CHALLENGE OF DEVELOPING GROUND WATER PROJECT ALONG FAULT LINE

FEATURING BOERA GROUND WATER PROJECT
PORT MORESBY , PAPUA NEW GUINEA

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Outline

1. Project Overview
2. Geology and Hydro Geological Setting
3. Surface Geophysical Survey
4. Drilling and Well Construction
5. Results of Aquifer Test
6. Challenges
7. Lessons Learnt
8. Conclusion

2. Project Overview

- <u>PNG –GSD Key focus area</u>
  Advocating an Integrated Geosciences for Humanity in Water Supply and Sanitation Projects

Problem

- Boera Ground Water project is developed to supply water to recently established town

- Initial Project Developed in 2014 .

Problem:

Bore was not producing water after a tremor in Nov 2016

Aim

(1) Identify the cause of water loss in the previous bore hole system

(2)Identify a suitable drilling site

(3) Assess whether it is feasible to supply water to the recently developed town with more than 500 houses .

Challenge?

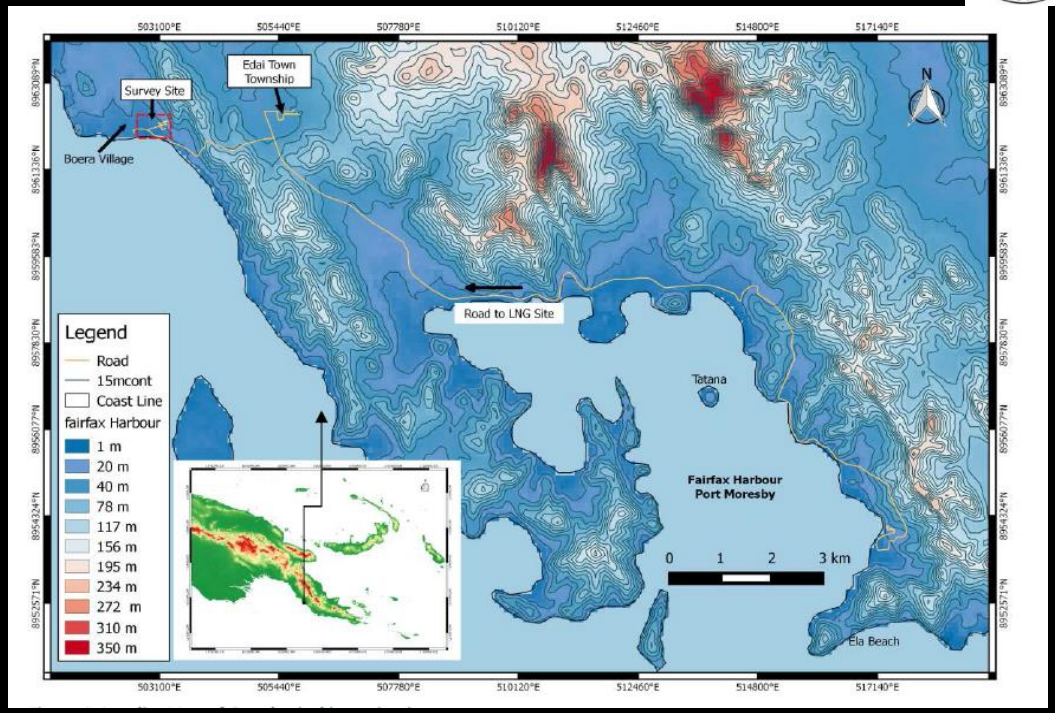
1. Is the Bore Hole Safe along the fault line?
2. Is it feasible to supply water for the recently established town

Location/Access

- Boera ground water project is located 15km away from Port Moresby CBD, Closer to PNF LNG Site
- Total population of Boera is about 4000 people living along the coast line.
- Access to site through a paved road

3. Topography

- Port Moresby is predominantly savannah grass land with scattered trees
- Hills and gentle slopes (30-40% rise) are mostly parallel and undulating
- Flat areas are closer to the coastline
- No major rivers or creeks flows within the city limits except for seasonal drains



3.0 Geology & Hydro Geological Setting

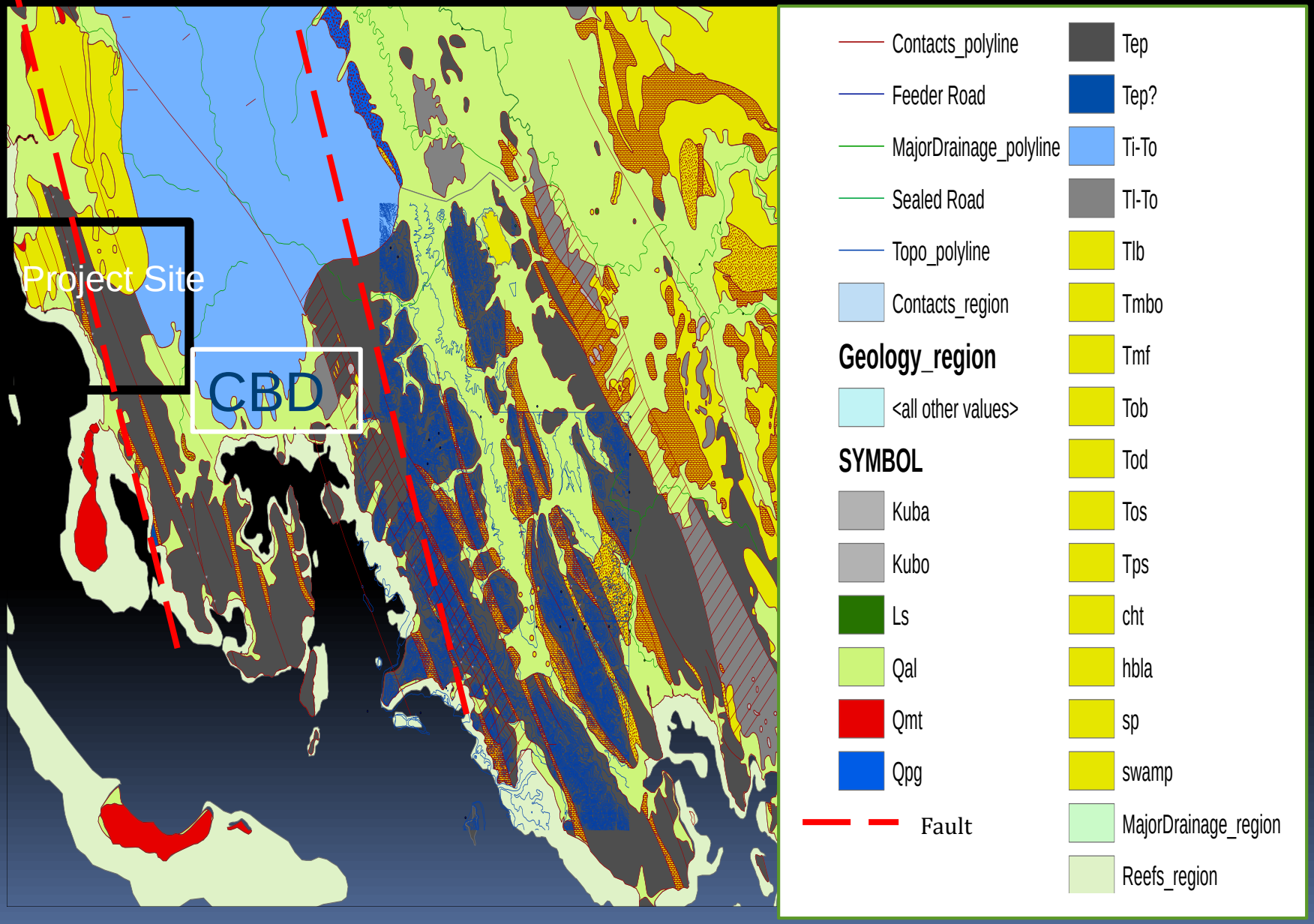
- Boera ground water project site falls within P***ort Moresby Kalo Aroa*** Sheet the 1:50k Geological Series

- Main rock unit is late Middle Miocene of Port Moresby Beds (Tep). Formation comprised of reef limestone, mudstone, tuff, lapilli tuff, tuffaceous sandstone and limestone breccia about 200m thick.

- Port Moresby beds overlain by Boera Limestone (Tmbo) Oligocene-Miocene 300m, Siro Conglomerate to East (Tms) (formation comprised of sandstone, siltstone, mudstone)

- Quaternary Alluvium (Qa) (sand, silt, clay and raised coral) deposited recently .

Geology (1:50K Port Moresby Kalo Aroa)



Project Site Geology

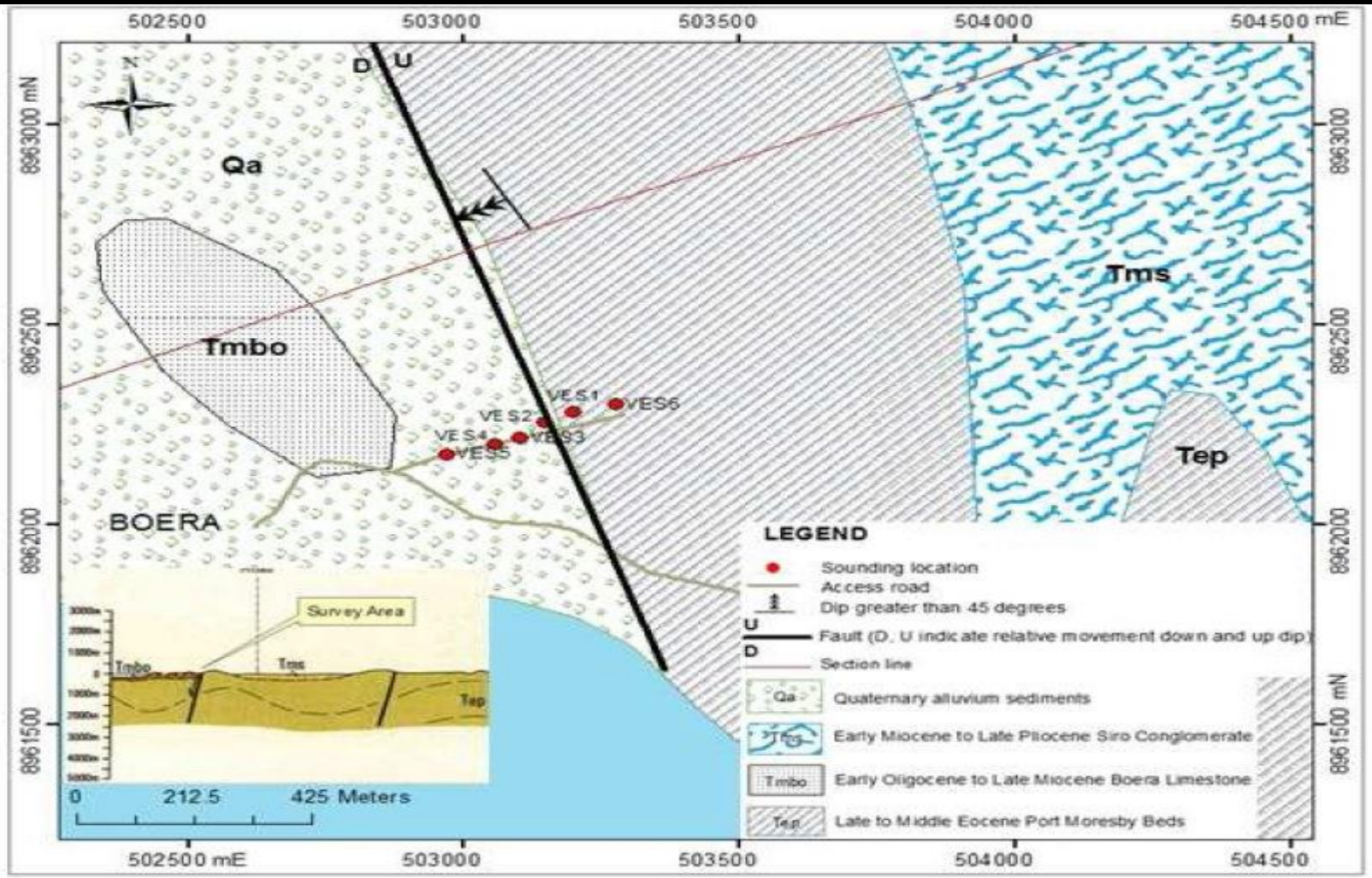


Figure 2: Geology map of survey area, after Pieter's (1978). Insert: A segment of section AB from Pom-Kalo-aroa 1:250K Geological Sheet.

Characteristics of Port Moresby Beds

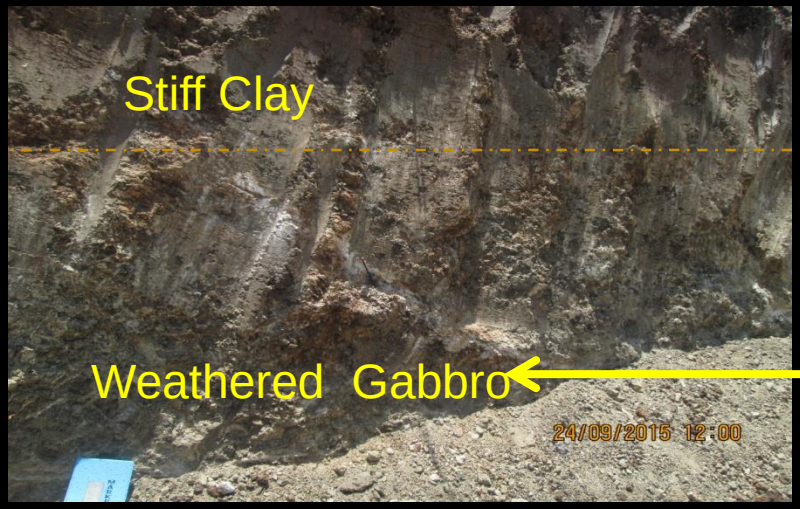
Mudstone: It is well-bedded, closely-fractured and jointed with abundant calcite veining. The unit is well-exposed in coastal exposures at Koki, Konedobu and Baruni, Boera. It is the most common rock unit in Port Moresby.

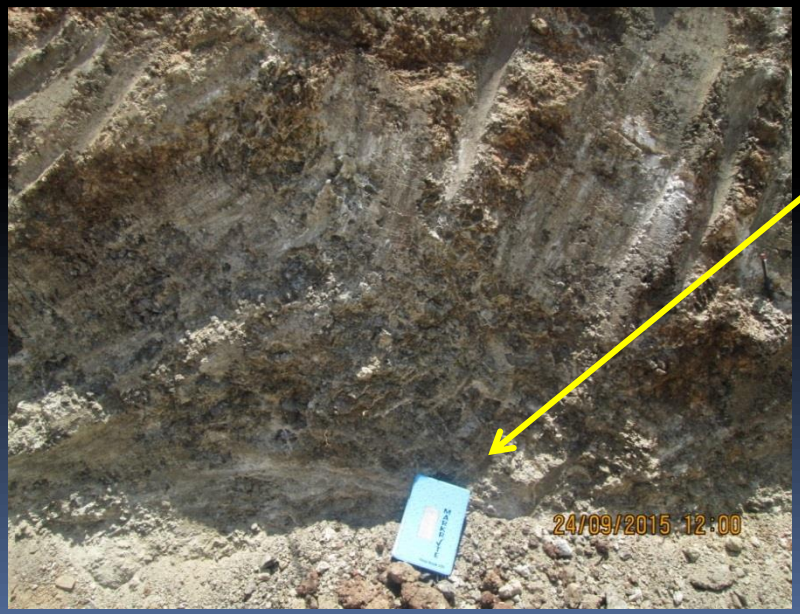
Baruni Limestone - fine-grained massive to well-bedded, hard and competent but closely-fractured and jointed. Exposures of this unit can be seen at Baruni, Kila Kila and other parts of Port Moresby.

Continue

- Port Moresby beds are generally well bedded and tightly folded and fractured
- Weathering profile of the Port Moresby Beds extends down to 10m.
- Fresh bed rock is mostly encountered at 10m below

Continue.





Sadowa Gabbro -medium- to coarse-grained. It is hard and competent when fresh but highly weathered exposures readily disintegrate to a sandy silty gravel. (Potential Source of Aquifer)

Highly weathered Gabbro overlain by the Stiff Clay along Gerehu -9Mile Highway, Port Moresby

Potential Aquifers

- Unconfined Aquifers
- Ground Water resources in Port Moresby City is accessed through drilling within the colluviums (gravel and sand) mostly derived from the hill slopes deposits.
-

Port Moresby Ground Water Conditions

- Total of 120 bores drilled in the past indicated that ground water in Port Moresby water is preferably found within gravel beds .

- Water table is at 3-5m.
- Production yield about 0.7-12L/sec in most bores tested.
- (Port Moresby Bore Hole Inventory)

Fractured Bed Rock Aquifer

- Only 5x bores drilled on a fractured bed rock intercepted a perched water table at 5-m,.
- No pump testing has been conducted for fractured bed rock
- So the possibility of tapping ground water on fractured bed rock was not feasible in the past.

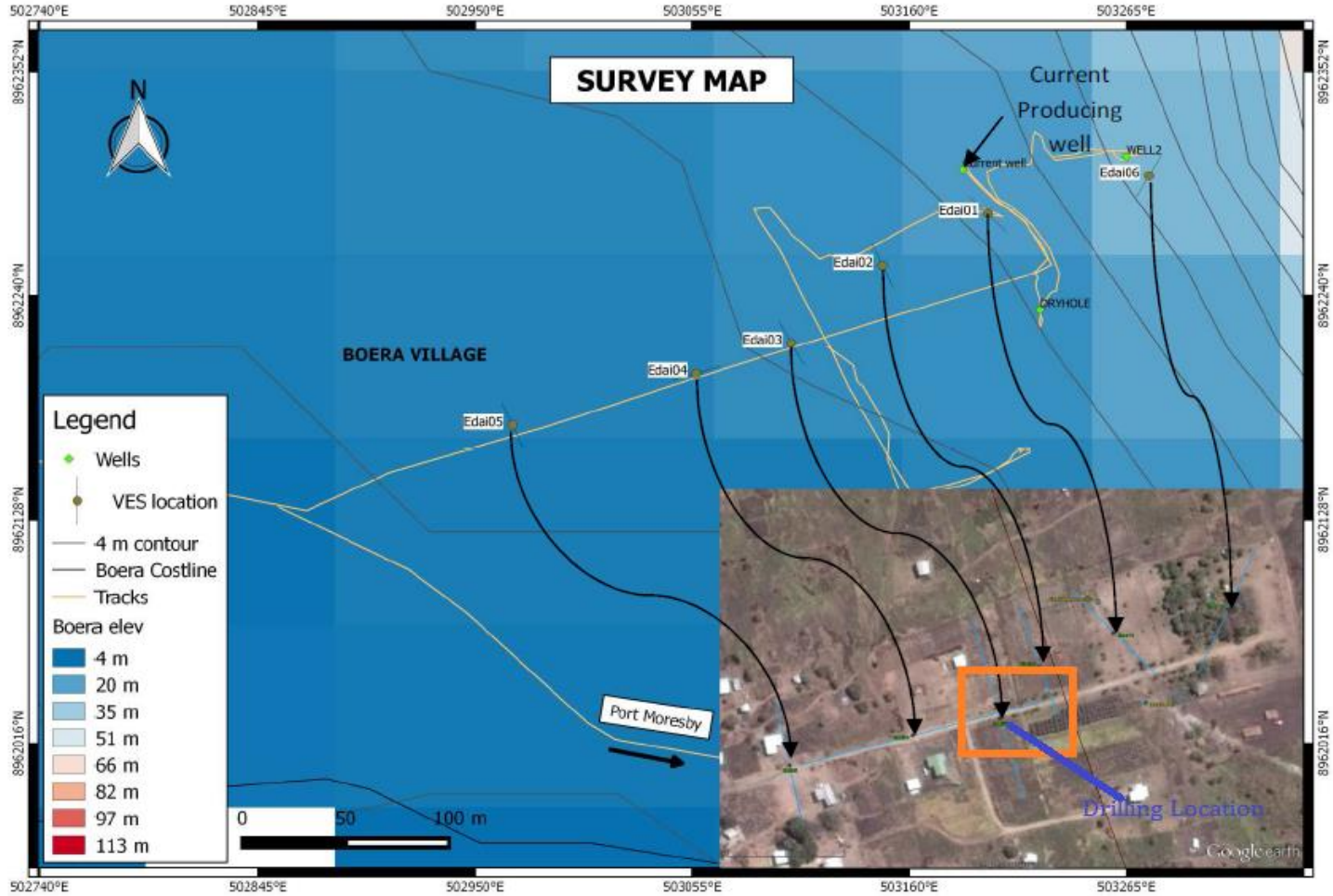
4.0 Surface Geophysical Survey

- Previous Work (2014)
- Conducted resivitivty survey in 2014 near the Eddai Town area.
- Identified Potential water bearing layers at 2-3m
- Drilled to 34m but no water found.

Recent Works -2017

- Conducted 6 vertical resistivity soundings over a site covering approx.100 square meters
- 300m away from the damaged bore hole.

Geophysical Survey – Site Layout



Geophysics Survey Layout

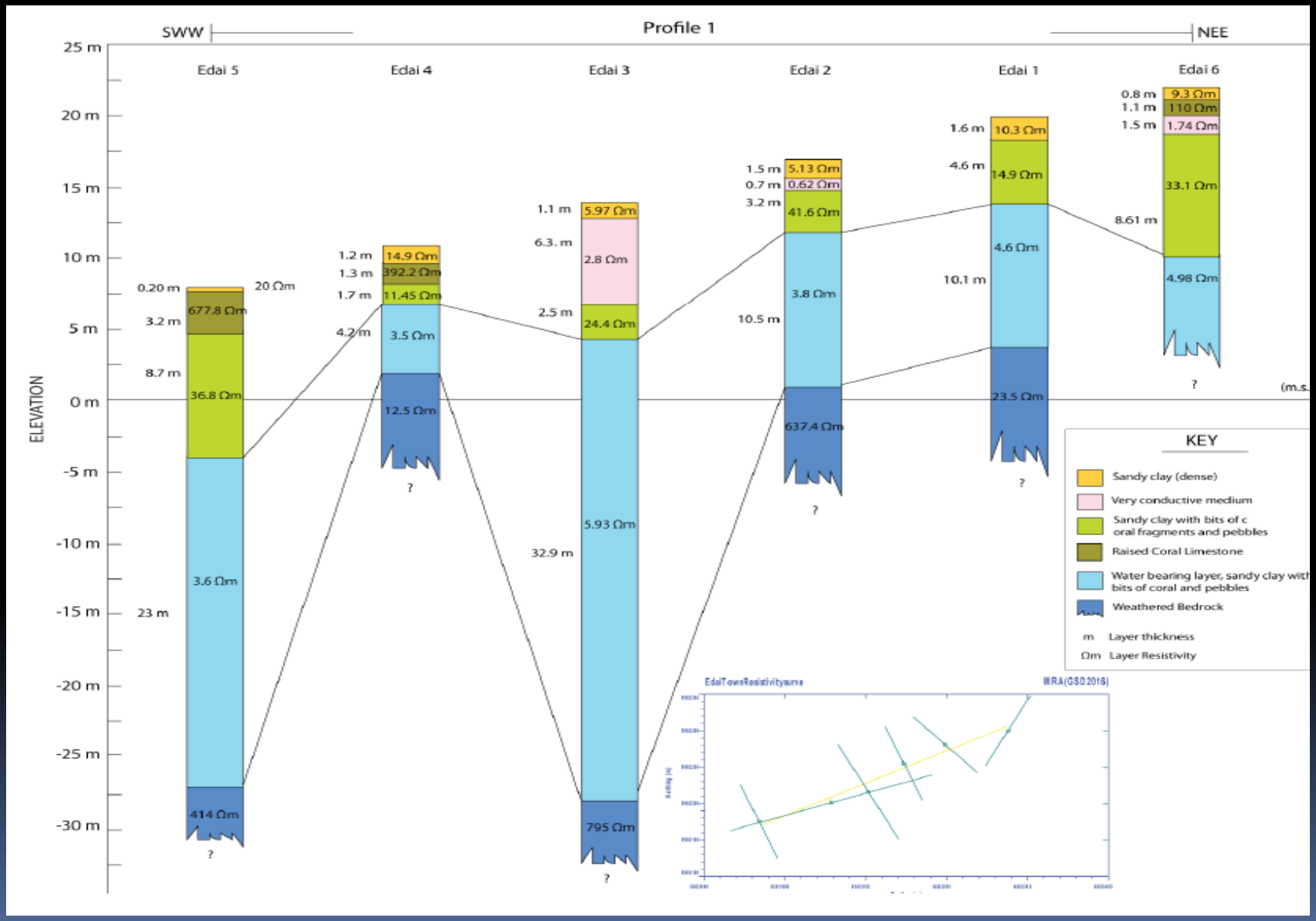
Results

Table 2: Aquifer parameters across all soundings

VES Station	Aquifer thickness (m)	Aquifer resistivity (Ω)	Depth to Groundwater Table (m).From surface	Elevation (m)
Edai1	10.1	4.6	6.2	13.81 → 3.76
Edai2	10.5	3.8	5.4	11.64 → 1.18
Edai3	32.9	5.9	9.8	4.20 → -28.65
*Edai4	5.1	3.9	3.6	6.72→2.53
Edai5	23	3.6	12.1	-4.1 → -27.0
*Edai6	?	4.9	11.9	18.66 → 10.05

* denotes some degree of error associated with results

1-D Resistivity Model of Site



Cross Section –1D Section Resistivity Line

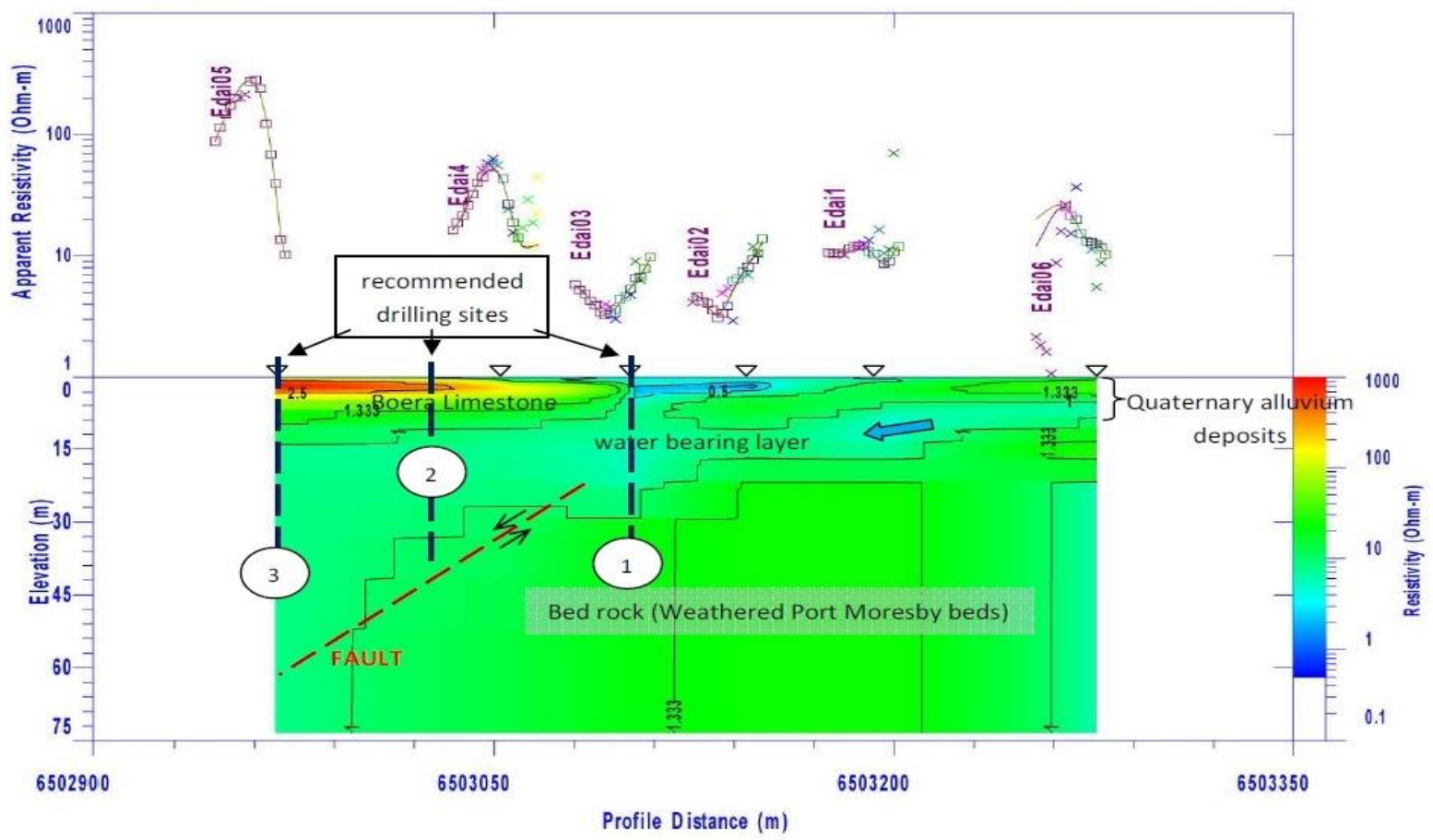
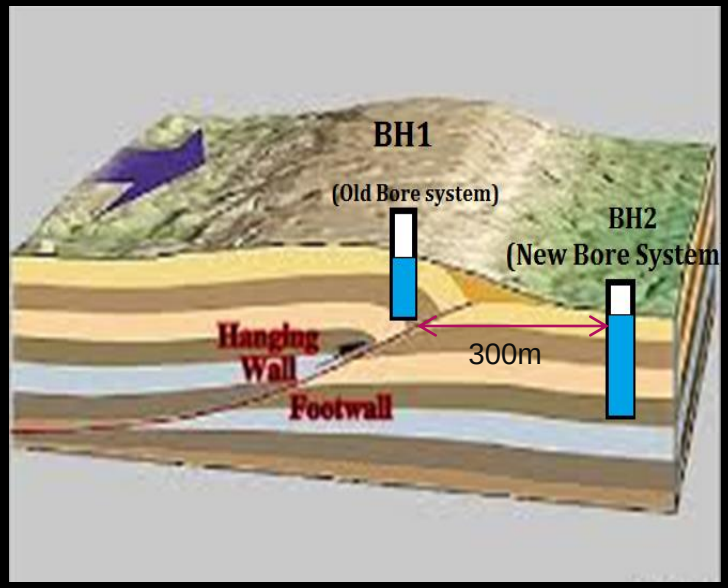


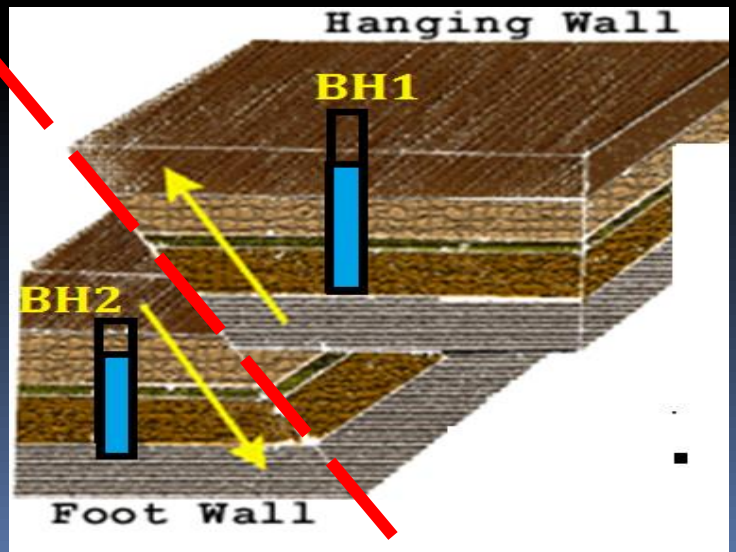
Figure 6: Graph showing resistivity 1D-section through Profile 1. The Top half of the figure shows the Zarbovsky plot of the apparent resistivity curve while the bottom half is the resistivity 1D section along profile 1.

Challenge

- From the geophysical survey , 2 possible sites were selected purely based on the following criteria;
- A fault detected from the resistivity survey and confirmed from the existing 50K geological series.
- (1) Good aquifer thickness (Eddai 03 =32.9m(Eddai05 25m)
- (2) Located on the footwall of a fault line NNW, SSE 45 (previous bore was located on the hanging wall of fault) .
- Naturally water would flow from a high elevation to low elevation.

(Ground Water Training Model 2017)



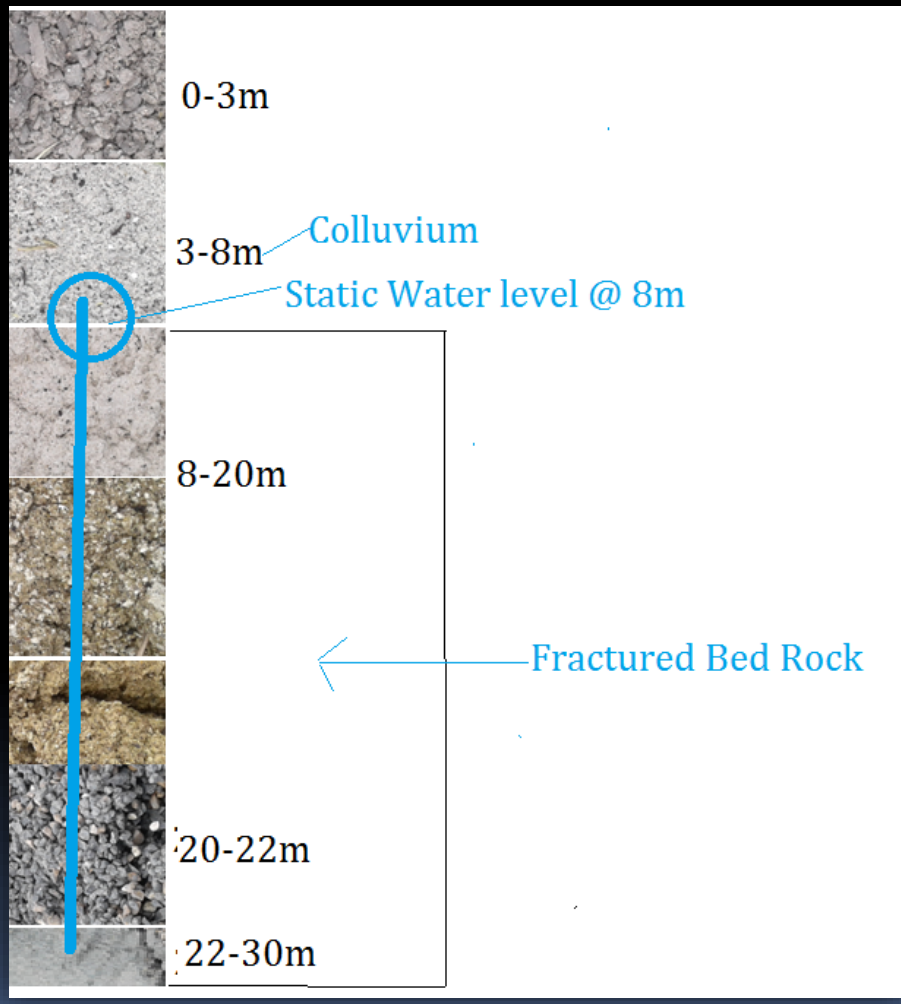


5. Drilling and Well Construction

- Drilling was done using Multitec 9000 tractor mounted RC drilling rig. With compressor unit mounted on a truck.
- 700L support water tanker, 4 1/2 inch submersible pump
- 300mm open hole drilled depth to 30m (EOH)
- Cased with 150mm PVC casing

Sub-surface Profile

- ✓ 0-3m- Top Soil (Greyish black)
- ✓ 3-8m- Gravel – White grading to brown, some pieces of coral limestone (lagonal deposit)
- ✓ Fluctuating water table at 5-7m (gravel , sand, and silt , colluvium)
- ✓ Water strike in at 8m (Static water level measured from Probe) ,
- ✓ 8-20m – Limestone , extremely weathered
- ✓ 20-22m- Gabbro Sill, highly weathered (Water still present at this depth)
- ✓ 22-30- Mudstone grey grading to blue, highly fractured . (due to faulting)



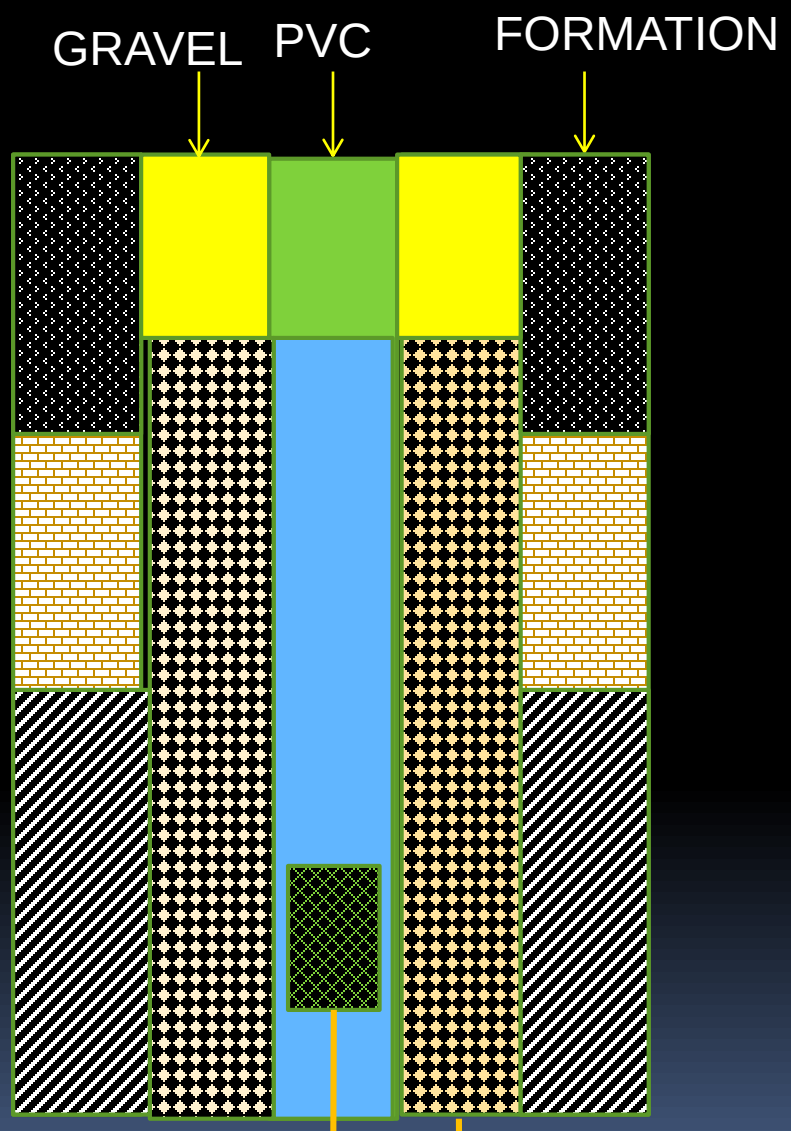
Well Construction

- A well was constructed with

A 150 mm PVC screen placed into the bore hole suspended at 26m.

- Total of 6m in length
- Gravel was used for grouting the bore hole. (space between formation and casing)

Well Construction Layout



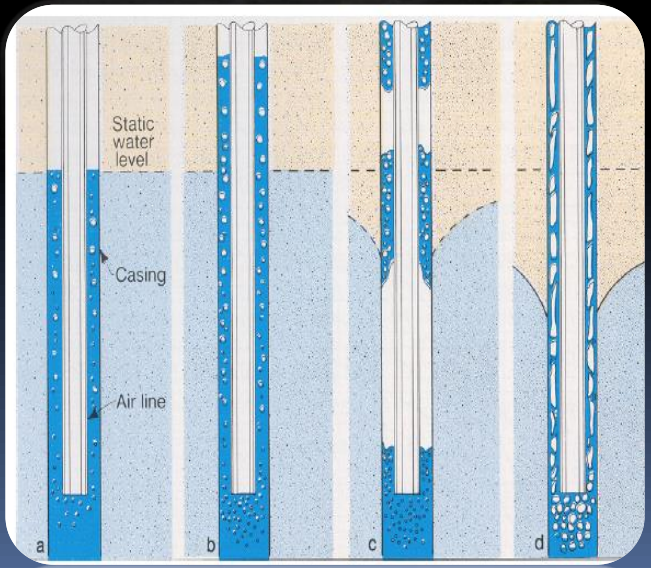
Perforated Screen
(6m) suspended at 23m

Gravel pack @ 30m

Well Development

The well was developed using air lift surging purposely to;

- Remove fines to enhance well efficiency
- Optimize specific capacity
- Stabilize formation and limit sand production .



Aquifer Testing

- The Bore hole was tested at maximum constant discharge rate of 2/L sec for 24hrs and draw done of 4m.

- After 24hr test, the standing water level was maintained at 9-5-10m

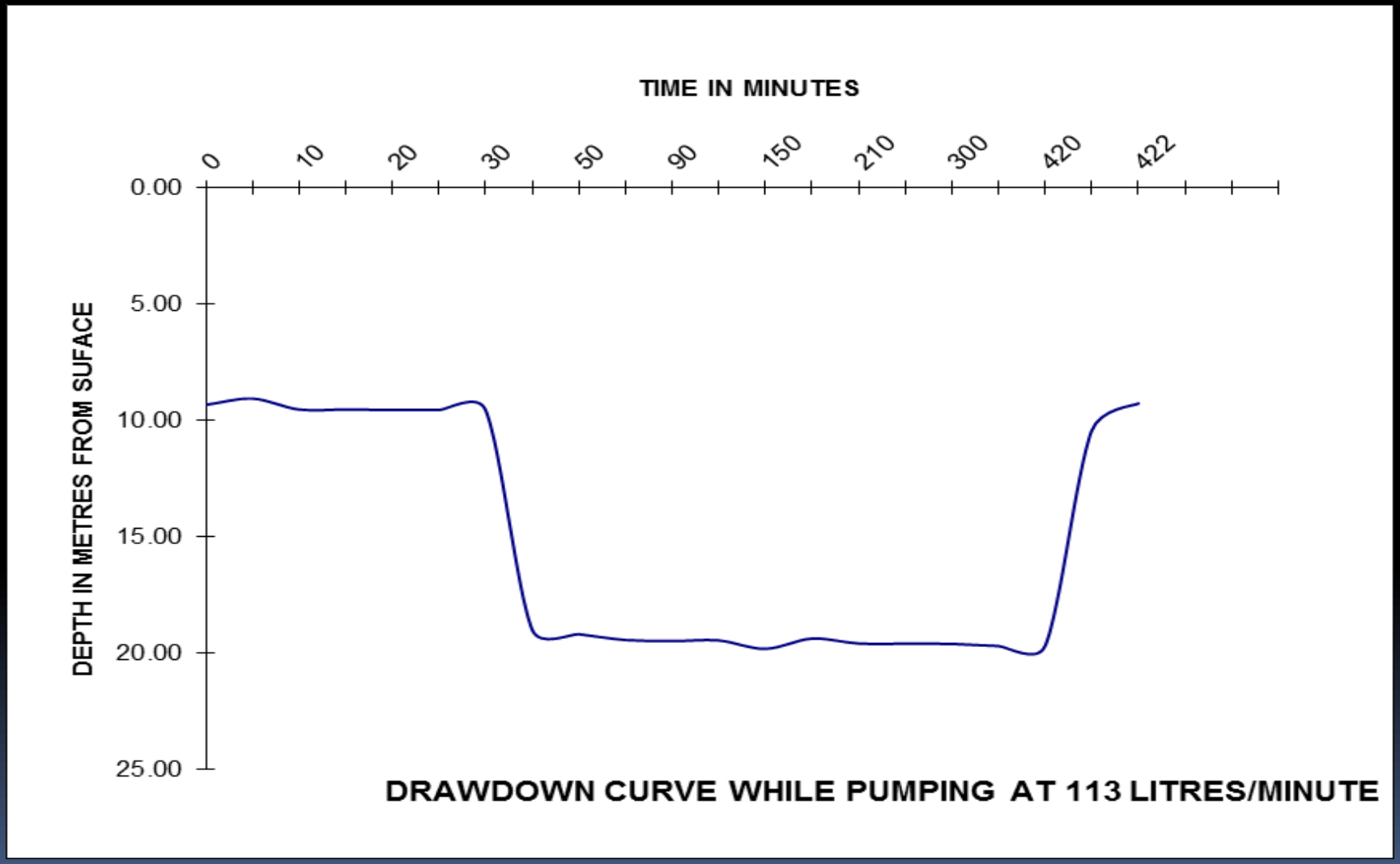
Pump Testing

Pump Test Results

- A pump test was conducted over 24hrs.
- A draw down of the well was measured
- Within of 24hrs test period water level was maintained at 9.32 10m
- Bore well yield (flow rate) measured is about 2L/s

TIME (m)	WATER DEPTH (m)
0.00	9.32
5.00	9.05
10.00	9.52
15.00	9.52
20.00	9.54
25.00	9.54
30.00	9.54
40.00	18.99
50.00	19.18
60.00	19.43
90.00	19.48
120.00	19.45
150.00	19.81
180.00	19.37
210.00	19.58
240.00	19.59
300.00	19.60
360.00	19.69
420.00	19.69
421.00	10.43
422.00	9.26

Draw Down Curve while pumping



Pump test results

- The bore pump discharge rate was set at 113 litres per minute with the pump at 23 meters. The pump was shut down at 420 minutes and the bore allowed to recharge .

- Based on the timer taken for the full recharge from ceassation of pumping , the bore hole is able to sustain a continual pumping rate of <u>113L per minute , 6780 litres per hour and daily yield (24hr) 0f 162, 720 litres</u>

Production

- Water is been pumped out of the bore hole to pump out facility located 200m away from test bore well.
- 2x15000L reservoir thanks filled to capacity and pumped out at 1.56L/s to Eddai Town.

Is the Water Safe to Drink?

- Water quality test were conducted to check for presence of;
  - *Total Coliform*
  - *E. Coli*
  - *Faecal Coliforms and other*

Lab Results – Water Quality

NARI CHEMISTRY LABORATORY
RECORD

REPORTS
ANALYSIS REPORT

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Ph: 321 3511
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Client Reference:
Our Job No: 17-019
Date: 27th February 2017

For the __5__ samples analysed "as received" by this laboratory on the __10 / 02/ 2017_____, the following is supplied:

Lab No	Client ref	Total Coliforms cfu/100 mL 9222 B	Faecal Coliforms cfu/100 mL 9222 D	E. Coli cfu/100 mL 9222 G	*Dissolved oxygen mg/L 4500-O G	pH pH units 4500-H+B	*TDS (Total Dissolved Solids) mg/L 2540 C	*Alkalinity mg/L 2320 B
17-0043	B-1	Nil	Nil	Nil	7.76	7.3 @ 25.8°C	477	314
17-0044	B-2	Nil	Nil	Nil	7.68	7.3 @ 25.8°C	471	312
17-0045	B-3	Nil	Nil	Nil	7.74	7.4 @ 25.6°C	530	314
17-0046	B-4	Nil	Nil	Nil	7.75	7.5 @ 25.4°C	494	318
17-0047	B-5	Nil	Nil	Nil	7.52	7.4 @ 25.7°C	484	314

-End of Results-

* Test methods under NISIT/PNGLAS Accreditation

PNGLAS Accredited Laboratory
Number: 52
The tests, calibrations or measurements covered by this document have been performed in accordance with PNGLAS requirements which include the requirements of ISO/IEC 17025 and are traceable to Australian national standards of measurement. This document shall not be reproduced, except in full.

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Page 1 of 2

Approved by Hilda Sim, Quality manag.

Providing Quality Analytical and Diagnostic Testing Services

Key Challenges

- Two important challenges
- (1) Site Selection for drilling
- (2) Is the flow rate or yield able to meet the demand ?
- (3) Aquifer can be depleted quickly due to low recharge issues in the future

Site Selection for Drilling

- From the geophysical survey , 2 possible sites were selected purely based on the following criteria;
- A fault was detected from the resistivity survey .
- (1) Good aquifer thickness (Eddai 03 =32.9m(Eddai05 25m)
- (2) Located on the footwall of a fault line NNW, SSE 45 (previous bore was located on the hanging wall of fault) .
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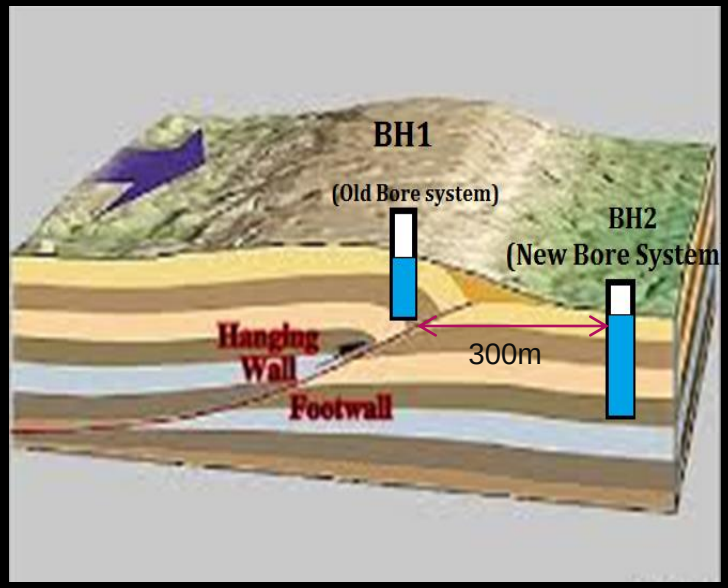
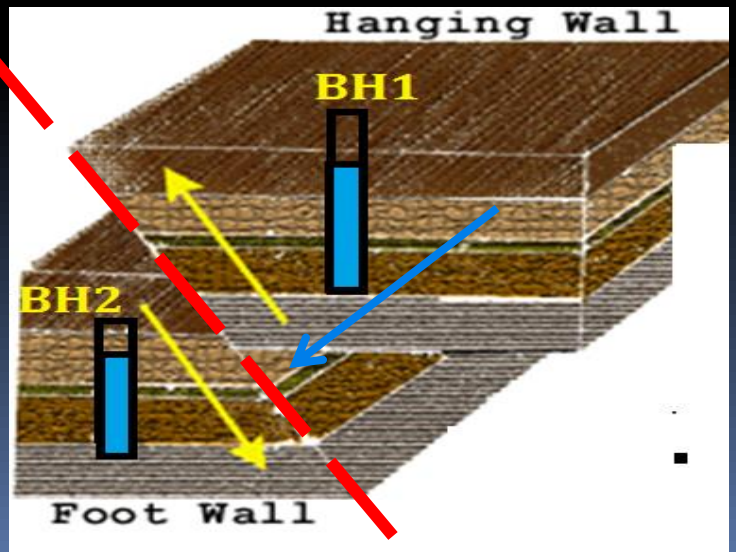
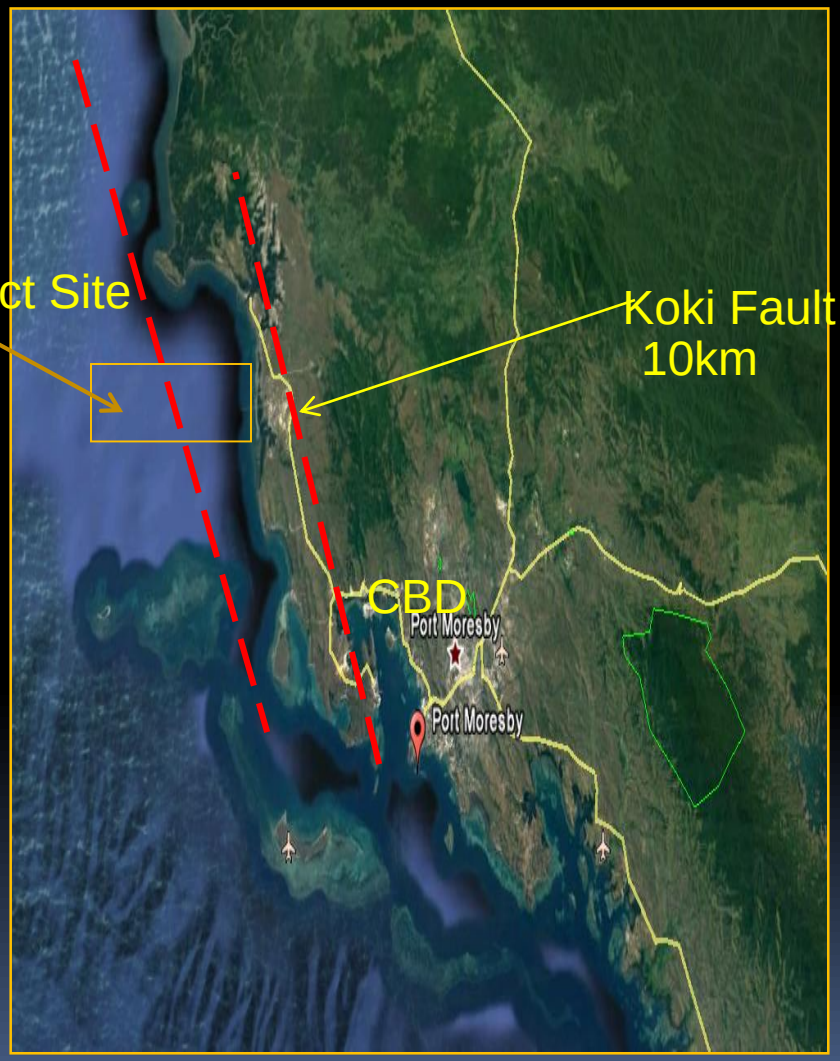




Important Lesson!

- A new geological information was added on the existing 1:50,000 series geological map that the confirmed active fault .
- Ground Water can now be accessed from fractured rocks in Port Moresby
- A collaborative effort required from all geoscientist in successful delivery of a project *safely on time and budget.*



Conclusion

- Results indicated Ground Water is Fault /Fractured fractured aquifer at Boera ground water project
- A combination of desk top study, site survey through to drilling , well construction and pump testing indicated that the site we have selected was the ideal and most importantly safe for the bore water system.. Current bore water hole is located 300m away from the fault line.

- Important decisions in identifying a suitble site for bore water drilling especially along fault lines poses significant challenges in terms safety and economics .
- The bore is feasible and now supplying water to more than 500 houses

Thanks

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