GEOLOGY AND URBAN ANALYSIS OF GUA MUSANG USING GIS

By

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DECLARATION

I declare that this thesis entitled Geology and Urban Analysis of Gua Musang by using GIS is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I/We hereby declare that I/we have read this thesis and in our opinion this thesis is sufficient in term of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honours.

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Date : ………………………………

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LIST OF SYMBOLS

cm	Centimetres
km	Kilometres
m	Meter
mm	Milimetres
ppl	Plain Polarized Light
xpl	Cross Polarized Light
%	Percentage

LIST OF ABBREVIATIONS

GIS	Geographical Information System
GPS	Global Positioning System
PPL	Plane Polarized
XPL	Cross Polarized
KM	Kilometre

Geology and Urban Analysis of Gua Musang City by Using GIS

ABSTRACT

Geological study in Gua Musang City covers lithology, geological composition, stratigraphy geomorphology and petrography. The study objective is to generate the 1:30000 Geological Map of Gua Musang City, to create flood hazard map for Gua Musang City, to produce safety map for Gua Musang City. The fieldwork and laboratory analyses have been carried out in this research. Aspects included in fieldwork were lithological analysis for all unit stones, geomorphology and structural geology discovered. Petrography analysis was conducted during this study using the samples taken from the fieldwork. The rock unit found in the study area is granite, limestone, marble, shale, slate, mylonite, and phyllite. Flood hazard is very dangerous to urban area. Looking back to the big Yellow Flood of 2014, plenty of losses was counted and injury was beyond counting. Therefore, a safety map was supposed to be produced to guide the responsible parties to have better exposure about flood hazard. Citizens should be able to be alerted by the authority. A safety map will highlight about a safer choices for urbanization, to avoid the flood hazard. Thus, the fatality can be reduced greatly.

Keywords: flood exposure, flood hazard, geology, GIS, urban analysis

GEOLOGI DAN ANALISA PERBANDARAN BANDAR GUA MUSANG MENGGUNAKAN SISTEM MAKLUMAT GEOGRAFIK (GIS)

ABSTRAK

Kajian geologi di bandar Gua Musang meliputi litologi, komposisi geologi, geomorfologi stratigrafi dan petrografi. Objektif kajian adalah untuk menghasilkan 1: 30000 peta geologi Gua Musang, untuk mewujudkan peta bencana banjir untuk Bandar Gua Musang, untuk menghasilkan peta keselamatan untuk Bandar Gua Musang. Kajian lapangan dan makmal telah dijalankan dalam kajian ini. Aspek yang termasuk dalam kerja lapangan adalah analisis litologikal untuk semua batu unit, geomorfologi dan geologi struktur yang ditemui. Analisis petrografi telah dijalankan semasa kajian ini menggunakan sampel yang diambil dari kerja lapangan. Unit batu yang terdapat di kawasan kajian ialah granit, batu kapur, marmar, syal, batu pasir, mylonit dan phylite. Banjir sangat berbahaya kepada kawasan bandar. Melihat kembali Banjir Kuning besar 2014, banyak kerugian telah dicatat dan kecederaan tidak dapat dikira banyaknya. Oleh itu, peta keselamatan sepatutnya dihasilkan untuk membimbing pihak yang bertanggungjawab untuk mendapatkan pendedahan yang lebih baik mengenai bencana banjir. Rakyat harus dimaklumkan oleh pihak berkuasa. Dengan adanya peta keselamatan, sedikit sebanyak dapat membantu memilih laluan lebih selamat untuk pembandaran, untuk mengelakkan bencana banjir. Oleh itu, kematian dan kecederaan boleh dikurangkan.

Kata kunci: analisa perbandaran, banjir, geologi, Sistem maklumat geografi

CHAPTER 1

INTRODUCTION

1.1 Research Background

This study is about urbanization analysis of Gua Musang, Kelantan using Geographical Information System (GIS). This research was carried out to analyse the flood hazard of Gua Musang city. This research is important to show the growing and rapid changes and also certain modified land use of Gua Musang city by the recent population.

Mapping was conducted throughout the research from certain period of time. Mapping is needed to create and form maps, which is portray of the features that are seen physically on the surface of Earth. Geological map and model could be produced through a systematic investigation of geological survey, a correlation from mapping activity and geology. Geological surveys are systematic and detailed investigations of the physical structure of rocks that form the topmost layer of the earth's crust. Field mapping that was carried out as a tool to determine the location of various types of formation appropriately. Methods of mapping such as outcrop and landform studying, the classic traverse walk on survey and also satellite imagery photo. Rock samples were collected from outcrops for further investigation in the laboratory.

Urban planners have lack tools in the above unregulated situation to calculate, track and comprehend urban growth processes. Multi-temporal remote sensing has become an important data collection tool for analyzing these changes. The aim of this research is to examine a method for merging remote sensing and spatial parameters to supervise urbanization and evaluate the relationship between urbanization and plans for urban land use.

Categorization and assessment of satellite imagery was carried out by using ArcGIS Software to generate maps of urban development. Evaluation of the frequency of urban development in the area was debated. A few factors that lead to modifying spatial preparation and urban legislation in these cities, including rapid demographic changes, less structured urban areas, and lack of information had a sense of urban growth monitoring and land-use change.

1.2 Study Area

1.2.1 Location

The study area is focusing at Lojing area which is a hill village in the Gua Musang constituency of Kelantan, Malaysia. This place is located near to Cameron Highland in Pahang, along the second East-West Highways. The study area has a total of 25km^2. It lies at longitude of E 101 ° 54’ 28’’ to E 102 ° 00’ 28’’ and latitude of N 4° 54’ 15’’ to N 4° 48’ 45’’. Figure 1.1 refers to base map of study area. Kelantan is located in the Northeast Peninsular Malaysia. Stratigraphic formation that can be found in the study area are a few formation from Gua Musang Group, which is Gua Musang Formation, Telong Formation, Koh Formation and also Gunung Rabong Formation.

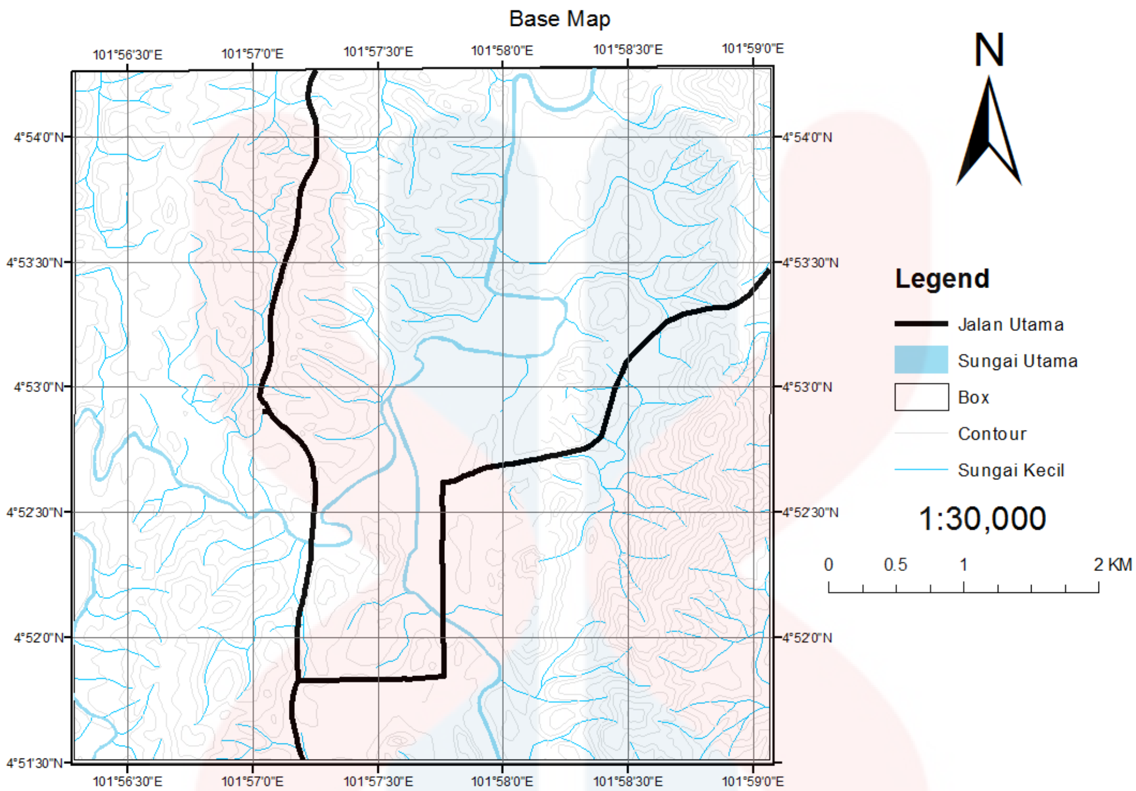

Figure 1.1: Base Map of study area.

Topography map was explained features detail on the earth. There are two categories of features that is natural features and man-made. Topography is a detail map of the surface features of land such as mountains, hills, creeks, river, lakes, building, road, bridges and many more.

The study area has different elevation based on contour. Based on topography map, the highest elevation is 890m while the lowest is 89m from datum. There are certain criteria of landform or morphology for the certain amount of elevation. The unit of rock can be identified based on the elevation at the area. The rock at low elevation is possibly the same with the rock at the higher elevation at the same location.

Geomorphology area was covered by hills and mountains. This area is developed as a result of weathering and erosion process that still actively occurring during the environmental impact. Mostly the high area was used for planting rubber trees and the replanting of oil palm trees. Next, within the topography map, the flood plains, sands mining area and river terraces. All of these characteristics can be observed during the transverse activity trough out the area of study.

Besides, the drainage pattern of this study area can also be determined based on the elevation because water has flow from the higher altitude to the lower part. The type of drainage pattern was influenced by geomorphology on the area. Based on topography map, the road, small river, main river, and also village at Gua Musang area can be determined.

The urban area is developed on the lower elevation that is 89m up to 185m. Roughly, up to 200m of elevation, there is no development of urban area presence can be determined. The area with a low and flat area much move have their major influences in this area. Table 1.1 refers to the mean of elevation of the topographic unit in the study area. The landform of the study area also can be seen after the map was produced. The produced map of landform is as shown in figure 1.2.

Table 1.1: The topographic unit based on elevation.

Description	**Mean Elevation**
Hilly	76 – 300 metre
Mountainous	>300 metre

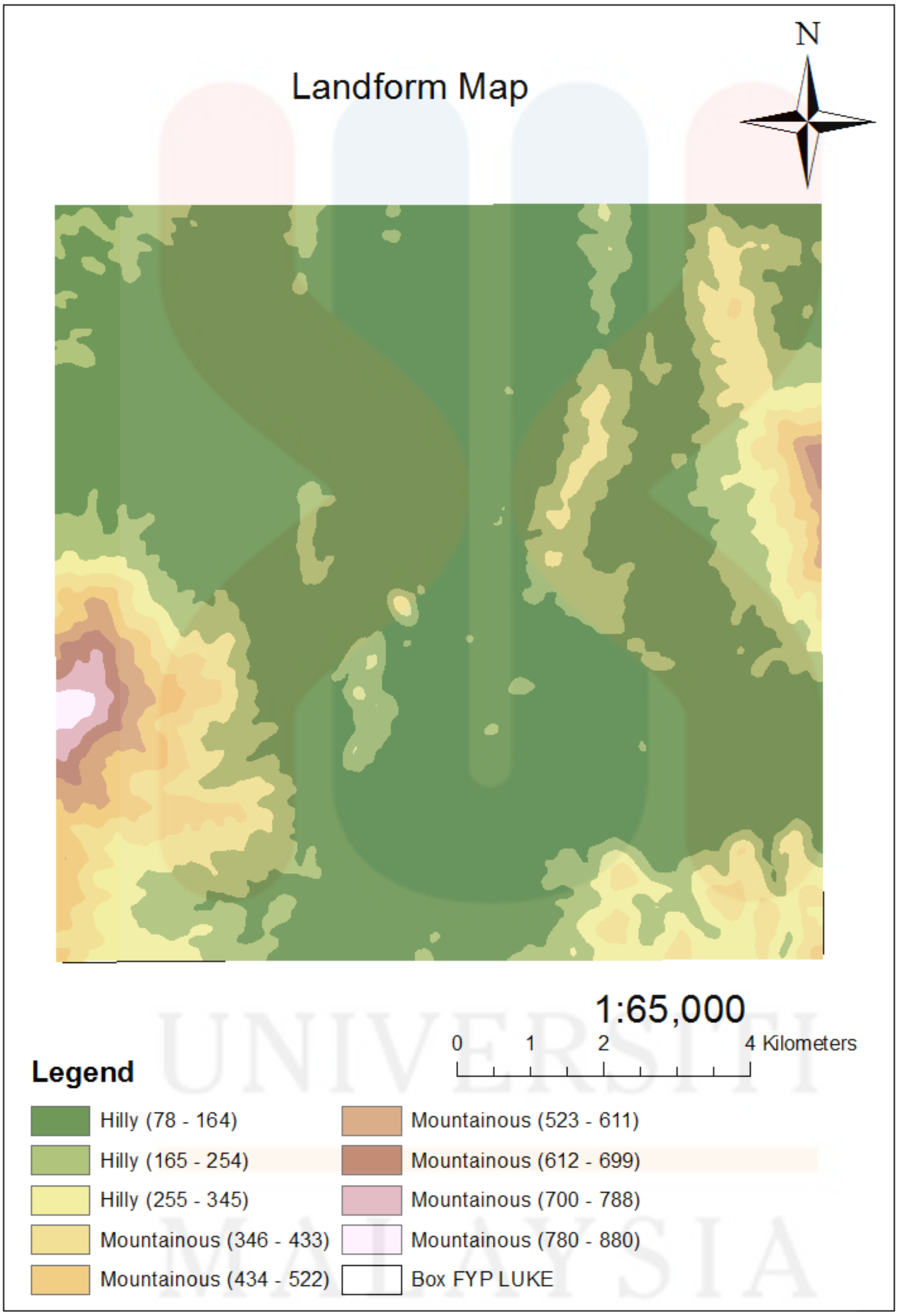

Figure 1.2 Topographic map of the study area.

1.2.2 Demography

The distribution of people in Gua Musang is shown in Table 1.2. The information was gathered from the National Population Statistics Department. The data shows the total population from the year 2010 in every district in Kelantan. Total resident of Gua Musang is 90,057. In 2014 the total population increased to 114,500 people. The latest population count of Gua Musang is at 2014. The total increment of population in Gua Musang from 2010 to 2014 is 24443.

Table 1.2: Total population of Gua Musang

Ethnic Group	Percentage (%)
Malay	76
Chinese	5
Indian	1
Natives	13
Others	5

Table 1.2 shows the record of the ethnic count of total population based on ethnic groups in Gua Musang. According to the data, there are 3 major races that lives in Gua Musang. The races can be classified as Malays, Chinese, Indian, Others. Malays are the dominant race in Gua Musang district with a total population of 76% followed by Chinese with 5% and Natives with 13%. The other ethnic group mentioned includes Indians of 1% that also resides in Gua Musang district. The total of other ethnics is immigrants in total of 5%.

1.2.3 Land use

The total land area of Kelantan is 15,012 km² which covers almost 4.6% of the total area of Malaysia according to Department of Statistics. Table 1.3 is a record of the committed land use of Kelantan in the recent year. In Gua Musang, the landuse is more focusing on plantation area, for example palm oil and rubber plantations. Normally, increasing number of population lead to the land use change in the area.

Table 1.3: Landuse of Gua Musang

Land Use	**Area (Hectare)**	**Percentage (%)**
Water bodies	56.9	2.53
Forest	359.67	16.01
Industry	113.76	5.07
Infrastructure and utilities	1.06	0.05
Institution and community facilities	84.42	3.76
Commercial	32.99	1.47
Mixed development	22.23	0.99
Transportation	18.25	0.81
Agriculture	1210.19	53.89
Residential	125.67	5.60
Bare soil	101.1	4.50
Open area and recreation	119.01	5.30
TOTAL	2245.65	100

1.2.4 Social Economic

Kelantan's business sectors primarily focused on agriculture, production, the agro-industrial sector, and even the tourist industry. Large numbers of residents are involved in the Gua Musang plantation field sector. There are two main agencies that are the Federal Land Development Authority (FELDA) and the South Kelantan Development Authority (KESEDAR) developing and shaping the landscape in Gua Musang district. The FELDA agency has planted about 84.7 percent of the palm oil that made up a large part of Gua Musang's land schemes while the rest were planted with rubber trees. In the meantime, many of the property projects under KESEDAR were harvested with rubber (67 %) whereas the rest were harvested with palm oil trees. Most of the community in the area works under both FELDA and KESEDAR agencies.

1.2.5 Road Connection/ Accessibility

Gua Musang is a district that is located at the end of Kelantan state. This district is bordered by three states, mainly by eastern of Terengganu, southern of Pahang and also western of Perak. In Kelantan, this district is connected with the neighbouring district called, Kuala Krai and also borders with another neighbour, Jeli which is located on the northern side.

The study area is located in the middle of Gua Musang City, which is assigned to be 100km2 in a given area. The area of study is 10 kmx 10 km. There are four main roads connecting the study area from other places. The first road is Federal Route 8, also known as Kuala Lumpur –Kota Bharu Highway, is a 402.7 km federal highway in Malaysia. It connects Bentong in the south to Kota Bharu in the north. Second road is Jalan Dabong–Gua Musang (Kelantan state road D29) is a major road in Kelantan, Malaysia. The road connects Dabong to Gua Musang in the north. The next road is D239, which is an alternative road from Bandar Gua Musang to RKT Sungai Terah. Lastly is the 185 route which connects Simpang Pulai–Kuala Berang Highway, Federal Route 185. Figure 1.3 refers to road connection within the study area.

Figure 1.3: Study area (10km x 10km) with road connections.

1.3 Problem Statement

The latest geological map of Gua Musang city is last updated by Geological Society of Malaysia on 2016. A newly updated geological map must be produced through the research that covers mainly 100 kilometers square area around Gua Musang City.

Secondly, the urban growth process of Gua Musang city is rapidly increasing, therefore, it is important to carry out a study to track and comprehend processes of urban sprawl. Multi-temporal remote sensing is becoming a significant data collection tool for monitoring these changes. Thirdly, there are changes on urban areas development. The changes can be seen through the creation of landuse map. There are many factors that leads to these changes, for example, the presence of geohazard. Therefore it is compulsory to identify the causes in order to relate land use changes and urbanization.

1.4 Objectives

1. To produce geological map of Gua Musang City with a scale of 1:25000.

2. To create flood geohazard map of Gua Musang City.

3. To produce safety map for urbanization of Gua Musang City.

1.5 Scope of study

This study's scope is classified into two parts. The first part is for general geology and the second part is for analysis of urbanization. The general part of geology, the study was conducted to produce the geological map of a given 100 km2 study area. The tools and materials to be used are basic geological mapping needs, Global Positioning System (GPS), compass and hammer, Hydrochloric Acid (HCL) and ArcGIS software to create geological maps.

Other than that, the study for Urbanization analysis involves the hazard of flood that happens in Gua Musang Kelantan. The flood hazard that happens in 2014 is considered the worst recorded. Safety map and hazard map was produced in this study.

1.6 Significance of study

The purpose of conducting this study is to produce geological map of Gua Musang city by updating the data and information that was gather in the study area. The data that was gathered and the geological map that was produced can be helpful and could contribute much to other researcher.

Besides, the production of flood geohazard map and the safety map of urbanization growth of the study area is going to be useful for a certain groups of Gua Musang and not to mention the community of Gua Musang city, government sector that relates to local planning. For community of Gua Musang city they will be aware of their population growth effect to the city. For local planning sector, This data is an extremely useful tool for policy-making and strategic planning by local governments and for making sure healthy urban growth and development in the study area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This research begin with analysing past research to review the upcoming study that is about to be done. Planning and ideas can be inspired from the past research, about the methods or the materials or even the flow of the research.

2.2 Regional setting

The study area was located in Gua Musang City between 10 kilometers square feet. Raub–Bentong suture is included in the tectonic setting. Raub–Bentong suture is divided into three parts, the eastern belt, the central belt and the western belt. Gua Musang is located in the central belt of Peninsular Malaysia between latitude 4.45 ° and 6.25 N and lengths 101.30 ° and 102.40 ° E. The peninsular Malaysia Central Belt consists of the formation of the Gua Musang Group where Aring is part of the group. Central area of regional geology of Kelantan, contain meta-sedimentary and sedimentary rock bordered on the west and east by Main Range and Boundary Range granites respectively (Heng et al. Al. 2006)

The major rock type can be found in Kelantan sedimentary or meta-sedimentary rock (51 percent), followed by granite rock (33 percent), volcanic rock (10 percent), then unconsolidated sediment (6 percent), (Asborne & Chappel, 2003). The argillaceous rock is much more abundant in the south of Gua Musang Formation to the Merapoh area than the calcareous and bulk sequence is formed. The depositional environment for the Gua Musang group is shallow marine shelf deposition while at the same time having active volcanic activity during deposition (Lee, 2004)

2.3 Stratigraphy

The Aring Formation is primarily volcanic (tuff) series along with thin sheets of argillite and marble interbeds throughout the Lebir River, lower reaches of Sungai Aring and Sungai Relai in southern Kelantan (Aw, 1976). Aring Formation ages varying from late Carboniferous to Early Triassic as evidence of brachiopod and fusullinaceous fossil found. The thickness of this formation is about 3000 meters where the Paloh member is located at the top level of the formation about 1000 meters, interbedded with slate / tuffaceous calcareous.

The Gua Musang formation in South Kelantan–North Pahang to describe Middle Permian to Late Triassic argillite, carbonate, and pyroclastic / volcanic facies in the Gua Musang area (Yin, 1965). The term has now been loosely used for almost all Permo-Triassic carbonate-argillite-volcanic sequences in the northern part of the Central Belt Peninsular Malaysia. The widespread distribution of argillite-carbonate-volcanic across the northern Central Belt has triggered problems with current assigned names. For example, similar lithologies to the Felda Aring Gua Musang formation are called Aring Formation.

The Telong Formation age is Permian – Upper Triassic as evidenced by the fossil of pelecypod, ammonoid, gastropod and brachiopod found. The ammonoid assemblage is indicator to Middle – Late Triassic age (240 – 220 Million years ago) and belonged to the Tethyan Province (Hussain *et al*, 2018). The rock sequence of this formation consists mainly of argillite and thin pyroclastic interbedded marble with minor tuff and andesit. At the middle reaches of Sungai Relai and upper reaches Sungai Aring, an extensively partly tuffaceous and locally carbonaceous argillite consisting interbedded tuff and occasional beds and lenses of marble and limestone.

Rock sequence of Gunung Rabong Formation consists of shale, mudstone, sandstone, siltstone, and also conglomerate (Ying, 1965). This sequence is a kind of deep sea sediment turbidit deposits. This sequence also contains volcanic materials. This formation is approximately to be around Middle – Late Triassic as the evidence of Daonella and Posidonia fossil found here. This formation is almost identical to Semantan Formation and Semantan Formation is often used widely than this formation.

Koh Formation is the Gua Musang group's youngest formation. This formation consists of interbeds of sandstones, argillite, and mudstone is Jurassic / Cretaceous terrestrial sedimentary rocks. Koh Formation of age Upper Triassic to Jurassic consisted of mudstone and sandstone with a small interbedded conglomerate and is metamorphosed to phyllite and semipelitic schist in the southwest (Leman 2004) and (Kamal Roslan, 2006). Due to structural differences, unconformity occurred between older Aring Formation and younger Koh Formation. The Koh Formation was also uncomfortable with Telong Formation.

2.4 Structural geology

The Telong Formation of the axial belt is correlated to the Gunong Rabong Dormation and the top part of the Gua Musang Formation with the Aring Formation to the rest of the Gua Musang Formation, (Aw, 1967). The Lipis Group is correlated with just the Kaling Formation in the central portion of the axial belt, that should be a good term taking into account that somehow the former could not be separated into formations.

Semantan Formation and Gemas Formation are homotaxial even though Samantan's limestone facies cannot be seen in Gemas Formation but both have a common, predominantly argillaceous character of chert (Ying, 1965).

The lithology of the study area is mostly made up of metamorphic and sedimentary rocks. Figure 2.1 explains the lithological deposition of the study area in a map.

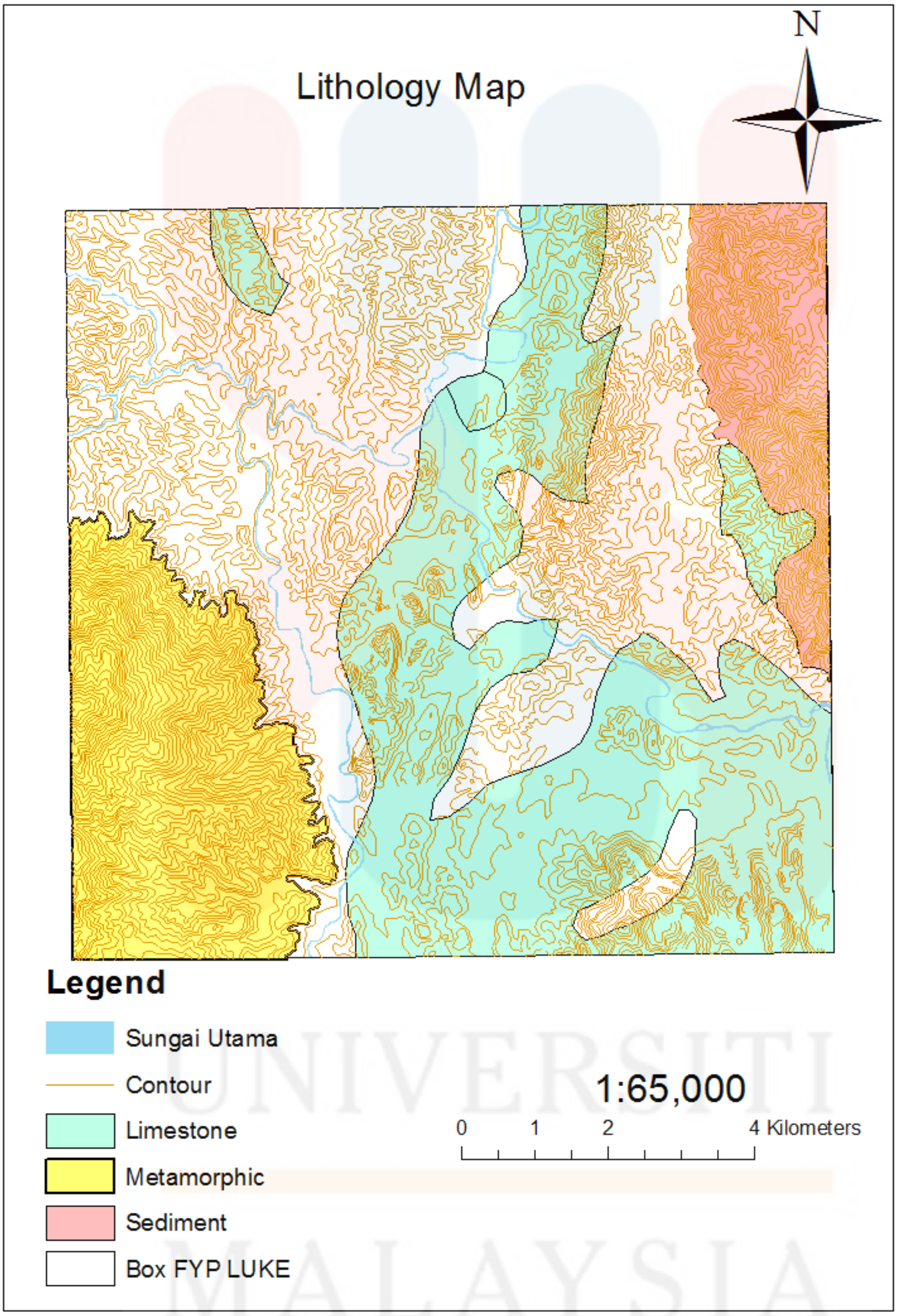

Figure 2.1: Lithological Map of Gua Musang city.

2.5 Historical Geology

The range of geological formation in Kelantan start from Lower Paleozoic until Quaternary. Paleozoic, Mesozoic and Cenozoic formation are the three main chronologies.

The Paleozoic formation was created in Peninsular Malaysia's central belt. The majority of the Upper Paleozoic was the sediments which comprise of marine Permian Strata which really happen in the Central Belt as sequential belts maneuvering Mesozoic sediments. The Upper Paleozoic lithology consists of Gua Musang Formation as well as Aring Formation throughout the south of Kelantan whereas the Taku schist is within the east of Kelantan. Argillaceous and volcanic facies are dominant in the Upper Paleozoic formation, whereas the remaining reside to calcareous and arenaceous facies. Starting from Late Carboniferous, the depositional environment in this formation is Shallow marine with periodic aggressive underwater volcanism hitting its peak during Permian and Triassic, (Lee, 2004).

The Mesozoic formation was indeed dominant throughout the central belt which really builds a continuous North-South trend belt stretching further than the country borders with Thailand (the Gua Musang formation) in the north and Singapore (the Jurong formation) in the south. The shallow marine clastics and volcanic interbed carbonates are dominant in the Gua Musang, Aring and Gunung Rabong Formation Permian–Triassic. Telong Formation is far more dominant in the South with the deeper marine turbiditic sediment. These turbiditics are frequently tuffaceous in existence with volcanic interbeds (Leman, 2004).

Finally, the Cenozoic formation has the deposits of sediments from Quaternary. The thoroughly unconsolidated to non-consolidated boulders, sand, gravel, silt, clay in north Kelantan is part of the quaternary sediment that undermines the coastal and inland plains.

2.6 Urban Analysis

2.6.1 Land Use Changes

Worldwide change is linked to land use and land cover change and relates to the physical matter on the surface of a provided piece of land (Vitousek, 1902), whilst land use applies to human actions on or using land (Longley, 2001). Examining satellite and aerial imagery can specify the land cover, whilst also land use cannot be identified by satellite imagery. Land cover images and maps provide information to help research teams comprehend and evaluate the current landscape.

The whole study was using Landsat images to measure VSW (vegetation-soil-water) index images which logically differentiate between vegetation, soil and water elements on the image.

GIS software has been used to digitize, integrate, overlay and present data on spatial and non-spatial land use change in the city. Field studies were performed all through the study area using the Global Positioning System (GPS) to acquire precise location point data from each class of land use included with the classification system.

2.6.2 Remote Sensing

Remote sensing will allow the user to use and access satellite imagery (Donoghue, 2002). Other than that, it can be used to examine carbon stocks and their response to human interference through deforestation, urban development and other land use changes. Remote sensor data is important in land use and land cover mapping and inventory. Remote sending data give information such as accuracy and scale to fulfil requirement for the specific objectives of an investigation on the past.

Integration of multi-source data allows remote sensors to create previously inaccessible geospatial data for monitoring and modelling. Remote sensors on the satellite, airborne platform, and a wide array of ground-based instrumentation including sensor networks, wildlife GPS collars, and the weather stations, produce sites of satellite data about the ecosystem and the species that occupy it. Satellite data can therefore identify global spatial (1 m to 1 km) and temporal (daily to annual) benchmarks to monitor most impacts on the environment such as climate change, disturbance, and land use.

The application of remote sensed data enabled people to analyse changes in land cover in much less time, at reasonable cost as well as with improved accuracy in involvement with GIS, offering an acceptable platform for data analysis, upgrading and retrieval. The user uses tones, shapes, texture, pattern and site association from what is basically land cover information to analyse and interpret information about land use activities. The remote sensor receives a response based on plenty of land surface features, including natural and artificial coverage.

2.6.3 Geographical Information System

The components of GIS software was hazard mapping that used to produce community vulnerability inventory. GIS software was mainly used to digitize and analyse the status area of the study area. The identified geohazard was labelled and hazard map was produced from the outcome. A safety map of the study area was determined using GIS.

The local knowledge was essential for disaster management which the information from the community of who involves in flood-prone area was gathered, also be used as a methodology for data collection. GIS maps has advantages compared to conventional map because the maps that produced from GIS software contain all the data such as, potential hazard map and an element that exposed to floods also provided when GIS software was used to generate maps.

2.6.4 Flood Geohazard

Rain is a factor each time there are more rains than the drainage systems can take, there can be floods. Sometimes, there was heavy rain for a very short period of time that results in floods. In other times, there was rain for many days and weeks than can also result in floods.

Flood geohazard is elucidated as an alarming incident, or the happening likelihood of a probably destructive phenomenon that occurs within the range of given area and time. Natural hazard relates to a natural environment trait or phenomenon that has the ability to cause harm to society. The company involves homes.

Examples of natural hazards include wind, tornadoes, flood water, flood soil, earthquakes, lava, rocks, and tsunami. This thesis focuses on flood risks.

The concept of hazard is defined as the potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and cconomic disruption or environmental degradation (UNISDR, 2004). Flood hazard is defined as the chance of a certain magnitude of flood event to occur in a given area and period of time (Alkema and van Western, 2005). An example of the human activity that may change the pattern of the hazard behaviour or alteration of natural drainage, creation of landfills, destruction of the natural environments and increased groundwater extraction.

Hazard zone need to be classified which are divided into of “high,”“medium” and “low” based on recommendations from a study (Bureau of Reclamation, 1988). Rapid urbanization, uncontrolled logging of natural forest or major changes in land-use can influence the spatial and temporal pattern of the hazards at Gua Musang.

In order, to determine the flood hazard the flood mapping was conducted to compare the water depth before flood and water depth after floods. A survey was made to determine the flood water depth and the flood risk level for each house that surrounded by floods.

100 questionnaires were distributed to the residents in the several villages at Gua Musang. For examples, Kg. Kerinting, Batu Papan and so on. The flood hazard levels can be classified along the Galas River based on information gathered from 100 respondents. Mostly, Gua Musang area can be categorized as high hazard level. This is because 60 out of the 100 numbers of houses were surrounded by 5 meter flood depth. For both medium hazard and low hazard were categorized as minor damage. This is because the flood depth for medium is 1-5 meters and low hazard is below than 1 meter.

CHAPTER 3

MATERIALS AND METHOD

3.1 Introduction

To complete this research, the needed data that was gathered and obtained by determined and examined the material and methods were required in this study. There are a few phases involved in the method and materials for geological study and specification of this topic as indicates in Figure 3.1. First phase is preliminary study, which mainly on the preparation of base map. The settlement, type of drainage pattern and contours were identified to serve as the basic element in the area of study. It is important to identify the base map as it indicates the geomorphology of the study area. Other than base map, published researched papers and literature, journals were obtained to add extra information regarding this study.

Second, data collection was done during the mapping of the study area, the geological data was collected and the sample of lithologic units is obtained to save cost and time. There were a few data that collected from agencies for the specification, demography of study area from District office of Gua Musang, landuse data was collected from Intergrated Landuse Planning Information System of i-Plan Malaysia, and road connection from Google Earth Pro.

Third, data processing was done to obtain information from the collected data. Rock samples that were collected during mapping process, go through thin section process to identify the minerals presence gathered in the sample. For specification, landuse changes from the year of 2008 and 2018 was determined to investigate the rate of development of the study area. After the landuse map of both year were identified and completed, data processing was done. The changes of landuse was correlated with the urbanization of the study area.

Last but not least the result was obtained and followed by discussion section. Then report writing was done to conclude the research. Based on the research planning, the material needed in the study was totally related with the method done within the research. The best method was sorted out and the idea was implemented during the first phase. The material and method needed was sorted out during the first phase.

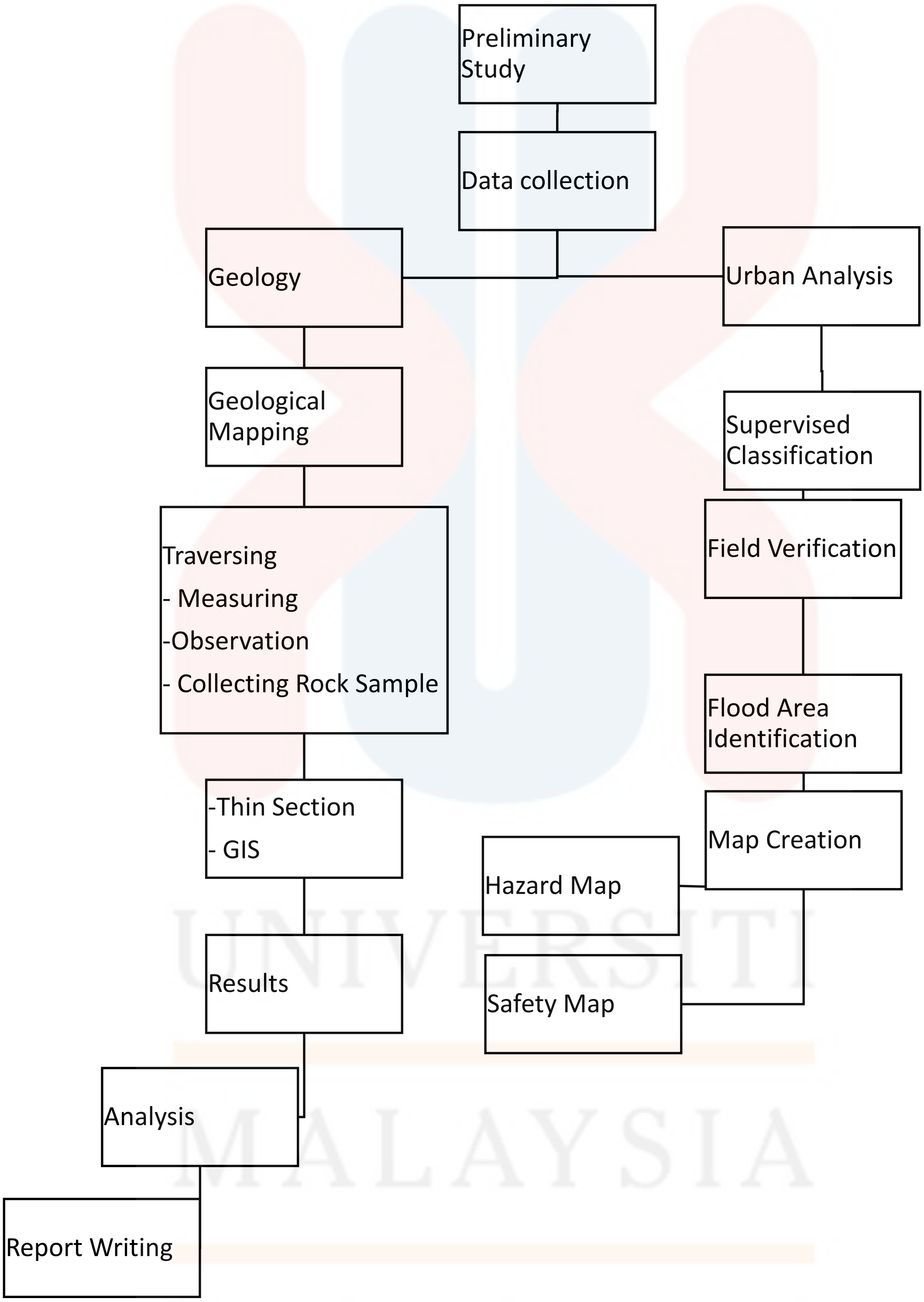

Figure 3.1: Flow chart of study

3.2 Materials for Geological Mapping

These are several materials that was used for geological mapping such as Global Positioning System (GPS), Hydrochloric Acid (HCL), Brunton Compass, Suunto Compass, Geological Hammer, sample bag, hand lens measuring tape and field camera.

3.2.1 Base Map

Before starting the research, the base map was produced using the application ArcGIS from ESRI. The base map contains a few elements of layer consist of river for the drainage pattern, contours layer for the geomorphology and elevation identification, and main roads connection of the study area for accessibility. Topographic condition can also be determined from this map. This map can help in indicates which point to go, and gives the idea for this research. The data collection of this research was easy to be conducted with this base map.

3.2.2 Geological Hammer

A geological hammer used to break rock in many ways and also to retrieve sample from an outcrop found located within study area. It is a basic mapping tool and very crucial for data collection. This hammer was also used to chipped away the weathered rocks around the site. There are two types of hammer, chisel and tip point. For this research, chisel was mainly used for sedimentary rock made of steel and rubber handle.

3.2.3 Compass

There are two types of compass in geology field, which is Brunton and Suunto. Brunton and Suunto compass were used to find degrees of direction, and also to measure the strike and dip reading of an outcrop. Compasses are used to measure the orientation of geological planes and the lineament of the rock units. Azimuth reading of the study area was also calculated using compasses. Besides, compass help greatly in determine the position of study area on topographic map with the indicator from magnetic poles in the compass.

3.2.4 Hand lens

Hand lens on the other hand, will be used to keenly study the mineral content on any sample which cannot be done with naked eyes. The main use of hand lens is to identify the rock sample in the field before the sample was sent to the laboratory analysis. Hand lens that comes with 10 times magnification will be very sufficient for the fresh rock surface identification, also the grain size of the sample and if possivle the microfossil found.

3.2.5 Global Positioning System

Next, a GPS was used to mark locate and track position, look for access point at any place, monitor elevation and track previous marks which will be very useful in geological mapping. It is compulsory to make sure the research is done within given area of study. The GPS was very useful for geologist to marked and produce valuable information at the site of fieldwork. However, the GPS runs on dry cell, the usage was needed to be monitored to avoid data loss and damage the cost of time and money.

3.2.6 Hydrochloric Acid solution

Hydrochloric Acid solution or known as HCL was needed to be used to investigate the presence of carbonate minerals inside any rock. The HCL solution can be used to identify many rock units with presence of calcium carbonate such as dolomite, limestone, and marble rock. This can help in differentiate the units easily. The HCL solution was dropped on the rock sample and if calcium carbonate is presence, the rock reacts with the solution producing hissing sound.

3.2.7 Measuring Tape

Measuring tape was used to none other, measure strata layer, which is very important in geological mapping. Other than that, measuring tape was used in identify the dimension of outcrop, which is width and length of outcrop. It was also used in structural geology to measure the length of joint, faulting line of an outcrop.

3.2.8 Field Book and Proper Attire

Field book was used in the fieldwork, mainly to record data collected during mapping. This important information was recorded based on previous literature review. This book also used to record location, sample number, coordinates and elevation of the outcrop in the study area. Sketches of the outcrop was also done in the fieldbook. Proper attire was also implemented during fieldwork. The attire consists of fieldwork jacket, safety boot, cap or hat and gloves. This is important to ensure the safety and secure the researchers during fieldwork.

3.2.9 Sample Bag

Other than that, sample bag was used to keep rock sample safely and was labelled differently to differentiate each sample taken.

3.2.10 Field camera

Furthermore, field camera was used to capture important structures and geological features found, a suitable scale is needed for references.

3.3 Materials for Urban Analysis

3.3.1 Software

There are certain software that were used during Urban Analysis studies such as ArcGIS software10.2 version, Erdas Imagine software and USGS Earth Explorer. ArcGIS software is needed to generate map of study area. Maps such as geological map, traverse map, and landuse map are needed during the study. Other than that, Erdas Imagine Software was used process and analysis all types of imagery and data such as multispectral and hyper spectral. USGS Earth Explorer was used to download satellite imageries.

3.3.2 Survey form

Survey form is also needed to identify the flood hazard victims and the location of the flood hazard, also the other important details such as depth of the flood and many more before creating flood hazard map and safety map.

3.3.3 Flood hazard data

Flood hazard related data such as hydrograph or rainfall distribution is needed before study can be carried out.

3.3 Methodology for Geological Mapping

3.3.1 Preliminary Study

Preliminary study takes place at the beginning of an event, often as a form of preparation by referring or study of past research such as journal or book which contain information that related with topic research and location of study area. Based on preliminary study, knowledge and better understanding of the research area and the area of study was gathered.

This information was obtained from new types of sources such as journal, thesis, test book, and geology private sector. This information was obtained from a new types of sources such as journal, thesis, test book, and private sector of geology. The geomorphology is a major part and the urban area is a main objective in this research. This research need to accomplish with mapping method. The geomorphology map was produced based on the data collection from the field observation and it was produced based on the data collection from the field observation and it was produced by using the ArcGIS software or remote sensing application. This research must be accomplished using a mapping method. The geomorphology map was produced on the basis of field observation data collection and was produced on the basis of field observation data collection and was produced using the ArcGIS software or remote sensing application.

3.3.2 Field Studies

Field studies involve collecting data outside of an experiment or lab setting that involves observation in the study area. It includes geological mapping, rock sampling and site visit. The field study was done for the whole two weeks and many aspect is needed to be prepared.

First, the study of the literature review was performed on the following area. This would be essential because it can include an overview of the area and what was the area's specialties. Many kinds of plan and method were constructed from the literature review. Then research remote sensing or any type of digitizing data about the study area. The GPS is valuable material for documenting the traverse and marking the outcrop location. It could also function as a compass to indicate the field coordinate and direction.

After that, all the equipment and materials were checked and completed during the field work to avoid any problem. After reaching the study area, the basic method found the outcrop as a n indicator to know the type and distribution of rock around the area.

3.3.3 Traverse mapping

Traverse mapping was performed during geological mapping. There were a few methods for traverse mapping such as walking, motorcycling, car and boat. Traverse map is a map that records the journey along field mapping activities.Traverse map also used to mark outcrop, hazard, land use, geomorphology and any structure found during traverse mapping in the area before producing map for each specification. In addition, these maps also used to mark the area covered to avoid mapping repetitions of the area. This could save a lot of time and cost.

The function of traverse mapping is as evidence that the researcher covered the area. Raw data related to this research was available on the internet, book or journal. This map can be produced using GPS ArcGIS software and data. GPS is very important equipment because it was used to record the coordinate and to show the exact direction.

Basic information that can be extracted from the traverse map is rock type, geomorphology, type of public facilities and geo-hazard area. Geo-hazard area was discovered in a few elements such as depth width and flood plain size.

3.3.4 Sampling

Sampling is part of the field work. Sampling was important to help interpret as and analyze the data after the fieldwork. Samples were collected in good condition. The sample was then labelled on the plastic sample. The sample taken was needed to be fresh and not weathered to avoid poor results and analytical difficulties.

The purpose of sampling was also to identify the age of rock formation and distribution around the study area. First, note the outcrop area geomorphology. Then roughly, observation was done to get the rough idea of the occurrences of outcrop history. It is important to note the outcrop's homogeneity and heterogeneity.

3.3.5 Laboratory Work

Laboratory works usually need to be done in lab using lab apparatus and materials which often involve study and observation of rock samples. During this study, laboratory work often involves thin section preparation and petrography analysis.

3.3.6 Data Processing

Decision-making requires information generated from spatial search and the necessary operations performed. The database and graphics was manipulated and processed to generate information for GIS analysis about the entities (spatial feature). Using ArcGIS, data was retrieved from the database such as graphics and tabular data. GIS analysis helps to determine the fitness of the database.

3.3.7 Data Analysis and Interpretation

Data analysis for geological mapping method was taken during field studies for laboratory works, data processing and data analysis with interpretation will be done by using ArcGIS software.

3.3.8 Report writing

The last step of the research is to make a report writing about the data and results of the research only. Conclusion and recommendation from the research study will be made either the objectives of research has been achieved or not.

3.4 Methodology for Urban Analysis

The study specifically focuses on interpreting patterns of land use change in the city and satellite and demographic data based on growth. This research was using Landsat images to calculate VSW (vegetation-soil-water) index images that clearly distinguish on the image between vegetation, soil and water elements. Image processing software will be used for geometric satellite data correction, supervised classification, classification accuracy assessment, land use maps, change detection, final output maps etc. GIS software was used to digitize, integrate, overlay and present spatial and non-spatial land use change data in the city. Field surveys was conducted throughout the study area using the Global Positioning System (GPS) to obtain accurate location point data for each land use class included in the classification scheme.

A hazard map and a safety map will be created for urban analysis. Based on (Seyf1 et, al. 2006), Applying the Flood Hazard Map (FHM) is a new approach to flood damage reduction. In order to the suitability of plains for economical activities and also population concentration, most of people, without any knowledge of flood risk, attempting to build structures and facilities. Flood Hazard Map as a guide, introduces appropriate locations for structure construction and also offers the population concentration sites. Mentioned map could represent the safe way out from flood plains and escape to pre-defined secure locations. A map which could presents the flooded locations and also emergency evacuation in a simple way and graphically, is called Flood Hazard Map. Flooded location prediction, depth of floodwater, safe and secure places for evacuation, the evacuation routes during flood and dangerous locations identification could be mentioned as the main items of a flood hazard map. In many developed countries, the preparation of FHM (Flood Hazard Map) is required for industrial and populated areas and most of settlement and development plans consider FHM.

CHAPTER 4
GENERAL GEOLOGY

4.1 Introduction

As far as this section is concerned, General Geology comprises the study area geological features. This chapter covered specific topics as well as by stratigraphy, structural geology, geomorphology, historical geology, fieldwork interpretation, as well as the maps necessary. Several maps was created in this chater which comprises in the geological study of this study area. The maps mentioned were geological map, morphological map, traverse map, and a few more. As mentioned earlier, the data obtained throughout fieldwork observation was explained among this section.

The area of study is 5 kmx 5 km. The study area is located in the middle of Gua Musang Town, while some of the forests and plantations are accessible. The general geology provides a great amount of geological information for this chapter for further analysis. This covers geomorphological sections, structural geology, analysis of petrography, stratigraphy, historical geology and, where appropriate, a lot of details.

Stratigraphy consists of understanding the rock layers, their relative ages and absolute ages and the relation of the strata. It may also be used with previous findings in the past to correlate between obtained observation. Rocks units are assessed for physical characteristics and geological structures. Gua Musang region stratigraphy which was focused on a literary review, it is between Gua Musang formation and Gunung Gagau group.

4.1.1 Accessibility

Gua Musang is a district that is located at the end of Kelantan state. This district is bordered by three states, mainly by eastern of Terengganu, southern of Pahang and also western of Perak. In Kelantan, this district is connected with the neighbouring district called, Kuala Krai and also borders with another neighbour, Jeli which is located on the northern side.

The study area is located in the middle of Gua Musang City, which is assigned to be 100km2 in a given area. The area of study is 10 kmx 10 km. There are four main roads connecting the study area from other places. The first road is Federal Route 8, also known as Kuala Lumpur –Kota Bharu Highway, is a 402.7 km federal highway in Malaysia. It connects Bentong in the south to Kota Bharu in the north. Second road is Jalan Dabong–Gua Musang (Kelantan state road D29) is a major road in Kelantan, Malaysia. The road connects Dabong to Gua Musang in the north. The next road is D239, which is an alternative road from Bandar Gua Musang to RKT Sungai Terah. Lastly is the 185 route which connects Simpang Pulai–Kuala Berang Highway, Federal Route 185. Figure 4.1 refers to road connection within the study area.

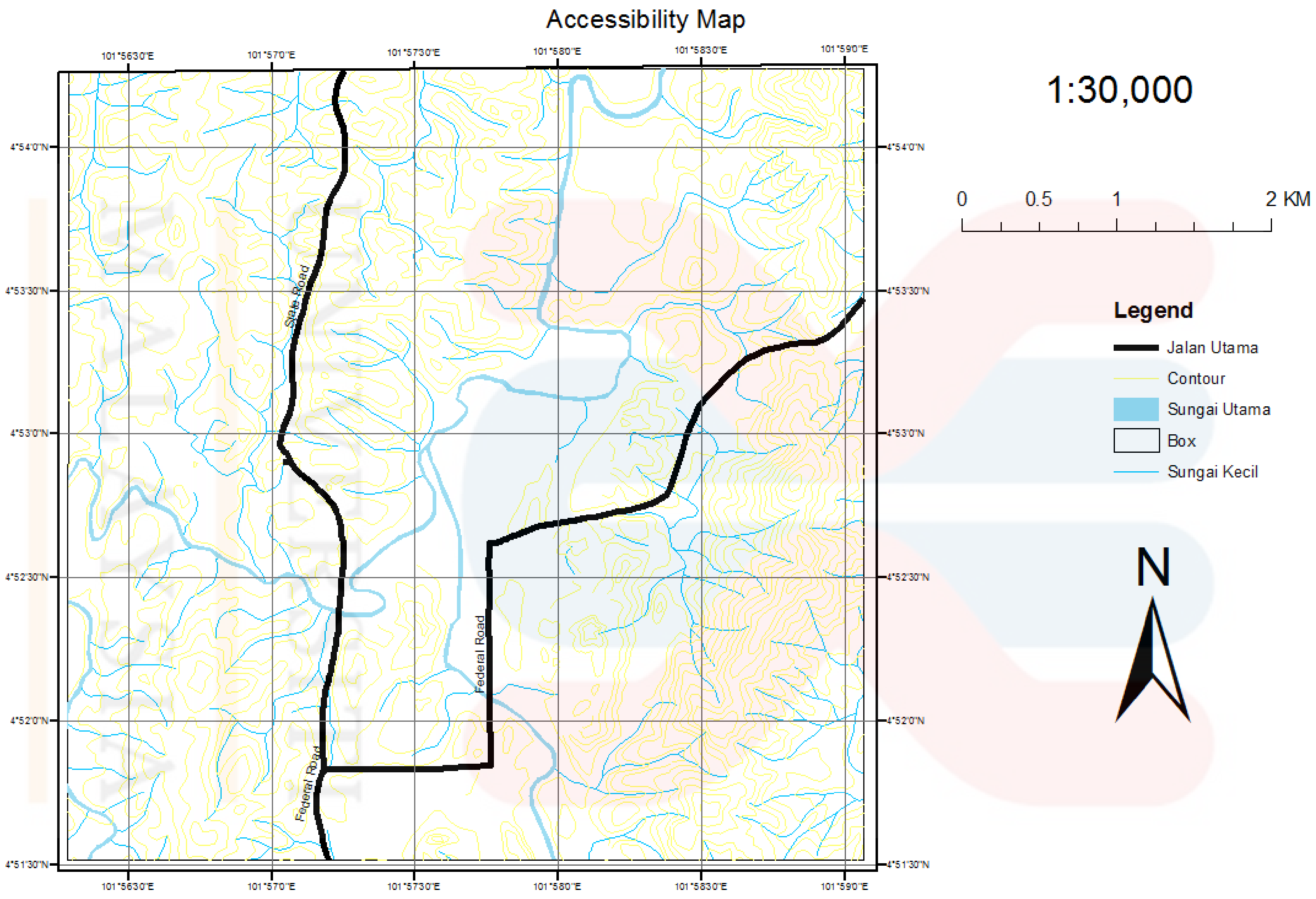

Figure 4.1 Accessibility Map of study area

4.1.2 Settlement

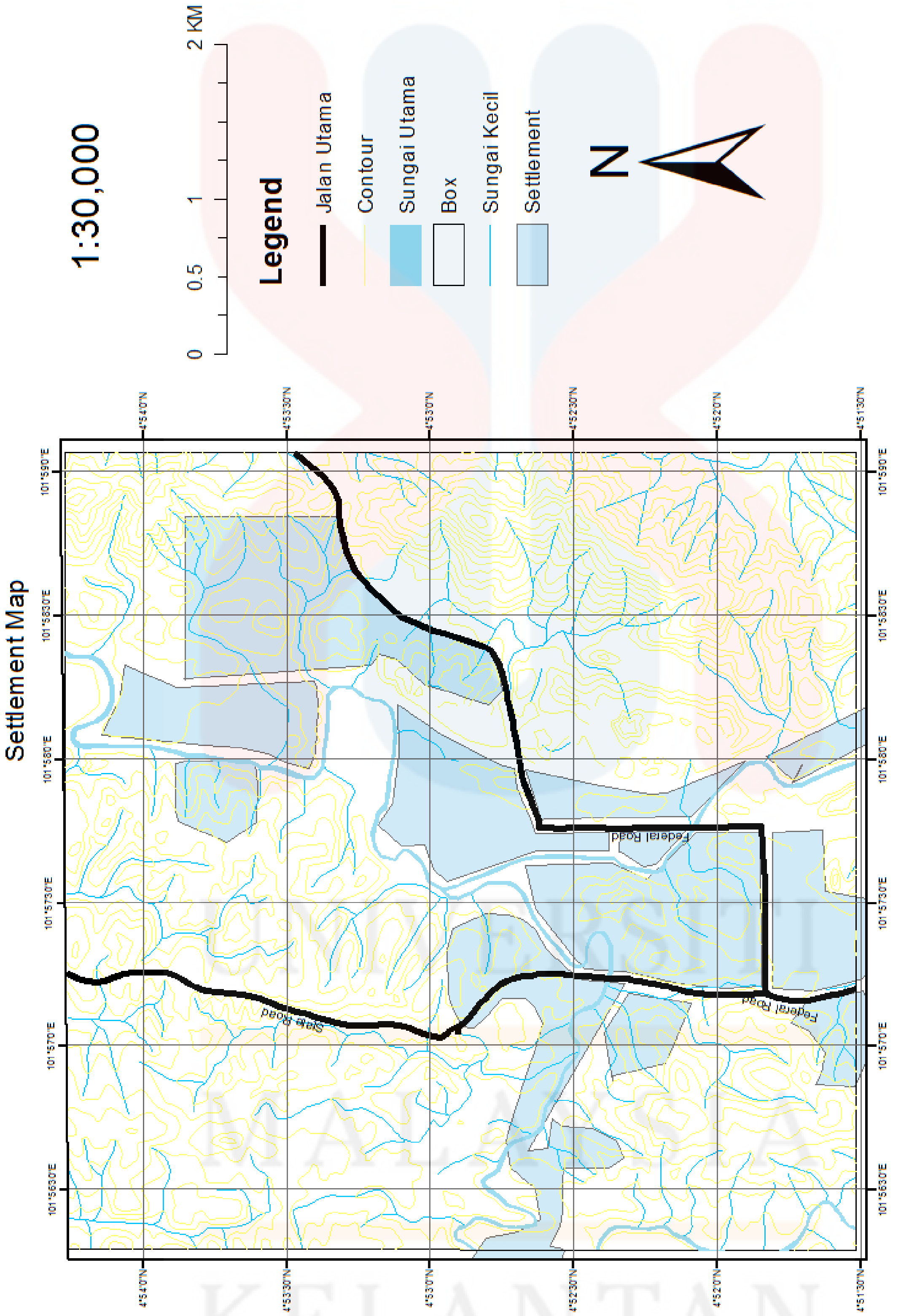

Figure 4.2 Settlement Map of study area

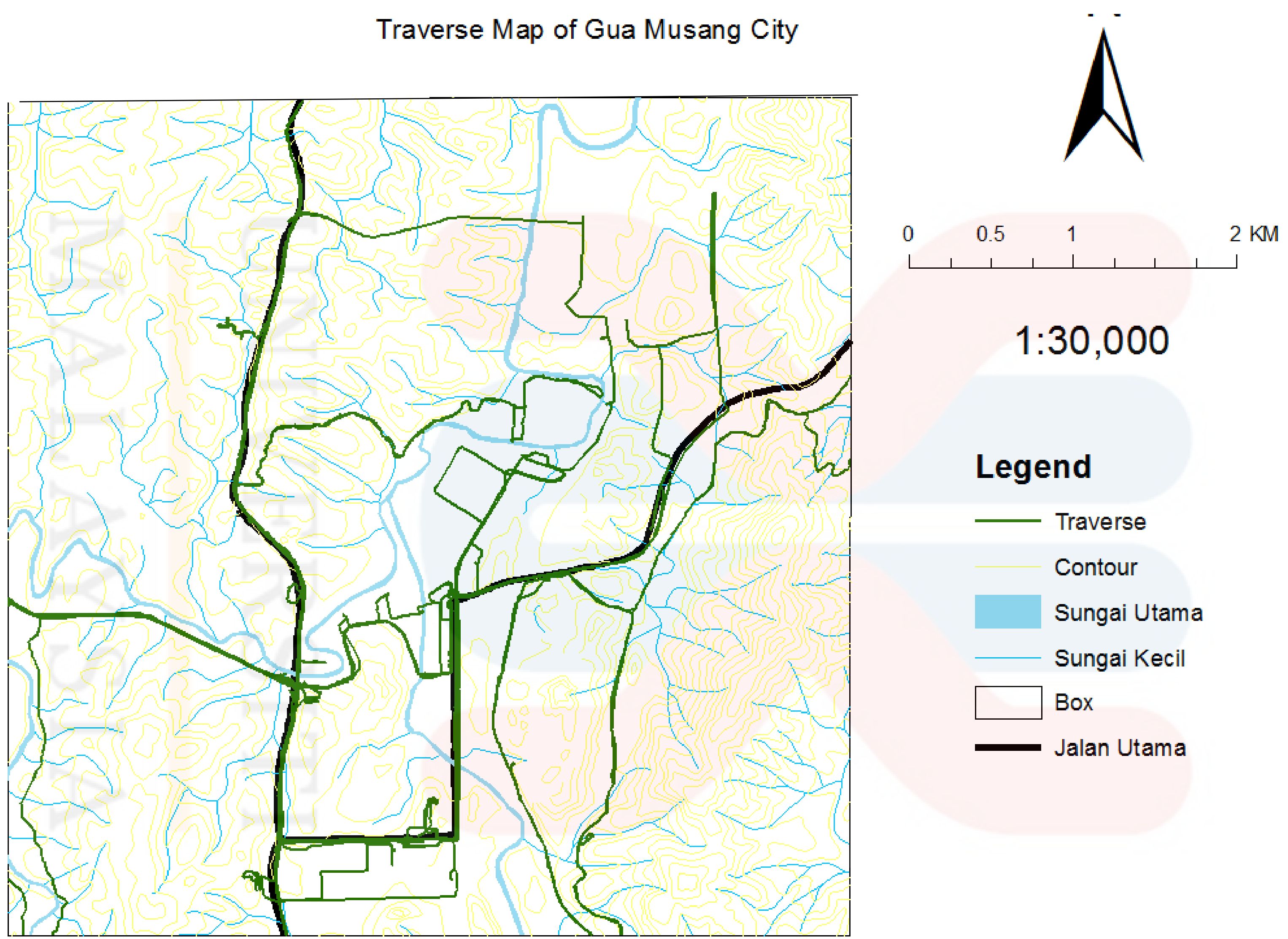

Figure 4.3 Traverse Map of Gua Musang City

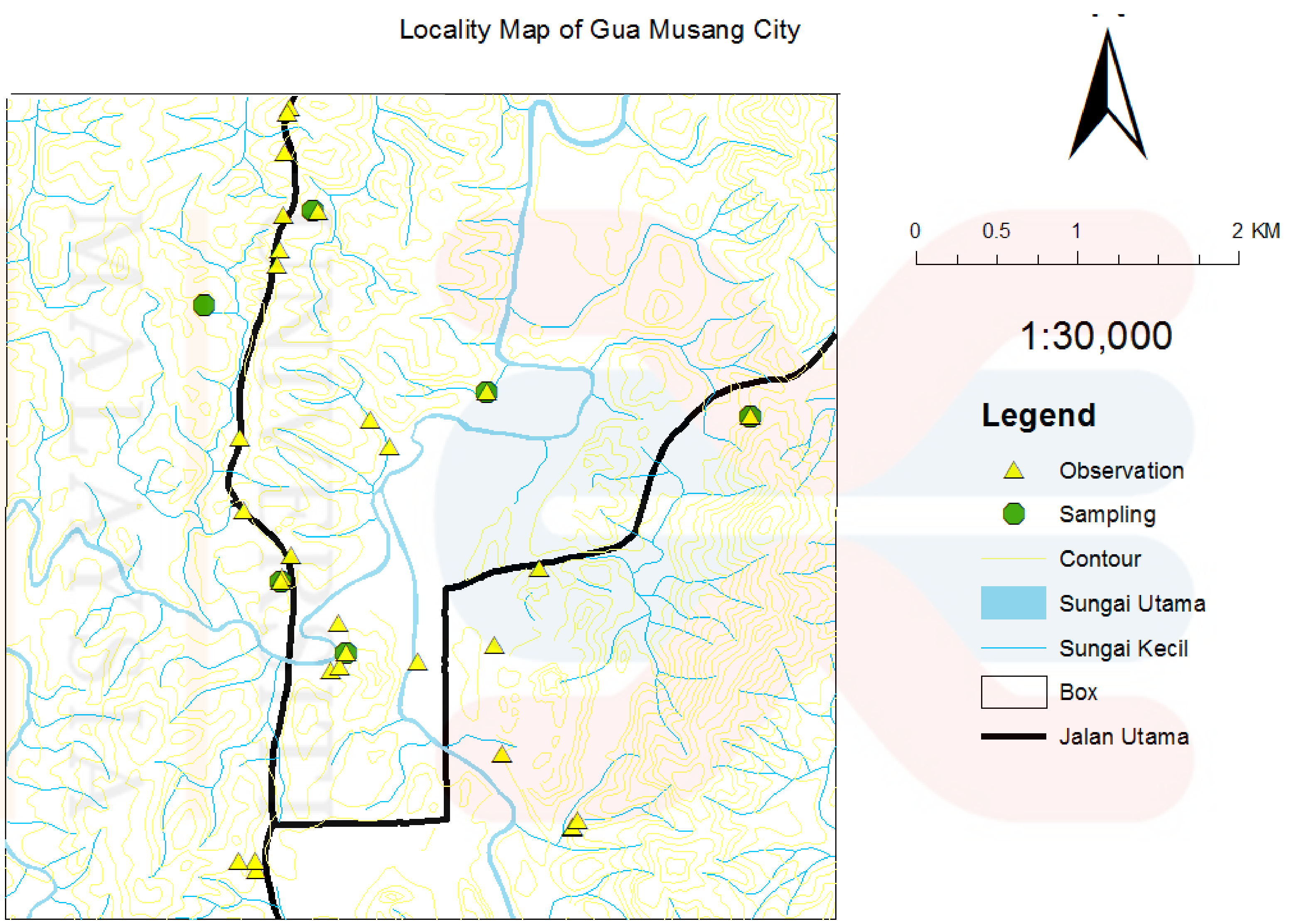

Figure 4.4 Locality Map of Gua Musang City

4.2 Geomorphology

The part of geomorphology makes reference about the landform examined of the Gua Musang region. In order to produce the geomorphology map, there are many parameters needed before study was conducted. These landform was there only because of the tectonic and geological activity that was happen in the past. It generally involves the fluvial morphology and the pattern of the stream in the river system.

Figure 4.5 Geomorphology on top of a hill in Gua Musang

4.2.1 Topography

In this part, the meaning of topography itself, the elevation was derived and studied elaborately. Topography is the central part of the study of geomorphology as well as the key criterion for the geomorphological unit either in the research area's physical requirements, hydrology parameters or any hazard exposure region. Topography can also differentiate between the types of landforms of different part of the study area. It is also possible to understand and comprehend the history of landform processes once the topography of one area was examine.

Figure 4.2 shows the slope map and elevation of the study area. The lowest elevation is 100 meters, whereas the highest elevation is 320 meters. For some elevation, there are different types of landform. The weathering and erosion cycle takes place significantly during the Cenezoic Period in that altitude.

Topographic units occur that has big gap in contour marks the depositional terrain inform the inland plains, filled valleys, flood plains and river terraces. No urban area in the highest elevation was developed in a range of 300 meters or above can be seen from the topographic. The lowland area has the greatest influence and a large amount of human activity have been carried out. This region is highly vulnerable to flood tragedy.

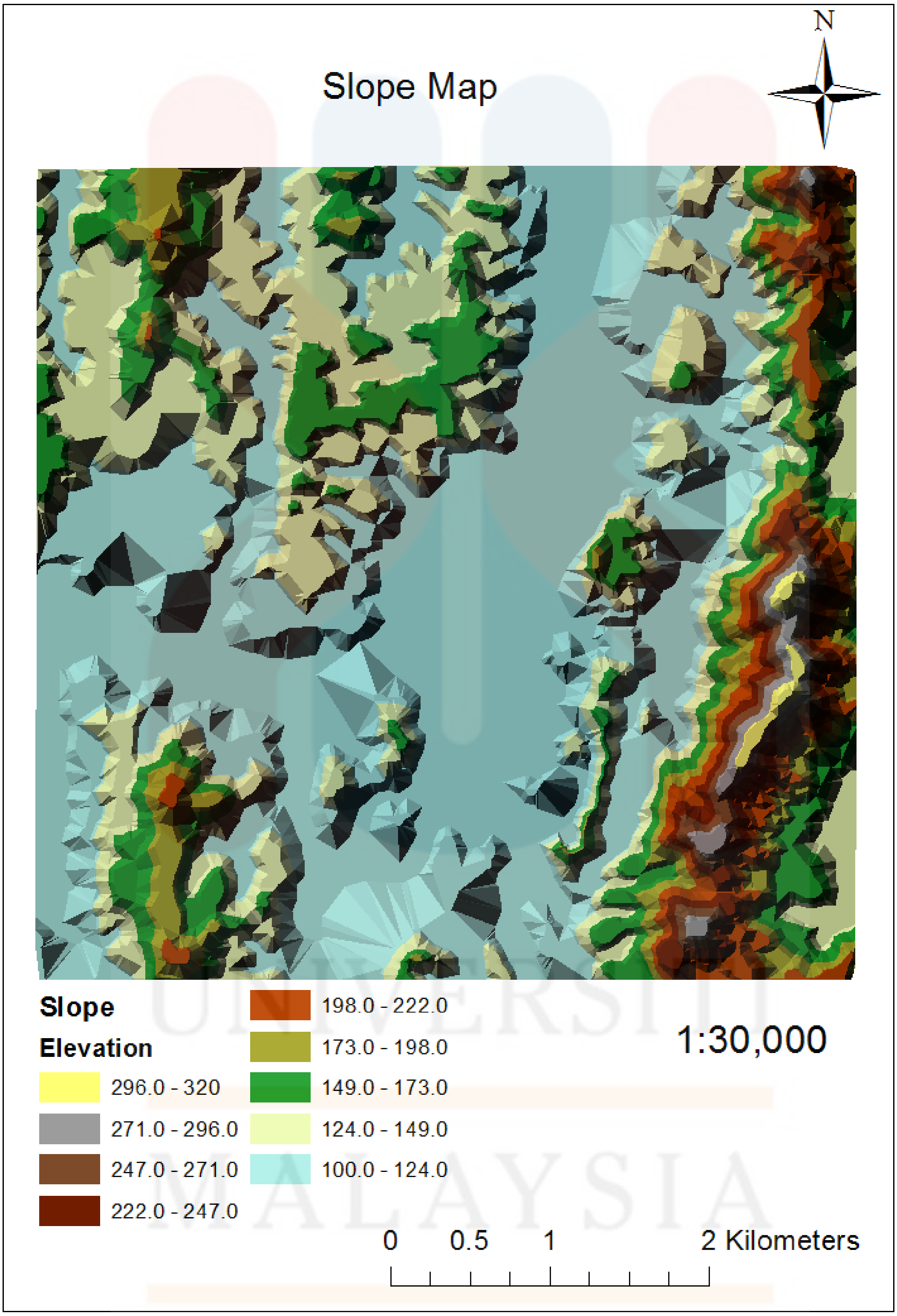

Figure 4.6 Slope map of study area

4.2.2 Drainage Pattern

The region of Gua Musang consists essentially of three main rivers contributing to Sungai Kelantan. Sungai Galas and Sungai Nenggiri are present. The research region topography system is hilly, the drainage can be defined on the basis of the drainage pattern. It is important to see the main rivers and to assess the whole catchment areas of the drainage region.

In order to determine land use changes in that region that have been related to urban development, field studies and further work have been conducted on the drainage systems of that environment. It is possible to interpret the projected flood zone. The main rivers are Sungai Ketil and Sungai Galas and also Sungai Kundur. The river is now 924.2 km in length. Sg. Bua. Baling, Sg. Baling, Baling. Papan Batu and others. Papan and others. There are a lot of tributaries along the main river such as Sg. Bua, Sg. Baling, Sg. Batu Papan and other.


Figure 4.7 and 4.8 Granite outcrop on both pictures at Sungai Ketil

According to Horton (1932), it is possible to define rocks, recharge areas and potential, and also the overall hydrogeological condition of the area through the recognized drainage patterns. Without geologic maps or other information on rock types, classification of the drainage pattern and landforms can provide an accurate interpretation of rock types and recognition of the area structure. The classification of the drainage patterns and density will show the degree of recharging in the area and path of groundwater flow by the form of aquifers.

Figure 4.9 shows the study area drainage map. In the given study area, the drainage pattern concluded from the map is a dendritic pattern. This pattern was caused by various forces act on the rock unit of the area and also causing all kinds alteration such as joints and cracks. There is no physical influence however from the water moves from its underlying bedrock.

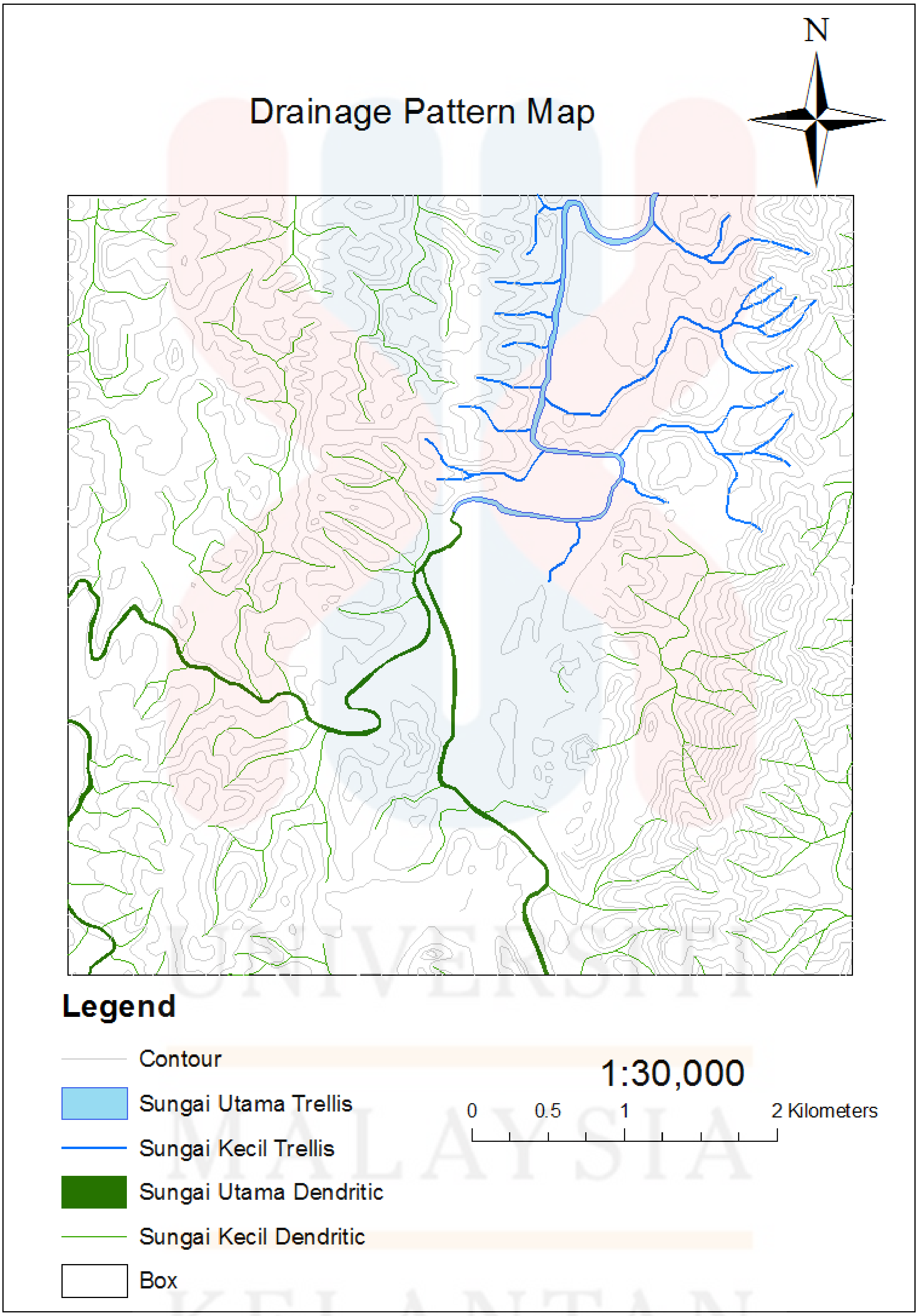

Figure 4.9 Drainage pattern of Gua Musang city

4.2.3 Weathering Processes

Weathering is the mechanism by physical, chemical and biological action that breaks down rocks and mineral resources on and under the surface of the earth. Chemical weathering is described when the rock degradation process that causes mineralogical reactions to water, carbon dioxide, and rock composition moisture content. Physical weathering, on the other hand, is a cycle of slaking and fracturing induced by pressure from heat, air motions and shifts in internal stress.

The weathering process takes place in a rock weathering process which alters its colour, texture, composition, texture and size to residual sediment, resulting in a physical and chemical weathering.

Figure 4.10 Physical weathering of Slate outcrop

Weathering may occur simultaneously or otherwise, chemical and physical. The weathering rate is determined by the factors lithology, climate, topography and a few more. Rock minerals are much more destructive by the tropical weathering but in cool climate, tropical weathering is less efficient. By reducing physical behavior, high humidity by air triggers chemical weathering are more destructive than crushing and degradation.

In the study area, there are biological, physical, and chemical weathering found along the outcrop. The biological weathering is much more effective in some areas, the vegetation on the rock unit destroys slowly from the soil. The chemical weathering on the other hand easily happened through the reaction of water on the rock unit. Lastly the physical weathering that simply happen naturally.

Figure 4.11 Limestone weathering of biological and chemical

Figure 4.12 Biological weathering of mudstone outcrop

4.3 Stratigraphy Analysis

4.3.1 Lithostratigraphy

The definition of the lithostratigraphy is rock units that defined with the lithological properties, physical features and what rock unit it is as well as its correlation of stratigraphy. Every rock was classified according to its physical characteristics into its stratigraphy. The study in the end will obtain the petrographical, mineralogical, geochemical, fossil and lateral variations including stratigraphical and other lithological characteristics.

After the geological mapping was conducted, there are 3 types of rock unit discovered. The first unit was the Granite unit, the second youngest in the stratigraphy column, a volcanic rock. Second is Mylonite, mudstone, shale and slate unit. Lastly is the limestone unit which is the oldest in the formation of Gua Musang.

4.3.2 Granite unit (Granitoid)

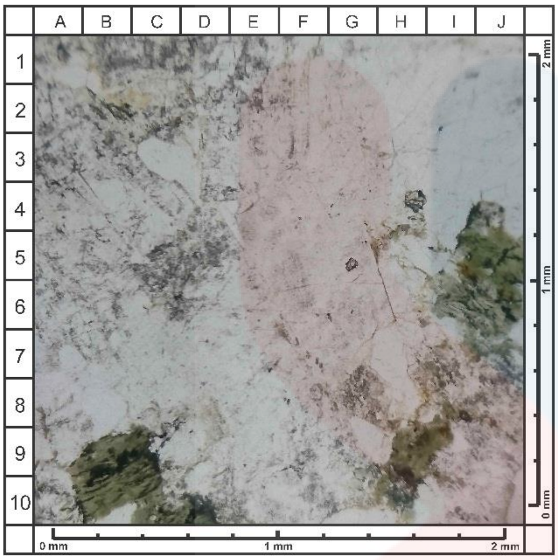

Figure 4.13 PPL view of granite sample

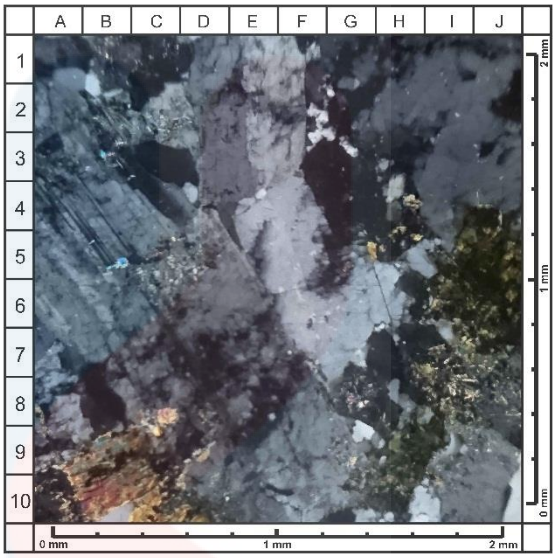

Figure 4.14 XPL view of granite sample

Microscopic Observation, the observations were carried out at 10x ocular magnification and 5x objective magnification and at observations of massive structures, fanatic textures, coarse-fine mineral sizes. Mineral composition, of quartz-rich granitoid. Anorthoclase. In observations of light brown PPL, white-gray, subhedral XPL, carlsbad twin, low relief, moderate Pleochroism, 1-way hemisphere, present spread in the incision. Abundance of 20%. Sanidin. In observations of light brown PPL, white-gray, subhedral XPL, carlsbad twin, low relief, moderate Pleochroism, 1-way hemisphere, present spread in the incision. 10% abundance. Quartz, In observations of white PPL, white-gray-black XPL, low relief without cleavage, low pleochroism, anhedral crystalline form, present spread in the incision as a microlyte base mass. 41% abundance. Chlorite. In the observation of greenish brown PPL, greenish XPL, 1-way hemisphere - absent, moderate relief, moderate-weak pleochroism, present spreading in the incision. 12% abundance. Sericite. In observations of brownish-white PPL, brown-red-gray XPL, low relief, moderate pleochroism, no hemisphere, anhedral crystalline form, present spread in the incision. Abundance of 15%.

Granite is between volcanic rocks or igneous rocks, usually with rough grained, igneous rocks consisting of quartz, mica, and biotite. Granite is developed inside the Earth's subsurface when Felsic magma, a magma rich in silica, starts to cool without reaching the surface. Because it stays under the ground as it cools, it creates huge crystals.

From the geological map of study area, the granite unit was located on the northwest of the map and on the east of the map. The age of this rock unit is among the youngest in the geological age of the tertiary period. This granite module is therefore an intrusive element.

Figure 4.15 Fresh granite sample on a weathered granite outcrop at 4° 52' 47'', 101° 58' 48''

4.3.3 Limestone, Marble Unit

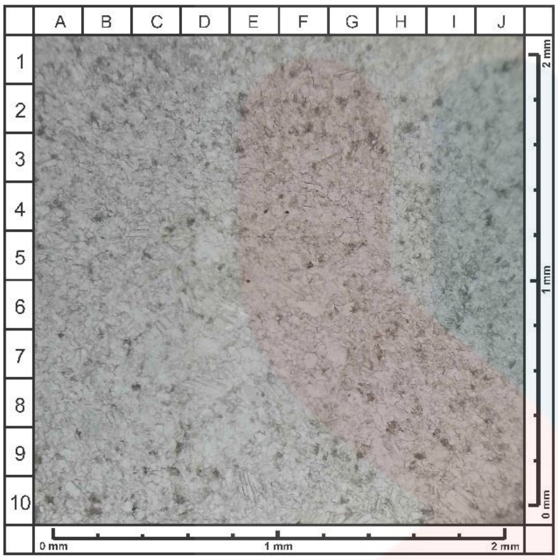

Figure 4.16 PPL view of Marble sample

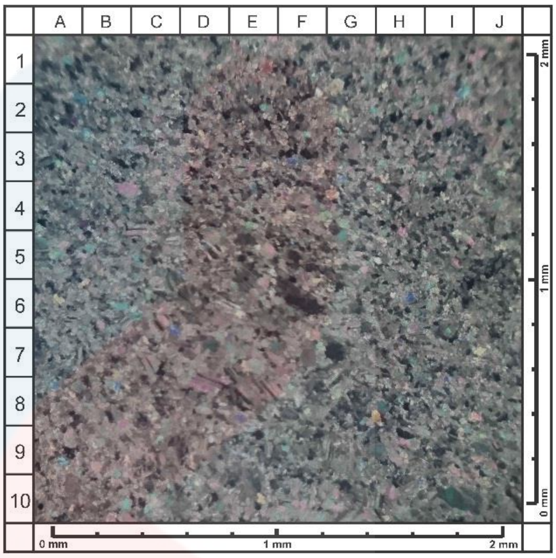

Figure 4.17 XPL view of Marble sample

Microscopic Observation, the observations were carried out at 10x ocular magnification and 5x objective magnification and on the observation of non-foliating structures (granulose), palimpsest textures including grain size <1/256 - 1/6 mm, good sorting. Mineral composition, Calcite. Micro-size, in observations of bright white PPL, pink-greenish XPL, 1-2 hemisphere hemisphere, has very high-low relief (double reflection), strong pleochroism, present to spread in the incision. 100% abundance

Limestone is a type of sedimentary rock that is rich with carbonate content. Limestone is formed through chemical precipitation, therefore it is usually fine grained. The limestone hill in the study area can be seen with a range of karstic landform at the centre of Gua Musang. The limestone rock unit in the study area takes place almost more than a quarter from the box area. The geological age of limestones in a range Triassic period.

As for Marble, it is a metamorphic state of limestone after being heated and under pressure for sometimes. It is also can be concluded that the heat from the uplifting granite is what heated up the limestone of this area and marbleised it.

Figure 4.18 Limestone outcrop at 4° 52' 40.8", 101° 58' 4.8"

4.3.4 Slate, Mylonite, Shale, Mudstone unit

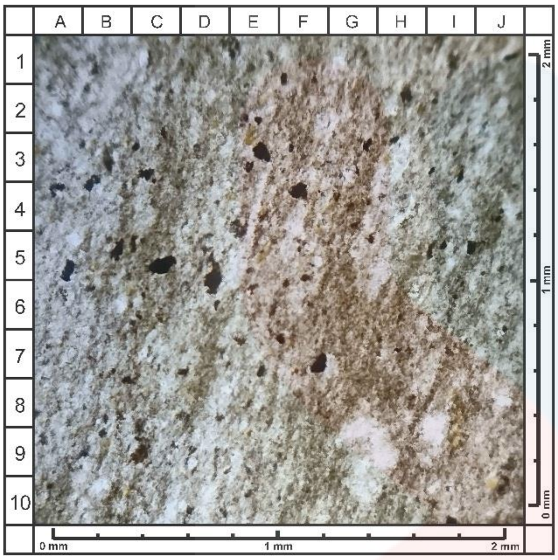

Figure 4.19 PPL view of Mylonite sample

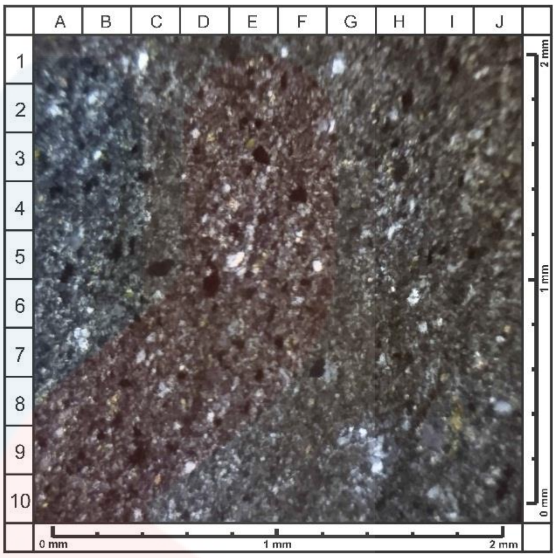

Figure 4.20 XPL view of Mylonite sample

Microscopic observation of the thin section, the observations were carried out at 10x ocular magnification and 5x objective magnification and at observations of massive structures, fanatic textures, coarse-fine mineral sizes.

Mineral composition of this unit, Anorthoclase, in observations of light brown PPL, white-gray, subhedral XPL, carlsbad twin, low relief, moderate pleochroism, 1-way hemisphere, present spread in the incision. Abundance of 20%. Sanidin, in observations of light brown PPL, white-gray, subhedral XPL, carlsbad twin, low relief, moderate Pleochroism, 1-way hemisphere, present spread in the incision. 10% abundance. Quartz, in observations of white PPL, white-gray-black XPL, low relief without cleavage, low pleochroism, anhedral crystalline form, present spread in the incision as a microlyte base mass. 41% abundance Chlorite, in the observation of greenish brown PPL, greenish XPL, 1-way hemisphere - absent, moderate relief, moderate-weak pleochroism, present spreading in the incision. 12% abundance. Sericite, in observations of brownish-white PPL, brown-red-gray XPL, low relief, moderate pleochroism, no hemisphere, anhedral crystalline form, present spread in the incision. Abundance of 15%.

Shale, mudstone and are sedimentary rocks that being classified into the clastic rock. The clastic material usually formed from fragmented rock pieces that were weathered and eroded by weathering and corrosion agents such as wind, water and sea waves. There is a wide range of morphology in which clastic rocks can be contained, such as lakes, flood plains and deserts and on the sea floor.

Meanwhile, the slate and mylonite is categorized as metamorphic rocks. These metamorphic rock were determined from the folitation formed from the outcrop which was beforehand, mistaken for shale. The metamorphism process in the point of view of stratigraphy, it was formed through the heated and pressure from Granite nearby. From the geological age, this unit is the oldest, and it is in the Permian period.

Figure 4.21 Outcrop of Slate that has already highly weathered at 4° 53' 5.99", 101° 57' 3.6"

Figure 4.22 and 4.23 Mudstone outcrop at 4° 52' 37.19", 101° 57' 10.8"

Figure 4.24 Mylonite outcrop at 4° 53' 41.99", 101° 57' 10.8"

Figure 4.25 Mylonite outcrop at 4° 53' 41.99", 101° 57' 10.8"

4.3.5 Stratigraphy column

The correlation between one rock unit and another can be obtained from the Gua Musang Formation column stratigraphy (Table 4.1). Based on the stratigraphy column, the lithological boundry and the age of the rock was identified. As a result, a correlation between rock units can be made through the column in that area

Table 4.1 The stratigraphy column of Gua Musang formation

Formation	**Age**	**Lithology**
Gua Musang Formation	Quartenary	Alluvium
	Early Triassic	Granite
	Middle Triassic	Mudstone/Mylonite Shale/Slate
	Middle Permian	Limestone

4.4 Geology Structure

4.4.1 Lineament Analysis

A lineament is a one of the structure indication from the Earths geological and tectonic movement. One of the example is faulting, lineament is formed from the faulting. Fracture zones, shear zones and igneous intrusions such as dykes may also be represented as geomorphic lineaments. Lineament can be seen from the topographic map or satellite imagery or even seen in front of the eyes if the lineament is obvious.

These data obtain from lineament analysis is very useful for the geomorphology analysis later. From the lineament, structural feature can be determined either on the map or satellite imagery. Interpretation from the field observation can also be used. The data collected were then imported to Georose software for rose diagram creation.

The direction of major force is Northeast (NE) direction in figure 4.18. This indicates the forece that contributes to the stream pattern underlies at the northwest direction. The angle of the major forces is at degree of 90 at the east of the rose diagram. Then, the extensional of the positive lineament is perpendicular from the forces. So that, for the extension force in this lineament is in northwest (NW) direction.

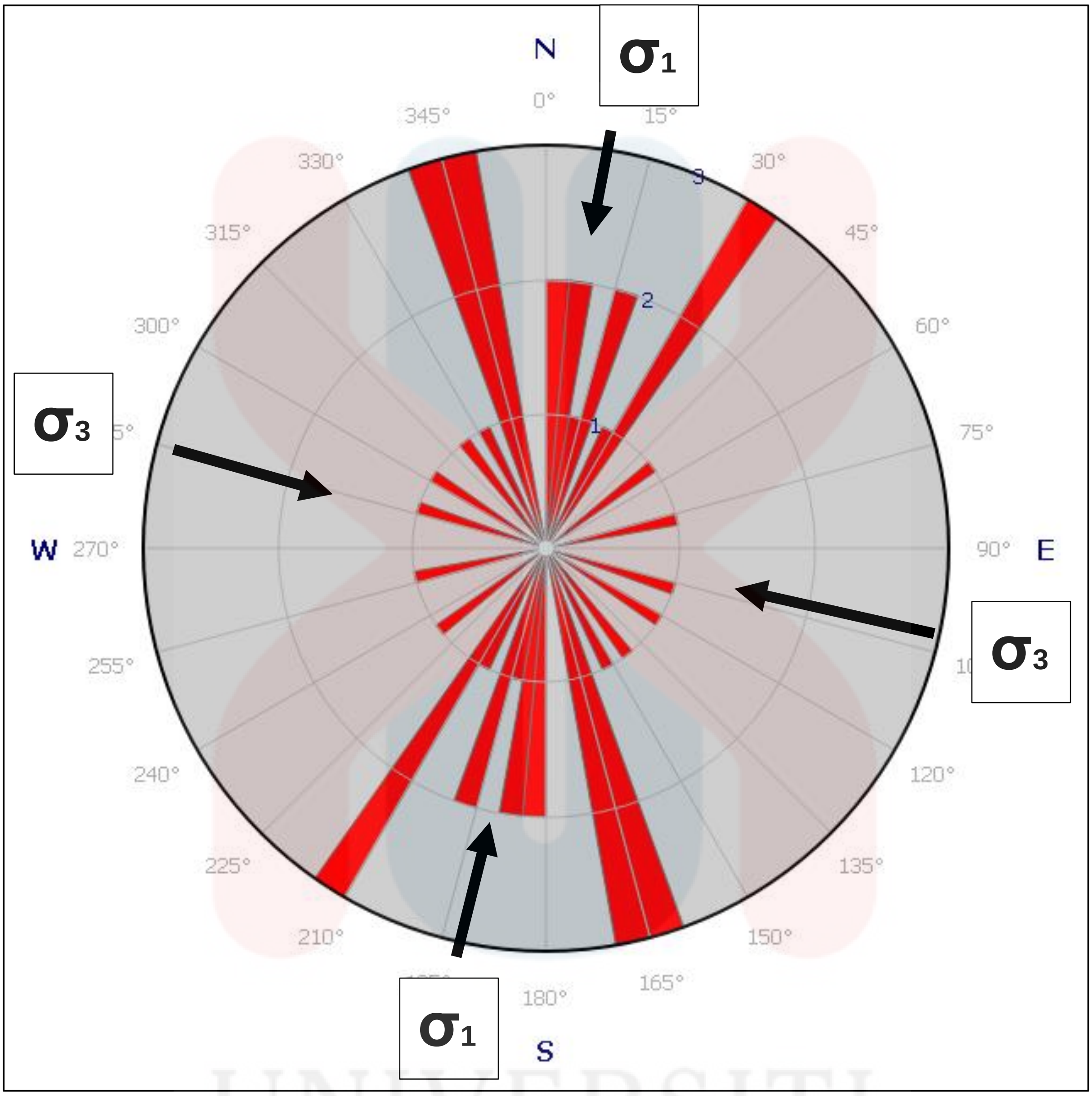

Figure 4.26 Rose diagram visual of Lineament of Gua Musang city

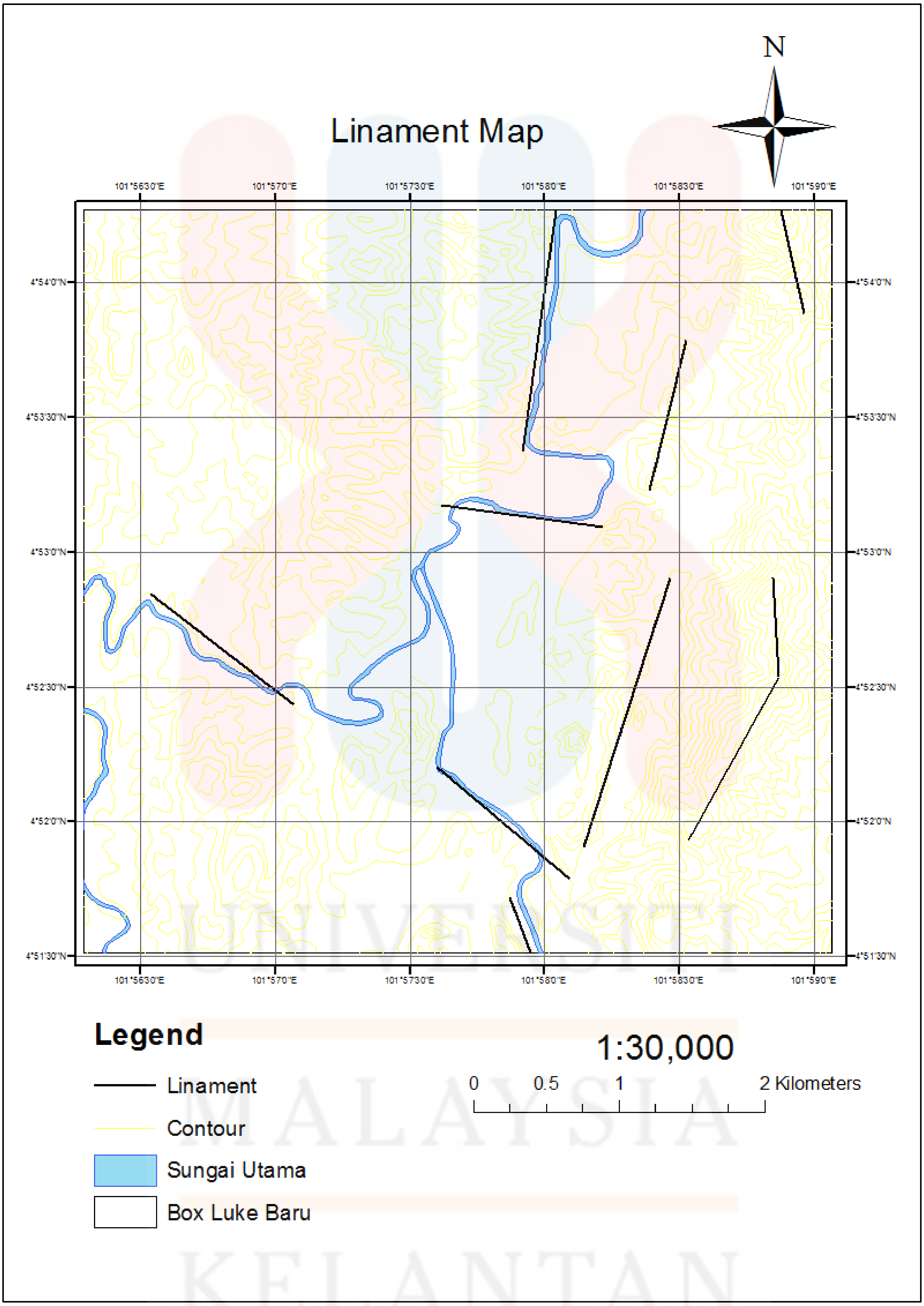

Figure 4.27 Linament Map of Gua Musang

4.4.2 Joint Analysis

Joint is one type of failure that occurs at the rock surface, This is concordant to the any rock other type of rock failure. Joint are continuously and through going planar fracture, commonly in the scale of centimetres to tens or hundreds meter in length.along which there has been imperceptible “pull apart” movement more or less perpendicular to the fracture.

Many data was collected during the field observation. Joint data was collected at one locality. Locality 1 at 4° 52' 43.701", 101° 57' 14.7096". From the rose diagram, the projections data are shown in Figure 4.10, it can be seen the major foces that create the joint is from NW-SE. The tensional force is on NE-SW.

Figure 4.28 Joints analysis of Locality 1 at 4° 53' 52.79", 101° 57' 17.99"

a) Locality 1

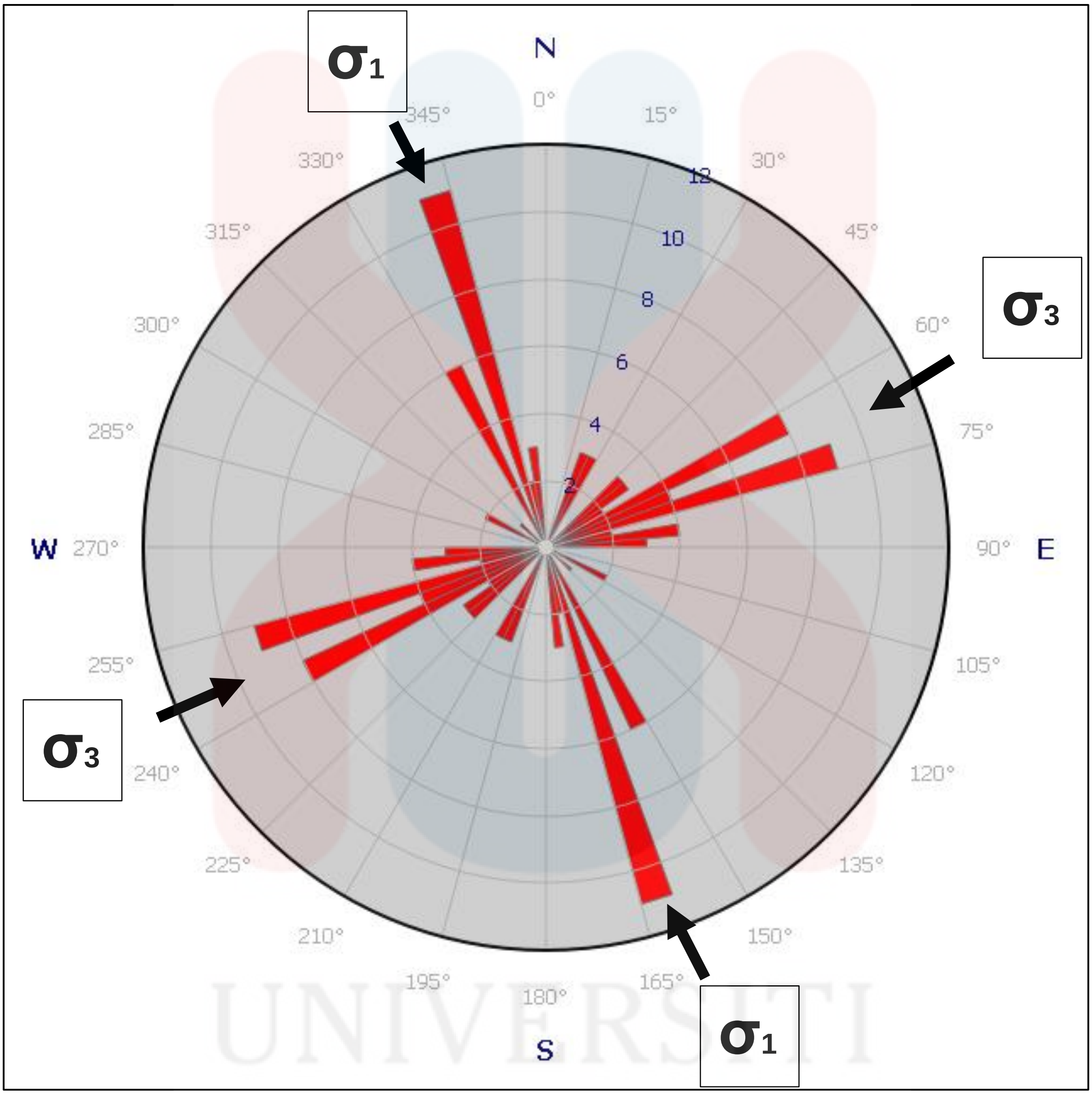

Figure 4.29 Rose diagram of joint in locality 1

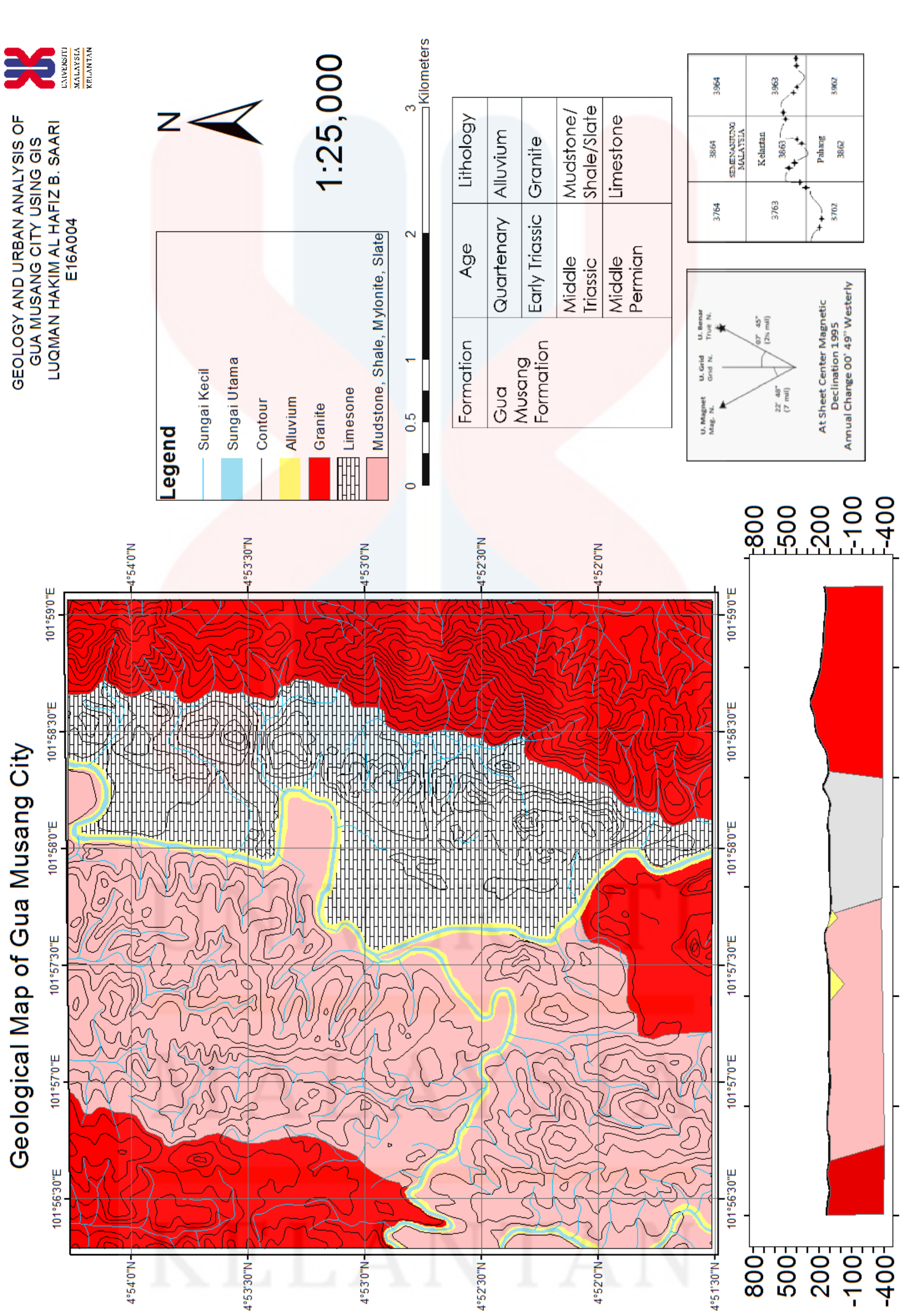

Figure 4.30 Geological Map of Gua Musang City

4.5 Historical Geology

Based on the stratigraphy column, the sequence are from older to younger, Limestone, shale-mudstone-slate, and Granite (volcanic). The sequence are interpreted through field mapping and also reference from Geological Society of Malaysia.

According to Yin (1965), it is described Middle Permian to Late Triassic argillite, carbonate, and pyroclastic/volcanic facies within Gua Musang area. The limestone of Gua Musang is the oldest, the abundant limestone mogotes in south Kelantan to north Pahang is inferred to be a continuous carbonate platform deposited within the Gua Musang platform during Permo-Triassic before subjected to erosion and karstification. Until further work is done on reassessing every limestone hill, the most plausible way for now is to divide limestone formations according to geographical distribution. These limestone bodies had been metamorphosed to marble while those in the south still shows distinction between micrites and allochems which consists of shallow marine benthic fauna such as brachiopods, bivalves, algae, and crinoids.

Second oldest of all is the shale, mudstone, mylonite and slate. These rock unit is classified as argillite. The Argillaceous facies which consists of shale, siltstone, mudstone, slate, and phyllite, is the dominant facies in Gua Musang and Telong formations, and occurs as interbeds or lenses in the Aring Formation and Nilam marble. The argillaceous facies is the most extensive and fossiliferous facies in the study area, with rocks distributed in the northern area being more fossiliferous compared to those occuring in the southern region of Gua Musang Group. Based on (Muir-Wood, 1948; Aw, 1990; Leman, 1993, 1994; Campi et al., 2002, 2005; Leman et al., 2004), Rich brachiopod assemblages and other benthic faunas were found in

Sungai Toh, Sungai Yu, Merapoh, Padang Tengku, Terenggun, Penjom, Sungai Aring, and Chegar Perah.

Second youngest of all is the Granite unit or granitoid. The volcanic-carbonate interbeds are common within the late Permian bottom section, which signify time of peak volcanism. This is followed by deposition of more pure carbonate upsection, deposited during the Triassic, where volcanism had become rare phenomena and eventually absent. Youngest of all is the alluvium which is deposited around quartenary period.

CHAPTER 5

URBAN ANALYSIS OF GUA MUSANG

5.1 Urban Analysis

High rainfall harm to the flood is one of the major natural disasters, impacting human lives and social development. In fact, global warming is considered to recently increase the frequency of its occurrence and catastrophe threat. Therefore, it is very important to develop strategies in order to prevent and minimize flood damage in the assessment of risk and the zoning of flood damage caused by high precipitation. Heavy precipitation flood damage is one of the most important naturally occurring disasters and affects human life and social development.

Moreover, global warming recently is considered to be increasing the frequency and risk of its occurrence and disaster. Therefore, it is important to develop solutions for the prevention and reduction of flood damages in a risk assessment and zoning analysis caused by heavy rainfall. Natural disaster risk assessments are characterized as an evaluation of both the probability of natural disasters and the degree of damage caused by natural disasters. The association between physical effects and human and environmental sensitivities can be expected to occur in natural disasters. The best method for the estimation of flood risk is to measure flood rates, produce flood risk charts, pick risk assessment methods and classify flood damages.

This paper will present the results from estimation of flood and flood risk mapping for the case study of Gua Musang city. The main steps in flood risk mapping (Evans et al., 2002) are: (a) identify the chronology (b) Causes of flood (c) Rainfall distribution (d) flood exposure (e) produce flood risk maps by use of GIS based models, (f) flood safety map creation.

Flood risk assessment and mapping is extremely difficult for urban areas. Urban areas can be defined by geographical position, climate, morphology, population, social relationship and economic activities. The complex relations in towns between physical, social and economic variables make it difficult to explain interactions among the population, environment and risk management.

5.2 Flood chronology

Every year Kelantan had experienced flood disaster. The differences based on water level and condition. The major flooding associated in year 1927 known as Bah Merah. Roughly 40 years later at the end of 1967, another great flood occurred that claimed approximately 38 lives and 84% population was effected. The most effected flood among the record is in 2014. In 2004, 507 mm flood level (rain) was recorded in one day compared to 80 mm per day in year 1967.

In 2014, Gua Musang was surrounded by major flood. The water began to rise at 8:18 am on 21 December 2014, 2 meters from normal face and up to the peak that is 13 meters above the normal appearance on 23 December 2014. On 21 December 2014, the intensity of rainfall distributions almost 52 mm and reached peak on 23 December 2014 that is 200 mm. The water receded at 23 December 2014 up to the normal appearance on 26 December 2014.

A flood condition in 2014 in Gua Musang was very terrible and considered as yellow flood or mudslide flood. Almost Gua Musang areas were covered with flood water. Among the areas that were affected by flood were Kampung Lebir, Kampung Tiong, Kampung Limau Kas & Kampung Limau Kasturi, Kuala Nerus, Chiku 7, Kampung Keriting, Kampung Batu Papan, Kampung Chalil, Sungai Cindai, Bandar Lama Gua Musang, Kampung Pulai and Taman Tropika. Industrial area and also a bridge that connects from one village to village were destroyed by the floods. Between the bridges were flooded was Sungai Kerak Bridge, Takir River, Serian River, Ketil River and Cindai River.

Residents of the Gua Musang arc not expecting this phenomena occurred in some area. This is because, the previous years was not all places or villages was effected by flooded. Some people in there were refused to move to a different place even though that area was affected by flooding almost every years.

They were injured due to water swept away and some death. For example, the boat overtuned and motorcycle carrying a water flow. Intangible damages at Gua Musang are environmental damages, opportunity losses,trauma and inconvenient.

There are three evacuation centers for the Galas area such as SMK Tengku Indra Petra 1, SMK Tengku Indra Petra 2 and SK Fakhri. Certain poople run on top of a hill and bridge. There about 8-10 mission delivery food and the doctor per day. The biggest mission is recorded as many as 22 missions per day. Approximately 50-100 volunteers where half of them ar¢ doctors. 50 tons of food and medicines were successfully delivered. BBNGO not only assisted by NGOs, but also alumni of the school include MCOBA, OPA and Dara.

5.2.1 Rainfall Distribution

Rainfall distribution is the main factor of a flood at the Gua Musang area. By the case, the chronology of the rainfall in that area indicated through the distribution map of rainfall in Peninsular Malaysia and focuses on the state of Kelantan. Daily rainfall which began on 188 of December and 27 December 2014 in the state of Kelantan vary according to place surrounding Gua Musang. This shows that Gua Musang gets a lot of rainfall in the upstream followed by downstream of Kelantan. Based on daily rainfall distribution map, in Kelantan on the date of 18 December 2014 until 21 December 2014 is above the normal level of 5 mm to 150 mm, while on 22 December 2014 until 24 December 2014 is the highest number of 200 mm to 600 mm and a return to normal on 25 December 2014 until 27 December 2014.

Table 5.1 Rain distribution of Kelantan district

DISTRICT	**TOTAL RAIN (mm)**	**REPEATITION (year)**	**AVERAGE RAIN DISTRIBUTION DIFFERENCES IN DECEMBER (mm)**
GUA MUSANG	992	> 100	2 times
KUALA KRAI	794	13	1.6 times
JELI	1124	> 100	2.2 times
TANAH MERAH	1067	> 100	2.1 times
KOTA BHARU	742	12	1.5 times

5.3 Flood exposure

Flood exposure is the predisposition of a system to be disrupted by a flooding event due to its location in the same area of influence. Exposure can be understood as the values that are present at the location where floods can occur. These values can be goods, infrastructure, cultural heritage, agricultural fields or mostly people. Even where a hazard exists, there is no risk unless there are assets that can be damaged, or there is danger because people live in, work in, or simply transit through the location of flood hazard. Exposure to flood hazard creates the potential for personal danger or property damage to occur during floods.

Generally, people at Gua Musang live in flood prone area (Figure 5.18). As well as Galas River, Ketil River and Kundur River. Galas River is the main river at Gua Musang and its area was 522.14 km. The area of Kundur River is 32.9 km and Ketil River is 369.51 km. The potential flood occurs is high. The topography of Gua Musang also influences the flood exposure of that area. The elevations below than 100 m tend to lead flood exposure. This can give the impact to the people and also their properties at Gua Musang. Since, the flood plain and near the river has been drowned by water.

a) Town/Village Effected

There are several effected towns and village affected by flood such as Kg. Baru Batu Papan, Kg. Batu Papan, Pejabat FELDA, Kg. Tapah, Kg. Gata, Simpang 3 Gua Musang, Kg. Kerinting, Kg. Kundur, Tg. Bua, Bandar Baru Gua Musang, Kg. Baru and RPT Sg. Terah. Many villages became an isolated area at that time because the flood overflows at Galas River.

b) Street Effected

The Main road at Gua Musang is Jalan Merapuh — Gua Musang, Jalan Bandar Baru, Jalap Kota Bharu — Gua Musang, and others. Several streets that affected by the Flood are Jalan Besar, Jalan Merpati, Jalan Merak and so on. The total length of effected road is 58067 meters from 162451 meters.

c) Railway Effected

The railway road that affected by the flood is a railway from Tumpat to Gemas. This railway was built near to the river which are Galas River and Ketil River. During the flood season, the water from river overflow to the railway and their working operation is closed. The railway hundred percent destroyed and the landslide occurs along the railway and gives the biggest impact to the economical aspect.

5.4 Flood Hazard

After the flood mapping was done, the hazard map was created. The hazard was classified into 3 category which is high, medium and low. The map was as shown in figure 5.1 below. Flood hazard mapping is the process of determining extents and depths by comparing the river water level with ground surface elevation. This study was done by observing human activities, water depth, and elevation of the study area. After the risk of three class was identified, the landuse are overlaid by the levels of risk which were produced using ArcGIS 10.2 software.

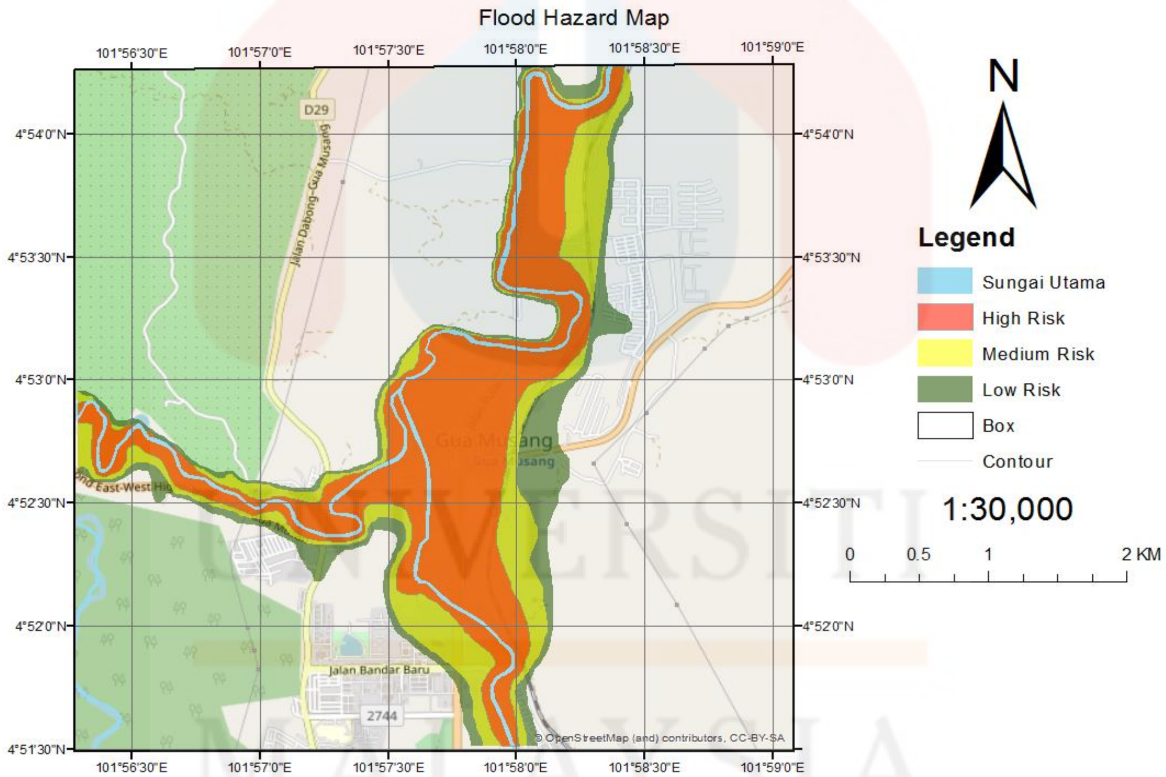

Figure 5.1 Flood Hazard Map of study area

5.3 Urban Development

Urbanization can be a very complicated thing to do for the authority to control. The people scatter and built houses on high risk prone area. The authority should make a guideline for the public to know where they should and where they should not base on the safety measures. This study concludes that, a safety map indicating a safer development area could prevent from more urban area to be affected by the flood hazard.

Based on (S.Seyf1, et.al, 2006), In order to the suitability of plains for economical activities and also population concentration, most of people, without any knowledge of flood risk, attempting to build structures and facilities. Flood Hazard Map as a guide, introduces appropriate locations for structure construction and also offers the population concentration sites. Mentioned map could represent the safe way out from flood plains and escape to pre-defined secure locations. A map which could presents the flooded locations and also emergency evacuation in a simple way and graphically, is called Flood Hazard Map. Flooded location prediction, depth of floodwater, safe and secure places for evacuation, the evacuation routes during flood and dangerous locations identification could be mentioned as the main items of a flood hazard map.

Figure 5.2 shows the safety map of the study area. The suggestion area was suggested after being taken the risk level and elevation into account. The suggestion area has not been discovered or open to any urbanisation, the elevation is also perfect for urban area and not a flood plain.

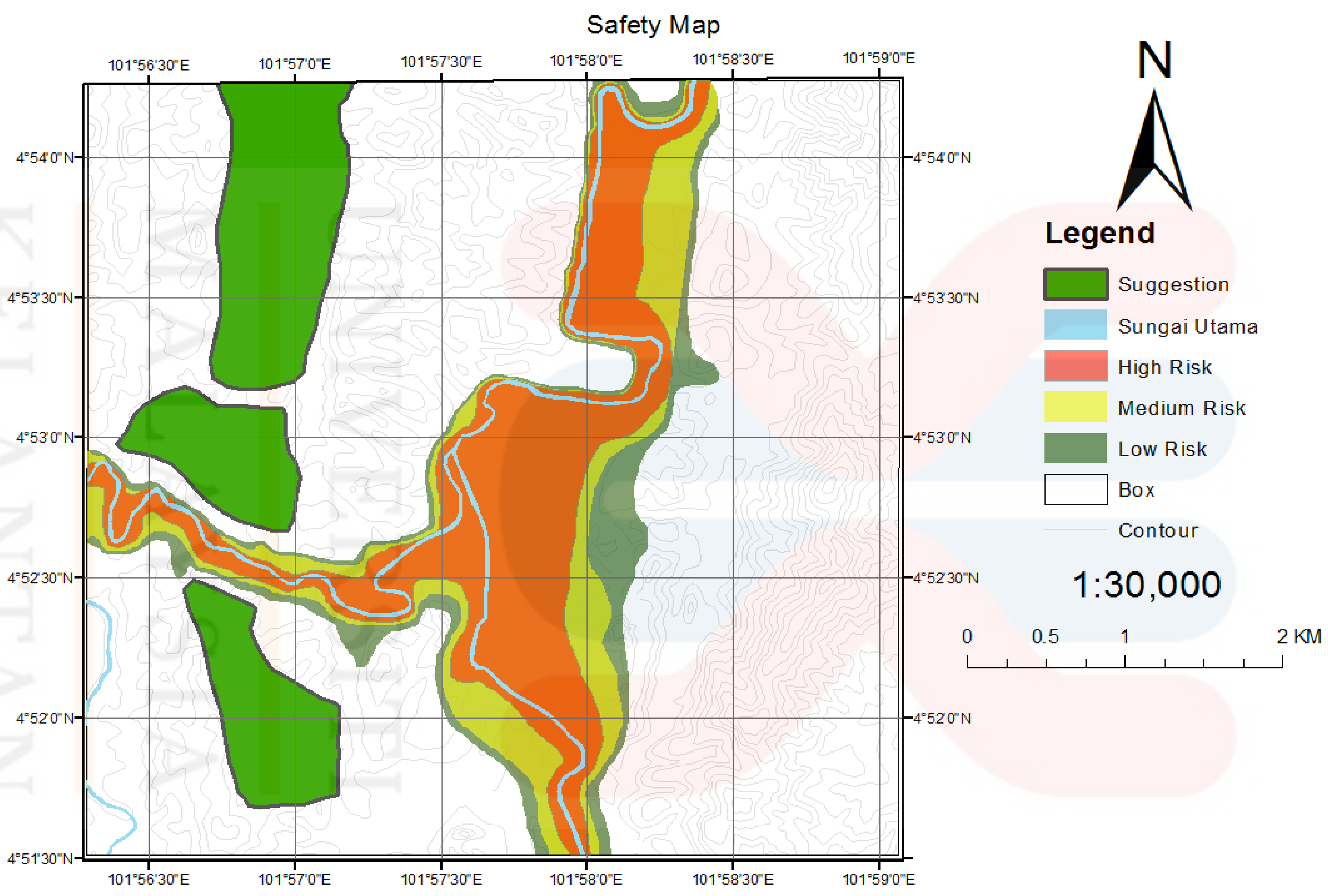

Figure 5.2 Safety Map of the study area

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Gua Musang has a very rare rock units or lithology as it compose of the three type of rocks which is sedimentary rock, metamorphic rock and igneous rock. The sedimentary rock found are Mudstone, Shale and also Limestone. However after the pressure and heat from the igneous rock nearby, metamorphic rock was formed. Metamorphic rock that are found here are Marble, Mylonite and also Slate. There is a faulting nearby the study are which is at Gua Madu, however it is not inside the study area. The geological map was created for the 5km x 5km study area.

Other than that, Gua Musang is highly potential urban area. However, because of the ignorance of humankind, the urban area was built without taking the hazard and other safety measures as consideration before. This area is exposed to the flood hazard and it is worrying. This study will help the future urban and town planner or any related responsible parties to take the safety recommendation into account. The safety map was produced for future development that has a great potential and could curb the risk of flood in the near future.

6.2 Recommendation

This recommendation is an advice for any future urban analysis geologist that want to study about flood hazard, a strong support data is needed before creation of a map. The use of 3D modelling is also a good expression for flood hazard. Focus are not only for flood hazard, there are a few more hazard that are exposed in Gua Musang.

Recommendation for the responsible parties, a better safety precaution is needed to minimise the risk of flood hazard. The authority and the public should together find a solution for the better safety precaution. A flood alarm also could help for future and current Gua Musang citizens from being alerted about the incoming flood from nearby river.

REFERENCES

Abdelkader El Garouani, David J. Mulla, Said El Garouani, Joseph Knight. (2017). *Analysis of urban growth and sprawl from remote sensing data*: Case of Fez, Morocco.

Alkema, Van Western. (2005). *Multi-hazard risk assessment.*

Alkema,D, Middelkoop, H. (2005). The Influence of Floodplain Compartmentalization of Flood Risk within the Rhine-Meuse Delta. *Natural Hazards*, 36, 125-145.

Ahris Yaakup, Mansor Ibrahim, Susilawati Sulaiman, Zulherman M.Sosi. (2000). *Assessment Of Urban Development And Land Use Changes' Impact On The Environment:* A Case Study Of Urban Development In Klang Valley Region, Malaysia.

Asborne, & Chappel. (2003). Quarry Resources Planning For The State of Kelantan. *Department of Mineral and Geoscience Malaysia, Ministry Primary Industries*, (pp.3-11)

Aw, P.C. (1967). Ignimbrite in central Kelantan, Malaya. *Geological Magazine, 104,* 13 – 17.

Aw, P.C. (1976). Geology of the Sungai Nenggiri-Sungai Betis Area, Sheet 44. *Geological Survey of Malaysia Annual Report*, 1972, 115- 119.

Campi et, al. (2005). *Guadalupian (Middle Permian) brachiopods from Sungal Toh, a Leptodus Shale locality in the Central Belt of Peninsular Malaysia.*

Donoghue, D.N. (2002). Remote Sensing: Environment Change. *Progress in Physical Geography,* 144-151.

Evans et, al. (2002). *Future flood risk management in the UK.*

Fazreen Nabila Salleh. (2016). *Flood Vulnerability in Gua Musang, Kelantan, Malaysia using Geographical Information System (GIS).*

Horton, R. E. (1932). *Drainage-basin characteristics.* Eos, Transactions American Geophysical Union, 13(1), 350 – 361.

Hussain et, al. (2018). *Geochemical characteristics of mafic and ultramafic rocks from the Naga Hills Ophiolite, India: Implications for petrogenesis.*

Hutchison. C. S. (2009). Regional geological setting, *Geology of Peninsular Malaysia.*

Hutchison. C. S. (2009). Bentong – Raub Suture, *Geology of Peninsular Malaysia.*

Heng,G.S., Hoe,T.G., Hassan, W.F. (2006). Gold Mineralization And Zonation In The State Of Kelantan. *Geological Society of Malaysia Bulletin 52*, 129-135.

Kamal Roslan Mohammed. (2006). Stratigrafi Semenanjung Malaysia, Geologi Kelantan Selatan.

Kamaruzaman, J. & Senthavy, S. (2003). Land use change detection using remote sensing and geographical information system (GIS) in Gua Musang district, Kelantan, Malaysia.

Kamal Roslan Mohammed, Nelisa Ameera Mohamed Joeharry, Mohd Shafeea Leman, Che Aziz Ali. (2016). The Gua Musang Group: A newly proposed stratigraphic unit for the Permo-Triassic sequence of Northern Central Belt, Peninsular Malaysia.

Lee, C.P. (2004). Part 1 Paleozoic. In: Lee,C.P., Leman, M.S., Hassanm K., Nasib, B.M. & Karim, R. (eds). *Stratigraphic Lexicon of Malaysia*. Geological Society of Malaysia, 3-35.

Leman, M.S. (2004). Mesozoic. In: Hutchison, C.S. & Tan, D.N.K., (eds). *Geology of Peninsular Malaysia*, Univeristy of Malaya and Geological Society of Malaysia, Kuala Lumpur.

Longley. (2001). Land Use and Land Cover Analysis Using Remote Sensing and GIS.: A Case Study in and Around Rajampet, Kadapa District, Andhra Pradesh, India. *Indian J.Sci.Res. 8* (1), 123-129.

Mohammad Alieff Aiman Rusmizi. (2018). *Geology And Applications Of Remote Sensing And GIS In Forest Cover Change In Lebir Forest, Gua Musang, Kelantan*.

Noorhasni Abu Hassan. (2016). *Geology and Flood Vulnerability at Gua Musang Town.*

Muir-Wood. (1948). *Malayan Lower Carboniferous fossils and their bearing on the Visean palaeogeography of Asia*

Shahani Wan Jamil Sulong. (2017). *General Geology And The Use Of GIS In Urban Analysis Of Dabong, Kuala Krai Kelantan*.

S.Seyfl, M. Ahmadi, P.Shirinzade, M.Sadeghi. (2006). *Flood Hazard Map in Urban Areas Located on Alluvial Fans.*

UNISDR (United Nations International Strategy for Disaster Reduction). 2004. Guidelines for Reducing Flood Losses. Retrieved from 2004. www.unisdr.org/files/5353_PR200402WWD.pdf

U.S. Bureau of Reclamation. (December 1988). *Downstream Hazard Classification Guidelines*.

Vitousek, P.M., (1992). *Global Environmental Change: An Introduction. Ann. Rev. Ecol. Syst. 23:* 1-14.

Ying, E.H. (1965). *Provisional draft report on the Geology and mineral resources of Gua Musang Area, Sheet 45.* South Kelantan: Geological Survey of Malaysia.

Zuhaira Nadhila Zahuri. (2017). *Geology And A Land Use And Land Cover Classification System For Use With Remote Sensor Data Of Kuala Tiga, Tanah Merah, Kelantan.*

Appendix A

Tarikh:

BAHAGIAN A: LATAR BELAKANG RESPONDEN

Bulatkan bahagian yang berikut:

1) Nama responden:

Alamat:

2) Jantina : a) Lelaki b)Perempuan

3) Bangsa: a) Melayu b) Cina c) India d) Lain-lain

4) Umur : a) 20 tahun ke bawah b) 21 – 39 tahun c) 40 – 60 tahun

5) Pekerjaan : Nyatakan _______________

BAHAGIAN B: KAJIAN BANJIR

6) Berapa lama menetap di kawasan ini?

Nyatakan ______________

7) Adakah kawasan ini pernah terlibat dengan banjir?

a) Ya b) Tidak

8) Berapa anggaran kedalaman semasa banjir itu berlaku?

a) 1 meter ke bawah b) 1 – 4.9 meter c) 5 meter dan ke atas

9) Berapakah jarak dari rumah anda dengan kejadian banjir tersebut?

a) 0 hingga 20 meter b) 21 hingga 40 meter c) 41 meter ke atas

10) Adakah anda diberi amaran mengenai banjir yang bakal berlaku, jika ya siapa?