Groundwater Level Monitoring of the Quaternary Aquifer at Al Ain City, United Arab Emirates (UAE) using Geophysical Methods

Ahmed Murad & Amir Gabr

Geology Department - UAE University

Outlines

- Introduction
- Geological setting
-
- Methodology
- Results and discussion
- Conclusion
- Recommendations

Introduction

- Al Ain City is located to South East of Abu Dhabi in UAE

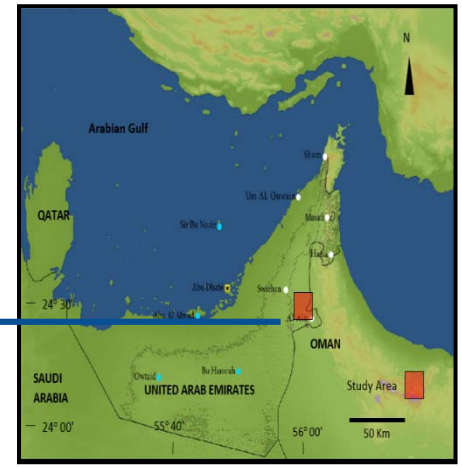
- The city is surrounded by Aeolian sands, fluvial, gravel deposits and conglomerates of Neogene and Quaternary ages which form :

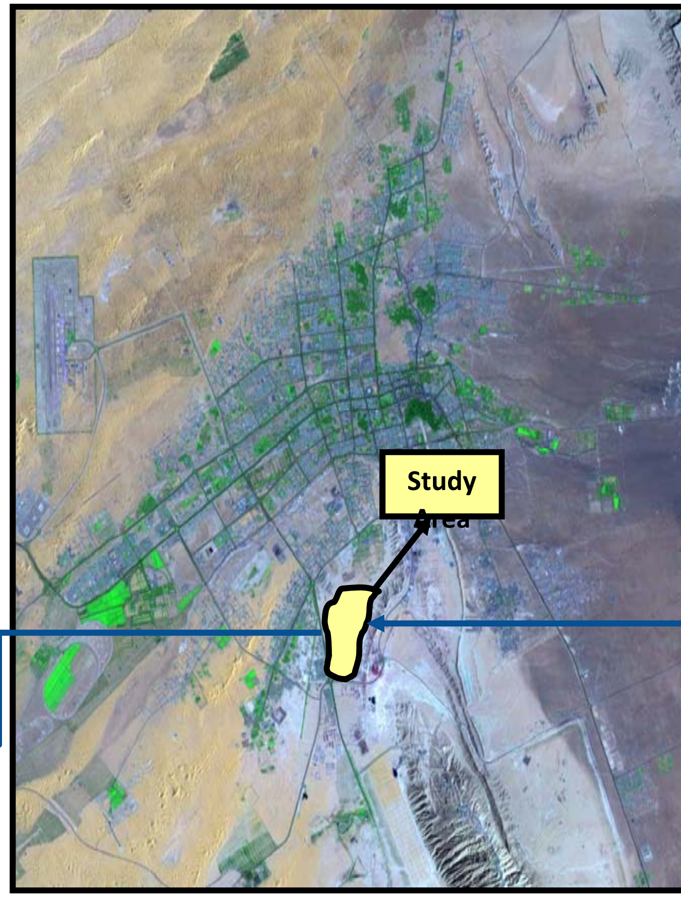
- A thin cover of Lower Oligocene Asmari Formation limestones that dominate the bedrock beneath the central and southern parts of the city
- Jabal Hafeet is one of the famous mountains in UAE and it is located to the south-east of Al Ain City

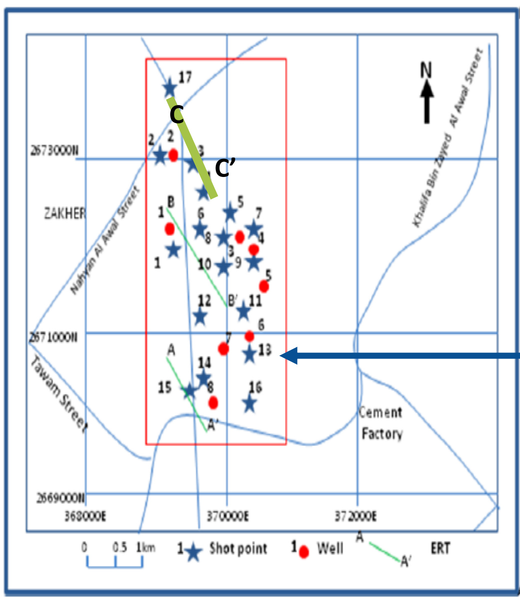
- It is an anticlinal structure with a length of 29 Km, width about 5 Km and elevation of 1160 m above sea level

Location

- The study area is located to the north Western part of Jabal Hafeet







Location Maps showing the study area, Shot points and ERT

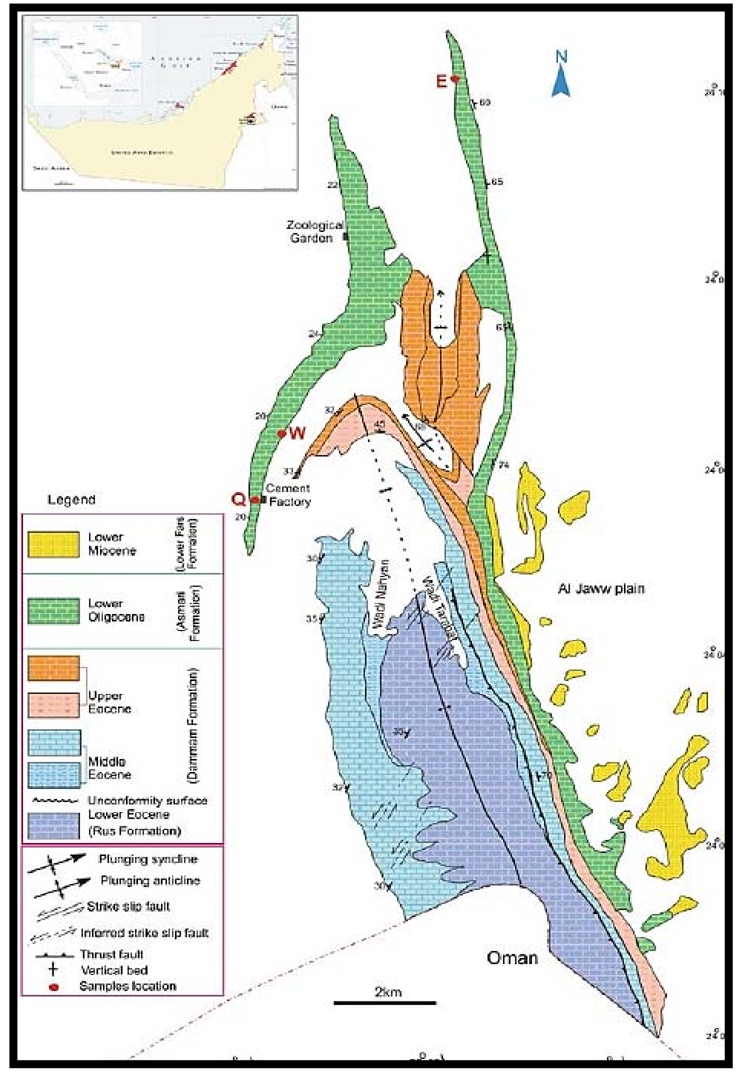
Geological Setting

Jabal Hafeet is classified into four main rock units:

1. Rus Formation (Lower Eocene)
2. Dammam Formation (Middle – Upper Eocene)
3. Asmari Formation (Lower Oligocene)
4. Lower Fars Formation (Lower Miocene)

These formations includes many types of fossils such as:

Foraminifera, Corals, Bryozoan, Mollusca and Echinoids shell fragments.



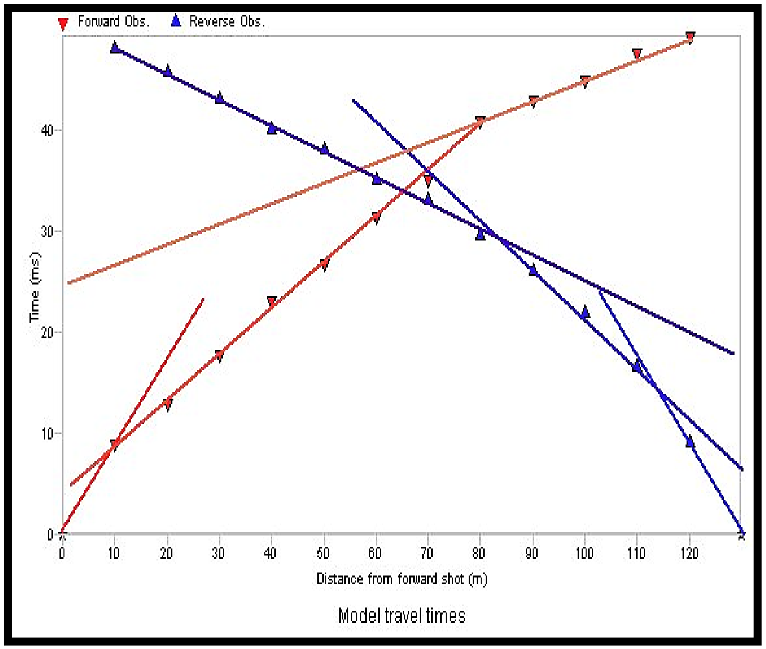
Methodology

Seismic Refraction Method

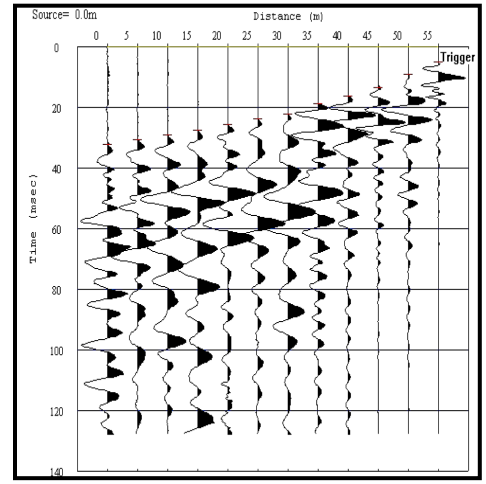
- Multichannel Geode ES-3000 seismograph operates from laptop loaded with acquisition program and Sledge Hammer with strike plate source, main cable 120 m length and 10 m geophone interval.
- Twenty Seismic Refraction profiles have been acquired along the study area

Seismic Refraction Processing

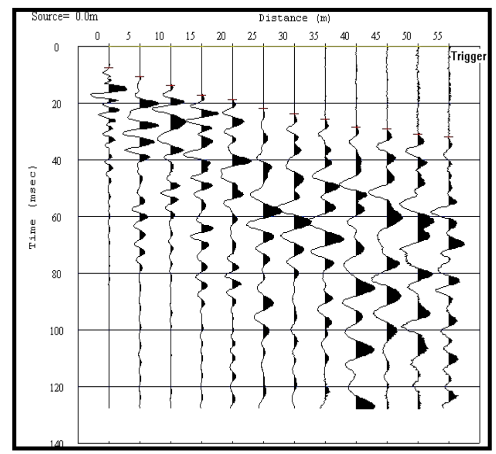
Time-Distance Curve



Shot Record



Forward shooting seismogram



Reverse shooting seismogram

$$Z_1 = t_o V_2 V_1 / 2(V_2^2 - V_1^2)^{1/2} \quad (1)$$

$$Z_1 = X_c/2 \quad (V_2 - V_1 / V_2 + V_1)^{1/2} \quad (2)$$

$$Z_2 = 1/2 \{ t_{i2} - [2h_1 (V_3^2 - V_1^2)^{1/2}] / V_3 V_1 \} \; V_3 V_2 / (V_3^2 - V_2^2)^{1/2} \quad (3)$$

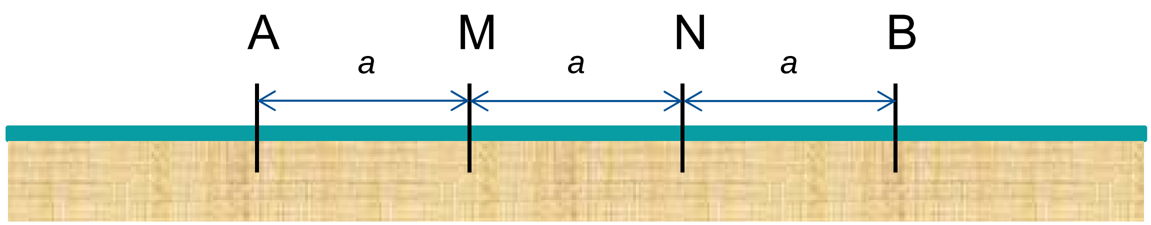
Electrical Resistivity Tomography

- Syscal Pro Resistivity meter with 96 electrodes and 10 m spacing is used.

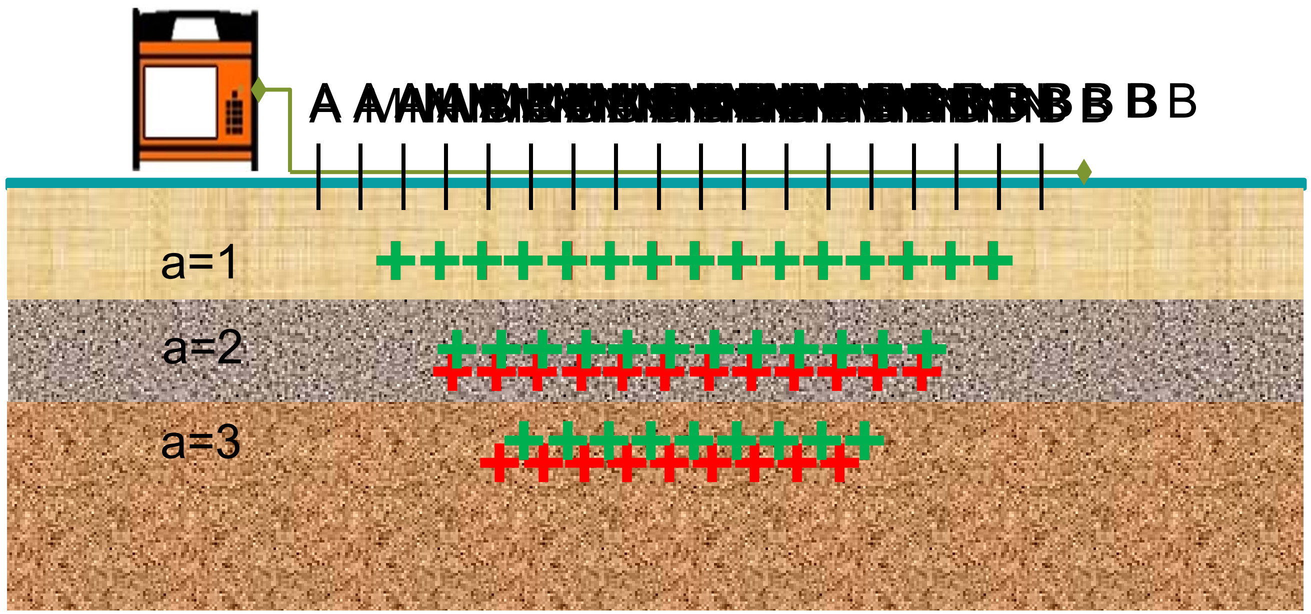
- Three (2-D) Electrical Resistivity Tomography (ERT) profiles have been acquired, using Wenner electrode configuration along selected sites.

Electrical Resistivity Tomography (ERT)

Wenner Array

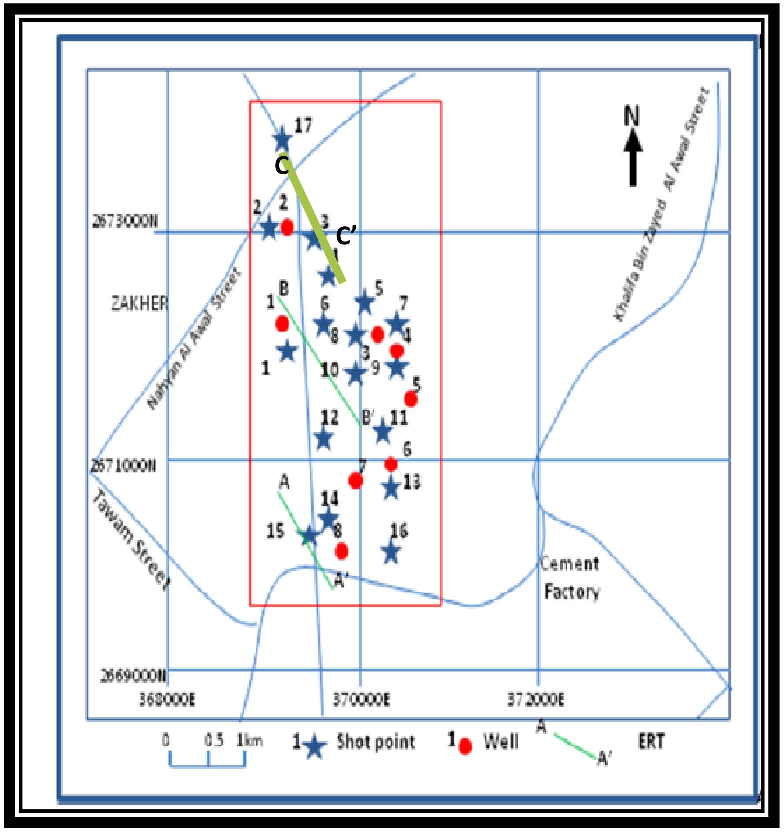


$$\rho_a = 2\,\Pi a R$$

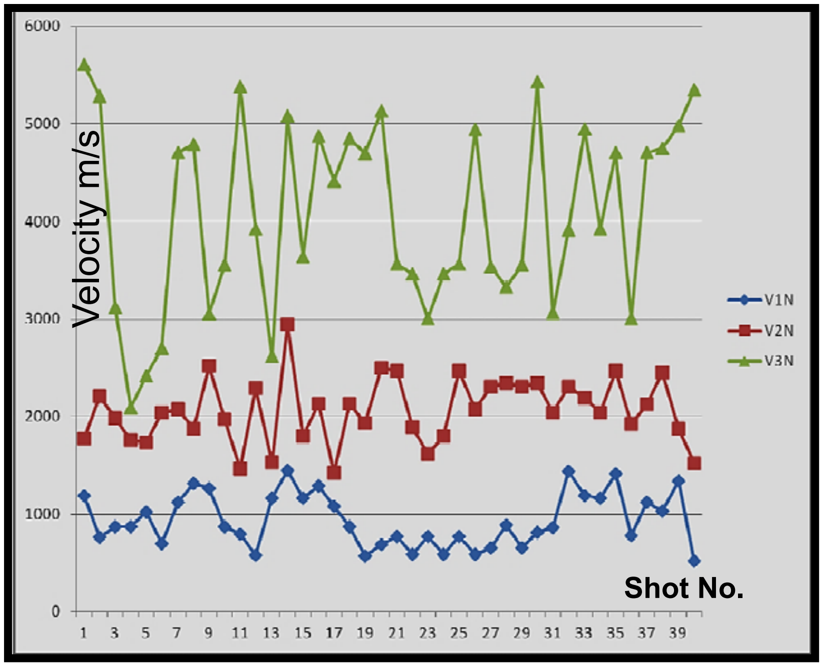


Hydrogeological Investigation

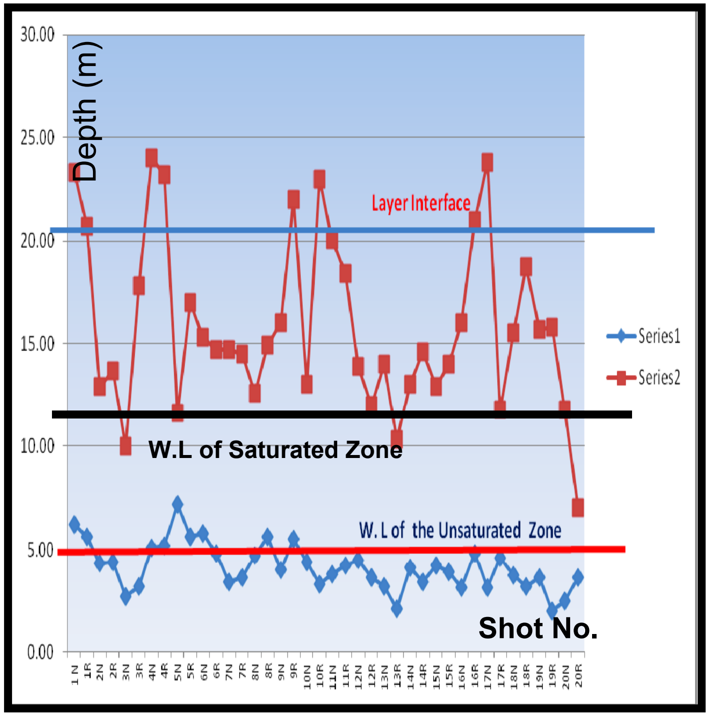
- Depth to groundwater level through nine wells have been measured. An electric sounder as well as the updated multi-parameter used for the field measurements.



Results and Discussions



Seismic velocities distribution in the study area

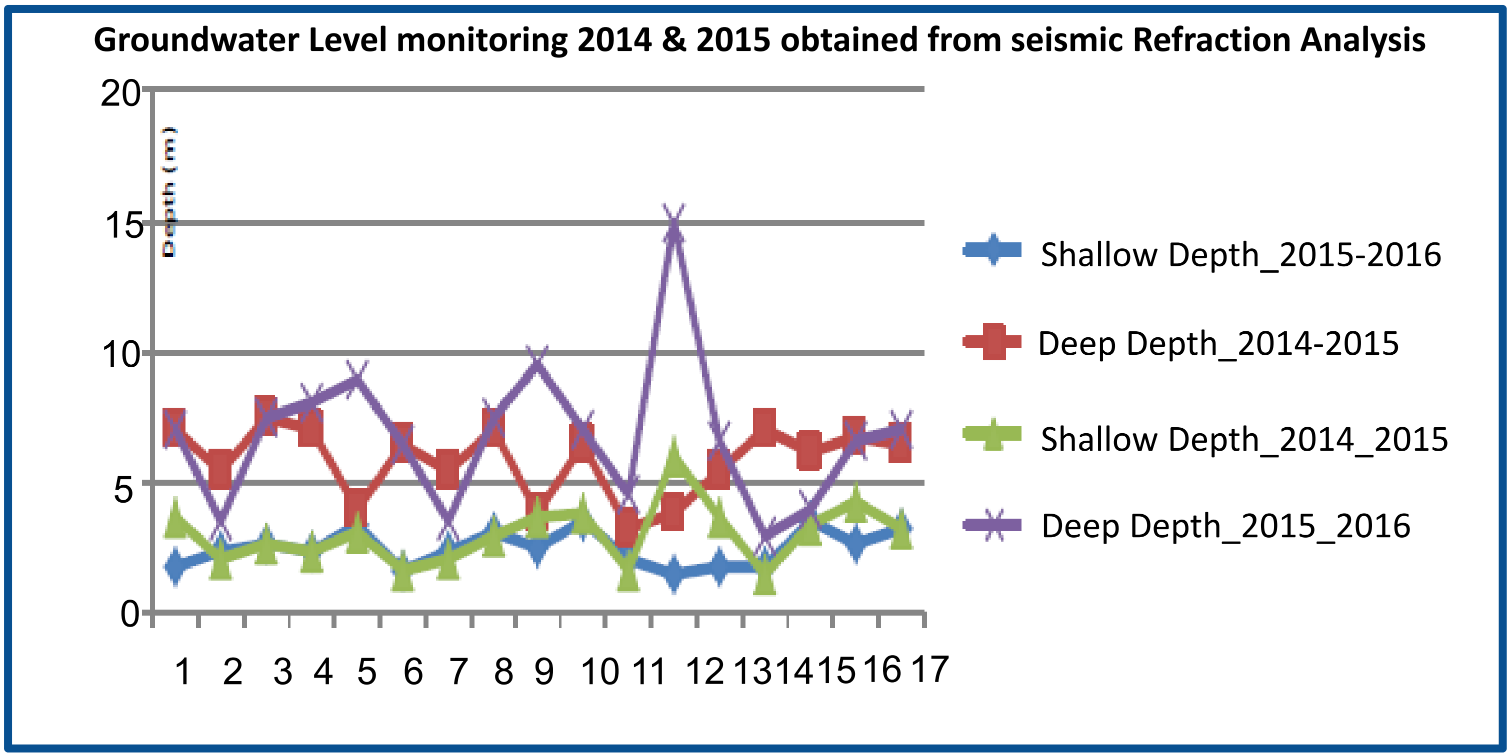


Seismic refraction interfaces depth Estimation

- The minimum seismic velocity of the unsaturated zone between 590 m/s to 1370 m/s
- A slightly increased in the velocity of the saturation zone from 1400 m/sec to1800 m/sec
- The velocity of the underlying rocks ranges between 1800 m/s to 5300 m/s

Results and Discussions

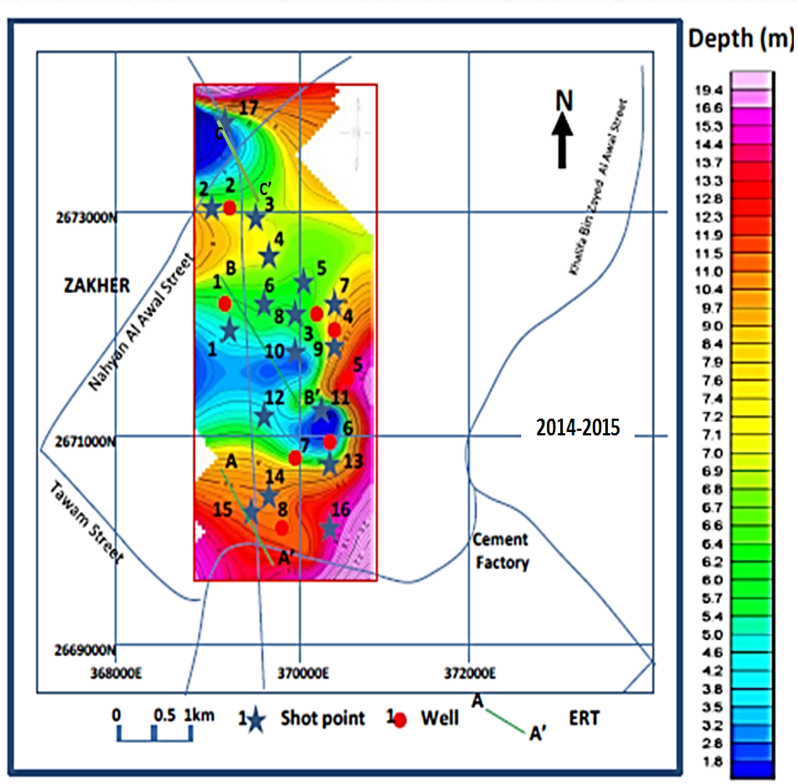
- Depths to water level obtained from Seismic Refraction analysis indicates that the minimum is 2.3 m, while the maximum is 19 m and the average depth in the area is about 10 m
- The high variation in water level depth within this limited area, refers to the complicated groundwater regime which may be due the heterogeneity in the water bearing formations as well as the sources of water supply.

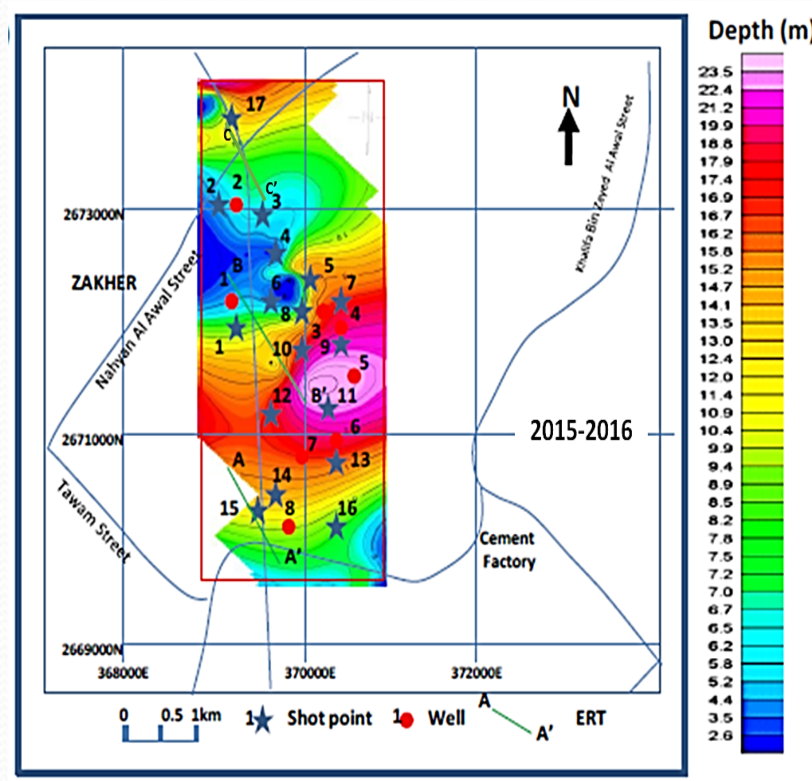


- Comparing the results of the two years 2014-2015 and 2015-2016, Depth of the groundwater level in the Unsaturated zone shows water level rising at some locations, this may be due to receiving additional amount of water and stored at shallow pockets as perched water in the fringe zone.

- Comparing the results of the two years 2014-2015 and 2015-2016, the deep depth of the groundwater level in the saturated zone shows deepening at most locations and rising at some locations. This may be due to the low rain fall and minor recharge water supply and may indicate the locations of poor surface infiltration. Water rising locations may be associated with good surface infiltration.

Groundwater Level Distribution in the study area





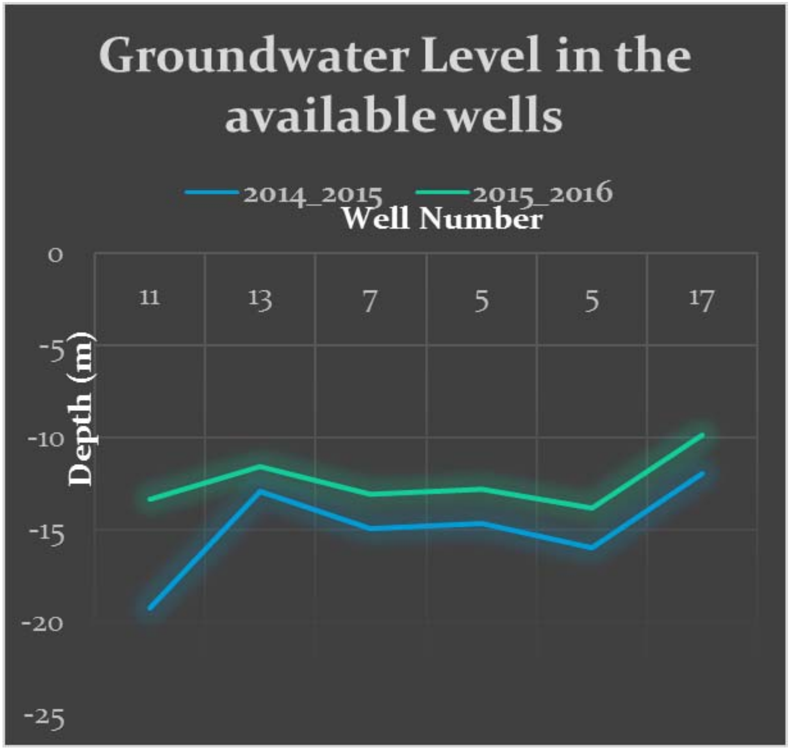
- Depth of Groundwater level during the last two successive years 2014 - 2015 and 2015-2016 show that, depth of groundwater level increases at some localities this may be due to the low rainfall rates and lack of aquifer recharge.

- The Groundwater level distribution maps which produced from the seismic refraction and the available drilled wells in the study area for the two successive years 2014 – 2015 and 2015-2016, show that, the groundwater level fluctuation and the shallow water depths reach to about 2 m at specific sites as estimated from Seismic refraction analysis this may represent the perched water in the partially saturated zone, where the average water level is ranging from 7 to 10 m depth.

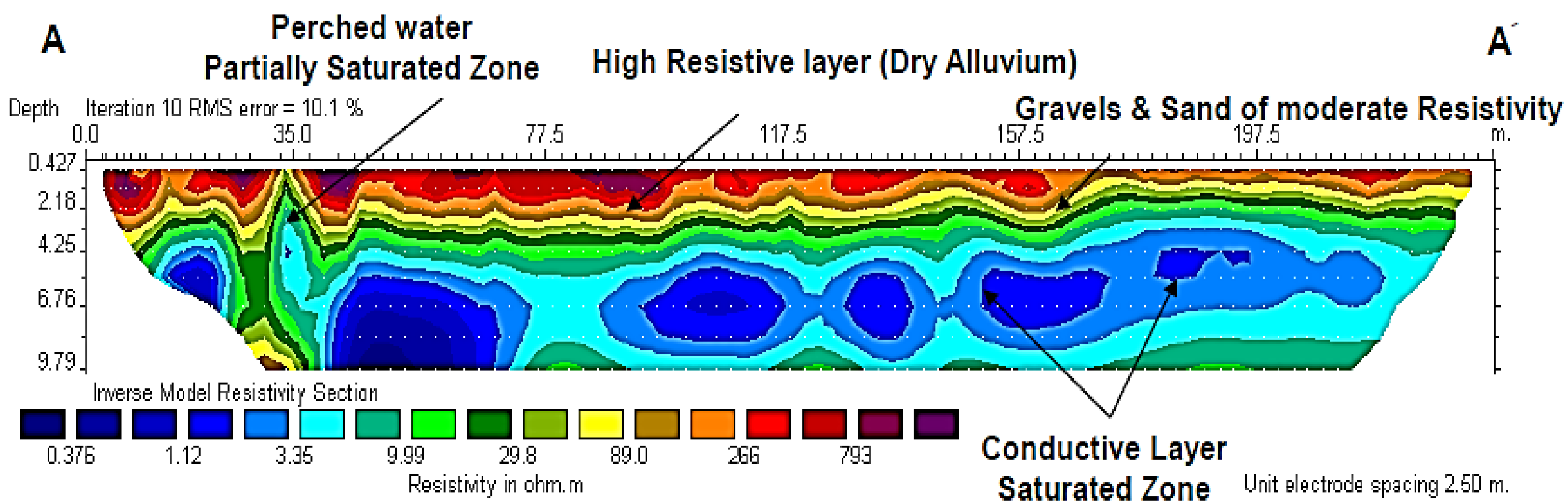
Groundwater Level Monitoring

- Groundwater level monitoring
- Water level rises from the range of 12 and 19 m to the range of 9.5 m and 13.5 m with much better water quality.
- Confirms the aquifer recharge and enhance the groundwater quality in which supporting the water sustainability.

- Rainfall of about 240 mm/h hit the region The seepage of this huge collected amount of surface water into the subsurface layers play a significant role in recharging the aquifer, decrease the salinity and increase the quantity of groundwater.(March, 2016)

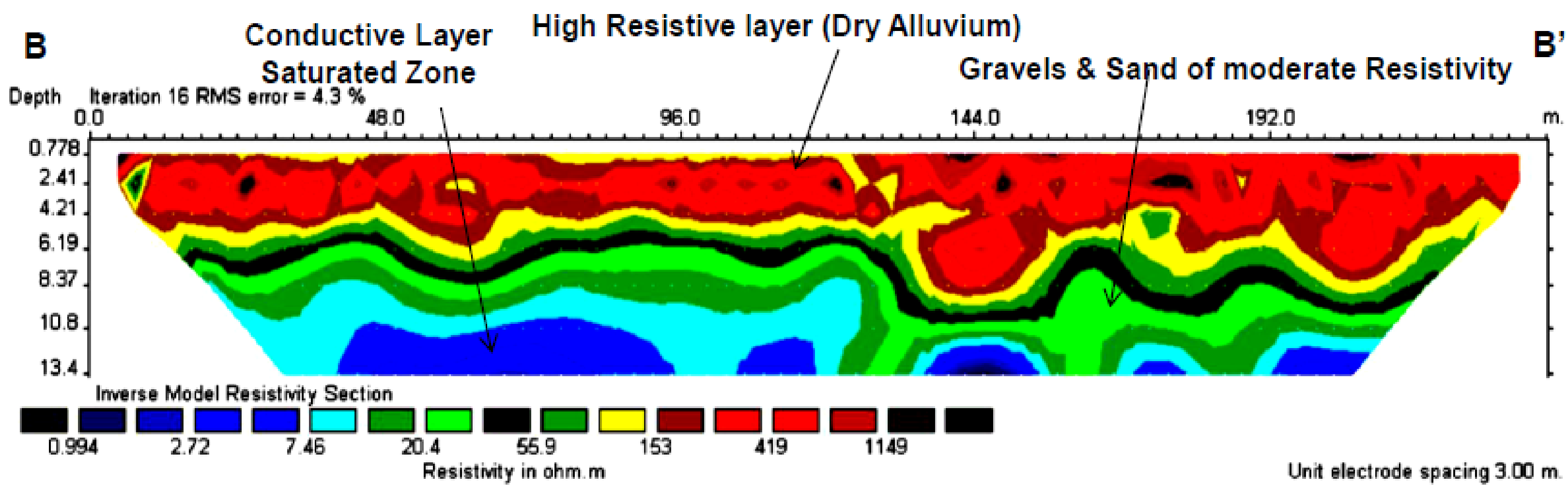


Results and Discussions



A-A' Tomogram reflects a high resistivity surficial layer with resistivity more than 300 Ohm.m, represented by brown and red colors, underlained by gravels and sand layer of moderate resistivity with range of 20 to 60 Ohm.m and shows a conductive layer saturated zone located at depth reaches to 2 m or less at certain locations which may indicate the partially saturated zone (Perched Water) which appears as deep blue and light blue colors

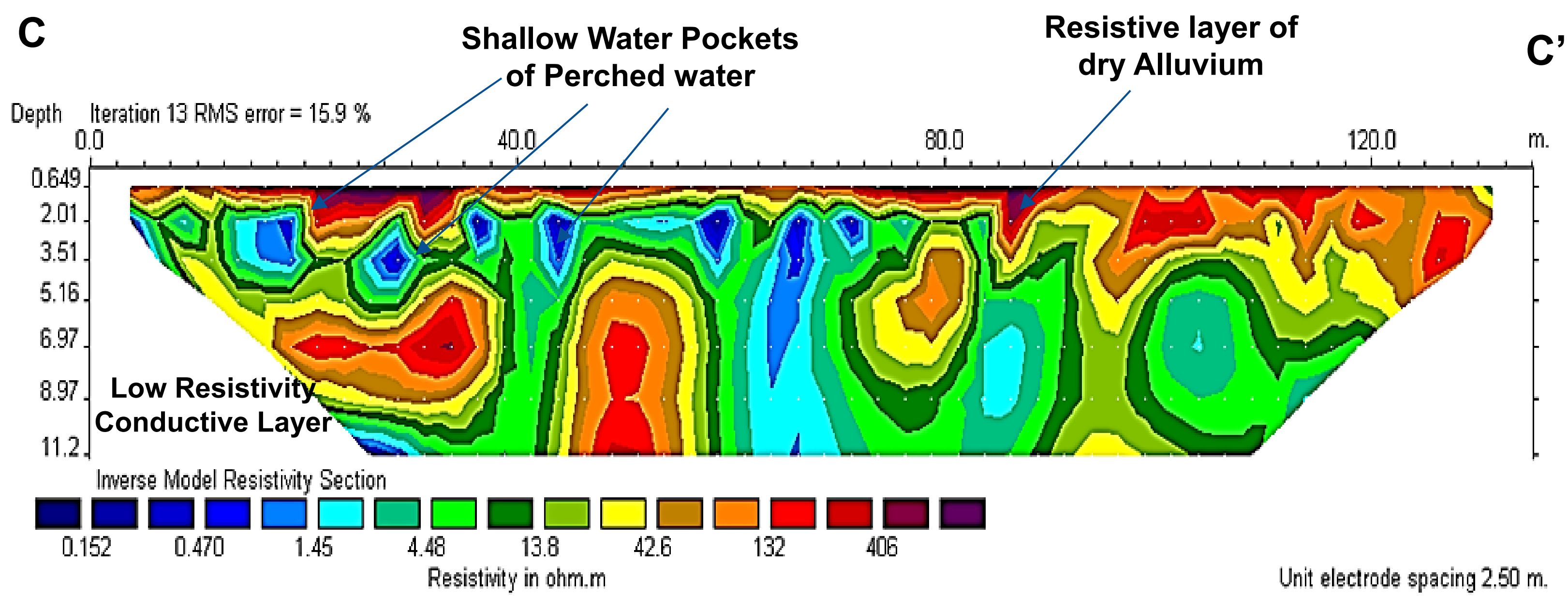
Results and Discussions



Depth range of the groundwater between 10 and 13m respectively

B-B' tomogram also reflects a high resistivity surficial layer with resistivity of 400 Ohm.m, represented in brown and red colors, underlained by gravels and sand layer of moderate resistivity with range of 20 to 60 Ohm,m and show a conductive layer of saturated zone located at a depth of 10 m and more with deep blue to light blue colors

Results and Discussions



C-C' tomogram shows highly resistive layer of dry alluvium underlained by isolated low resistivity pockets represent groundwater accumulation at sallow depths reaches to 2 m or less. Then isolated high resistivity compacted layers of Limestone

Conclusion

- The groundwater flow regime starts from the eastern borders of Oman mountains as catchment and recharge area to the collective western gravel plain.
- Seismic Refraction and Electrical Resistivity Tomography are suitable geophysical techniques to detect the groundwater level changes.
- The processed seismic data in integration with the water level measurements suggest that the deepest and shallowest groundwater levels are 19 and 2.5 meters respectively.
- The shallow water depths may reflect the surface of perched water zone. The average depth is about 10 meters suggesting the accurate water level of the area.
- Electrical Resistivity Tomograms (ERT) reveals the existence of different hydro-stratigraphic units of changeable water quality and it varies between fresh, brackish and saline water as well.

Recommendations

- Water level in the study area should be assessed periodically to protect the residential areas from sudden rise in water level.
- Continuous monitoring of water level and quality can be achieved thorough installation of remotely operating network system.
- Apply the same techniques to cover most of Al-Ain City to have a complete figure about the water level changes in the City.
- Study any other artificial rechargeable wells to enhance the aquifer productivity and to increase the groundwater sustainability.

Thank You
for Listening