Groundwater Sustainability at Wadi Al Bih Dam, Ras El Khaimah, United Arab Emirates (UAE) using Geophysical methods

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Outlines

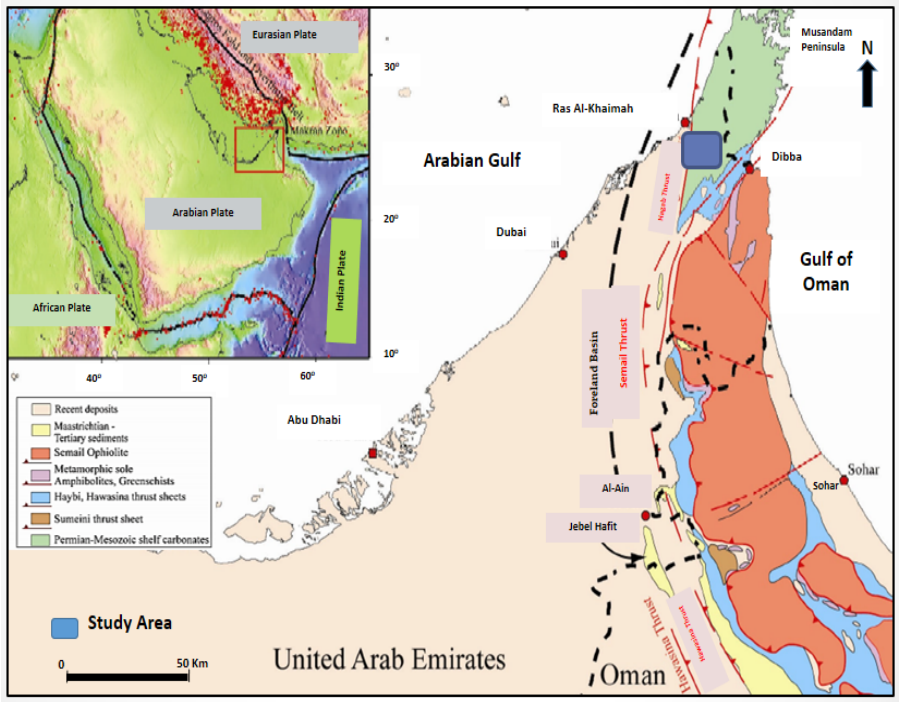
- Introduction
- Objective of the study
- Methodology
- Results and discussion
- Conclusions

Introduction

- The investigation site represents one of the significant locations for water accumulation in the United Arab Emirates (UAE). It lies in the downstream of one of the biggest valleys which starting from the water divide area along Oman Mountains in Ras Al-Khaimah Emirate.

- The Wadi-Bih dam plays a great role in stooping the flash floods and asset the infiltration process to recharge the aquifer.

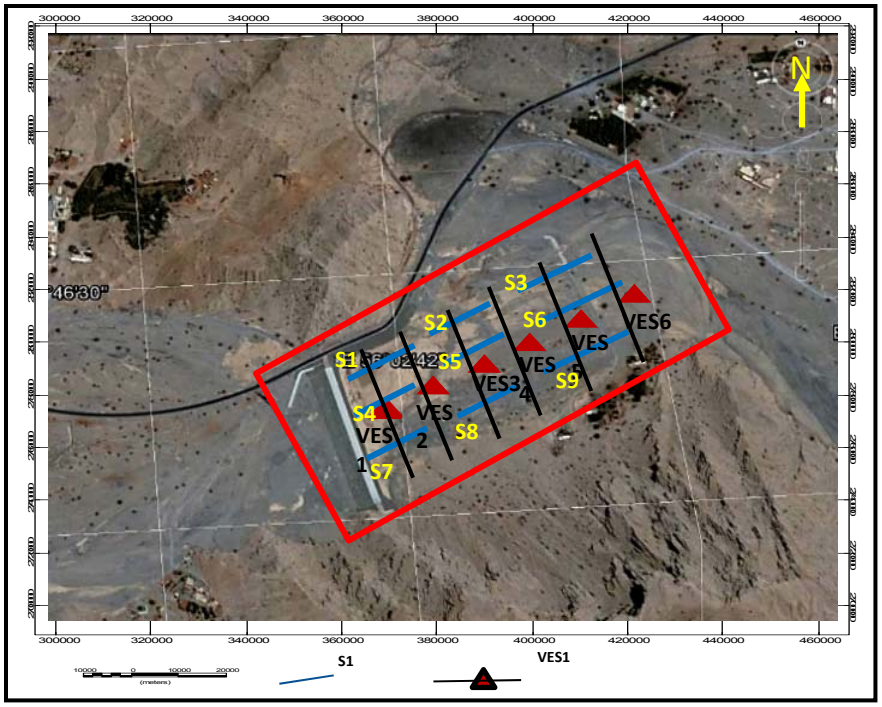
- The dame ability to store and collect the surface water.



Objectives

- Estimate the thickness of the shallower deposits and the subsurface lithological layering.
- Predict the depth to the water level.
- Measure the infiltration rate at the dam site and emphasize the relationship between precipitation and infiltration rates as well as the dam ability to store and collect the surface water (Dam Efficiency) and groundwater Sustainability.

Study Area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VES 1
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S1
VES1

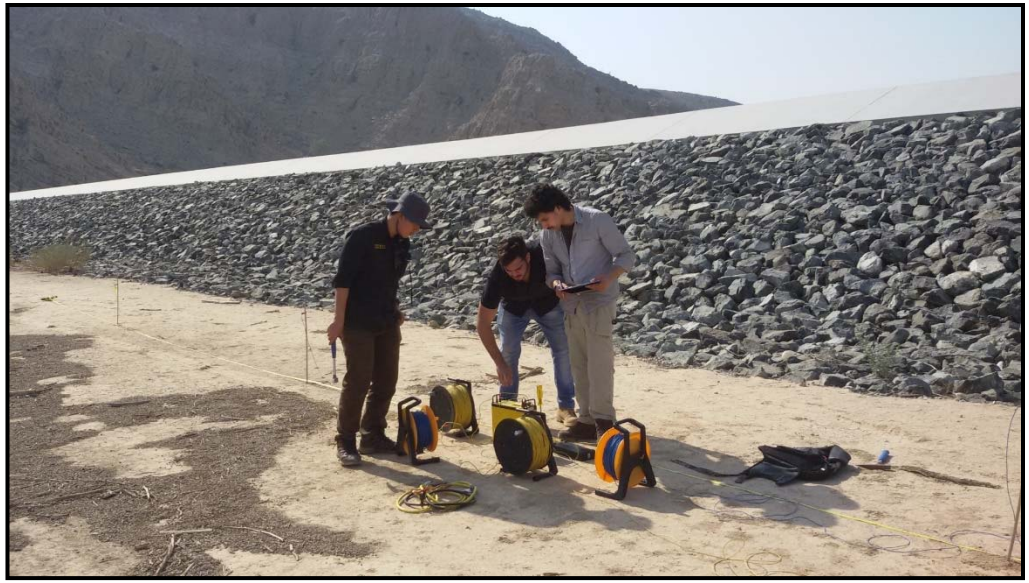

Wadi Al Bih Dam
46'30"

Geophysical Investigation
Seismic Refraction Acquisition

Nine seismic refraction profiles as forward and reverse shooting have been acquired in the study area with 60 m profile length and geophone interval of mainly 5 meters, using the multi-channel Geode ES3000 seismograph with 12 geophones and sledge Hammer source equipment surface water.

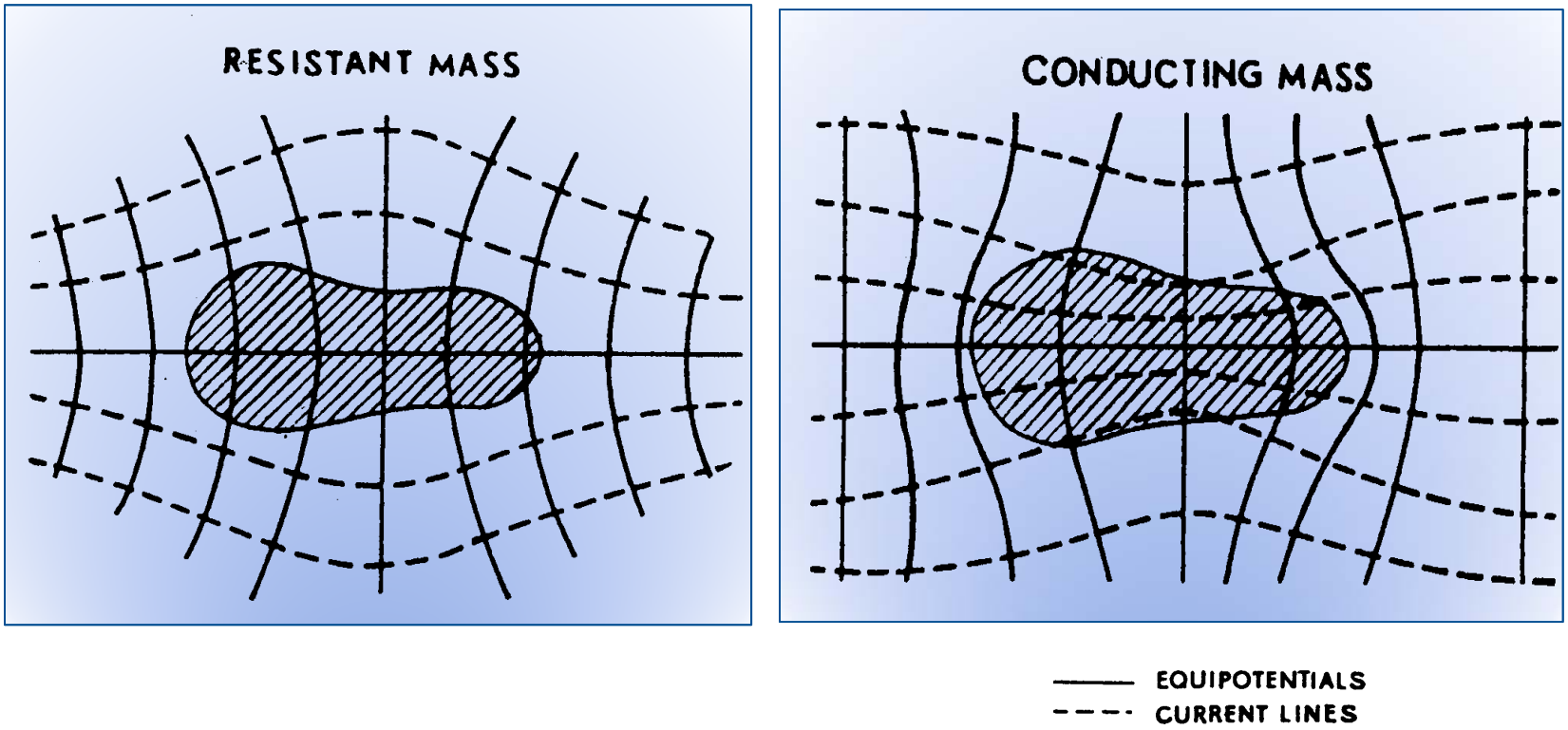
Electrical Resistivity VES Survey

- Six Vertical Electrical Soundings (VES) using Wenner array and Schlumberger configurations were carried out with electrode separations up to AB = 150 m
- This separation could penetrate the ground layers to a depth of 50 m.



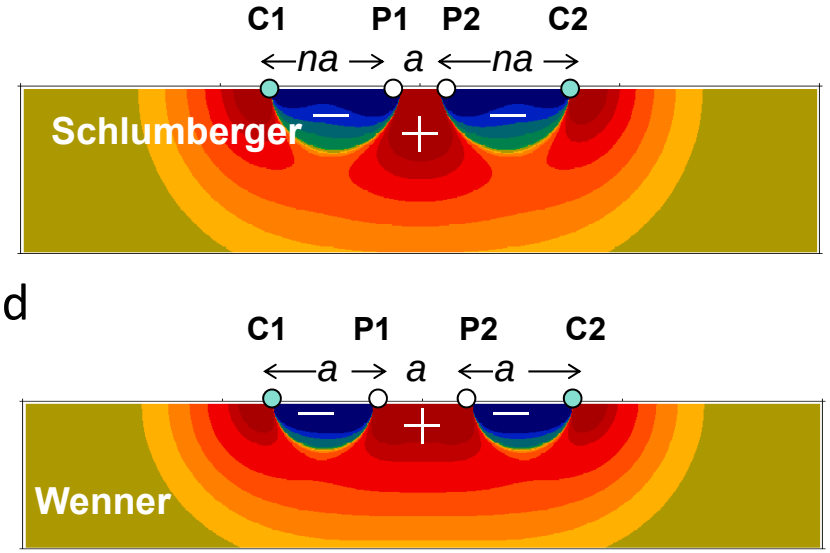
Current distribution due to inhomogeneties

- The resistivity will vary with the relative position of the electrodes.
- Computed value is known as the apparent resistivity ρ_a and will be a function of the form of the inhomogeneity.

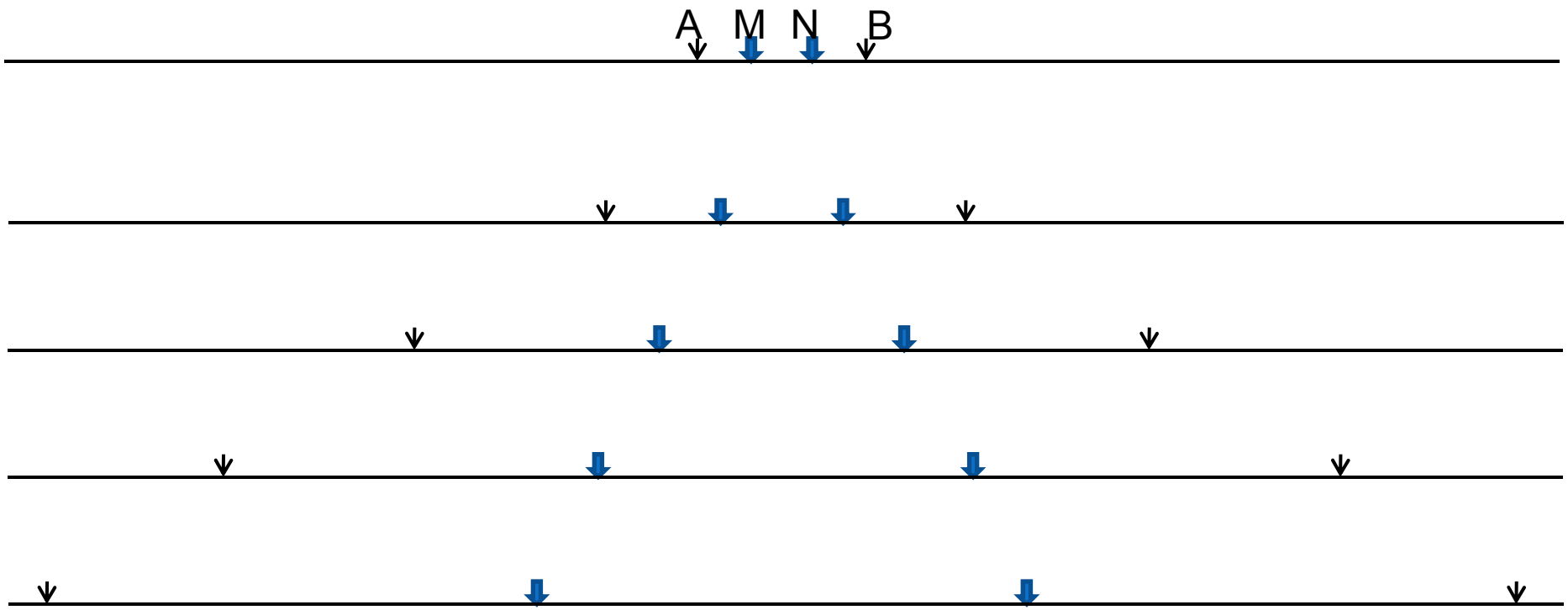


VES - Vertical Electrical Sounding

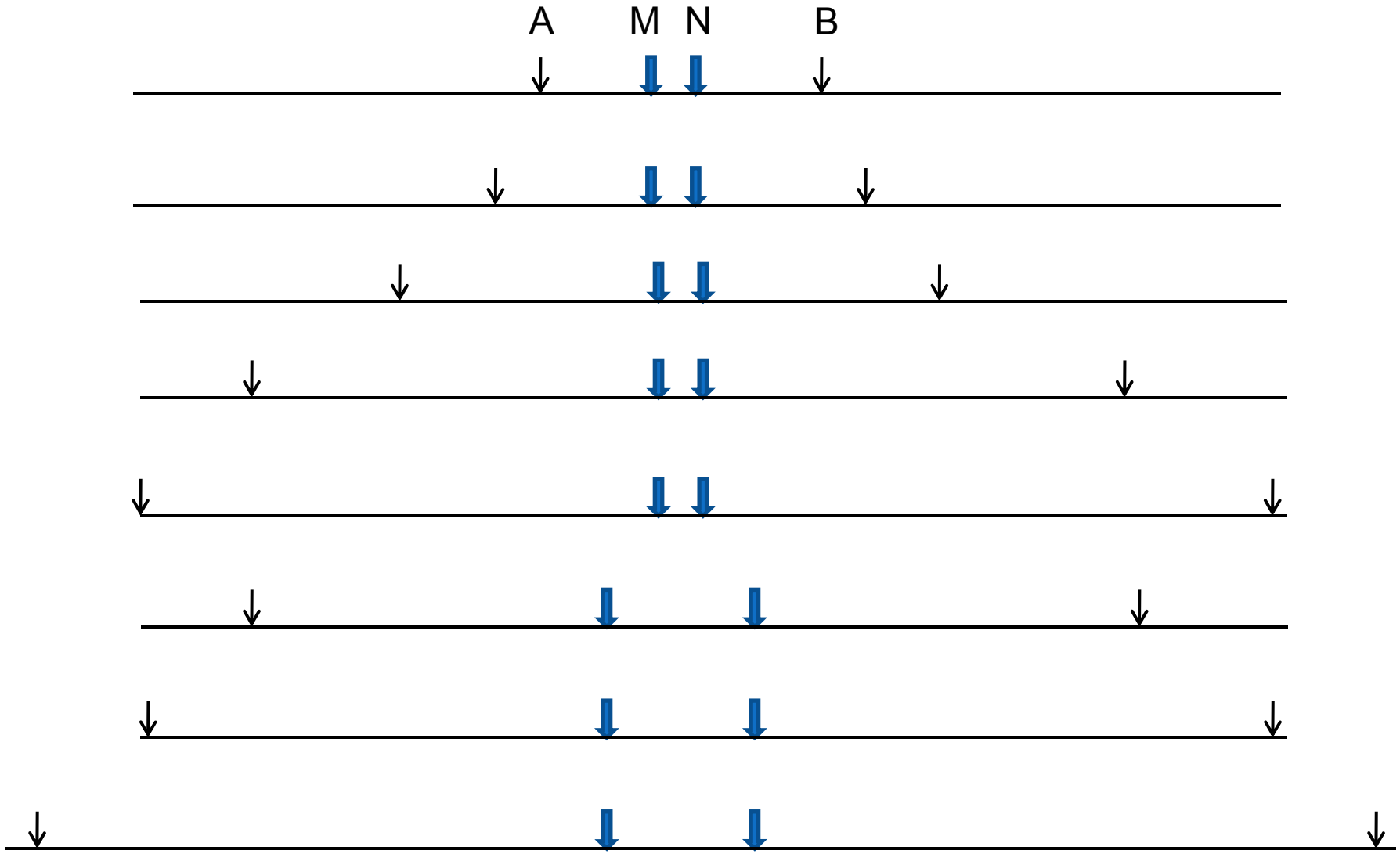
- All data points under one surface position, only depth varies
- One-dimensional (1D) assumption for interpretation
- Expansion of electrode separations around midpoint, usually logarithmic expansion
- Schlumberger array often most practical
- Wenner array is also applied



Wenner array



Schlumberger array

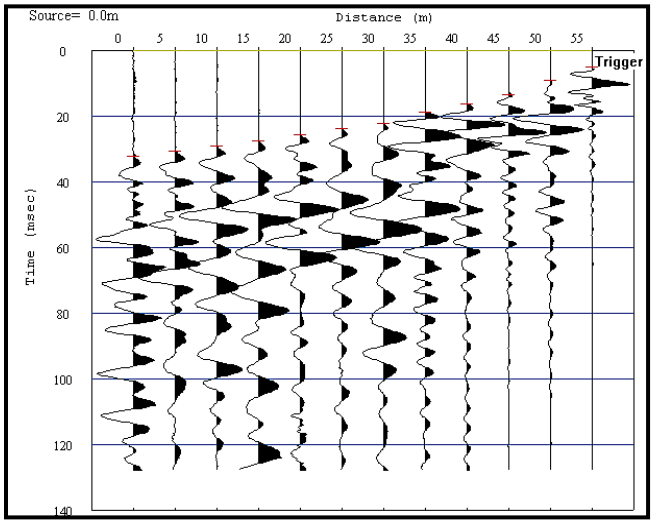


Double Ring Test

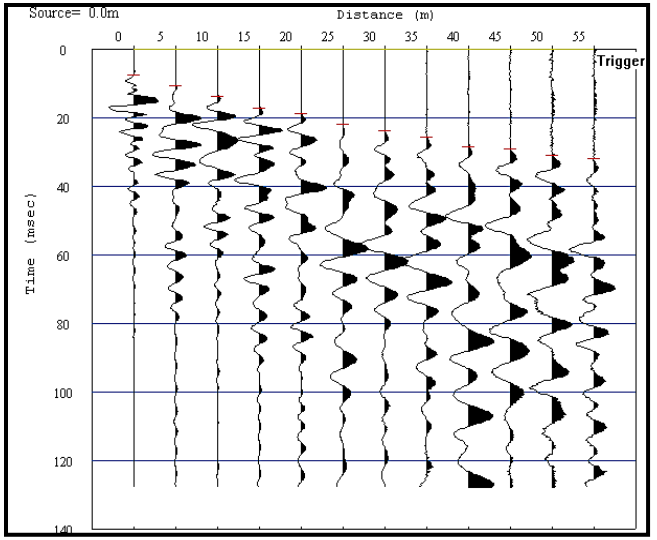
- Five double ring, one single ring, five open pit infiltration tests have been conducted and accompanied by soil sampling to affirm the soil zone characterization and its effect in surface water sealing or absorption

Seismic Data Processing and Interpretation
Forward and Reverse seismograms

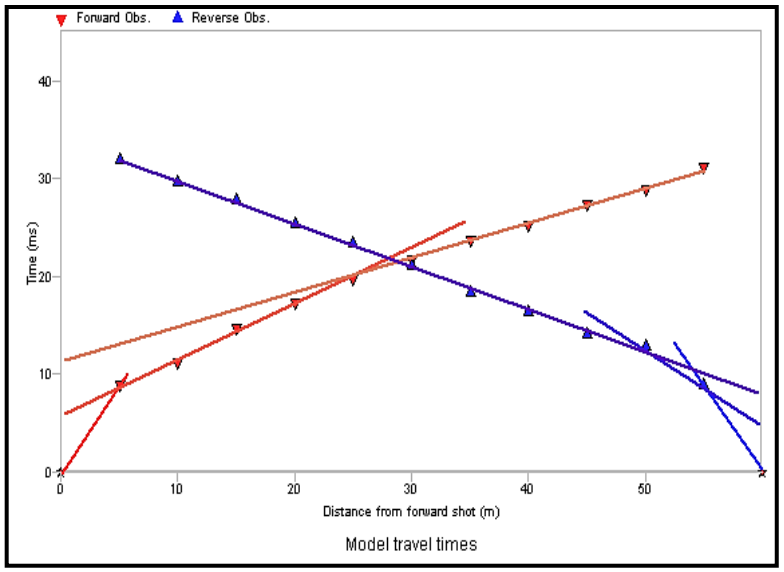
- Picking of first arrivals have been carried out for both Forward and reverse shooting.
- Time Distance Curve is produced, to estimate seismic velocities and depths of interfaces.
- Seismic velocities have been calculated
- Depths of interfaces have been estimated



Forward shooting seismogram



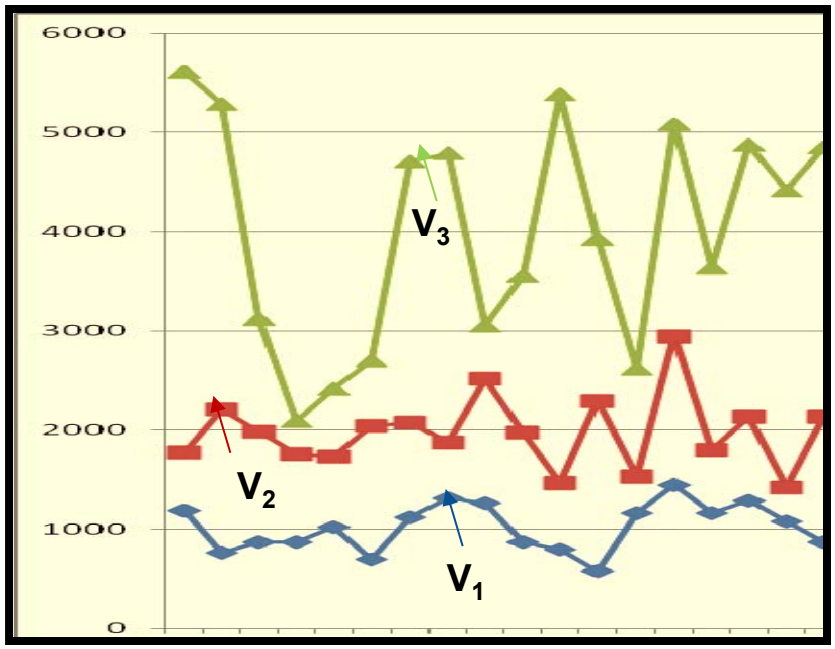
Reverse shooting seismogram



Seismic Refraction Results

Three different ranges of seismic velocities indicate three different zones

- Zone 1 Velocity ranges from 600 m/s and 1400 m/sec (water level depth ranges between 4 to 6 m)
- Zone 2 Velocity range of 1500 m/sec - 2400 m/sec (Lithological layer interface depth at 15 m)
- Zone 3 Velocity range of 2400 m/s - 5300 m/s (Lithological layer interface depth > 40 m)

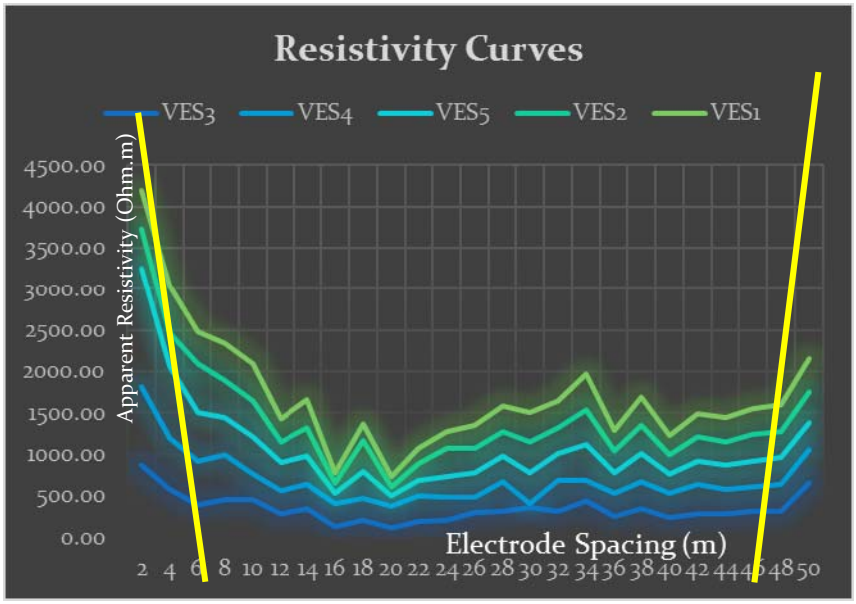


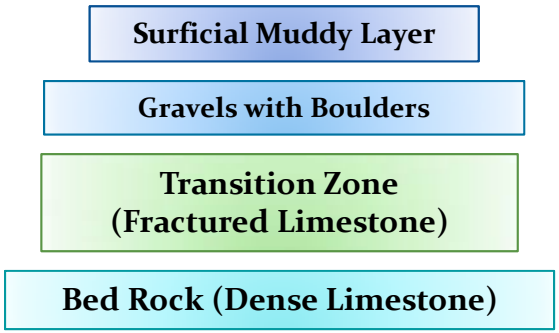
$$Z1 = t_o V_2 V_1 / 2(V_2^2 - V_1^2)^{1/2} \quad (1)$$

$$Z2 = 1/2 \{ t_{i2} - [2h_1 (V_3^2 - V_1^2)^{1/2}] / V_3 V_1 \} V_3 V_2 / (V_3^2 - V_2^2)^{1/2} \quad (2)$$

Electrical Resistivity Measurements Results

- The interpretation of the geophysical data indicates that, the estimated depth to the water level reaches to 4 - 6 m depth.
- The VES results evidenced that, water salinity may increase with depth due to interaction with fractured limestone and may be due to seawater intrusion
- Both arrays obtain the same results, the water depth and confirm the water level at 4-6 m and the fresh water interval





Description of material	Resistivity (Ωm)
Topsoil	20 - 2000
Fluvial deposits	40 – 100
Saturated Limestone and Marly limestone	100 – 400
Dense limestone	400 – 7000

Double Ring Test Results

- Infiltration rate varies from 0 to 56 cm/h and hydraulic conductivity ranges between 0.56 and 4 cm/s which reflect the variability of soil nature in the dam area
- Most of these sediments of big size contribute the infiltration and hydraulic conductivity rates but the clay layer with about ≥ 40 cm, which appears near dam building

Dam reservoir conditions after stormy weather

Cross-section of the study area through Vertical Electrical Soundings

Seismic Refraction and VES results indicate four different lithological intervals:

- Surficial mudstone layer ≅ 0.2 m thickness, this surficial layer may cause surface water accumulation and slowing the infiltration rate to recharge the aquifer.
- Gravel layer of loose, coarse, and permeable alluvial gravels of carbonate origin reaches to about 6 m and extends to 15 to 20 m depth
- Transitional fractured limestone reaches to 40-50 m, then dense compacted bedrock of limestone extended to 100 m and below.
- The interpretation of the geophysical data indicates that, the estimated depth to the water level reaches to 4 - 6 m depth.
- The VES results evidenced that; water salinity may increase with depth due to interaction with fractured limestone and may be sea water intrusion.

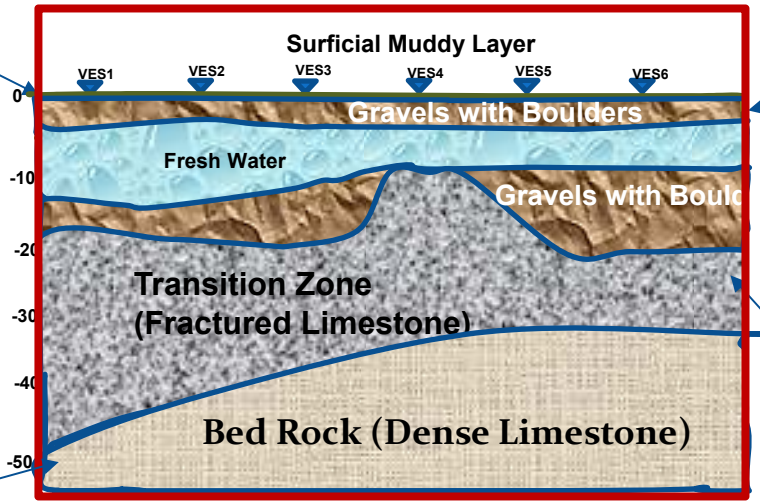
Cross-section of the study area through Vertical Electrical Soundings

Surficial Muddy Layer

Gravels with Boulders

Dense Limestone

Fractured Limestone



Conclusions

The expected outcomes of this research project indicate that, the vertical and horizontal seismic velocity variations, and the qualitative and quantitative interpretation as follows:

- The depth of the layers interfaces and the estimated water level ranges between 4 to 6 m.
- The VES survey reflects the vertical electrical resistivity distribution, representing the lithological succession to 50 m depth.
- The saturation zone is mainly Gravel layer of loose, coarse, and permeable alluvial gravels of carbonate origin reaches at about 6 m and extends to 15 to 20 m depth and the fractured limestone reaches to 40-50 m
- The probable water saturation zone, confirms the groundwater depth and the existence of fresh water at shallow interval.
- This study confirms the dam efficiency and recommends the artificial removal of the thin surficial muddy layer which ranges from 15 -20 cm thickness, to enhance the infiltration rate and for better recharge of the aquifer from the surface water and sustain the groundwater resources.

Thank You for Listening