	Y

### 2.2 GENERAL INFORMATION ON BOREHOLES IN THE NORTHERN REGION

HAP (the Hydrogeological Assessment Project) of northern Ghana, situated within the Water Resources Commission (WRC) in Accra, holds a database of boreholes drilled within the

Northern Region. The database has the GPS location of borehole, information on success, and where available yield, summary of geology and chemistry. Most of the data are from boreholes drilled before 2007, however, there has been sporadic updating of the database since.

CWSA in Tamale had several databases from the previous AFD and EU projects which between them drilled approximately 1500 boreholes in the Northern region (less than a third being successful). Some of these data were already in the HAP database.

### **2.3 REPORTS OF PREVIOUS PROJECTS**

The final report of the AFD project was available, and discusses some of the issues about poor success rates. The final report from the EU project was not available from CWSA, HAP or the local contractors. We will get in touch with the international consultant IGIP to see if they can make a copy available. For neither of these projects however, could we obtain detailed reports on each borehole (e.g. geophysics, drilling log, pumping test etc). A subset of this information would have been useful to complement the recent IWASH reports.

Reports were available from the previous drilling in Northern region of 200 boreholes by the Church of Christ. These include geophysical survey and drilling logs, and indications of success.

Detailed reports from the HAP monitoring well drilling were made available by HAP and WRI.

### **2.4 GENERAL GEOLOGICAL DATA**

The geology of the Voltaian Basin has recently been remapped using remotely sensed information. The Ghana Geological Survey (GGS) agreed that these data can be used for this project. The new geological line work is complemented by TEM airborne survey lines at 20 km spacing across the basin, magnetic data and radiometric data. A comprehensive report on the geology is also available.

### **2.5 HAP MONITORING PROJECT**

Twenty-seven monitoring boreholes were drilled across northern Ghana as part of the HAP project. These boreholes were drilled to depths greater than 100 m and geophysical logging and detailed pumping tests were undertaken in each borehole. Detailed geophysics was also used to site the boreholes. The boreholes are now equipped with Diver water level monitoring sondes. The data and reports were provided by HAP.

## **3 Initial findings**

There has been little time to examine or interpret the data collected during this visit, however here are some initial observations.

The northern region is a particularly difficult place to find groundwater. Mudstone, siltstone and sandstone are interlayered and unsuccessful boreholes are found throughout the region and in all rock types. Particularly poor areas are underlain by unfractured mudstones.

Management of primary data (e.g. reports on drilling and geophysics etc) is weak within CWSA and UNICEF. Even recent reports from IWASH proved difficult to come by. There is little lesson learning between consultants and different projects, although some indicated that they consult between each other when working in similar areas and conditions. WRC with the mandate to receive borehole data, and the good experience of HAP, may be the obvious institution to receive information and help coordinate lesson learning.

The main geophysical method used to site boreholes is dipole-dipole. There is little widespread surveying, rather a few VES are done at each site. The method seems to be poorly applied with questionable interpretation of survey results. EM34 is carried out by the Church of Christ and possible World Vision. Some 2D profiling using the LUND system is carried out by WRI and international consultants. There is little consensus on the targets that are trying to be identified using geophysics. Is it high resistivity or low resistivity and how are fractures identified? A good conceptual understanding of the hydrogeology is required before applying geophysical survey methods.

The supervision of the drilling process is difficult, given the geological environment. Changes in geology are subtle, and sometimes difficult to identify, therefore the information from geological logs is often poor. The lack of good quality data being collected from all boreholes (successful and unsuccessful) also mitigates against lesson learning and enhancing the understanding of how groundwater exists in this area. In an area such as the Northern Region, where groundwater is very difficult to exploit, careful data collection and lesson learning are disproportionately important.

Private sector consultants carry out the geophysical surveying, drilling supervision and pumping tests. The CWSA hydrogeologists have to spend much of their time evaluating tender documents and monitoring progress. Therefore to increase the capacity in the region, the private sector consultants have to be involved in any discussion/workshop of survey and data gathering methods employed by the contractors/consultants as well as being fully involved in any training exercise that aims towards the standardisation of data gathering especially during the borehole drilling and testing phases.

## 4 Next steps

The next major task is to systematically sort through the data collected to assess the efficacy of the geophysical siting methods and to assess whether sufficient data are available to examine how groundwater exists within the area and production of realistic conceptual models for groundwater development. Before this can be done, however there are some specific tasks to be undertaken with the data:

- Identify and chase up data gaps, particularly outstanding data from the IWASH project and the final report from the EU project.
- Analyse all existing information with GIS, and sort out duplicates between different databases.
- Locate the IWASH boreholes on GIS.

### PRELIMINARY OUTLINE FOR THE WORKSHOP AND TRAINING

**Participants:** practitioners involved in the siting and supervision of boreholes, and those with a good understanding of hydrogeology in the Voltaian. Given that much of the work is contracted out, there must be a strong representation from the private sector.

**Venue:** in or close to Tamale, with access to field sites within 20 – 30 minutes drive.

**Workshop:** 2 – 3 days. Lesson learning and sharing about groundwater occurrence and siting methods in the northern region. Output – a finalised groundwater potential map, with consensus on the different siting methods to be used in various areas, and also the likely success rate across the region.

**Training:** 6 – 7 days. Practical methods in geophysics. 1 -2 days in the field, 1 day in the office interpreting the data. Drilling supervision: how to supervise drilling. NB this will require a drilling rig to be available and drilling (preferably one site where water may be expected, and



another where believed to be dry). Pumping tests – how to assess yield reliably (1 day in the office). Report writing and map making: how to document data and pull together in GIS (1 day in the office).

# Appendix 1

## VISIT TO UNICEF GHANA, 25TH OCTOBER – 4TH NOVEMBER 2010

### Itinerary

**25<sup>th</sup> Oct.** Fly BA081 from London Heathrow to Accra, arrive at 20:30. Transfer to La Palm hotel.

**26<sup>th</sup> Oct.** To UNICEF HQ where briefed by Othniel Habila. Introduced to Deputy Head of Programme.

10:00. With Emma-Joan Halm drove to CERGIS at Legon University for discussions with Mr Foster Mensah. CERGIS have undertaken a pilot study of for locating water sources in Ghana. Need a letter from UNICEF requesting copies of database files that they are happy to supply.

11:30. Drove to WRI office where met Dr William Agyekum, who has been involved in the drilling of the monitoring wells in Northern Ghana for HAP. He also has access to various regional hydrogeological maps though not of parts of northern region of interest to the project.

14:00. Drove to WRC where introduced to Ben Ampomah who in turn introduced Enoch in charge of the HAP project. Enoch passed on a copy of the WRC HAP access database for the northern region. He introduced us to James R, Advisor to the HAP project. James briefed the team on the activities of HAP and promised to supply copies of necessary reports and data.

16:30. Drove to CWSA main office where met Mr Gaze and Mr Van Ess with whom discussed the purpose of our visit and the detailed terms of reference. Mr Gaze will arrange meeting with John Aduakye (Hydrogeologist for the Northern region) at 15:00 tomorrow, who will provide data and information on the IWASH project area.

Made appointment to meet Dr Kwameh at the Geological Survey at 9:00 tomorrow.

**27<sup>th</sup> Oct.** To UNICEF where briefed Othniel Habila on activities of day before. Emma-Joan to organise flight to Tamale and accommodation. Checked into the UDS Guest House.

9:00 Met with Dr Kwameh at the Geological Survey where obtained copies of geological map of Ghana and hydrogeology maps of two areas located on the Voltaian sediments mapped by CGS. Would like two of his staff to attend any workshop/training organised in February.

11:00 Drove to WRC for further in-depth discussions on HAP with James Racicote and to receive promised reports and data.

13:30 Drove to the Legon University where met with Prof Bruce Banoeng-Yakubu with whom discussed present status of consultants and siting and drilling contractors in Ghana. He has had 2 PhD students recently submit theses on aspects of the hydrogeology of the Voltaian, William on correlation of geophysical boreholes logging with contractor supplied information on geology and bh construction, of the HAP monitoring Bhs. And Julius on some aspects of the application of resistivity to the siting of boreholes in the region.

14:30 Drove to CWSA where met with John Aduakye who briefed the team on borehole siting and drilling activities in the IWASH and adjacent areas of that part of northern region of Ghana. He also advised on consultants to meet in Accra and Tamale. Passed on various summary spreadsheets of borehole data. Detailed siting and drilling reports were available at his office in Tamale.

18:00 Drove back to UDS guest house.

**28<sup>th</sup> Oct.** Drove to UNICEF where met by Othniel Habila who made arrangements for meeting with Mr Kabuka Banda. UNICEF IT scanned hard drive, lap top drive and flash drives for viruses picked up during visit to GS Ghana. Discussed the development of groundwater within the IWASH area with Kabuka Banda (UNICEF, Tamale) and the availability of data and information from the various institutions, consultants and contractors present in Accra and Tamale. Discussed arrangements for visit to the Tamale area with David Ede who had arrange a meeting with Watersites at 13:00 tomorrow. Obtained flight tickets. At 13:00 drove to Makarty Hill area where met Sam Owusu, hydrogeologist from Comwassan who guided us to their office. Met Mr Kwei with whom discussed in general terms the activities of siting consultants and drilling contractors in the northern region of Ghana. He was not able to supply any digital information.

**29<sup>th</sup> Oct.** Taxi to Accra airport for flight at 8:45 to Tamale. From airport taken to the Gariba Lodge then to UNICEF office where met Dr Ede. During discussions with Dr Ede introduced to Mr Muduk of APDO and Mr Ahmed of CWSA. Dr Ede advised on who we should meet of the local consultants.

13:00 meeting with Mr John Osman of Watersites from who acquired various spreadsheets and hard copy reports. At UNICEF office started the scanning of reports.

15:30 Meeting with Mr Alfred Osafo-Yeboah of Terrahydro from whom .btained reports and data that he had on EU, AFD and IWASH projects. Returned to hotel at 17:00.

**30<sup>th</sup> Oct.** To the UNICEF office by 08:30 to look at data collected so far and discussions with Dr Ede. Set up in the conference room and worked out how best to copy reports by scanning then transferring by e-mail to laptop of Dr Ede. Download via usb stick. Georeferenced data and put together GIS for the Northern Region. Scanned reports until 16:30.

**31<sup>st</sup> Oct.** To the UNICEF office by 08:30 for further discussions with Dr Ede. Downloaded digitised Prohydro reports from Dr Ede. Continued scanning and downloading of Church of Christ reports until 15:45.

**1<sup>st</sup> Nov.** To the UNICEF office by 07:45. Met Michael from Church of Christ at 08:00. Discussed hydrogeology of IWASH area. Departed for field visit to north eastern area at 09:00. Day in the field visiting geological sites and also failed and working boreholes. Returned by 5:45 pm. See separate field visit itinerary

**2<sup>nd</sup> Nov.** To the UNICEF office by 08:30. Obtained series of reports from CWSA office. CWSA reports scanned and downloaded. Discussions and debriefing with Dr Ede. Sorted and georeferenced photographs. Scanned reports obtained from Terrex. Visited the local Geological Survey Department office where obtained further information from Timothy (works for Terrex as consultant on occasion). Returned to UNICEF office where scanned and photocopied reports obtained. Listed data and information gathered.

**3<sup>rd</sup> Nov.** To Tamale airport by 06:50 where had to wait for flight at 10:45. Arrived at Accra at 12:45. Checked into UDS guesthouse then to UNICEF office by 13:15.

14:00 At WRI for discussions with William and Dr Dapaah-Siakwan. Collected additional data on HAP monitoring boreholes from William.

15:15 Drove to WRC/HAP office for discussions with James and collection of additional information on monitoring boreholes.

**4<sup>th</sup> Nov.** To UNICEF office at 8:30 for windup meeting with Michael and Adam Thomas when discussed progress so far and plans for the analysis of data and the workshop/training to be undertaken in Jan/Feb. Made notes of minutes from the meeting and sent these to Dr Ede in Tamale. Contacted Unihydro and Mr Gaze at CWSA for additional information on EU and AFD project data. Collected additional scanned reports from World Vision and Church of Christ.

Returned to the UDS Guesthouse from where drove to the airport at 20:00. Departed from Accra at 23:45 on flight BA78 to London.

**5<sup>th</sup> Nov.** Arrived in London at 06:30. AMM Arrived Edinburgh 14:00.

## Appendix 2

### PERSONS AND ORGANISATIONS MET WITH CONTACT DETAILS

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## Appendix 3

### INFORMATION COLLECTED

#### Hard Copy Reports and Maps

Geological Survey Department of Ghana and the Bundesanstalt für Geowissenschaften und Rohstoffe, 2009. Geological Map of Ghana, scale: 1:1 000 000. For the Ghana National Geological Map Project.

Hydrogeological Assessment Project of Northern Ghana (HAP II), 2010. Geo-logging and Diver Installation of 15 Newly-drilled Monitoring Boreholes. Geo-logging and Diver Installation Report. For CSIR Water Research Institute, Ghana.

Sami, K. And Van Rooyen, R.C., 2009. Hydrogeological Map Explanation – Map Sheet 1001D (scale 1:100 000). CGS/BRGM/Geoman, Geological Survey Department of Ghana (GSD) report No. MSSP/2005/GSD/4

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Viljoen, J., Reddering, K., Thomas, E., LeBere, P. and Gyapong, W., 2009. Geochemical Synthesis Map of Ghana, Map Sheet 1001D (scale 1:100 000). CGS/BRGM/Geoman, Geological Survey Department of Ghana (GSD)

Water and Sanitation Monitoring Platform, 2010. A Directory of Ghana's Water and Sanitation Sector: Who does what, where and how? [www.wsmp.org](http://www.wsmp.org)

A separate listing of soft copy information collected is being produced.



## Appendix 4

### FIELD TRIP TO THE AREA NORTH EAST OF TAMALE TOWARDS TONG

Nov 1<sup>st</sup>

BGS team (Jeff Davies , Alan MacDonald ) COC Michael Dumolga and David Ede.

Record created 20.45 hrs Nov 1<sup>st</sup>

#### *Locations Visited:*

1. Waypoint 350 / 351 Distance from office 18km . Coords  
Laterite on Tamale Sandstone --- manganese and iron laterite “vuggy”, nodular highly permeable pisolithic. Laterite thickness 3m . Sdst medium to coarse grained , poorly jointed horizontal
2. Waypoint 352 28km Coords Muddy siltstone ,  
Waypoint 353 Coords spring from laterite at base junction laterite pisolithic lighter brown.  
Waypoint 354 COORDS bouldery laterite on siltstone water out of laterite thickness of laterite 1-2m
3. 355 36 km coords bridge over river Nabugu
4. 356 having turned right off tarmac 37km rain catchment off roof small excavation
5. 357 39km coords silty light brown ant hill
6. 358 47km -- HDW micaceous slightly fissile siltstone , ripple marks would be logged as shale or mudstone calcareous vein hard
7. 359 54 km having taken approx 1.5 km turnoff to right coords fenced borehole with outcrop medium to occasionally coarse grained sst borehole samples purple and light to dark grey medium micaceous fissile some coarse uneven , interbedded ? fines Several boreholes 8 inch plastic casing .  
Travel through Bagurugu road bending right then through Nyong Goma (Sompuli)
8. 360 73 kms coords laterite exposure (geol data point?)
9. 361 83 kms Cords Sung  
362 Coords HDW – latrine cover  
363 Cords HP operational  
364 coords IWASH limited mechanized scheme  
365 coords HP BH with video  
366 coords HP not used broken?
10. 367 88kms coords massive sst med-fine felspathic manganese in weathered sample
11. 368 89 kms coords joint direction east Massive medium fine not Aeolian crossbedding ??
12. Walking 369 coords BH near Dam Tong
13. 370 other borehole near (very near!!!!!!) Dam Tong

## Appendix 5

### NOTES FOR MINUTES OF MEETING AND UNICEF, ACCRA - 4TH NOVEMBER 2010 AT 9:00AM

**Present: UNICEF – Michael and Adam Thomas**

**BGS – Alan MacDonald, Jeffrey Davies**

#### FIRST PHASE OF THE PROJECT

What data has been collected from which agencies describing visits made to WRI, WRC/HAP, CWSA and the University of Legon. Need to send letter to CERGIS requesting data from their water source survey.

##### *Main sources of data:*

IWASH area – various consultants – geophysical data, borehole geological log data, test pumping data and water quality data – individual reports, summary data sheets from CWSA, WRI and WRC.

EU project northern region – IGIP main consultants – 600 boreholes have summary spreadsheets from Bh locations and gross geology from WRI and CWSA and HAP, need the detailed geophysical data, borehole geological log data, test pumping data and water quality data – individual reports – will try to obtain from CWSA and from IGIP in Europe.

AFD project – consultants include Unihydro – received main project summary report from CWSA with summary spreadsheet from CWSA/HAP - need the detailed geophysical data, borehole geological log data, test pumping data and water quality data – individual reports – will try to obtain from Unihydro.

Also have the WRC/HAP access database for 10,000+ boreholes in northern region but lacks detailed information.

Have visited consultants in Accra who were able to provide indications of what has been undertaken in the northern region but not able to pass on detailed soft report information.

Consultants approached in Tamale included Watersites, Terrahydro, Terrex and CWSA. UNICEF and CWSA able to supply some reports in soft form others from Prohydro and Church of Christ were scanned at UNICEF office.

Field visit made to the region NE of Tamale to look at exposures of typical Voltaian lithologies such as the Tamale Sandstones, mudstones, siltstones, and the Tong sandstones. Also looked at flooded alluvial areas, laterite formations, termite mounds, hand dug wells (unprotected and protected), hand pumped boreholes (all equipped with Afridev pump) and semi-motorised systems with distribution systems from overhead tanks, and roof top rainfall catchment systems. Visited the area between Tamale and Tong/Karaga. Accompanied on field visit by Dr D P Ede (UNICEF) and Michael (Church of Christ).

#### PHASE 2

Workshop and training taking into account the HAP experience. Aim to produce preliminary groundwater resources maps of the IWASH project area. Need to assess effectiveness of geophysical siting methods currently in use. Need to improve data acquisition during borehole siting, drilling and test pumping activities. Also assess water quality of groundwaters available especially the quality of waters encountered in deep boreholes.

Make use of the shape files derived during the recent geological mapping of the Voltaian Basin by BGS et al. Need also to obtain IGIP contact details via the web.

Legal instruments relating to water development have been copied from HAP. CWSA should be collecting all borehole data.

Obtained from Michael copies of 2 World Vision reports and a multi-volume Church of Christ report.

### **PROGRESS MADE SO FAR**

Have been amassing data from as many sources as possible, these data to be collated and assessed.

Initial thoughts include:

#### **GEOPHYSICAL SITING METHODS:**

Dipole-dipole – may not work as expected – see original JICA project report re introduction of method. Limited penetration. Need to have BGS geophysicists assess information. Need to derive typical resistivity ranges for main rock types.

EM34 – 20-30 metres penetration used mainly to locate vertical to sub vertical fracture patterns. Used by Church of Christ.

World Vision use TEM equipment for the last 4 years.

TEM flown by helicopter by Fugro – broad structure 20km spacing, 100-120m penetration, quite coarse. Need to have developed a high resistivity map of the Voltaian next phase for groundwater - to the Geological Survey of Ghana.

2D res – limited to 60 metres penetration, computerised to produce electronic cross sections – WRI have used it on the HAP project and NRST project. Expensive equipment not so robust – lots of electrodes – difficult to use. Need to have a concept of targets to be assessed – differentiate high res – low res rocks and fractures.

#### **DRILLING DEEPER BOREHOLES:**

Afram plains , 5 boreholes to 150 metres. HAP project some success to 200 metres – very few boreholes, insufficient to state that all boreholes need to be drilled to 150 metres. Buepi artesian borehole in Central Gonja, an area of low potential. Those in favour of deep boreholes include Wigbert Dogoli Direct CWSA in Northern Region also a hydrogeologist, as well as Enoch Asere at WRC and Mr Gaze of CWSA. Van Ess of CWSA is more cautious.

Need to have further research in areas such as central Gonja with the drilling of properly documented deep exploration boreholes – use these to define the nature of the underlying lithological variations in detail and the occurrence of groundwater. 2 or 3 boreholes need to be drilled to 200 metres each under very tight supervision with geophysical borehole logging. If all boreholes are dry then write the area off for groundwater. Problem with current geophysical methods currently in use not being able to investigate down to anywhere near these depths and even then will only produce very gross results that may not be able to identify minor targets. Need to provide more information and ideas on what can be done before areas are written off completely.

Information from drilling – most geological logs will not be accurate – leads to poor borehole construction with incorrect emplacement of casings and screens.

Private sector to oversee the drilling process according to upgraded code of conduct designed to improve siting and drilling. Are contracts to be let for siting and drilling combined or let separately .

Need better understanding of lithological variations from analysis of geophysical logs of HAP deep boreholes – need to be able to interpret what is available for the production of groundwater resources maps.

## **1. Workshop**

Assess the collective experience of consultants and others engaged in the siting and drilling of boreholes in the IWASH area and come up with a consensus of opinion.

## **2. Training**

To include demonstration of basic field methods for practitioners in :

- (a) Geophysical surveying methods – use of the methods that are used at the present – run a comparison.
- (b) Drilling supervision and data collection
- (c) Test pumping and interpretation of the results as this is not being done at the present.
- (d) Water Quality aspects

Where to go from here –

- (a) Consolidate data
- (b) Assessment of geophysical methodologies
- (c) Produce conceptual ideas of how groundwater occurs
- (d) Groundwater resources maps.

Request for recharge studies and assessments of distribution of where and why boreholes are tending to dry up/reduce in yield after 3 or more years of use are suggested for inclusion within a follow on phase. To include use of isotopes and CFCs as well as chloride balance to recognise and maybe estimate possible rates of recharge.

Need to produce a short concept note indicating possible form of workshop/training course timed for the second phase in Jan-Feb 2011.