Research Journal of Earth Sciences 1 (2): 35-42, 2009
ISSN 1995-9044
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Water Resources Study and Modeling at North Kedah: A Case of Kubang Pasu and Padang Terap Water Supply Schemes

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Abstract: The increasing demand between man and water makes "urban water" an issue: water resources and services including public water supply, water resources availability and future water projection. In North of Kedah, the area has suffered from extreme serious water deficiency for decades. Except for the climate change in physical dimension, unlimited industrial enlargement, extensive agricultural irrigation and continuous improvement of living standard constitute the main factors in human dimension to influence the change of balance between water supply and demand. This article focuses on the research carried out in Kubang Pasu and Padang Terap regions with the aim to obtain the clear information on the potential water resource availability. Current water resources conditions and future water supply projection will be discussed in the context of water supply and demand characteristics. The resulting water demand per water supply schemes can be useful information for forecasting water demand in the area as well as actual water supply particularly those come from Sungai Tok Kassim.

Keywords: Water Resources % Water Demand % Water Supply % Streamflow % River Modeling

INTRODUCTION

The yearly report on water practices in the State of Kedah in 2006-2007 shows that the main economy of Kedah is concentrating gradually on the north part of Kedah, especially towards the three urban groups of Alor Star, Jerlun and Changloon. In 2005, over 48 percent of the national GDP is contributed by these areas. The continuous growth of economy often exerts more and more pressure to resources and environment and in return the resources and environment will restrict the economic development to a great extent. Especially in the area around Alor Star with both resource shortages and environmental threatening for a long time, the rational allocations and protections of resources and environments have already become the bottleneck for the regional sustainable development of these areas [1].

In general, the water resource in Kedah could basically meet the requirement of economic development currently. However, due to the uneven distribution of water resources, the situation of water shortage is very serious in most northern areas particularly related to major irrigation schemes such as MADA and MUDA. The water resources play more and more important role in restricting the economic growth in those areas [2-4]. Like other states, lacks of water resources are among major challenges in managing fresh water for economic activities [5]. In Kedah, major fresh waters were obtained from two reservoirs operated namely Pedu Dam and Ahning Dam. Apart from them, problems of *Non-Revenue Water* (NRW) are also identified. *Non-Revenue Water* (NRW) is lost either through breakage, theft, seepage or other unaccountable ways once it leaves the treatment plant. For Malaysia, the average NRW is about 38 % (in 1995) while some states have NRW as much as more than 50 % (Government of Malaysia, 1996) (Table 1). In fact, Kedah is the second highest state that recorded NRW as reported in 2003/2004 (Fig. 1).

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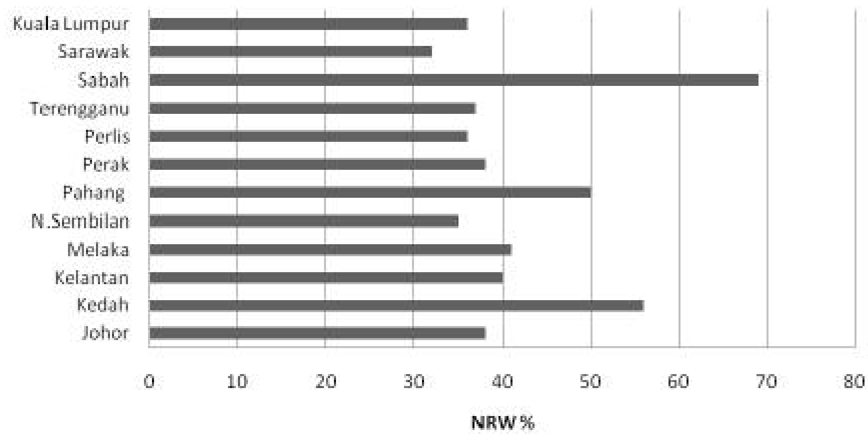

Fig. 1: Amount of Non-Revenue Water (NRW) by State in Malaysia (Source: Malaysia Water Industry 2005)

Table 1: Water Supply Capacity and Non-Revenue Water in Malaysia

Year	Capacity (MLD)*	Consumption (MLD)	Water loss	Water loss (MLD)	Estimated loss in revenue per day (RM)	Annual loss (RM)
1995	9,442	7,704	3,587	38 %	1.84 m**	671.6 million
2000	11,800	9,160	3,304	28 %	1.69 m	616.9 million

* MLD = million litres per day (1 litre = 0.001 m^3; 1 MLD = 1,000 m^3 per day)

** Based on cost of water sold at 51.3 sen per m^3 (Based on average price in Penang)

(Source: Government of Malaysia, 1996)

Experimental Design and Study Area: The study applies current practices on water resources study including the use of general equations carried out by Drainage and Irrigation Malaysia (DID). The current water resources conditions and water supply projection were analysed based on the secondary data obtained from Jabatan Bekalan Air Kedah. Potential water supply from new water treatment plant, especially at Sungai Tok Kassim was estimated using –D hydrodynamic model XPSWMM.

To estimate the effects of design structures to river hydraulic, the 1-D hydrodynamic model using XPSWMM software will be used. The software simulates one-dimensional channel flow by solving the fully dynamic de Saint-Venant equations, which, define the conservations of mass and momentum. The computational grids are created with alternating Q (discharge) and h (water level) points. The h points are created at the location where cross sectional data are available and Q points are generated automatically in between the h points. The XPSWMM provides an option where bed resistance (Manning's n) can be calculated as a function of hydraulic parameters such as water depth, hydraulic radius and flow velocity [6].

The study focuses at North Kedah consists of two major regions, namely Kubang Pasu and Padang Terap. In terms of general climate, the areas are characterised by dry and wet seasons which governed by the regime of the south-west monsoon. This monsoon blows from approximately between May and September. The average temperature throughout the year is constantly high (26°C). The diurnal temperature range is about 7°C. The humidity is high (about 80%) due to the high temperature and a high rate of evaporation. The Potential runoff (precipitation, P – Potential evapotranspiration. PE), as calculated based on hydrological region of Peninsular Malaysia (2003) is less than 500 m for the area. Fig. 2 and 3 show trends of mean monthly temperature and mean monthly rainfall as recorded at Mardi Bukit Tingga Climatological Station (N06° 25' E100° 26').

The computed *PE* using the Thornwaite equation compared with actual evapotranspiration (*AE*) for the site project is presented in Fig. 4. In this respect, the actual evapotranspiration is calculated using a simple linear relationship between the potential evapotranspiration and the initial moisture content of the soil (i.e., the moisture content on the previous day) [7]. When the moisture content is above the field capacity for the specific soil type, the actual evapotranspiration is equal to the *PE*. When the moisture content is below the permanent wilting point of the soil, the evapotranspiration is set to zero. For times when the moisture content lies between the field capacity and permanent wilting point,

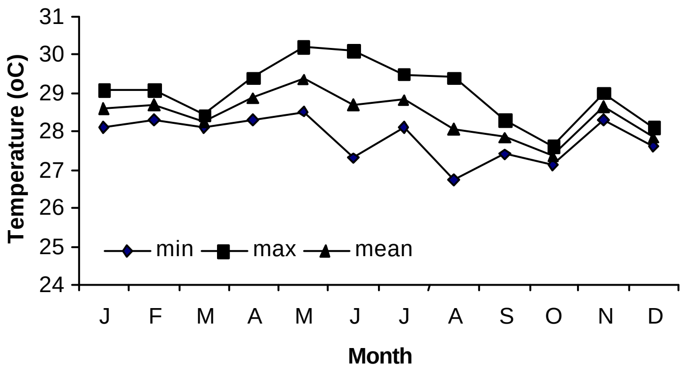

Fig. 2: Mean monthly temperature (°C) recorded at Mardi Bukit Tangga climatological station (1995-2006)

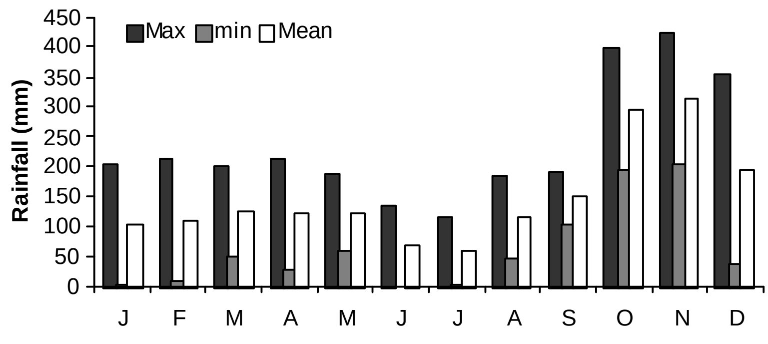

Fig. 3: Mean rainfall (mm) recorded at Mardi Bukit Tingga Climatological Station (1995-2006)

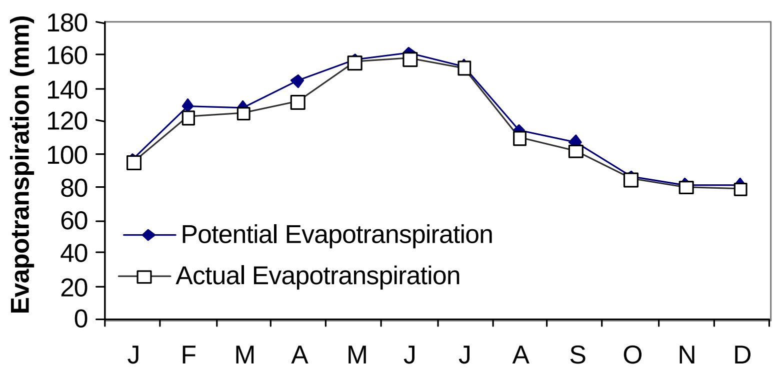

Fig. 4: Mean monthly PE and AE for the proposed site project

the *AE* will equal the *PE* multiplied by the fraction of saturation between the permanent wilting point and field capacity. The cumulative estimated *PE* and *AE* for the site project watershed for the calculation year are approximately 1487 mm and 1286 mm, respectively.

It can be noticed that the *PE* during dry and low humidity months (May-July) are much higher. Conversely, during the wet months (November and December), the *PE* was calculated lower due to increased humidity. The computed *PE* for the site project when compared to the annual *PE* map produced by the DID, (Publication No. 5, 1976) generally show good agreement within ± 15 percent. In this area, annual *PE* and *AE* were 1441.5 mm and 1397.7 mm, respectively. The mean annual rainfall calculated at the proposed site project is 1778.8 mm. This means that, only 337.3 mm will remain in the form of surface and sub-surface runoff and storage. The value found to be less than mean annual runoff (in mm) calculated for the Sg Muda (CA= 1220) at Station 6007415, Nami (730 mm), station 580 6414, Jening and Padang Terap (CA =1270) at Station 6204421 (480 mm).

RESULTS AND DISCUSSION

Current and Future Water Resources Conditions: The north of Kedah experiences frequent water shortage problem particularly during the dry seasons. Even the wet seasons, the area also has a water shortage problem because of lack in water supply and large padi area which consumes a large proportion of the available water. Over the last 10 years, the north of Kedah faces a water shortage problem as a result of the increasing population and industrialization as well as to meet the peak irrigation demand by MUDA padi scheme during the planting season. The Muda and Pedu Dams were built in 1970 solely to irrigate about 114, 000 hectares of padi land in the Kedah-Perlis plain of northwest Peninsular Malaysia. Dry spell every year have drastically reduced the volume of water of both dams. For example, in 1976 and 1994, one off-season padi crop had to be cancelled and the off-season padi harvest in subsequent years showed some decline in production. This scenario indicates how critical water resources in the State of Kedah as a whole [8].

Overall, surface waters are the main source for water in this area, accounting more than 79 billion m^3 in 2007. Noted that the value in not include the irrigation water consumption which constitutes more than 50 % of the total demand as well as *Non-Revenue Water* (NRW) or water that is lost either through breakage, theft, seepage or other unaccountable ways once it leaves the treatment plant (average about 40 % annually). Ahning Dam is a major water supply scheme for Kota Perdana and the whole Kubang Pasu district. This scheme supports five major water treatment currently operated at Padang Sanai, Kuala Nerang, Bukit Pinang, Pelubang and Jeragan [9] (Table 2).

For specific areas at Kota Perdana, Felda Bukit Tangga, Kg Bukit Tangga and MARDI, the waters were supplied through water tank and water storage pond (Table 3). All water distribution systems are linked through 650mm main pipe from Telaga Dalam Pump House at Changlun. The 250mm pipe then is linked from water treatment pond at Laka Temin to Bukit Tangga at a distance about 5.3 km. Fig. 5 and 6 illustrate water treatment schemes for Kubang Pasu and Padang Terap, respectively.

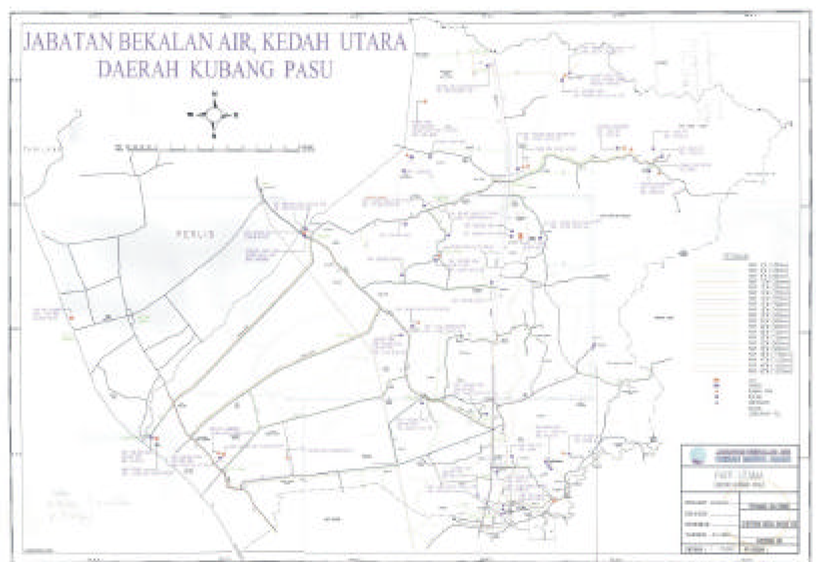

Fig. 5: Water Treatment Scheme for Kubang Pasu District

Table 2: Present water treatment and intake schemes for Kubang Pasu

No	Scheme	Capacity	
		MGD	M^3/day
1	Loji Air Padang Sanai	0.3	1, 360
2	Loji Air Kuala Nerang	5.0	22, 726
3	Loji Air Jeragan	2.0	09, 091
4	Loji Air Pelubang	55.0	250, 000
5	Loji Air Bukit Pinang	30.0	136, 000
		3	419, 177

Table 3: Design water supply system in Kota Perdana, Felda Bukit Tangga, Kg Bukit Tangga and MARDI (m^3/h)

No	Area	Type	Unit	CAP (m^3)	TWL (m)
1	Bukit Tangga	Water storage pond	2	909.21	106.81
2	Bukit Tangga	Tank	1	181. 84	-
3	Laka Temin	Water storage pond	1	454.60	85.57
			3	1 545.65	-

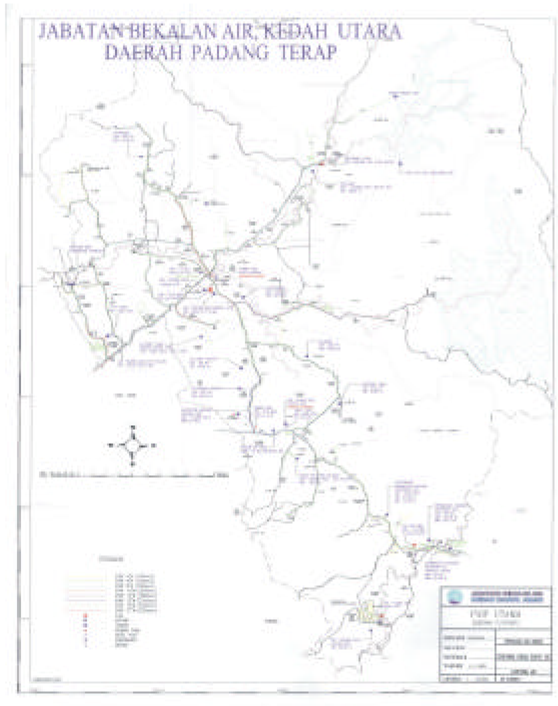

Fig. 6: Water Treatment Scheme at Padang Terap District

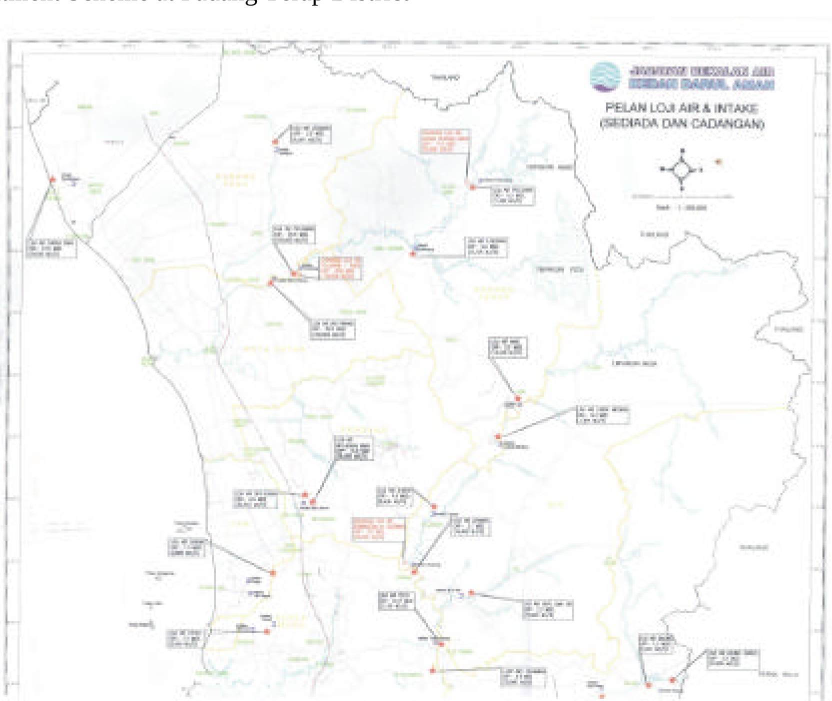

Fig. 7: Proposed and current water treatment plant and water intake in Kubang Pasu district

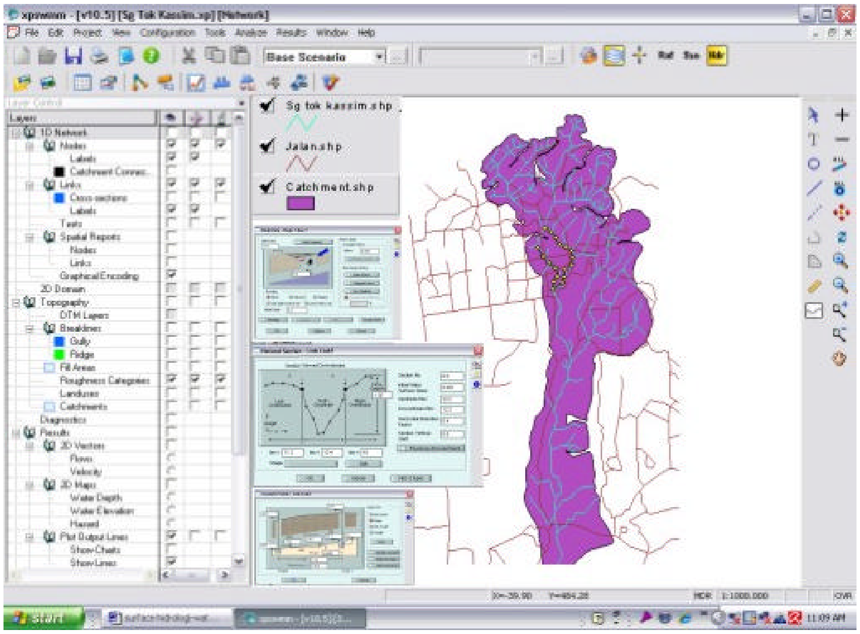

Fig. 8: Sg Tok Kassim showing nodes and conduits of hydraulic simulation model

Table 4: The hydrological characteristics of Sg Tok Kassim

River catchment description	Value
Total stream length (km)	38.4
Size of catchment area (km^2)	18.6
Length of main channel (km)	13.5
Drainage density km/km^2	0.48(low)
Average slope	38.2
Manning roungness	0.0010
River morphology	Meandering stable with minor bank erosion
Flooding	Minor downstream

The government, through Jabatan Bekalan Air Kedah Utara was planning to build another two water treatment plants, namely Loji Air Pelubang and Loji Air Durian Burung to cater water demand in Kubang Pasu district. The plants, which are design for 10 years capacity are expected to fully operated in February 2009 with capable to supply approximately 136 000 m^3/day for Loji Air Pelubang and 50 000 m^3/day for Loji Air Durian Burung (Fig. 7). Under these additional schemes (186 000 m^3/day), it is expected that the total projection of availability of water treatment scheme for Kubang Pasu will be increased to 605, 177 m^3/day (186 000 + 419 177 m^3/day).

Potential of Water Resources- Modelling of Sg Tok Kassim: Sg Tok Kassim located at latitude 6° 30' and longitude 100° 27'. This unregulated river is sub-tributary of Sg Temin catchment which flowing from north to south. Topographically, about 20 percent of the catchment is hilly with elevation over 150 m. The land cover is consists of grass and secondary forest with oil palm, rubber and mix cultivation are main agriculture activities within the river system. The total catchment covers, calculated in ArcView is approximately 18.6 km^2. The main river of Sg Tok Kassim starts from international boundary at elevation about 170m. It flows approximately 9.4km towards south to Sg Temin.

During the survey on the rainy day of 24th November 2007, Sg Tok Kassim demonstrated significant sediment load. However, the river was quickly recovered after a few hours storm. This may be due to land clearance for agriculture activities in the river catchment. Exposed land surface may increase peak streamflow by replacing subsurface flow paths with surface flow paths. The stream characteristics are presented in Table 4.

Due to large amount is required for the input to the hydrologic and hydraulic model, most of the processes were carried out using GIS tools. Most of the GIS analysis was carried using ArcView 3.1 developed by ESRI. The main input for the hydraulic model is the river cross section. The cross section survey was done at 1-2km interval which extents up to bankfull discharge each side of the river bank. For Sg Tok Kassim, there is no streamflow gauging for the river. Therefore, a 24-hour temporary gauging station was set up on 26 February 2008 to obtain surface flow characteristics of the river. The values of long term streamflow for Sg Tok Kassim then were calculated and predict using XPSWMM.

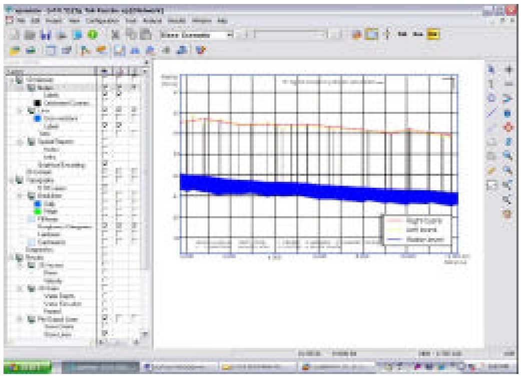

Fig. 9: Water level simulation model of Sg Tok Kassim-present condition

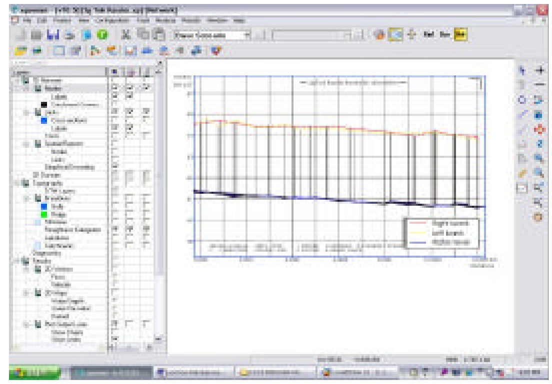

Fig. 11: Water level simulation model of Sg Tok Kassim-30 % reduction

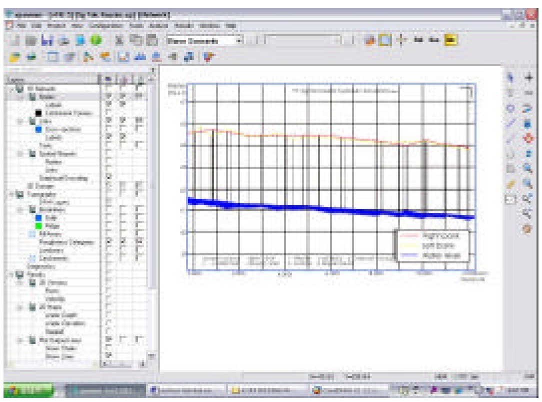

Fig. 10: Water level simulation model of Sg Tok Kassim-5 % reduction

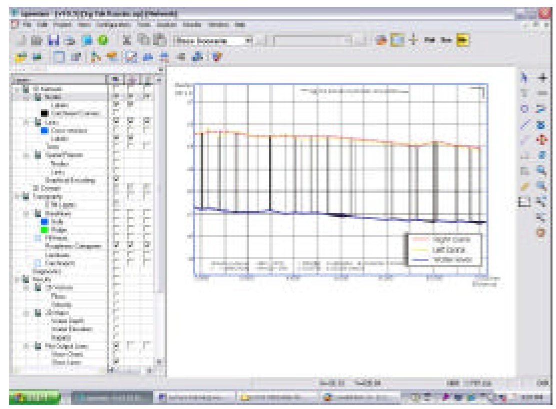

Fig. 12: Water level simulation model of Sg Tok Kassim-50 % reduction

The 24-hours streamflow data for Sg Tok Kassim is presented in Fig. 8. The results indicate that:

C Minimum daily runoff is 0.003 m^3/s
C Maximum daily runoff is 0.952 m^3/s
C Average daily runoff is 0.4775 m^3/s

The hydraulic model was developed using XPSWMM. It is a 1D hydrodynamic model which is able to simulate both steady and unsteady flows. The main input to the model is rainfall, river cross section, spill level, flood plain information. In this exercise, the simulation will be focused on four scenarios:

C Scenario 1: Represents the present condition.
C Scenario 2: 5 % reduction on the volume of river flow.
C Scenario 3: 30% reduction on the volume of river flow.
C Scenario 4: 50 % reduction on the volume of river flow.

The result is presented in Fig. 9 and 12. From the simulation, various behaviour of the river flow can be observed. At present condition, simulation on water level along the river indicates that the flow is fluctuates between 0.3 to 1.2 m. However, with 30 % reduction on water level, some areas become shallower particularly closed to sand banks and river meanders. At 50 % reduction on the volume of flows, almost all river stretches are registered to dry. At this stage, the river capacity will nearly to zero to support any aquatics. It also can reduce river bank stability and more importantly, reducing its capability to supply fresh water to Sg Temin treatment plant.

The hydraulic simulation carried out for Sg Tok Kassim clearly indicates that the river flow is really sensitive to any modification on its volume. Any reduction on the volume will reduce the water level. It also causes severe damage on river ecosystem particularly along the proposed project site. In long term basis, the river must be preserved and restored as part of the runoff system, flood releases, sediment transported as well as aesthetic values for the surrounded areas.

CONCLUSION

Water Is a Renewable Resource: rivers, lakes, springs and other water sources are all periodically replenished by natural processes. However, this does not mean it is inexhaustible; one the contrary, water is a finite good. Moreover, water is a vulnerable element liable to be easily polluted, wasted or in other ways damaged, with long-term consequences for human livelihoods and the environment. In this regard, water is expected to be the main issue in the north of Kedah as this vital resource becomes increasingly polluted and scarce [10]. Information on quantity of natural resources is essential for sustainable development. In particular, information on freshwater resources, their availability and use is becoming increasingly important with the emergence of regional water shortages and the need to improve water use efficiency.

ACKNOWLEDGEMENT

This study was conducted and supported by the GUP fund (UKM-GUP-ASPL-07-06-002). The authors are also thankful to the Centre for Research and Innovation Management (CRIM), Universiti Kebangsaan malaysia for funding the research. Special thank also due to the Lestari Software (M), UKM Pakarunding Sdn Bhd, Kota Perdana Development Project and Water Supply Department, State of Kedah for general assistant.

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