GEOSPATIAL APPROACH FOR GROUNDWATER EXPLORATION AT UTM JOHOR BAHRU CAMPUS

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ABSTRACT:

A major concern in groundwater exploration is to determine a precise location of the groundwater resources. The geospatial technology such as UAV mapping, precise GPS surveying and GIS data management could be integrated with other geospatial information to augment the groundwater exploration. The aim of this research project is to support groundwater exploration at UTM, Johor Bahru campus by employing the geospatial approach. In doing so, the aerial photo captured by using UAV and GPS will be utilised to support geology and geophysics data collection. Subsequently, subsurface information such as lithology, stratigraphy and geological structures have been used to form the subsurface profile. Afterward, development of the groundwater geospatial database had commenced by using a GIS approach. It is expected that by integration of geospatial technology in groundwater exploration works will help to identify the location of potential groundwater zone in the study area.

1. INTRODUCTION

Malaysia is a tropical country and receives an annual rainfall of 2500 mm until 3000 mm (Paterson et al, 2015). In fact, the country has a considerable degree of surface water reserves due to river and lakes. However, there are some disturbing issues to meet the demand for water resources, especially water supply for drinking (Ahmad et al, 2014). This problem arises from several factors such as widespread water pollution and weather changing. In fact, this problem will cause incensement cost in the process of clean water treatment and the amount of fresh water supply also decreases (Abou-Elela et al, 2019). Hence, there is an alternative to overcome this problem with fully utilized of groundwater resources (Nescerecka et. al, 2018).

The best approach to identify subsurface layer thickness and location of groundwater resources are provided by using drilling test. However, this approach is too expensive and requires skilled manpower (Yang et al, 2018). Nowadays, the integration of geological and geophysical studies is commonly used in groundwater exploration. Usually this approach is combined with geoinformation knowhow such as field survey and supported with existing topographic and thematic maps. Nevertheless, the advancement in geospatial technology such as Unmanned Aerial Vehicle (UAV) mapping, precise Global Positioning System (GPS) surveying and Geographical Information System (GIS) data management could be utilized to augment the groundwater exploration (Savita et al, 2018; Pandey et. al, 2015; Mishra et al, 2019; Nair et al, 2019; Nag et al, 2019; Thakur et al, 2018). Moreover, the applications of geospatial technology such as GIS can reduce cost and time in order to assess and manage geospatial information of groundwater resources (Adiat et al, 2012).

Groundwater exploration in this country requires a support and integration of the geoinformation technology into the exploration works to maximise high chances in identifying groundwater resources potential zone. The aim of this research project is to support groundwater exploration at Universiti Teknologi Malaysia, Johor Bahru campus by employing the geospatial approach. In doing so, the geospatial technologies such as UAV mapping approach and GPS positioning has been employed to generate the topographic map and to support geology and geophysics data collection in the study area, respectively.

Subsequently, the existing subsurface information such as lithology, stratigraphy and geological structures have been utilised to form the subsurface profile in the study area. Subsequently, development of the geospatial database and analysis for groundwater exploration at UTM has been commenced by using a GIS approach. It is expected that the technology and analysis by using the geospatial approach will provide a promising result for groundwater exploration project at UTM.

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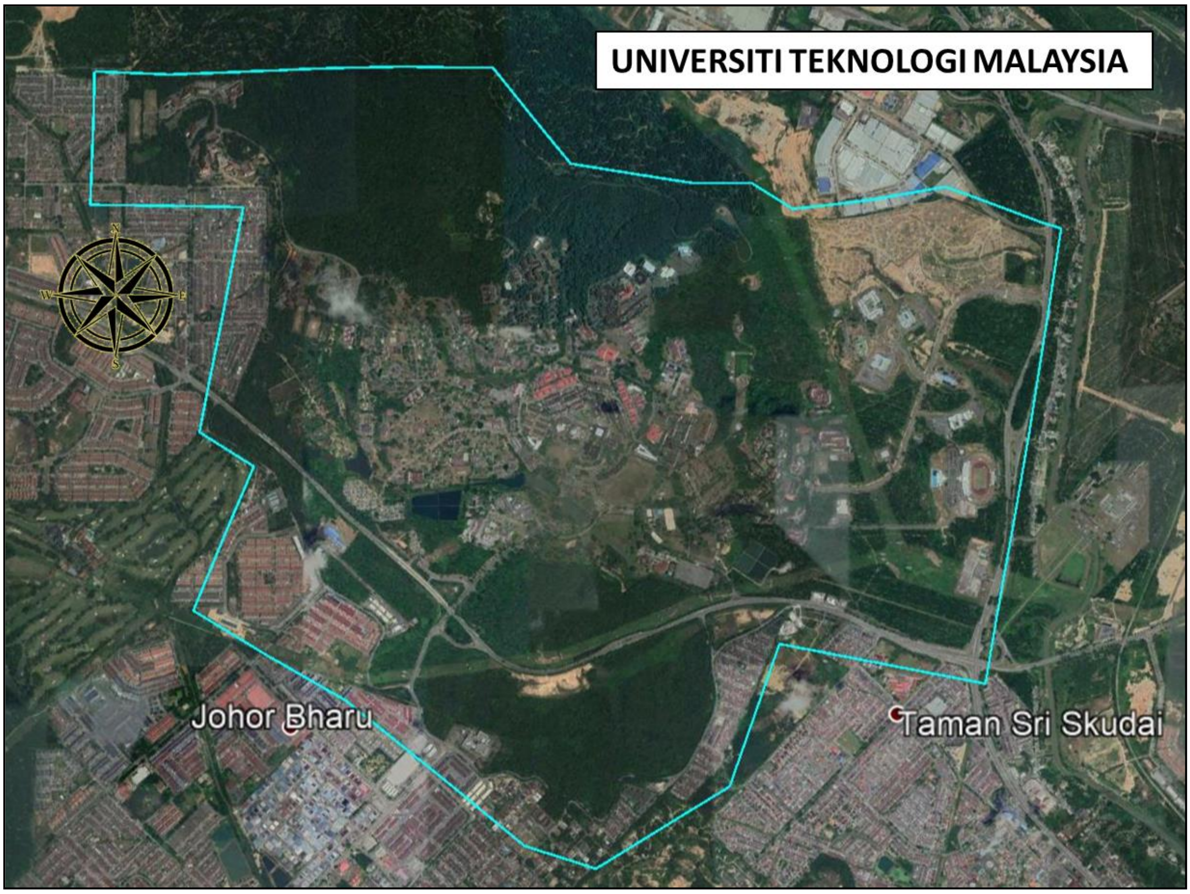

Figure.1 Location of the study area.

2. METHODOLOGY

The study area was conducted at Universiti Teknologi Malaysia (UTM), Johor Bahru Campus within the district of Johor Bahru in south of Johor (Figure 1). The project cover 2,816 acre of land area with range of latitude between 1° 34' 7" N to 1° 34' 36" N and longitude between 103° 36' 52" E to 103° 38' 20" E.

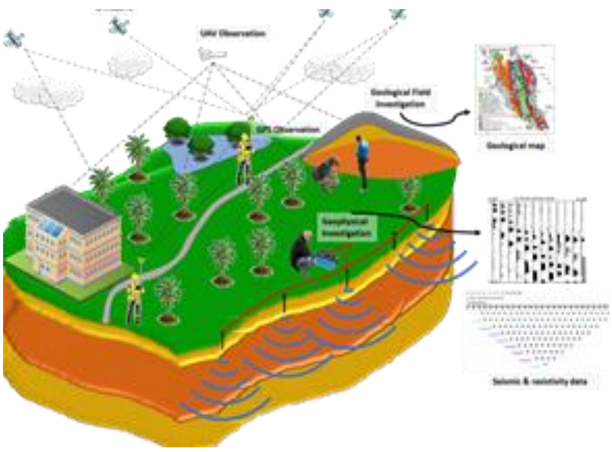

Figure 2 Conceptual design of the project.

The conceptual design of the project is illustrated in Figure 2. There are two types of data that have been utilized in this study which are primary and secondary data. The primary data consists of Global Positioning System (GPS) measurements and digital aerial image meanwhile the secondary data consist of geophysical and geological data based on the previous research in the study area.

2.1 UAV Data Collection.

In this study the digital aerial images were collected using multi rotor UAV. There are two important phases in this data collection which are the establishment of ground control point (GCP) and check point (CP) by using the GPS observation technique, and flight planning preparation for the study area.

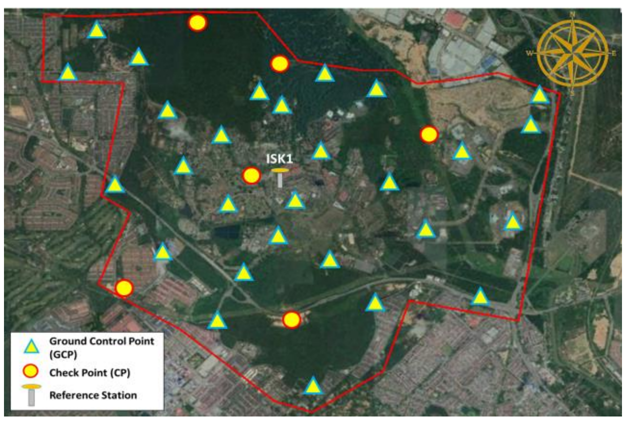

Figure 3 Location of GCP and CP in the study area.

The GCP and CP will be used as reference for UAV processing and to validate the accuracy of photogrammetric products, respectively. Figure 3 shows the location of GCP and CP within the study area. There were two methods of GPS observations have been applied in this study, i.e., static and fast static technique. The static observation was used to establish the GCP stations in the study area and these stations were relatively connected with reference stations of MyRTKnet and NRC-net that being operated by the Department of Surveying & Mapping Malaysia (DSMM) and the Geomatic Innovation Research Group (GnG), respectively. Meanwhile, the fast-static observation was applied to establish few CP stations in the study area. The static observation was conducted for 1 hours for each control station while fast static observation was conducted from 30 to 45 minutes for each CP. The GPS data were processed by using Trimble Business Centre (TBC) software in post-processing mode. As the result, this process has provided final GCP and CP coordinates in Geocentric Datum of Malaysia 2000 (GDM2000) and these 3D coordinates were projected onto 2D mapping coordinates system.

There are several parameters were required in preparation of the flight planning such as overlapping of images, flight path determination and UAV altitude as shown in Table 1. The DroneDeploy application software has been utilised in order to prepare the flight planning in this study. Figure 4 shows the design of flight planning for UAV data collection. In this study, the proposed flight altitude in this data collection was 100 meter with lapped of images was 75 % for the whole study area.

Table 1 Parameter for preparation of the flight plan.

Parameter	Details
Flight Altitude	100 Meter
Coverage	2816 acre
Flight direction	0
Side lapping of image	75%
End lapping of image	75%

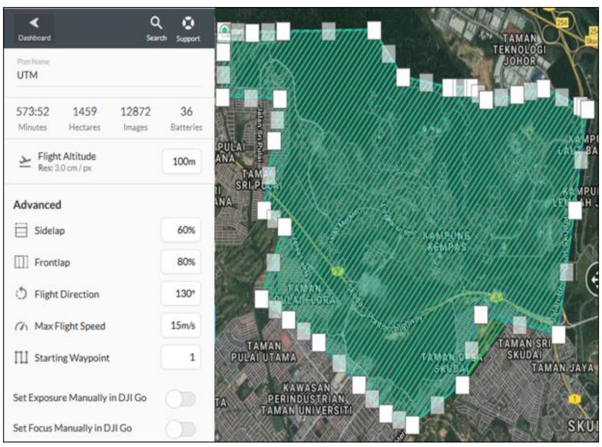

Figure 4 UAV flight plan.

In this study, the digital aerial images of the study area as captured by the UAV technique have been processed in order to produce digital orthophoto and digital elevation model (DEM). The Agisoft software was used to process the digital aerial images and Figure 5 shows the processing procedure.

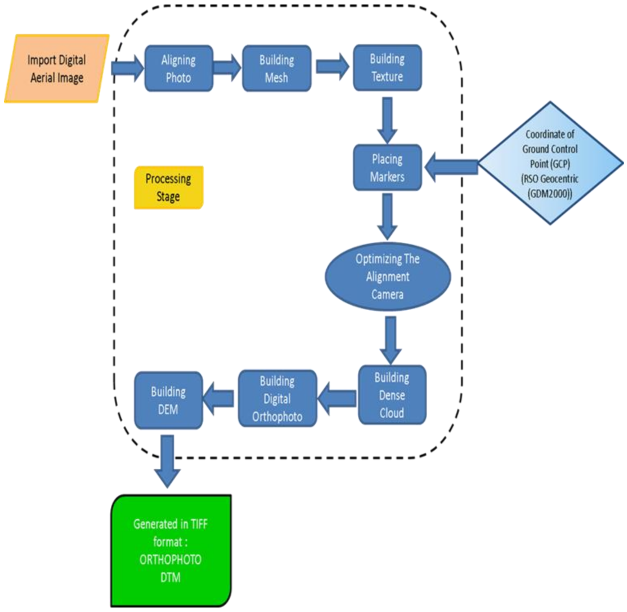

Figure 5 Procedure of UAV data processing.

2.2 Geological and Geophysical Data.

For geological data, the existing geological map in hardcopy has been digitized and georeferenced by using GIS and GPS technique respectively. In addition, geology field investigation has been conducted to verify geological information in the study area. During this field investigation, the GPS observation has been utilized to validate location of the geological information in the geological map (Figure 6).

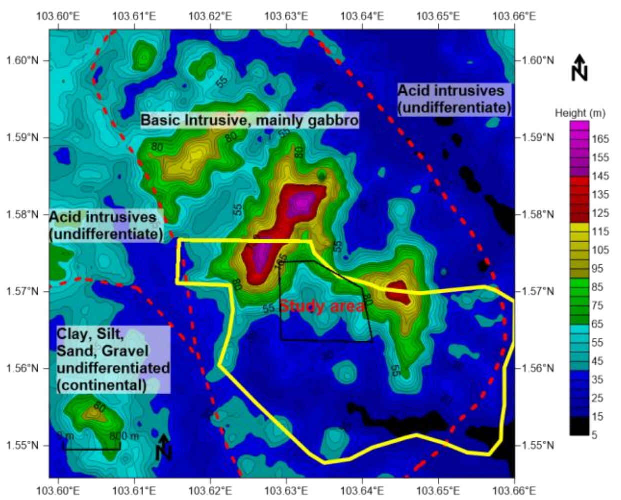

Figure 6 Site elevation and geology boundary of the study area.

Meanwhile, geophysical data that based on previous resistivity and seismic survey lines have been integrated into the geospatial database for further analysis. There were 4 lines of resistivity and 1 line of seismic have been established within the study area (Figure 7). Each length of resistivity line was 800 meters meanwhile length of seismic line was 200 meters. During this seismic survey, the GPS observation has been employed to provide precise location of the seismic line.

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Figure 7 Resistivity and seismic survey

3. RESULT AND DISCUSSION

3.1 Development of Geospatial Database and Mapping

Geospatial database is a medium for storing and managing the spatial data and its attributes that can be applied in groundwater exploration work. Three (3) components will be used to develop a geospatial database of the study area: (1) feature datasets, (2) raster dataset and (3) tables. The overall framework in developing a geospatial database for this study is illustrated in Figure 8.

Based on this database, the information such as topography and profile information of the geological subsurface have been integrated in the GIS environment. Figure 9 shows topographic information of the study area and is being used as the base map for the geospatial database of groundwater exploration in UTM.

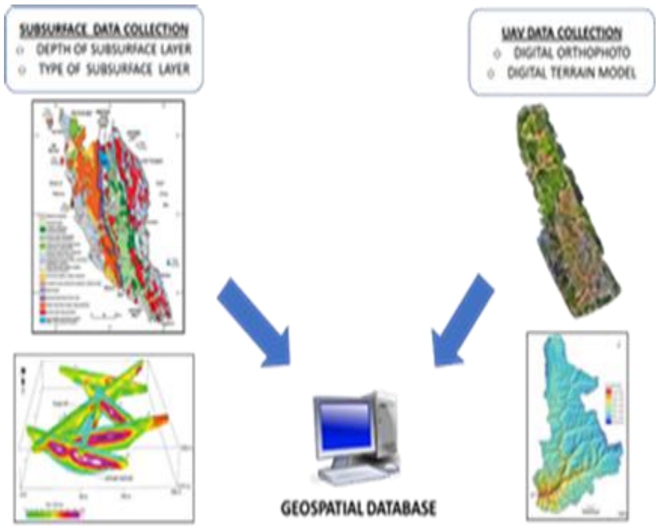
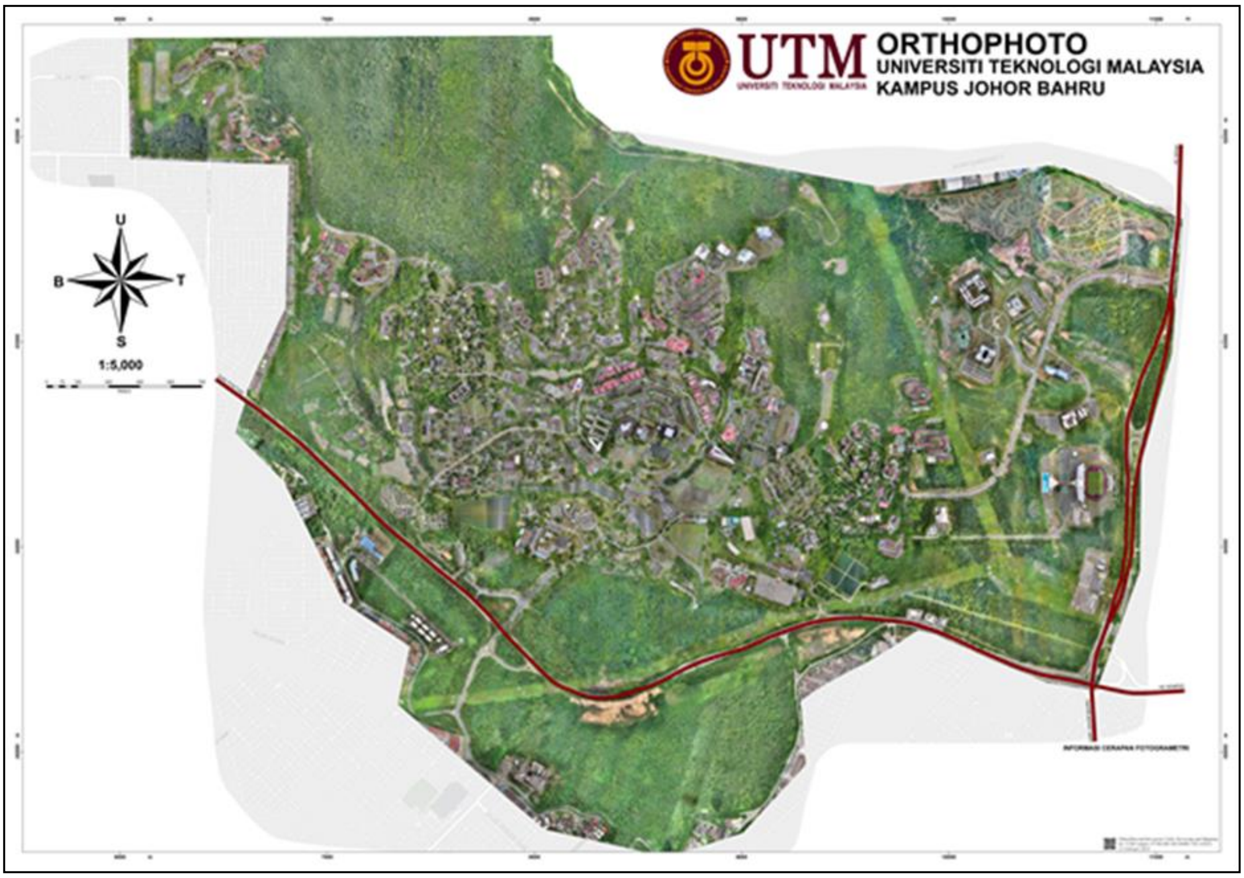


Figure 8 Framework in development of groundwater exploration database.



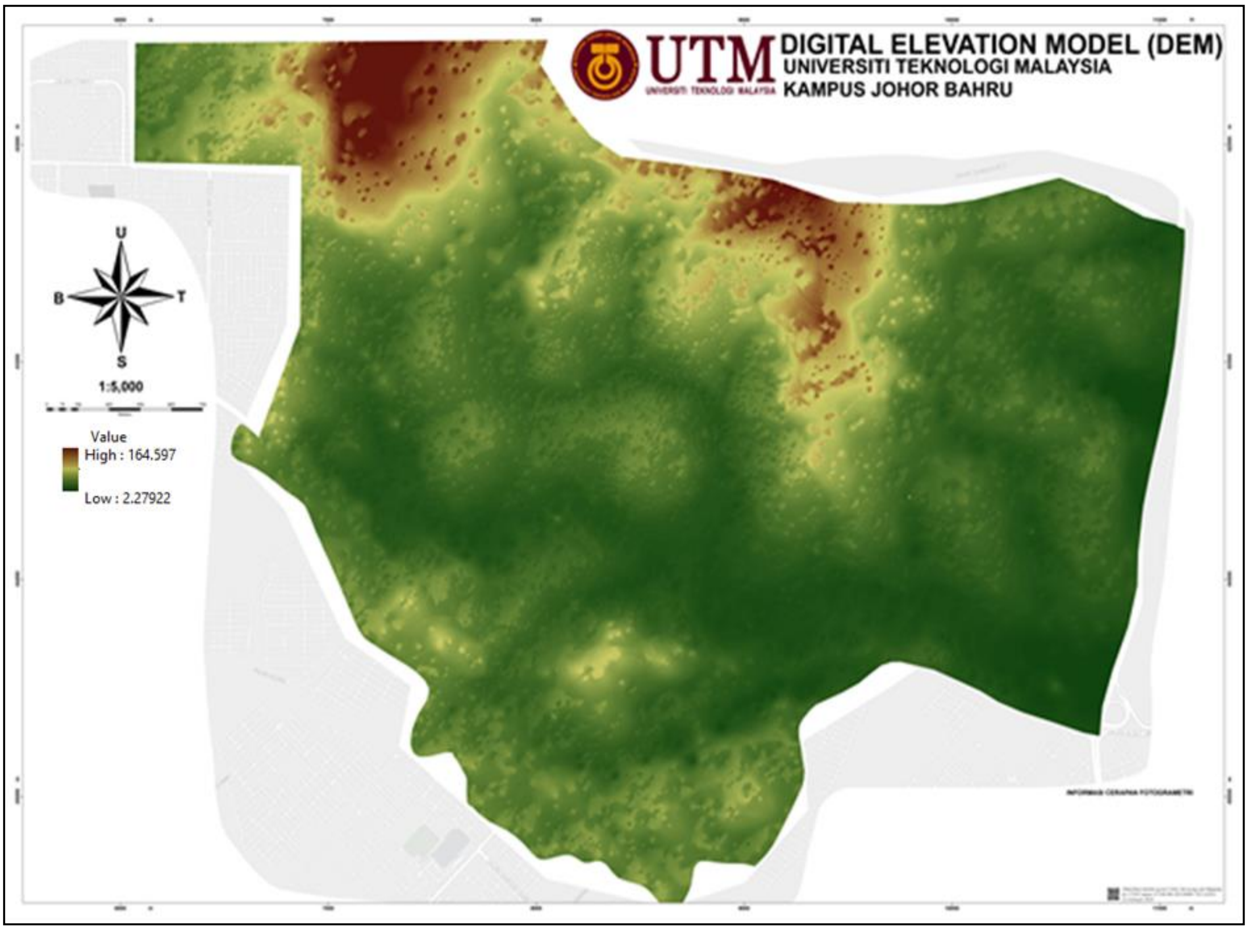


Figure 9 Digital orthophoto and DEM for the study area.

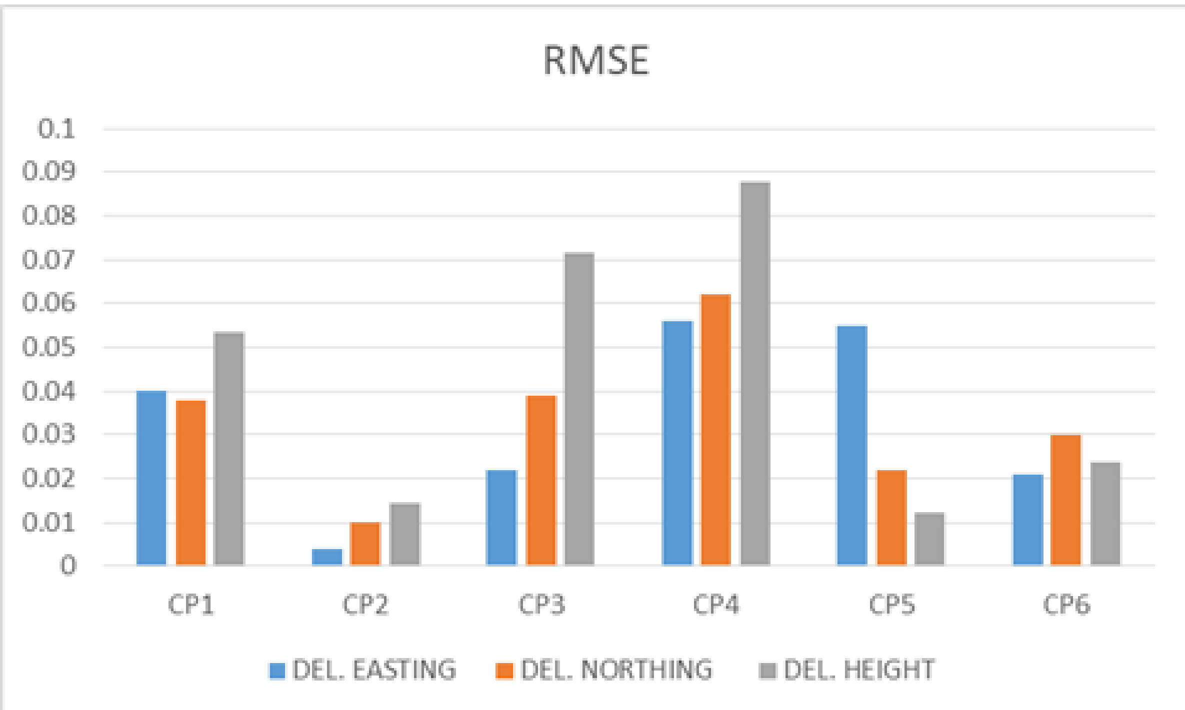


Figure 10 Error for each CP in horizontal and vertical component.

Table 2: RMSE of horizontal and vertical component.

Check Point	Del. Easting (m)	Del. Northing (m)	Del. Height (m)
CP1	0.04	0.038	0.053
CP2	0.004	0.01	0.014
CP3	0.022	0.039	0.071
CP4	0.056	0.062	0.088
CP5	0.055	0.022	0.012
CP6	0.021	0.03	0.024
RMSE	**0.048**		**0.044**

3.2 Accuracy Assessment

Accuracy analysis was performed by using the CPs established in the study area and identical points as extracted from the UAV processing result. The calculations were carried out as follow (Azmi et al., 2014; Darwin et al., 2014);

$$RMSE = \frac{\sqrt{(Ai - Bi)^2}}{n} \quad \text{.........eq. (1)}$$

The result from the calculation can be found at Figure 10 and Table 2. According to Table 2, the average RMSE of horizontal and vertical components for UAV final product were 0.048m and 0.044m, respectively.

3.3 Mapping Subsurface Profile

Two types of geophysical data were involved in this study which are resistivity and seismic data. The resistivity data processing has been utilized RESIS2DINV software to generate 2D resistivity profile. Meanwhile, the seismic data has been processed by using FIRSTPIX and GREMIX15 software to generate two-dimensional (2D) seismic refraction profile.

Based on the resistivity results, it indicates that the depth is between 310-340m with resistivity value of 0-50,000 Ohm (Figure 11-14). Meanwhile, the seismic result indicate that the depth is between 65-70m with seismic velocity value in 250-8,000 m/s as shown in Figure 15. In the study, zone of low resistivity value is 300 Ohm, which was detected at resistivity line R2 and R3. This value is interpreted as saturated zone where it shows the potential groundwater resources. The results of seismic were divided into two layers of subsurface material. The first layer from 0m to 20m (250- 1500 m/s) which consists of topsoil meanwhile the second layer is between 20m to 70m (1500-8000 m/s) which consists of weathered rock of granite. Both geological map and geophysical parameter profile have been integrated to generate subsurface profile for groundwater potential zone.

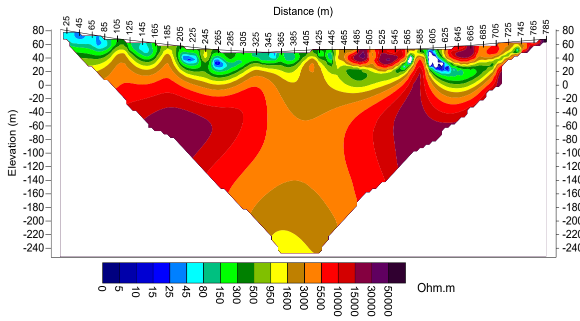


Figure 11. Resistivity section of line R1

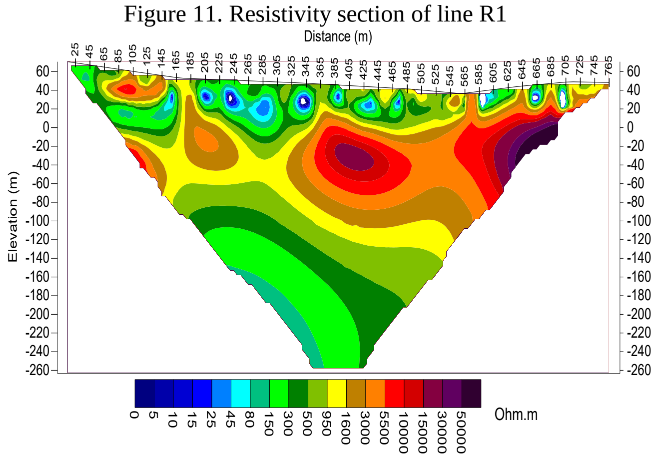


Figure 12. Resistivity section of line R2

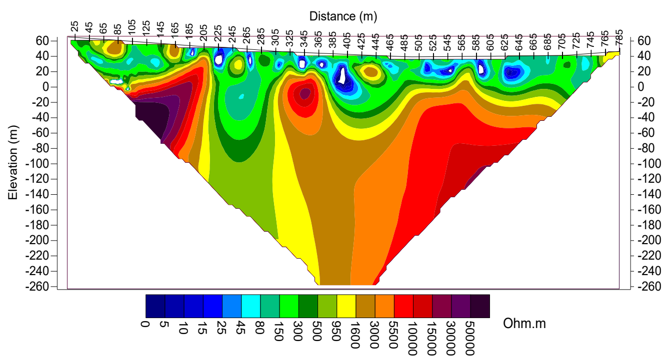


Figure 13. Resistivity section of line R3

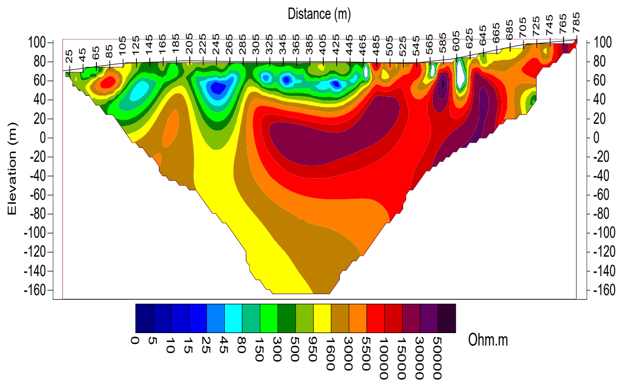


Figure 14. Resistivity section of line R4

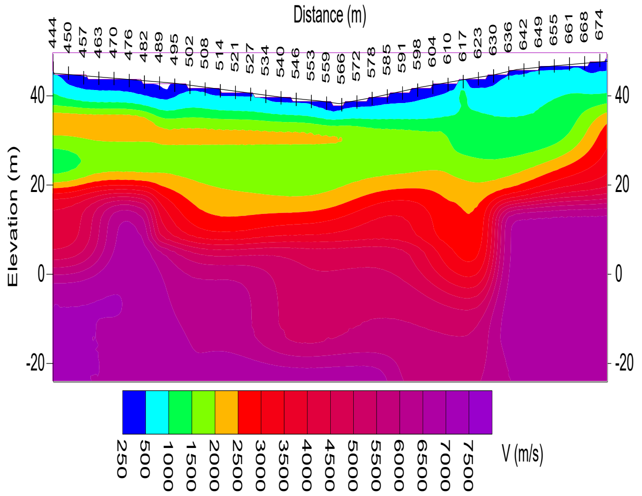


Figure 15. Seismic section of line S1

CONCLUSION

The aim of this research project is to support groundwater exploration by employing the geospatial approach. The potential area of groundwater exploration has been focused at UTM campus Johor Bahru in south of Johor where major water shortage frequently happened. The primary data which consist of GPS measurements and UAV digital aerial image were utilised in this study to produce the topographic map of the study area. It was found that the average RMSE for horizontal and vertical components of the topographic map were less than 5 cm. Meanwhile, the secondary data consist of the existing geologic map has been digitized and georeferenced by using GIS and GPS techniques.

There are two types of geophysical method data collections had involved, which were resistivity and seismic data. Based on the resistivity results, it indicates that zones of low resistivity value is < 300 Ohm which were detected at resistivity lines R2 and R3, and interpreted as saturated zone with potential groundwater resources. All the datasets had been integrated into a geospatial database which is useful to provide insight in decision making and future planning for groundwater exploration in the study area.

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