Modeling The Natural Drainage Network In Bukit Kledang, Perak

Azmi Ibrahim[1,a)], Nazran Harun[1], Norasalwa Zakaria[1] and Ahmad Hasnulhadi B. Che Kamaruddin[1]

[1]Malaysian Nuclear Agency (Nuclear Malaysia), Ministry of Energy, Science, Technology, Environment & Climate Change (MESTECC),Bangi, 43000 Kajang, Selangor.

[a]azmiibrahim@nm.gov.my

ABSTRACT

The Johan River and Sungai Kledang are important area in Bukit Kledang, with several large and growing municipalities. It is very important to know the drainage system in this area to ensure that development planning can be planned in a more structured manner. Based on digital elevation models (DEMs), the natural drainage network was modelled to predict flow paths. Channel lengths and locations of the predicted network were defined to determine efficacy of the models. The model was able to predict, based on topography, 78.14 km of actual channel present in the watershed. Channels not anticipated by topography were mostly first-order with low sinuosity, were most common in areas with reserve forest, and were likely excavated extensions to headwater streams to facilitate drainage.

ABSTRAK

Sungai Johan dan Sungai Kledang adalah kawasan penting di Bukit Kledang, dengan beberapa kawasan perbandaran yang besar dan berkembang. Adalah sangat penting untuk mengetahui sistem saliran di kawasan ini untuk memastikan bahawa perancangan pembangunan dapat dirancang dengan lebih tersusun. Berdasarkan model ketinggian digital (DEM), rangkaian saliran semula jadi dimodelkan untuk meramalkan laluan aliran. Panjang saluran dan lokasi rangkaian yang diramalkan ditentukan untuk menentukan keberkesanan model. Model ini dapat meramalkan, berdasarkan topografi, 78.14 km saluran sebenar yang ada di DAS. Saluran yang tidak dijangkakan oleh topografi kebanyakannya adalah orde pertama dengan sinuositas rendah, paling umum di kawasan dengan hutan simpanan, dan kemungkinan penggalian digali ke aliran air untuk memudahkan saliran.

Keywords: drainage system, digital elevation models, municipalities

INTRODUCTION

During rain or irrigation, the lands become wet. The water infiltrates into the soil and is stored in its pores. When all the pores are filled with water, the soil is said to be saturated and no more water can be absorbed; when rain or irrigation continues, pools may form on the soil surface. Part of the water present in the saturated upper soil layers flows downward into deeper layers and is replaced by water infiltrating from the surface pools. When there is no more water left on the soil surface, the downward flow continues for a while and air re-enters in the pores of the soil. This soil is not saturated anymore.

The water flowing from the saturated soil downward to deeper layers, feeds the groundwater reservoir. As a result, the groundwater level (often called groundwater table or simply water table) rises. Following heavy rainfall or continuous over-irrigation, the groundwater table may even reach and saturate. The removal of excess water from the ground surface, is called drainage. A drainage system is necessary to remove excess water from the irrigated land. This excess water may be from surface runoff from rainfall and also include leakage or seepage water from the distribution system.

Drainage network a network of channels and drains constructed on marshy or excessively wet land. It is the key element of a drainage system and consists of regulating, protecting, and conducting networks with drainage outlets, manholes, overfalls, chutes, bridges, pipe crossings, and other such structures. The type of drainage network is determined by the cause of excess water.

When looking at the location of rivers and the amount of streamflow in rivers, the key concept is the river's "watershed". A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The word "watershed" is sometimes used interchangeably with drainage basin or catchment. Ridges and hills that separate two watersheds are called the drainage divide. The watershed consists of surface water--lakes, streams, reservoirs, and wetlands--and all the underlying groundwater. Larger watersheds contain many smaller watersheds. It all depends on the outflow point; all of the land that drains water to the outflow point is the watershed for that outflow location. Watersheds are important because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point.

Watersheds have emerged as the basic unit for most hydrologic analyses. Manual survey of a watershed can be expensive and time consuming. However, geographic information systems (GIS) have become valuable investigative tools with respect to stream visualization and analysis. With GIS, one can add spatial elements and also perform analysis of variables such as slope, aspect and other watershed parameters including climate, topography, soil type, vegetative cover, population density, point source of pollution and farming practice. With GIS, it is possible to greatly reduce processing time (as compared to field surveys) and elements of subjectivity that are frequently encountered with the manual measurement of features on maps and aerial photographs. When large watersheds are being studied, digital data resolution is important since digital elevation models (DEMs) are the primary topographic inputs of hydrologic modelling. A digital elevation model is a numerical representation of a surface that represents the height of the terrain.

THE KLEDANG WATERSHED

Sg. Kledang is located at the Menglembu area, concentrated with industrial outlet. Sungai Kledang flows for 6.4 km into Menglembu area before entering Sungai Kinta. There are two contributors for this site which are the residential estate and the industrial. The Sg. Kledang originating from housing estate of Tmn Bukit Kledang indah will meet-up with the industrial area and then flows into the Kinta River.

METHOD

Stream Delineation

ESRI's ArcMap 10.6.1 Hydrology tool was used to delineate the Kledang River watershed using a preprocessed digital elevation model (DEM) (Figure 2). The main steps that were followed are: hydrological conditioning, watershed delineation, and derivation of stream network characteristics. A flowchart for the procedure is as follows (Figure 3).

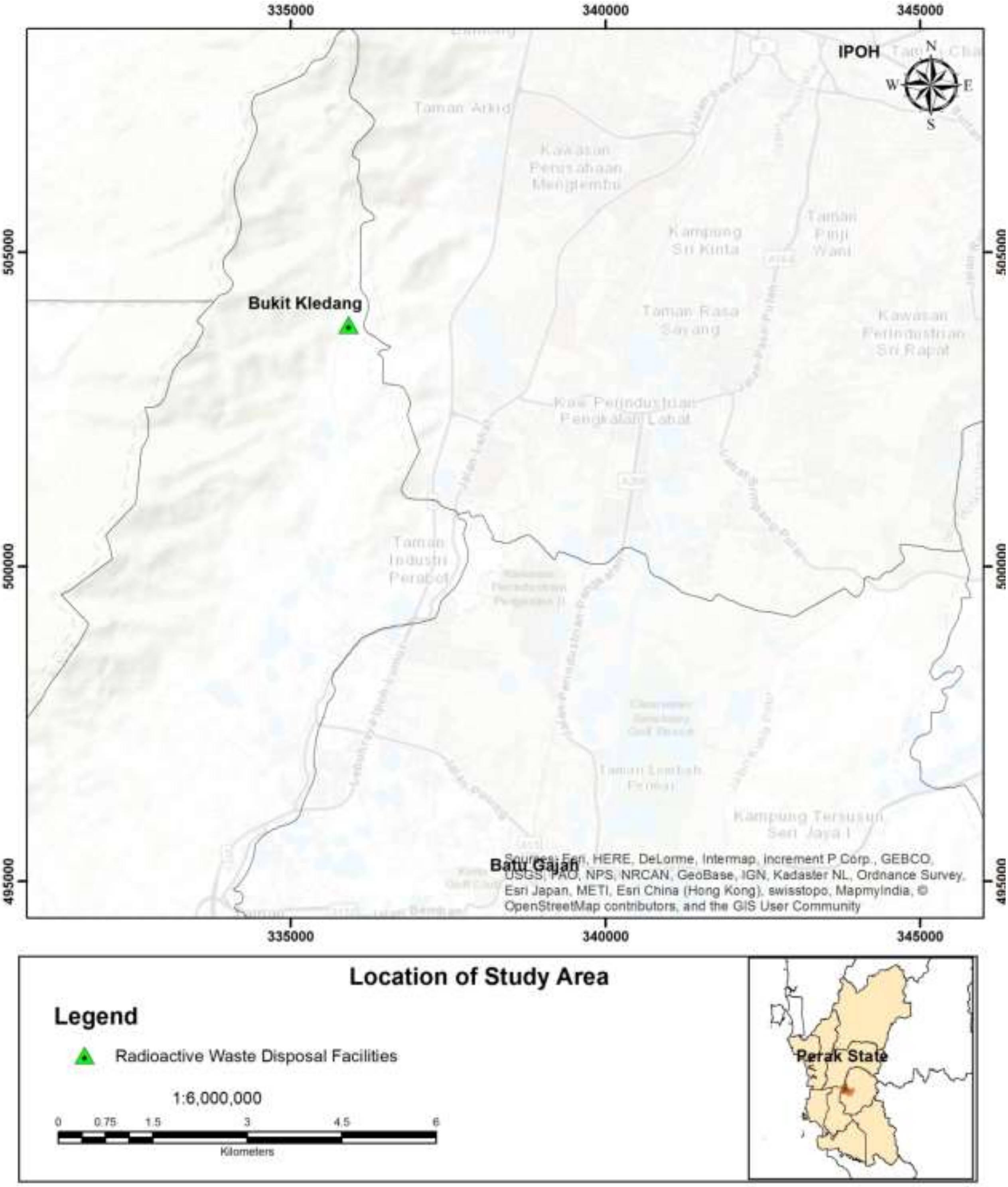

Figure 1. Location of study area.

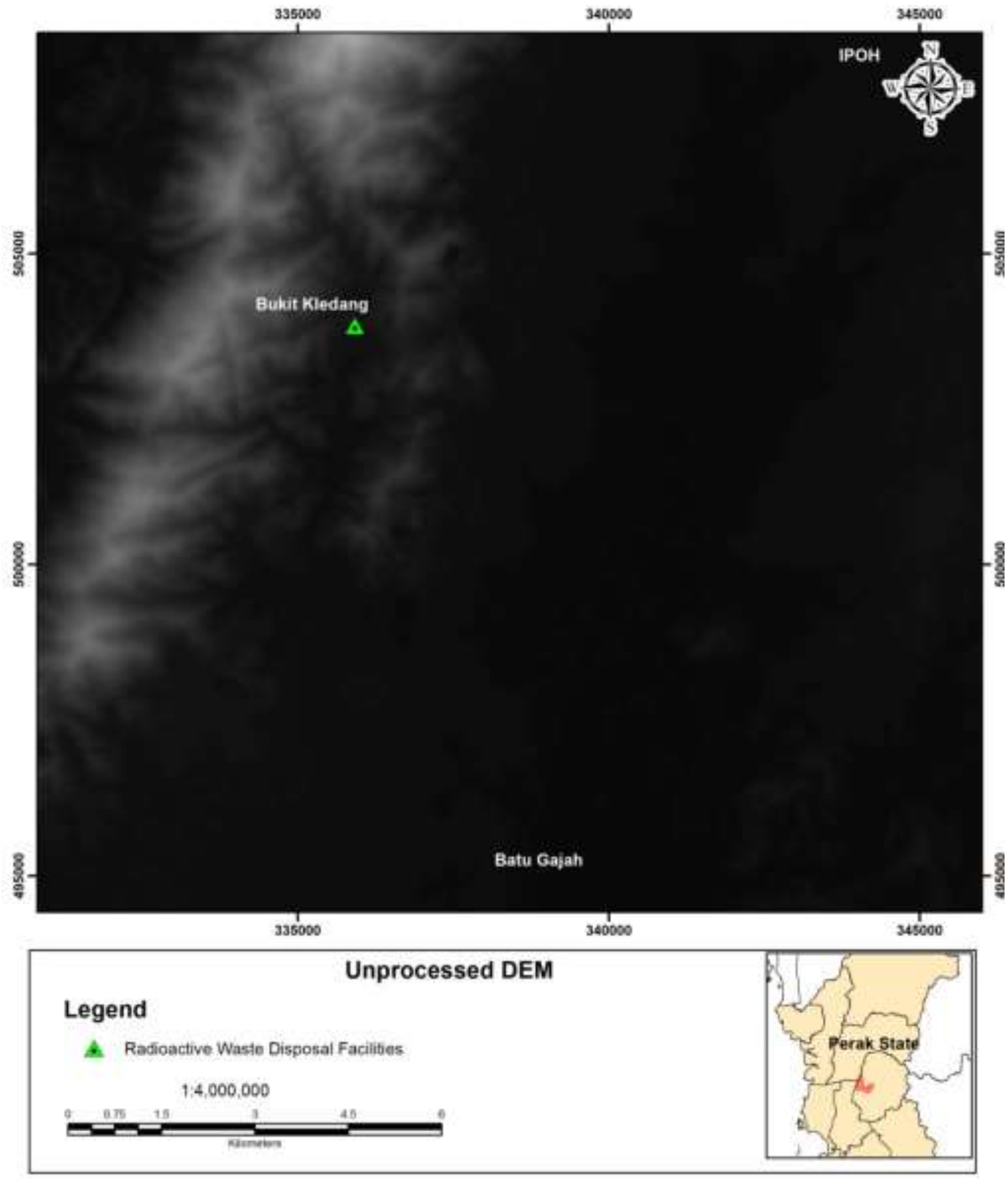

Figure 2. Unprocessed digital elevation models (DEMs) data.

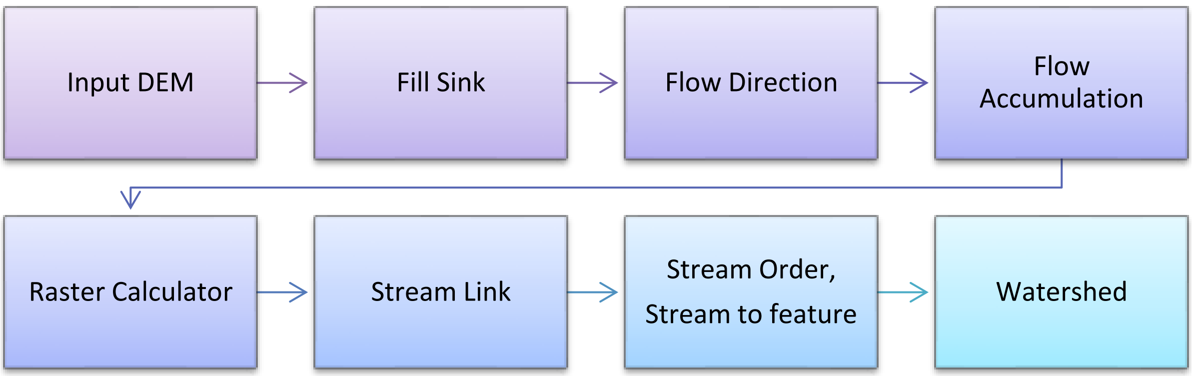

Figure 3. Procedure for hydrological conditioning, watershed delineation and derivation of stream network characteristics in ArcMap 10.6.1.

RESULTS AND DISCUSSION

Natural Drainage Network Modeling

As a result, for Johan River and Kledang River districted with usage of DEM map, collected data from Spatial Analysis module of ArcGIS program which fill sink, flow direction, flow accumulation, raster calculator (Hydrological condition DEM), stream link, stream order & stream to features, and watershed are given in Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8. The end result of this model shows that the parts up of an application made with ArcGIS in Figure 9. Table 1 shown the numerical value for Johan River and Kledang River and its basin.

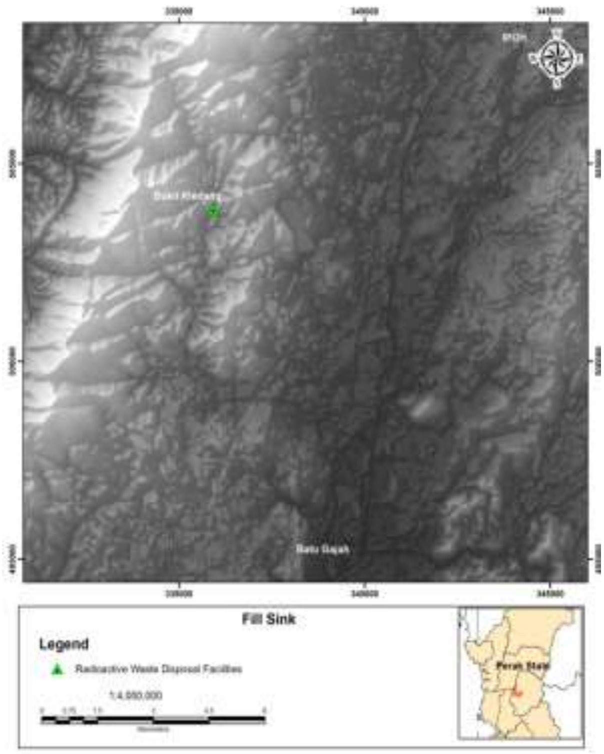

Figure 4. Fill sink.

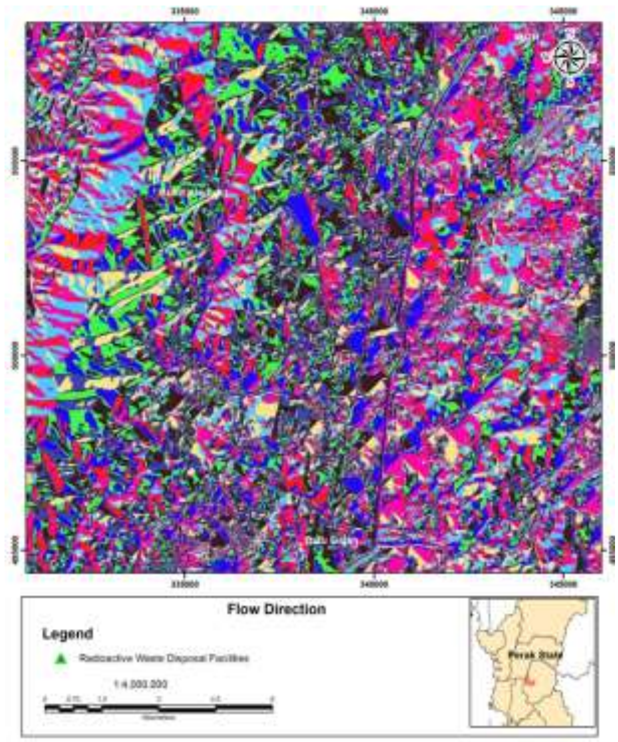

Figure 5. Flow direction.

Table 1: The numerical values attached Basin

Basin area	61.00 km²
Basin environmental length	78.14 km
Longest river bed	2.54 km

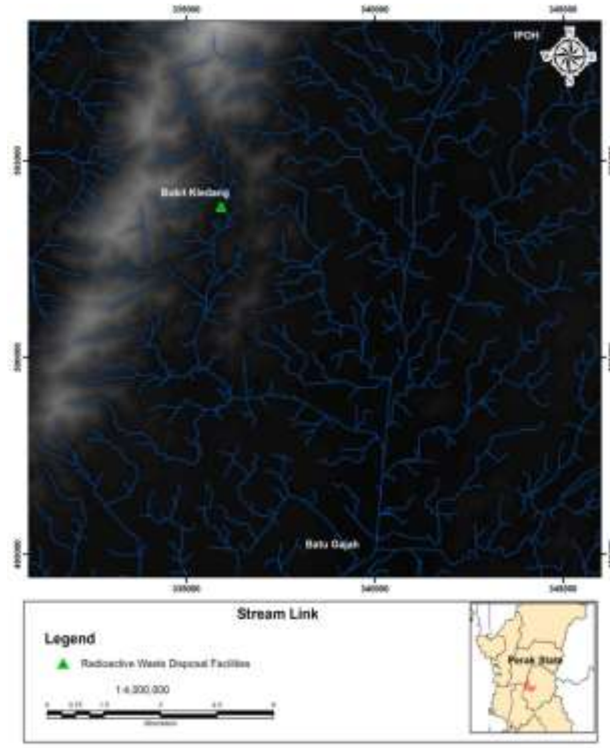

Figure 6. Stream link.

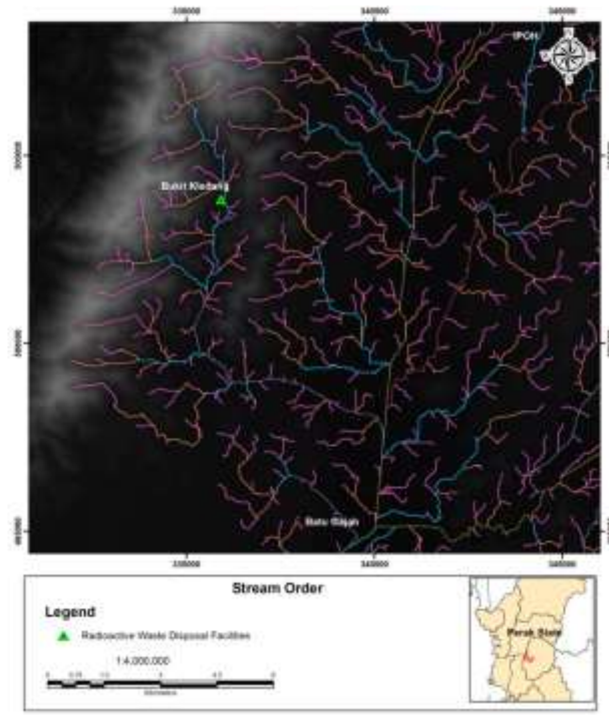

Figure 7. Stream order.

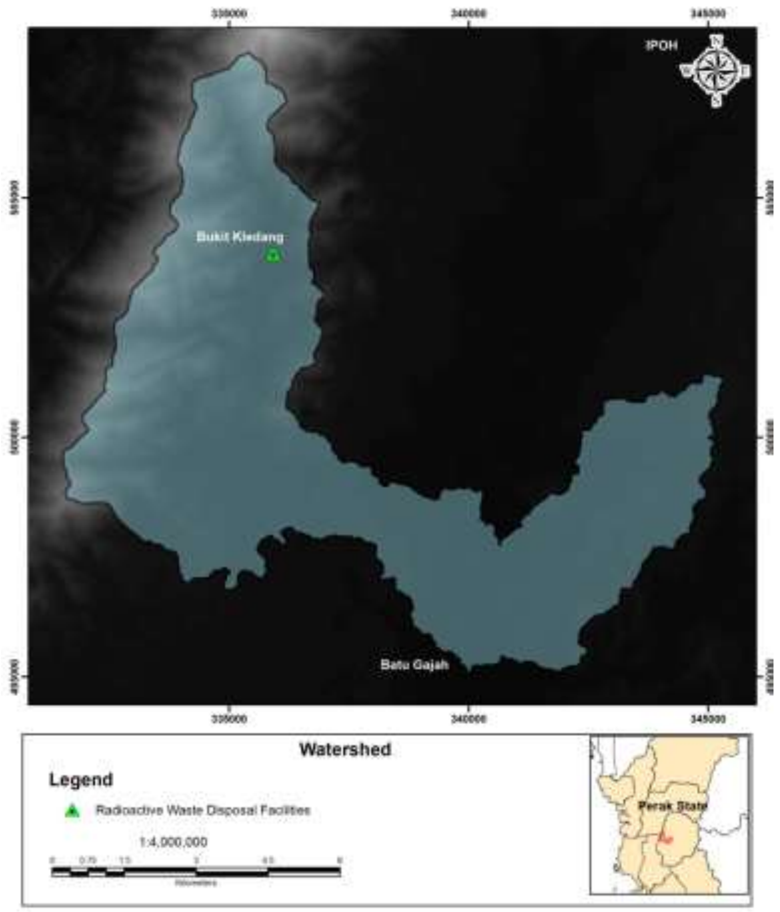

Figure 8. Watershed.

Characterisation of Drainage Patterns

The drainage patterns are characterised by different geometric indicators measured on each segment of a network or describing the shape of the drainage. This study focuses on the description of individual patterns, and addresses the identification of the patterns based on geometric characteristics identified inside a network. Based on the drainage patterns in Figure 9, dendritic drainage pattern is the drainage pattern for this study area. Dendritic pattern is the most common form of river system. In a dendritic river system, there are many contributing streams (analogous to the twigs of a tree), which join together and are the tributaries of a main river.

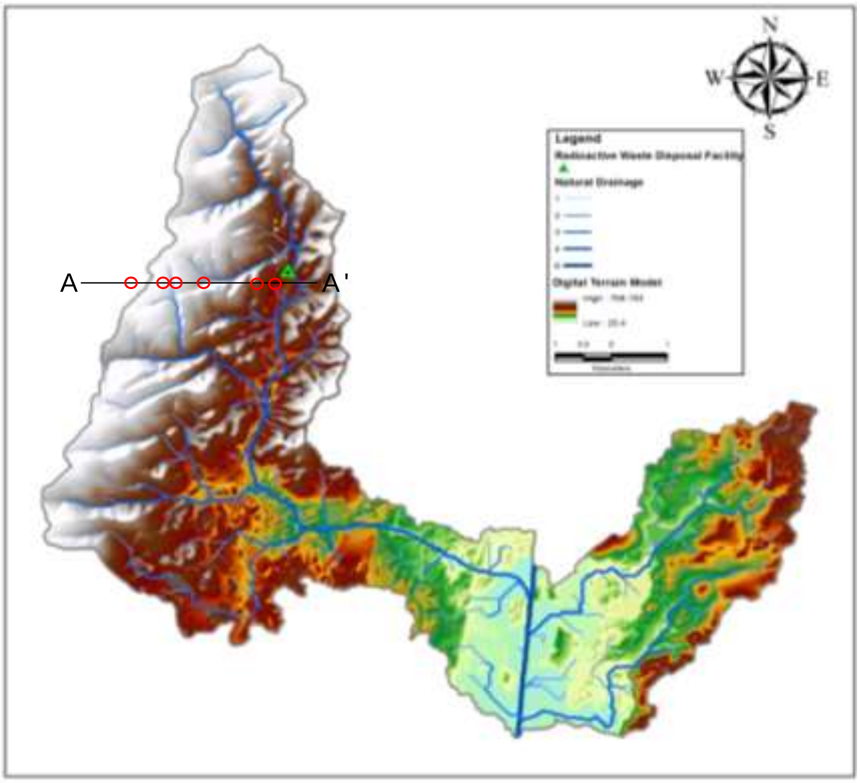

Figure 9. Stream order of the natural drainage network in middle Perak.

Stream Order For Geomorphic Classification Of Rivers

Stream order is perhaps the most widely used descriptive classification for rivers. In this approach, the river network is divided into links between network nodes (channel heads and tributary junctions), and links are numbered according to their position in the network: First-order channels are those at the tips of the river network (channel head to first tributary junction), second-order channels occur below the confluence of two first-order channels, and so on down through the river network. Stream order correlates with link length, drainage area, slope, and channel size, providing a relative sense of physical conditions, but is sensitive to how the river network is defined.

Table 2. The stream order and stream number.

Stream Order	Number of Streams
1	443
2	197
3	185
4	84
6	53

First- through third-order streams are also called headwater streams and constitute any waterways in the upper reaches of the watershed. Over 80% of the world's waterways are estimated to be these first- through third-order or headwater streams (Amanda Briney, 2019). In this study case, going up in size and strength, streams that are classified as fourth- through sixth-order are considered a river. Unlike the smaller order streams, the rivers are usually less steep and flow more slowly.

The extent of the river network and consequent stream ordering may differ on topographic maps, synthetic stream networks based on area–slope criteria, and field observations of the channel network. Moreover, not all channels of a given order behave similarly. For example, reach-scale morphology and the associated processes that occur in first-order channels will depend on basin topography (i.e., channel slope and confinement) and physiography (the supply of water and sediment to the channel), such that first-order channels in mountain basins may be very different from those of plateaus, coastal plains, or glacial lowlands.

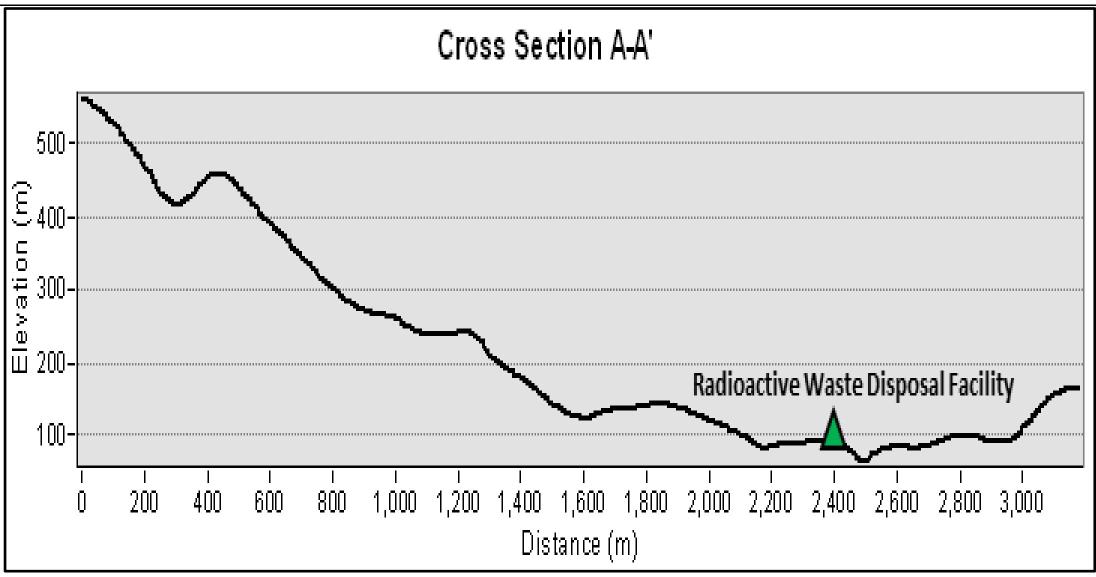

Figure 10. Cross section area A-A'.

Hence, stream order provides little information about stream morphology and processes; rather, it classifies the river network structure. Nevertheless, it is a useful communication tool for describing relative stream size and location within a basin (Figure 10), as well as the overall basin size in terms of maximum stream order. Structural classifications have also been developed for nested scales of sub-basins (hydrologic units) within watersheds as shown in Figure 11, but as with stream order, they offer little inherent insight regarding geomorphic processes.

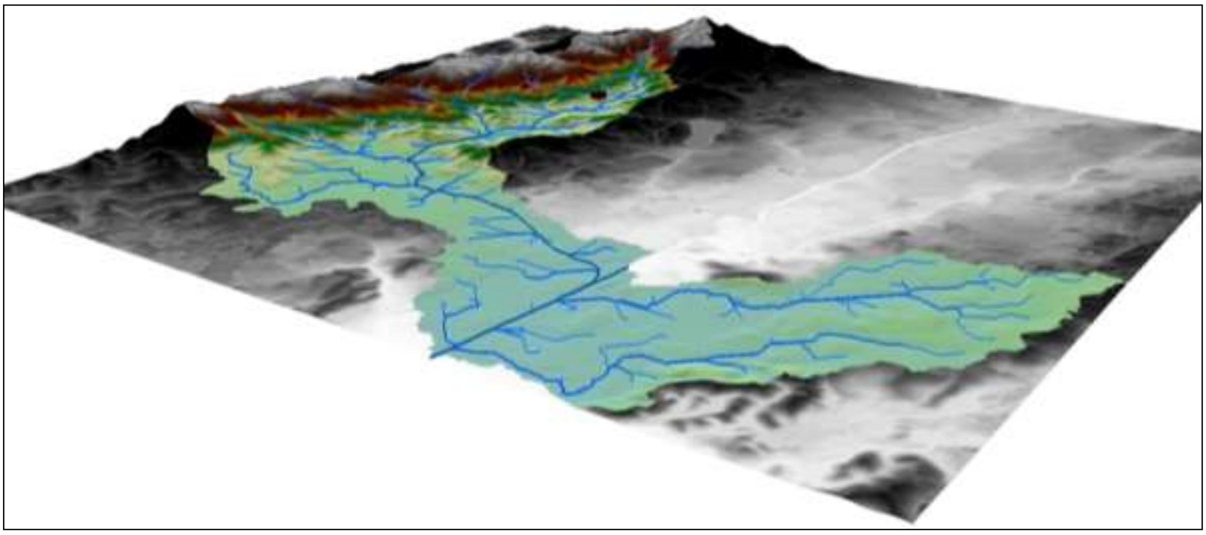

Figure 11. 3-Dimension view of study area.

CONCLUSION

Dendritic drainage pattern is the drainage pattern for this study area. The advantage of this study that proposed geometric indicators are easy to obtain and calculate. They can easily be implemented in a GIS and application to a river network defined in a Shapefile or extracted from DEMs. However, the quality of the classification may depend on the quality of the extracted network from the DEM As rules defining each pattern are vague and depend on a combination of indicators, classification made use of fuzzy logic to improve robustness of the result. Such classification and organisation can be useful for terrains analysis as it can help provide a qualitative description of the terrain or for generalisation as river selection can be adapted to the type of network.

REFERENCES

[1] Hanief A, Laursen A E 2019 Modeling the natural drainage network of the grand river in southern Ontario: Agriculture May increase Total Channel Length of Low-Order Streams *Geosciences*.

[2] Briney A, Order S 2019 A classification of the rank of streams and rivers https://www.thoughtco.com/what-is-stream-order-1435354.

[3] Buffington J M and Montgomery, Geomorphic classification of river, *Treatise on Geomorphology* 9.

[4] Zhang L, Guilbert E 2013 Automatic drainage pattern recognition in river networks *Int. J. of Geo. Inf. Sci.*

[5] Dashti N G, Malakahmad A 2015 Approximation of polycyclic aromatic hydrocarbons (PAHs) presence in Kinta River and its tributaries *Adv. in Env. Bio.* 9(6) p 21-27.

[6] T.I. Eldho, *Watershed Management*, Department of Civil Engineering, IIT Bombay

[7] http://www.waterproject.net.my/index.cfm?&menuid=50, Introduction to Sungai Kinta river education programme.

[8] The free dictionary by Farlex 2019 https://encyclopedia2.thefreedictionary.com/Drainage+Network.