Remote sensing, GIS and groundwater exploration

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4th United Nations / Pakistan / Prince Sultan Bin Abdulaziz International Prize for Water
International Conference on the use of Space Technology for Water Management

Groundwater Relief

GROUND WATER RELIEF

- A service user of remote sensing data
- Providing hydrogeological services to other charities and not-for-profit organisations
- Technical expertise sourced through a membership of over 200 groundwater experts
- In last 12 months Groundwater Relief has carried out 15 projects working with UN, INGOs and smaller charities.
- Projects have included: borehole siting and drilling in northern Uganda; groundwater resource assessments at two Protection of Civilian camps in South Sudan; supporting the humanitarian response through developing water supplies in Cox's Bazaar, Bangladesh
- Over the course of the last two years Groundwater Relief has also been working in partnership with E04HumEn+ to explore remote sensing opportunities for groundwater supply;

Remote Sensing- key tools

GROUND WATER RELIEF

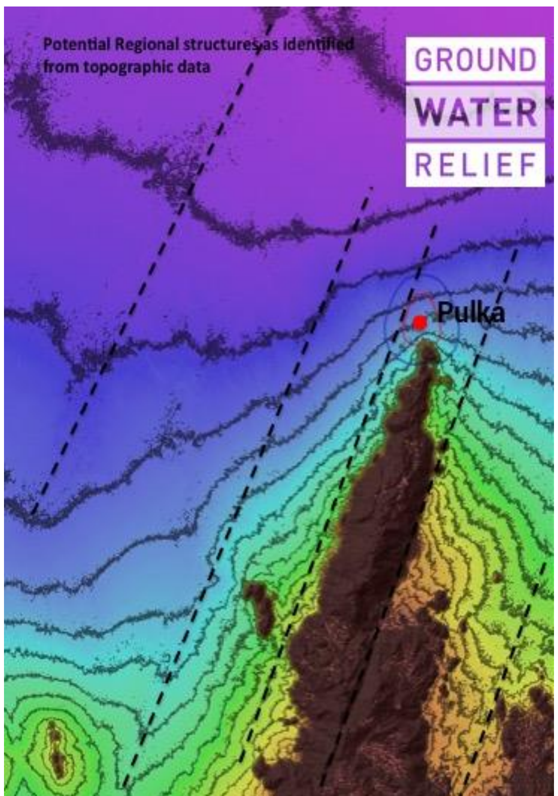
- Topographic data (e.g. SRTM-DEM, TanDEM-X, Sentinel 1)
- Multi spectral optical data (Landsat-8, Sentinel 2)
- Aerial magnetic data
- Synthetic Aperture Radar data (Sentinel 1)
- Satelitte derived rainfall data (TAMSAT)

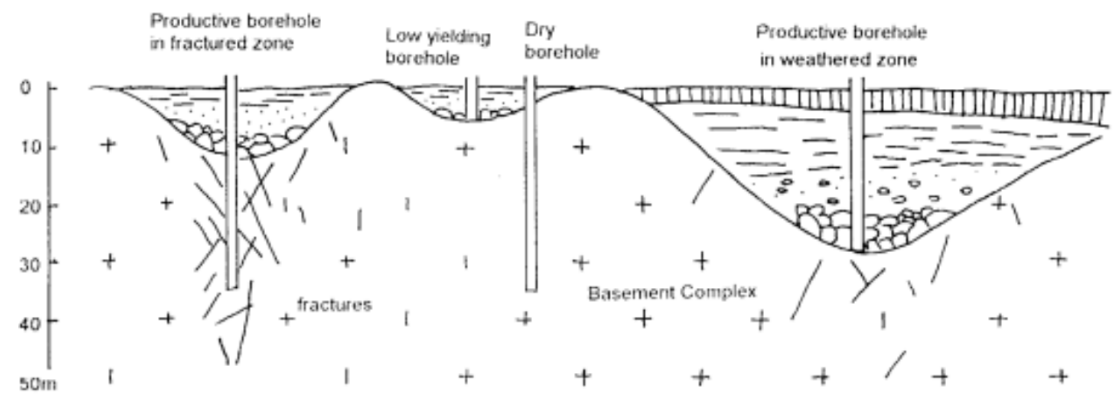
Topgraphic data

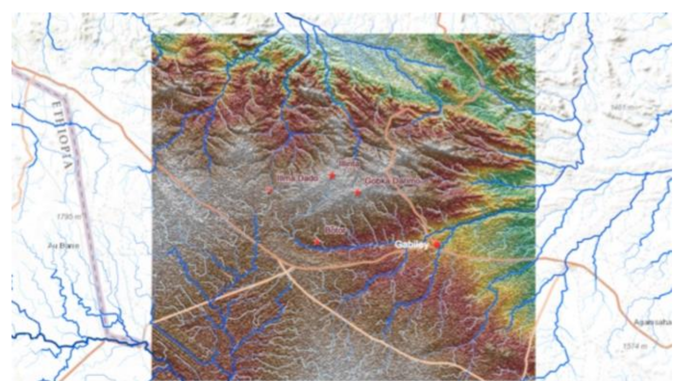
Identification of geological structures and fracture systems

Groundwater is stored within fractures and the weathered zone. Topographic data has proved useful to help identify lineaments/fracture systems/deeper weathered zones

Identification of catchments and recharge potential



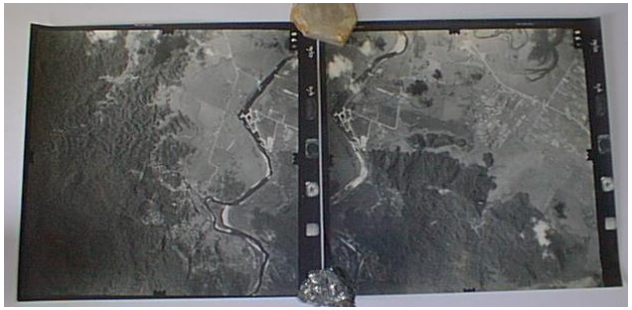




Fracture identification

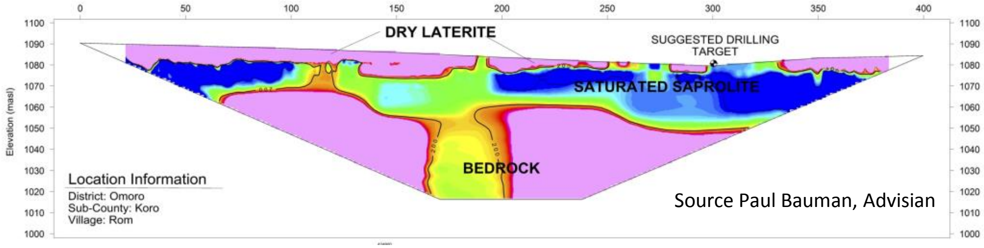
- Historical technique –aerial photography and a stereoscope was used for fracture identification
- Now lineaments normally derived from digital elevation models (DEM). This is the most common use of satellite data for borehole siting

However remote sensing data needs to be used with geophysical techniques (eg. EM or resistivity)



Source David Jeffries, BGS

Stereoscope for photograph interpretation



Source Paul Bauman, Advisian

Siting boreholes using topographic data and dowsing - Kenya

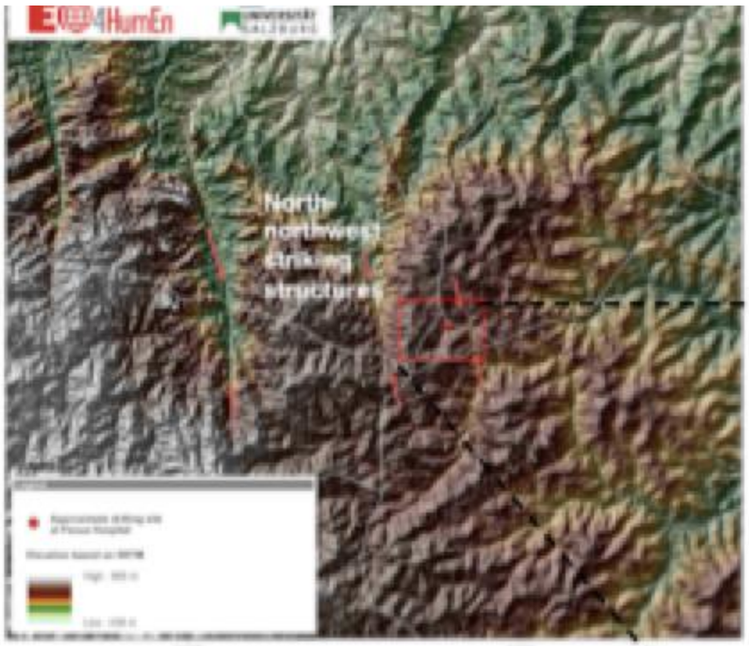
The local hydrogeologist used abrupt changes in wadi channel direction to indicate faults

He then dowsed on the outside angle of these directional changes

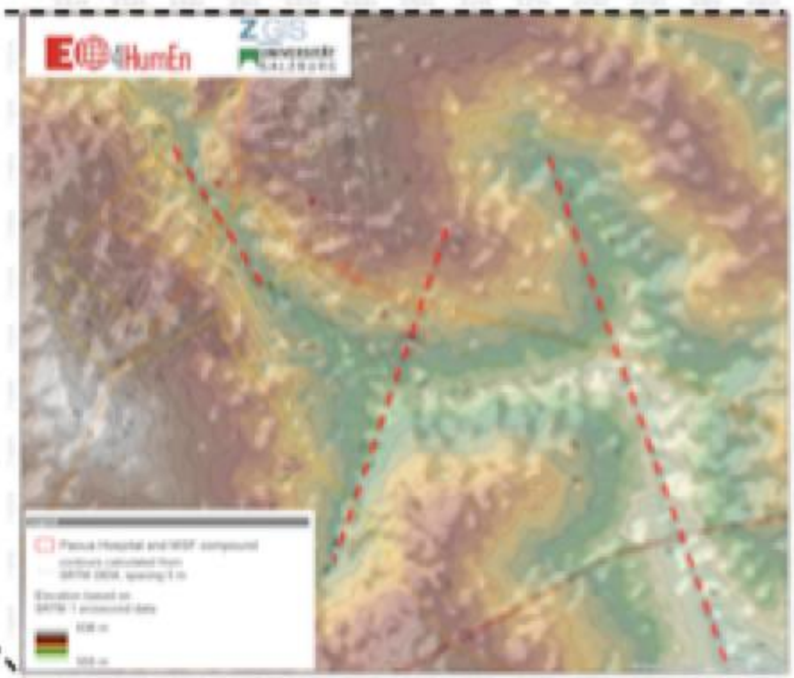
Emergency water supply, Central African Republic

E04HumEn provided Groundwater Relief with topographic maps using SRTM DEM data.

This data was then interpreted by the Groundwater Relief hydrogeologist to identify potential water bearing structures that could the be more closely investigated using electrical resistivivity



At a regional scale large north-northwest striking structures are visible. These are also identified in the regional geological map.

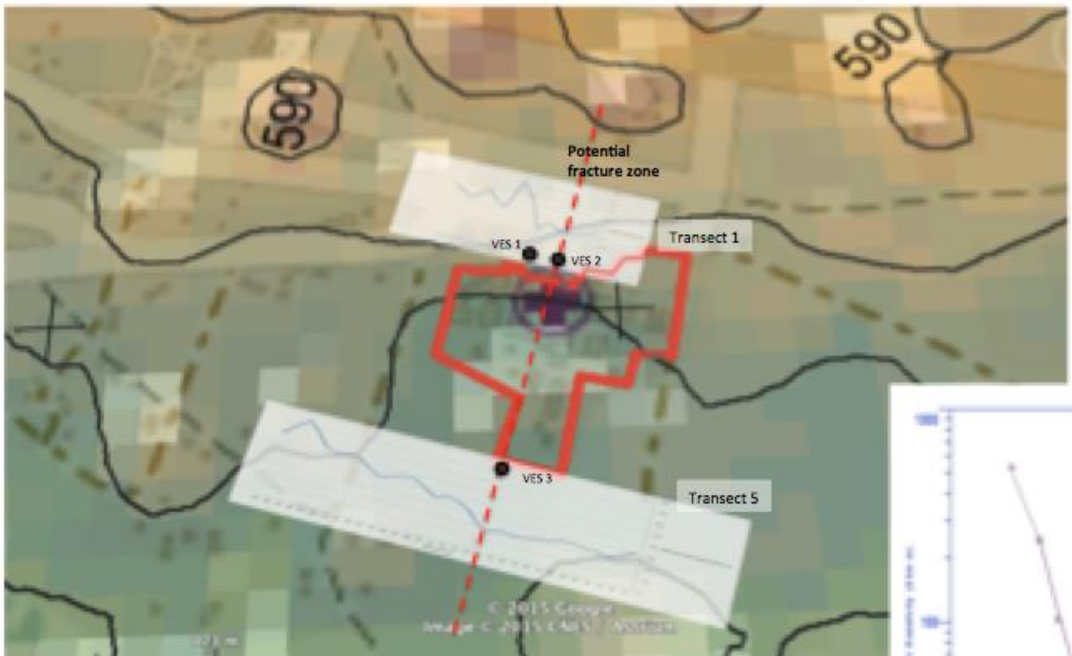


At a more local scale, at least three structures are potentially revealed by the topographic data, striking northwest, north-northwest and northeast The northeast structure passes close to the hospital. From this information, there was a focus on carrying out east-west striking geophysical transects at the hospital site.

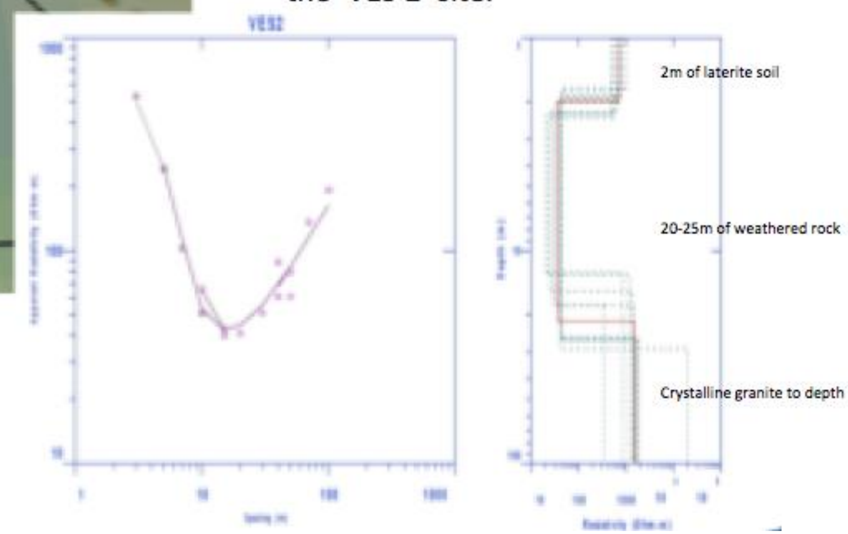
Geophysics

An electrical resistivity survey was carried out to help site the borehole.

A number of east-west Constant Separation Traverses (CST) were carried out. The fresh crystalline granite bedrock has high resistance and so low resistivity values were indicative of deeper weathering and more likely to yield a greater volume of water.



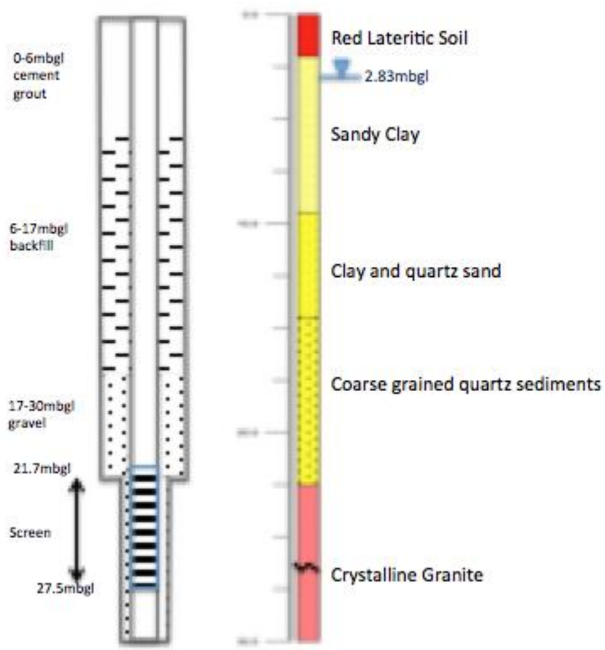
Vertical Electrical Soundings (VES) were carried out at locations identified by the CST to have low resistivity. VES provides information on how resistivity changes with depth and infers lithological variation. Following data interpretation it was decided to drill the borehole at the 'VES 2' site.



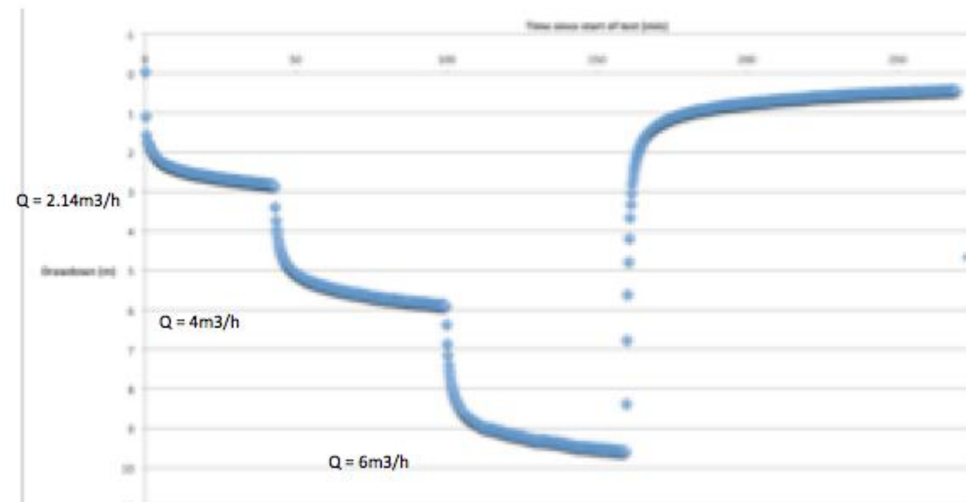
Borehole Construction

Drilling
A 10 inch, telescoping to 6.5 inch, diameter borehole was drilled to a depth of 30m below ground level after encountering saturated coarse quartz sand and fractured granite at the rockhead.

Pumping Test
A 3 step step-test was carried out and a recovery test. The borehole was found to be highly productive, with a specific capacity of $15 m^3 day^{-1} m^{-1}$. The borehole can yield significantly more water than is required at the hospital potentially over $10 m^3/h$.



Paoua Hospital geological log and well completion details



Paoua Hospital step test and recovery test data

UN House PoC 3
rapid groundwater assessment

- Groundwater Relief asked to review the groundwater resource potential underlying the PoC by OFDA
- Rapid time response required of just 3 days
- Crystaline basement rock
- Some failed drilling

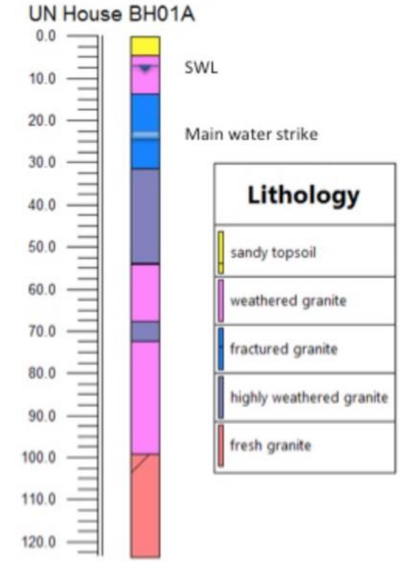
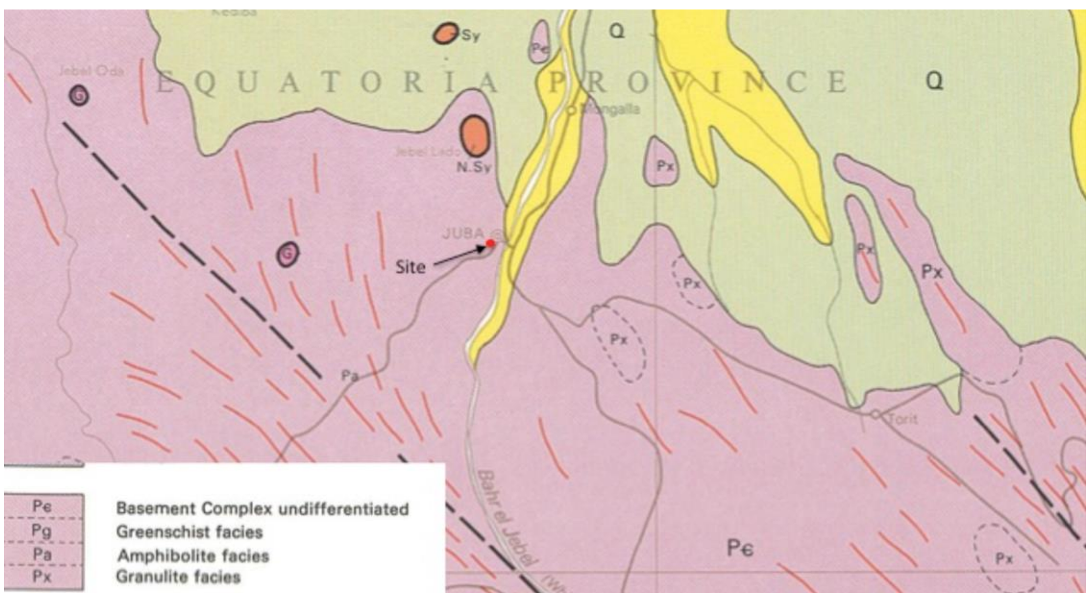
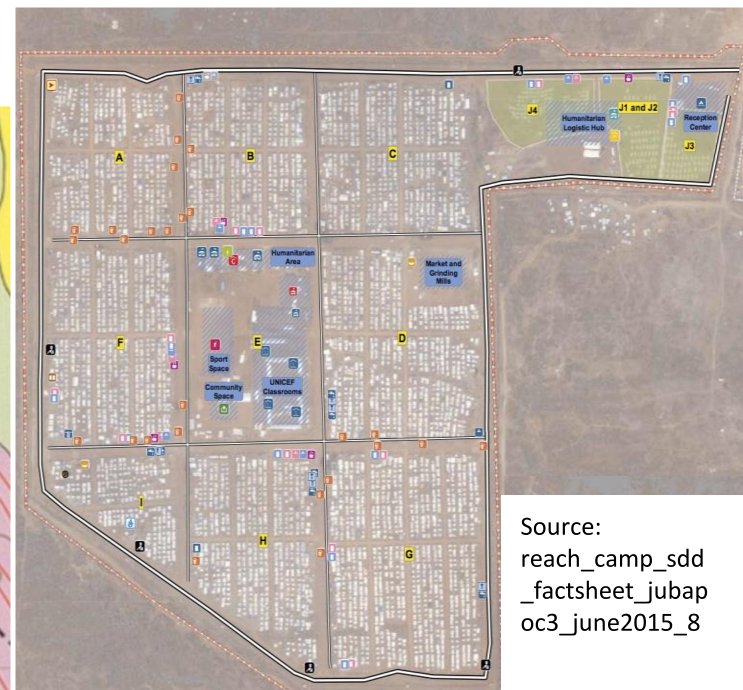


Figure 4 - Simplified log of borehole drilled by Oxfam at UN House

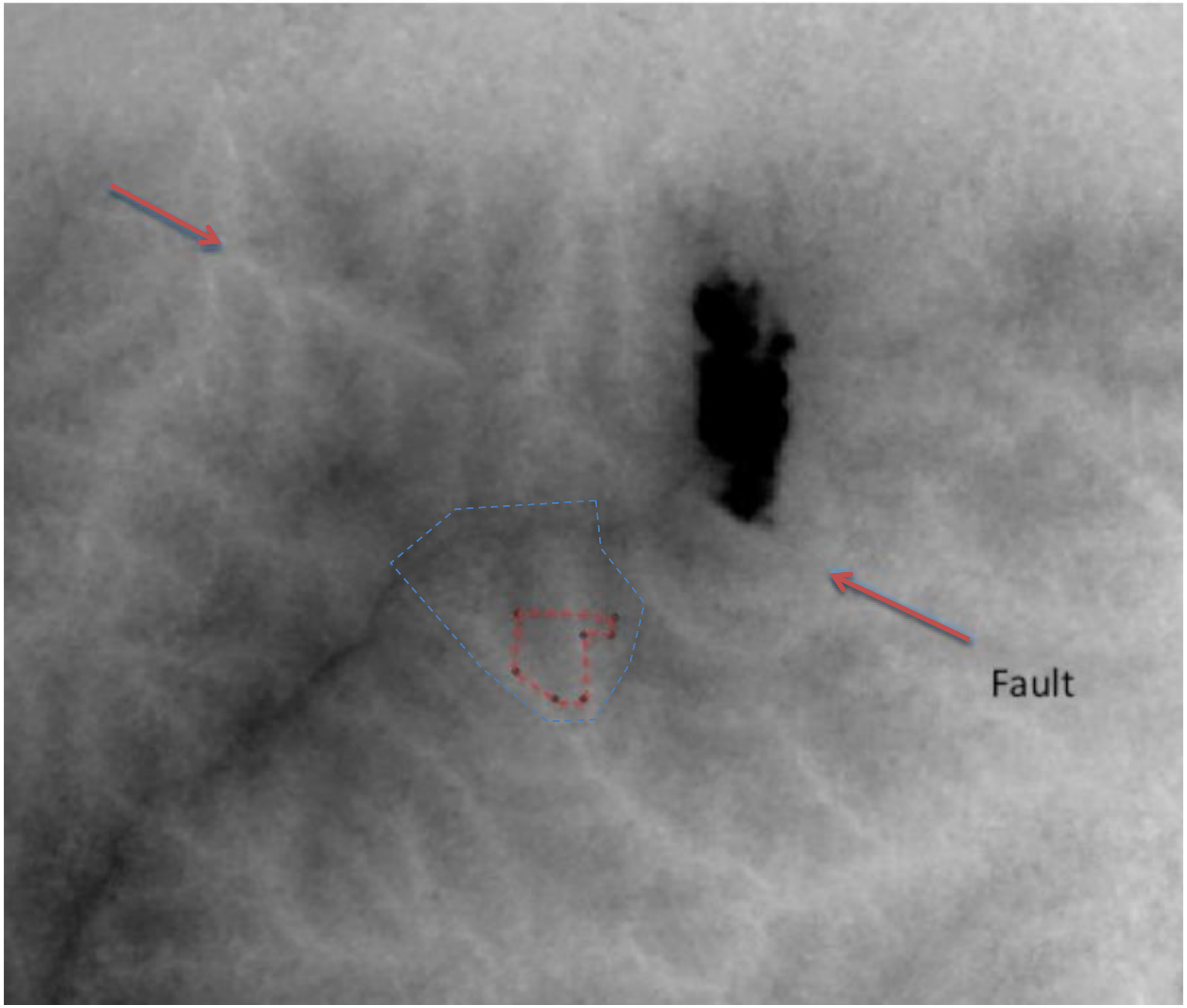


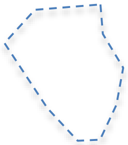


Source:
reach_camp_sdd_factsheet_jubapoc3_june2015_8

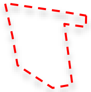
SRTM topographic data used to identify:

- Recharge potential at camp site
- Nearest regional structure for groundwater exploration





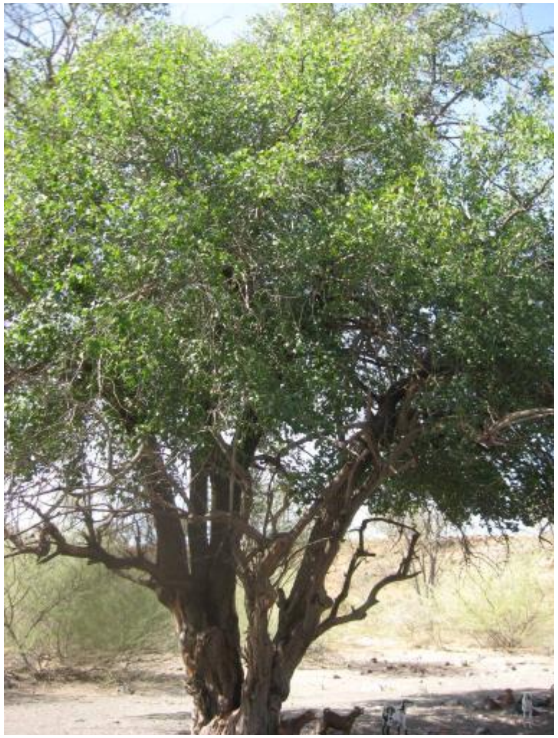
Catchment = 5km^2
1000mm rainfall/annum
1% recharge
5.7m^3/h maximum available



POC 3
Camp population = 20,000
Water demand therefore = 12.5m3/h

Multi Spectral Optical datasets

- Again historic technique where vegetation changes help to indicate water availability



Certain trees are used as signs of aquifer recharge

Multi Spectral Optical datasets

- Now use optical image sensors which obtain data from multi spectral bands
- NVID or false colour imaging (infrared-red-green)
- Useful to date in terms of identifying zones of recharge in arid environments

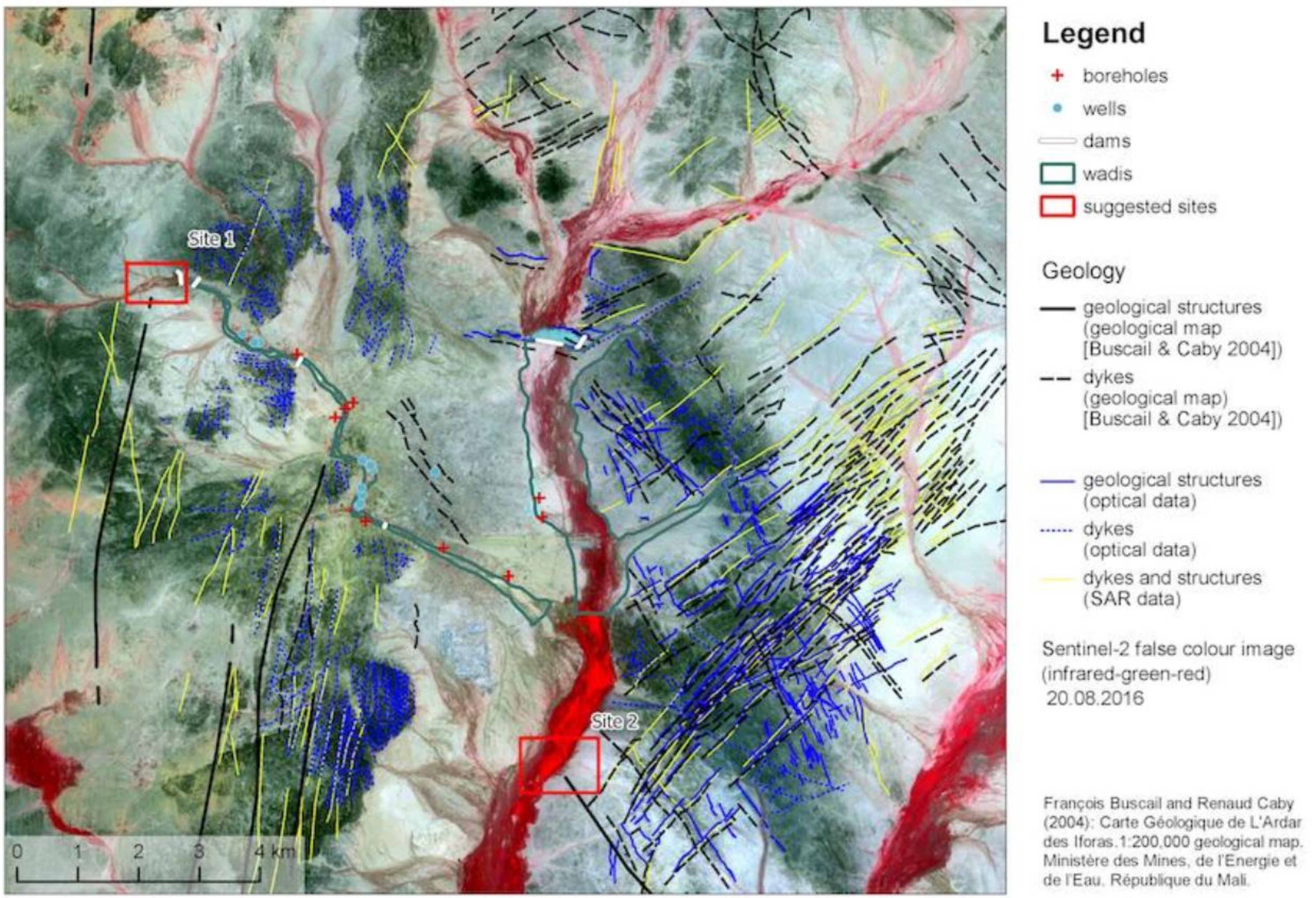
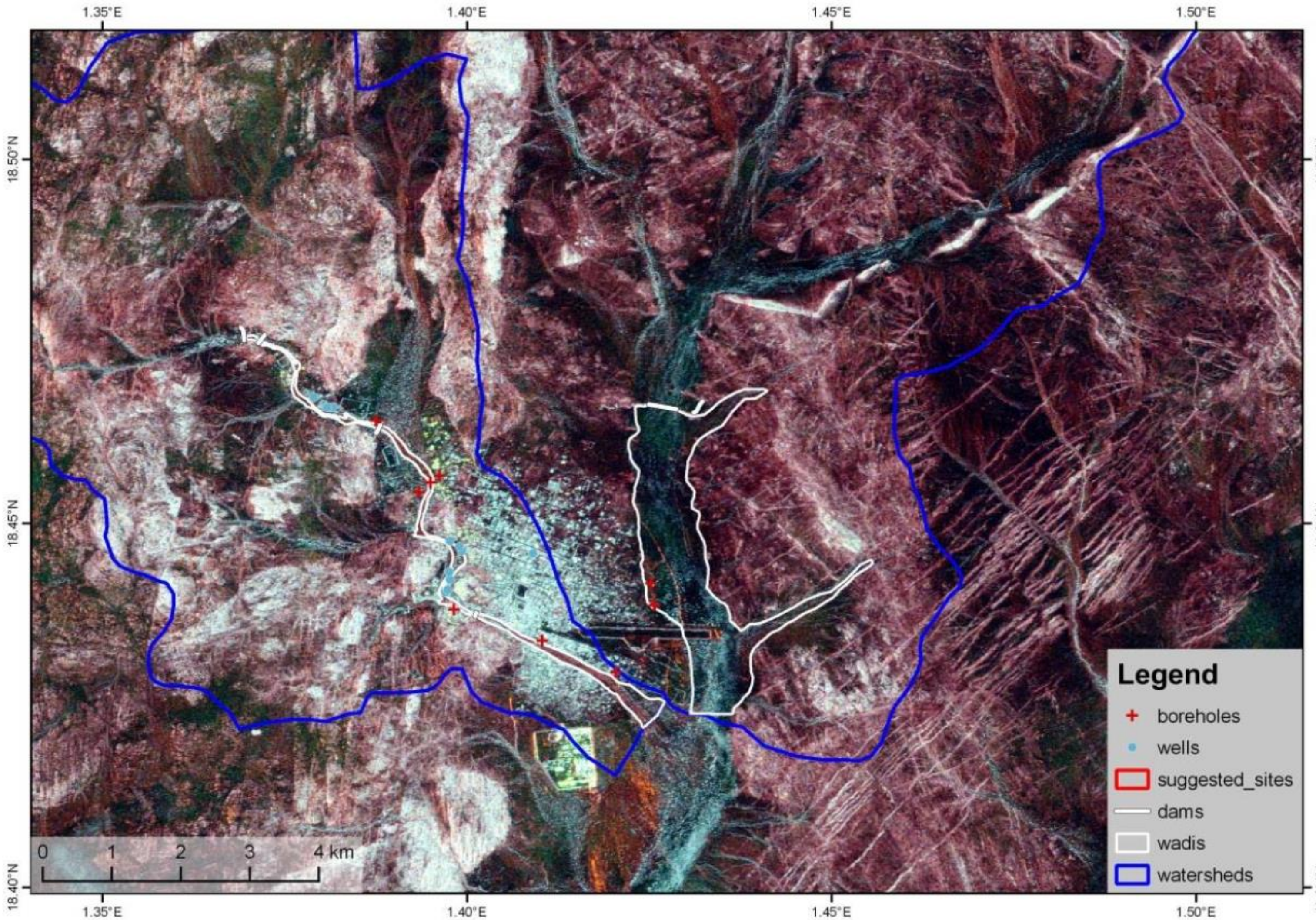


Figure produced by E04HumEn+ as part of a Groundwater Assessment carried out on behalf of IFRC for Kidal, Mali

Synthetic aperture radar (SAR) data

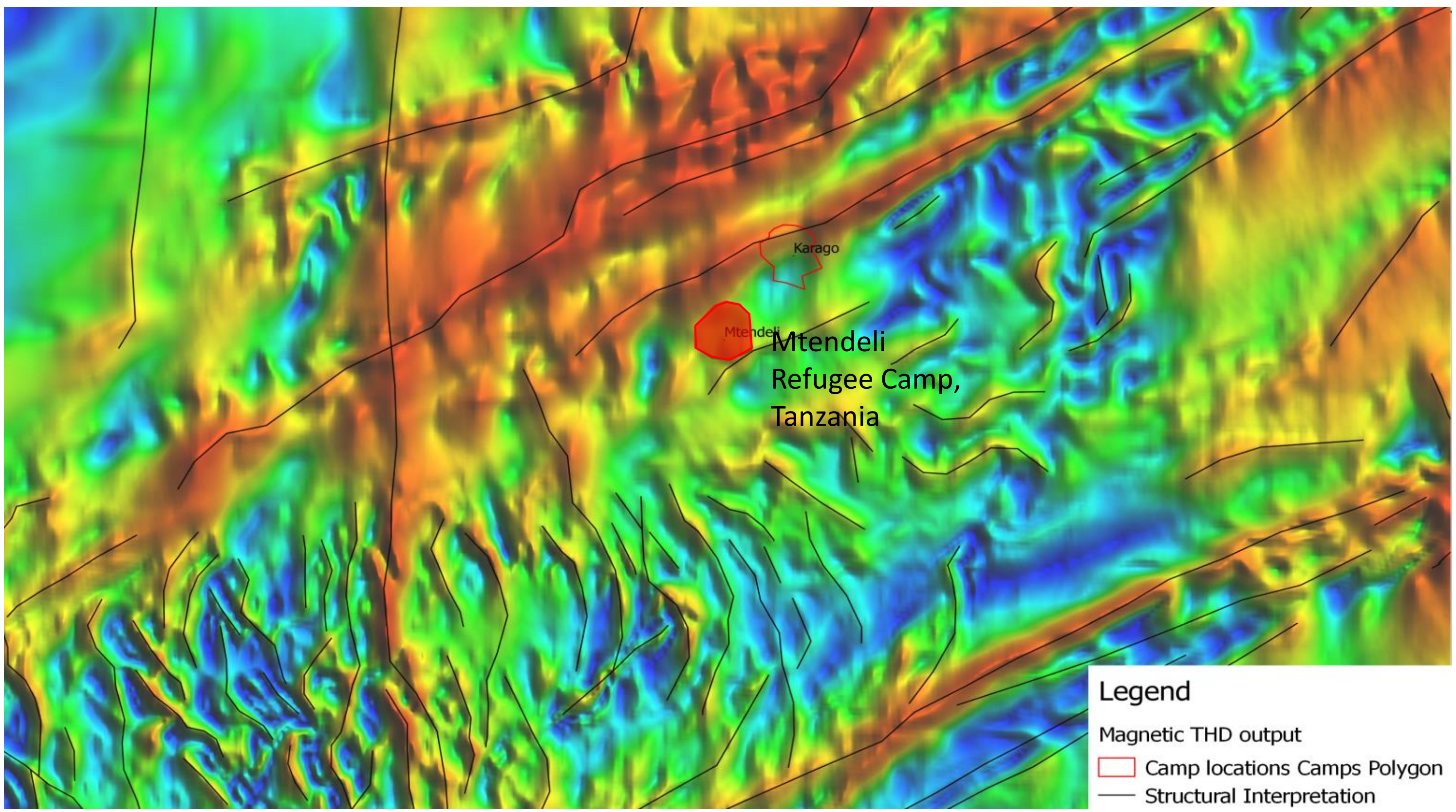


Coherency matrix of a quad-polarized ALOS-2 scene. It enables the analysis of single scattering mechanisms for the discrimination of different surfaces. However in this example the enhanced structures are mostly geological rather than structural.

Figure produced by The University of Tübingen and E04HumEn+ as part of a Groundwater Assessment carried out on behalf of IFRC for Kidal, Mali

Aerial magnetics Mtendi refugee camp, Tanzania

- The magnetic data was collected using a magnetometer carried in a plane at a height of 120 m, with an E-W flight line spacing of 1000 m for mineral exploration purposes
- Three types of anomalies recognised
- Borehole siting – sites chosen for geophysical investigation where magnetic anomalies corresponded with topographic structures



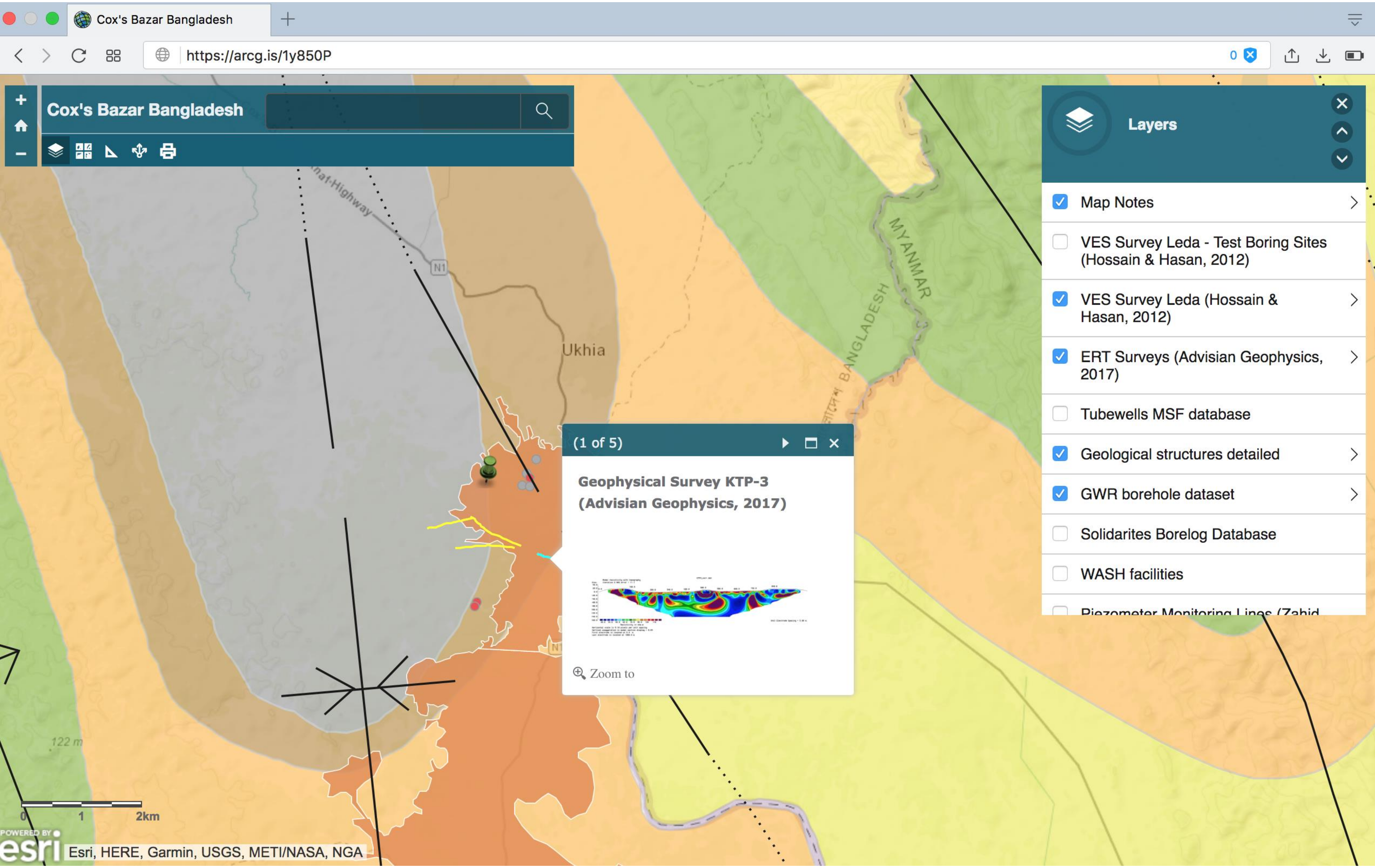
Source:
Data and interpretation provided by Getech

GIS

- QGIS – free, open source, has many useful functions
- Google Earth – most used in the field, needs very low internet band width – easy to share point data
- Online ArcGIS – easy to share shape files, can be used with a phone app, easy to share online with other users or for viewing of data.

An example of an online ArcGIS map developed by Groundwater Relief:

- Cox's Bazaar, Bangladesh: https://arcg.is/1y850P



Cox's Bazar Bangladesh
https://arcg.is/1y850P
Cox's Bazar Bangladesh
Layers
Map Notes
VES Survey Leda - Test Boring Sites (Hossain & Hasan, 2012)
VES Survey Leda (Hossain & Hasan, 2012)
ERT Surveys (Advisian Geophysics, 2017)
Tubewells MSF database
Geological structures detailed
GWR borehole dataset
Solidarites Borelog Database
WASH facilities
(1 of 5)
Geophysical Survey KTP-3 (Advisian Geophysics, 2017)
Zoom to
Ukhia
MYANMAR
BANGLADESH
N1
122 m
0
1
2km
POWERED BY esri
Esri, HERE, Garmin, USGS, METI/NASA, NGA

Looking forwards

- Seeking to build relationships with others to fully utilise the potential of remote sensing data within our groundwater exploration and management programmes
- Seeking to develop agreements with data providers to make satelitte data available at low cost to humanitarian sector (e.g. TanDemX data
- Continue to build our own capacity as a groundwater charity – rapid response unit, better equipment for ground investigation to compliment remote sensing data
- Working with ArcGIS online and other apps to make data readily available to field workers
- Building apps in collaboration with Practica Foundation to support data collection
- Reviewing remote sensing techniques for groundwater exploration as a study within the E04HumEn+ project. Hoping to compare high quality ground data with many different remote sensing techniques. Project to be done in partnership with Oxfam over the next four months.