The Effect of Land Changes Towards in Sg. Pandan

Perwira Bin Khusairi Rahman [1,a*] and Kamarul Azlan bin Mohd Nasir [1,b]

[1]Faculty of Civil Engineering, Universiti Teknologi Malaysia, Malaysia

[a*] wirakhusairirahman@gmail.com, [b*]kamarul.azlan@yahoo.com,

Keywords: Oil Palm, hydrology, HEC-HMS, HEC-RAS

Abstract: Due to high demands on the palm oil products, people tends to move onto those businesses which are seems to be promising and profitable. A lot of area had been reused in order to build a Palm oil plantation, subsequently will affect the nature of nearby river hydrological system. Regarding to that, this study is carried out in order to explores the effect of land usage towards the nearby river by identify the changes of flow rate and sediment transport capacity in the river. In this study, the HEC-HMS modelling will be used in order to get the value of flow rate in the river, meanwhile HEC-RAS modelling will help to find the value of water level, velocity and sediment transport capacity. In order to do HEC-HMS and HEC-RAS modelling, value of river catchment area, length and cross section, precipitation data, and percentage of sediment finer, should be determined. A project area drawing is required in order to determine the location and boundaries of the Palm oil plantation and to determine the river catchment area and length. We also need to acquire sets of river channel data which consist of 13 different cross section, bed elevation, and water temperature, all along the river. The precipitation data is required in order to define the value of rainfall intensities of which were estimated by using MSMA Design Storm for 5 years, 50 years, and 100 years event. A total of 13 samples of river sediment was analyzed by using sieve analysis method in order to get the percentage of finer in the river. All the sediment samples is taken in 13 different locations all along the studied river. After all the data is determined, we decided the river that will be studied is Sungai Pandan. Sungai Pandan is the river that flow right in the middle of Palm oil plantation before discharging towards Sungai Kuantan, has a catchment area of about 50.53□□^{2} and maximum river length of about 27□□. This study consist of 33.98□□^{2} of Sungai Pandan catchment area and the longest rivers is 6.66□□. The rainfall intensities is gained by referring to fitting constants for IDF Empirical equation in Station 3930012 Sungai Lembing PCC Mill. After all the input data is determined and analyzed by using HEC-HMS and HEC-RAS modelling, we could see that the average peak discharge, velocity, and sediment transport capacity shows increment about 7%, 3%, and 20% respectively. Therefore, it is approves in the study that the land changes in river basins of a river will affect its flow rate, water level, velocity, and sediment transport capacity.

Introduction

River is one of the natural sources of water in Malaysia. There are more than 150 rivers in Malaysia, and 90% of them provides raw water to the countries. The river is supposed to give a lot of advantage to the human but because certain factors river can give a dangerous disaster to human. The previous flood that happen in Malaysia had caused a lot of damage on property, facilities, social structure, agricultural, economy and most sadist lot of human live sacrificed. The flood happens is mostly due to failure of river basin to hold water due to high intensity of precipitation over long period. However, there must be something else that we can do in order to prevent this kind of event never happens again. It was suspected that most river in Malaysia have lost its efficiency in delivering water due to an uprising development and urbanization that creates changes of land usage that affect characteristics of the river. Typically, development in the river basin area will make the river sedimentation rate increased.

The aim of this research is to study the effect of the development that will change the characteristics of river basin of Sungai Pandan, Kuantan Pahang. Sg. Pandan is the river that flow right in the middle of Palm oil plantation before discharging towards Sungai Kuantan, has a catchment area of about 33.98□□^{2} and maximum river length of about 6.66□□. This change of land usage will surely affect the hydrological nature and sedimentation of Sg. Pandan. This study will determine the effect of changes in land usage towards Sg. Pandan, which is naturally is forested area turn to palm oil plantation. The extend of changes in Sg. Pandan will be determined based on changes in flow rate, velocity, water level depth, and sediment transport capacity rate that happened in the river. HEC-HMS is used in order to determine the peak discharge of the river. The loss method and transform method used in the HEC-HMS model are “Initial and Constant” method and “Clark’s Unit Hydrograph” method. Next, HEC-RAS is used to generate the sedimentation transport capacity rate of Sg. Pandan. In HEC-RAS, geometrical data of the river in term of cross-section of the river is inserted together with the peak discharge value in order to perform steady flow analysis. Meanwhile, the sieve result of the soil sample obtained from Sg. Pandan is used in order to perform sediment transport capacity analysis. This study will produce the forecast of the sedimentation rate that will occur in 5 years, 50 years and 100 years’ time and how the change in land usage will affect that rate.

Literature Review

There are several indications that changes in land cover have influenced the hydrological regime of various river basins. In addition, the effects of climate change on the hydrological cycle and on the runoff behavior of river catchments have been discussed extensively in recent years. However, it is at present rather uncertain how, how much and at which spatial scale these environmental changes are likely to affect the generation of storm runoff, and consequently the flood discharges of rivers [1]. It is well known that changes in land use that involve a significant increase in impervious area result in increased surface water runoff. Although typically we think of the hydrologic impact of land-use change primarily in terms of the increased peak discharges that are responsible for local flooding, there are a range of other important impacts. One of the most important additional impacts is an increase in surface runoff volume, which may contribute to downstream flooding and can also represent a net loss to groundwater recharge [2].In addition to the basin ratio and lag time, the regimen of a stream, however, can be described in many other ways, including flood frequency, flow duration, mean annual flood, discharge at bank full stage, and frequency of bank full stage. This is evidenced in past studies of the effects of urbanization on the hydrology of an area. Many different techniques of relating rainfall to runoff have been used, along with various parameters to measure the degree of urbanization [3].The primary tool for assessing land-use-related changes in hydrology is the computer-based numerical model. Such models simulate the important hydrologic processes that operate in watersheds, and thus allow for assessments of the sensitivity of the hydrologic system to changes in environmental conditions. Existing hydrologic models, such as those developed by the United States Department of Agriculture, the Environmental Protection Agency, the United States Army Corps of Engineers and various other organizations, provide tools for determining the effects that changes in watershed characteristics may have on surface water and sediment supply [4].

Methodology

There are several steps of work that must be done in this research. Besides knowledge gained by reading previous studies and literature reviews, one must got skills and experiences in order to do the hydrological modeling. These are list of methodology which is needed in this research.

Area of Sub-Catchment

The area of sub catchment is calculated by using the drawing plan of the river which is in its actual scale. According to Figure 1, there are 13 sub-catchment in total and is separated by different colors. The boundaries of the palm oil plantation are marked by blue color line. Table 1 shows the area of all the sub-catchment.

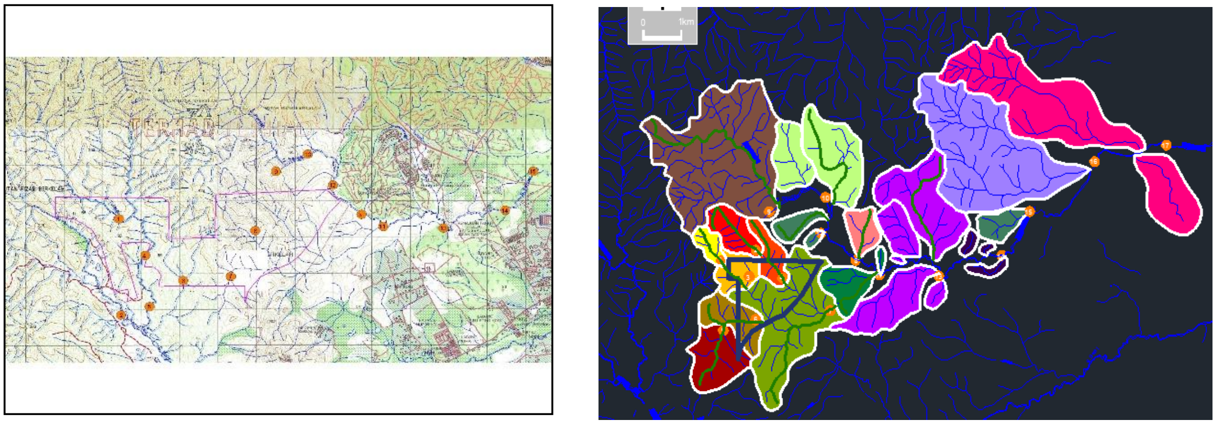


Figure 1: Sub-catchment use in this research

Table 1: Area of all the sub-catchment

Sub- Catchment	Area (km^2)
Catchment 1	0.49
Catchment 2	1.12
Catchment 3	0.87
Catchment 4	0.90
Catchment 5	1.88
Catchment 6	1.36
Catchment 7	5.11
Catchment 8	0.77
Catchment 9	8.44
Catchment 10	3.80
Catchment 11	1.25
Catchment 12	0.74
Catchment 13	6.49

Initial and Constant Method

Loss methods that are used in the HEC-HMS model for this research are initial and constant loss method. For this method the parameters that need to be inserted are initial loss, constant rate and impervious percentage value. For Initial loss value, the range that should be used is in between 10-20% of total rainfall. The average total rainfall used in this study is 80mm and this model are using 20% of the total rainfall which make the initial loss value equivalent to 15mm. The constant rate used depends on the soil group of the project area. By the Table 2, soil group A will give the infiltration loss rate in the range of 0.30-0.45 (in/hr). This research are using 0.4 in/hr as the rate of infiltration loss which equivalent to 11 mm/hr. For impervious percentage parameter, this research will used 10% to represent the condition before the change in land usage and 50% after the change in land usage.

Table 2: SCS soil groups and infiltration (loss) rates

Soil group	Description	Range of loss rates (in/hr)
A	Deep sand, deep loess, aggregated silts	0.30-0.45
B	Shallow loess, sandy loam	0.15-0.30
C	Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	0.05-0.15
D	Soils that swell significantly when wet, heavy plastic clays, and certain saline soils	0.00-0.05

Clark Unit Hydrograph Method

Transform method used in this model are Clark Unit Hydrograph Method. In this method, the parameters that are needed in order to generate results from HEC-HMS are time of concentration (t_c) and storage coefficient (R). These two parameters can be obtained from observed hydrograph. In the absence of the observed hydrograph, the parameters can be estimated from regression equations derived areas with gauged data. The regression equation used in this study is derived from a study in small rural watersheds in Illinois, USA [1].The regression equations are as listed below.

$$T_c = 1.54\, L^{0.875}\, S^{-0.181} \quad \text{......Equation 2}$$

$$R = 16.4\, L^{0.342}\, S^{-0.790} \quad \text{......Equation 3}$$

The T_c and R value within the sub catchment are listed below in Table 3. L is the stream length measure along the main channel from the outlet to the watershed. S is the slope of stream flow path.

Table 3: Time of concentration and storage coefficients used

Catchment	C. Area (km^2)	L (km)	S(m/km)	T_c	R
Catchment 1	0.49	1.11	1.65	1.5	11.5
Catchment 2	1.12	2.2	0.83	3.2	24.9
Catchment 3	0.87	0.84	27.94	0.7	1.1
Catchment 4	0.9	1.85	96.88	1.2	0.5
Catchment 5	1.88	1.75	20.55	1.5	1.8
Catchment 6	1.36	1.79	31.16	1.4	1.3
Catchment 7	5.11	3.42	46.35	2.3	1.2
Catchment 8	0.77	1.28	2.14	1.7	9.8
Catchment 9	8.44	5.04	1.51	5.9	20.6
Catchment 10	3.8	3.23	4.53	3.3	7.4
Catchment 11	1.25	1.57	1.94	2.0	11.3
Catchment 12	0.74	1.75	72.63	1.2	0.7
Catchment 13	6.49	3.12	11.33	2.7	3.6

Design Storm

In this study, 60 minutes design storm used are in 5 year, 50 year and 100 year time. In order to obtain the design storm values for the project area in this research, the nearest JPS rain gauge station need to be determine. In this study, the nearest JPS rain gauge station is Sungai Lembing PCC Mill (Station ID: 3930012). The IDF constant for Kg. Sungai Yap station are shown in the Table 4a below. The IDF constant value were then utilized to obtain rainfall intensity for 60 minutes and rainfall depth for 60 minutes. The values of both data are shown in Table 4b Because of the project area located at Pahang, the normalized design rainfall temporal pattern used is displayed in Table 4c. With all the obtained values, 60 minutes design storm for 5 years, 50 years and 100 years can be derived. The results of the drainage storm that will be used in this research are shown in Table 4d.

Table 4a: IDF constant coefficient

Station ID	Station Name	λ	κ	θ	η
3930012	Sg Lembing PCC Mill	45.999	0.21	0.074	0.817

Table 4b: Rainfall intensity and rainfall depth

ARI (years)	60 minutes	
	Rainfall intensity (mm/hr)	Rainfall depth (mm)
5	60.84	60.84
50	98.67	98.67
100	114.13	114.13

Table 4c: Normalized design rainfall temporal pattern

No of Blocks	60 minutes
1	0.053
2	0.059
3	0.063
4	0.087
5	0.103
6	0.153
7	0.11
8	0.088
9	0.069
10	0.06
11	0.057
12	0.046

Table 4d: Design Storm (60 minutes) for 5 years, 50 years and 100 years

Pattern	5 year	50 year	100 year
0.053	3.2	5.2	6.0
0.059	3.6	5.8	6.7
0.063	3.8	6.2	7.2
0.087	5.3	8.6	9.9
0.103	6.3	10.2	11.8
0.153	9.3	15.1	17.5
0.11	6.7	10.9	12.6
0.088	5.4	8.7	10.0
0.069	4.2	6.8	7.9
0.06	3.7	5.9	6.8
0.057	3.5	5.6	6.5
0.046	2.8	4.5	5.3

Geometrical Data

For the modeling work in HEC-RAS, cross sections of the river need to be inserted. For this model, the cross-section is inserted in every chainage from the downstream end to the most upstream end. Table 5 shown below will display all the cross sections coordinated used in this research. Manning's roughness coefficient value used is 0.033 as suggested in MSMA second edition table shown in Table 5a.

Table 5a: Coordinates of all the cross section used.

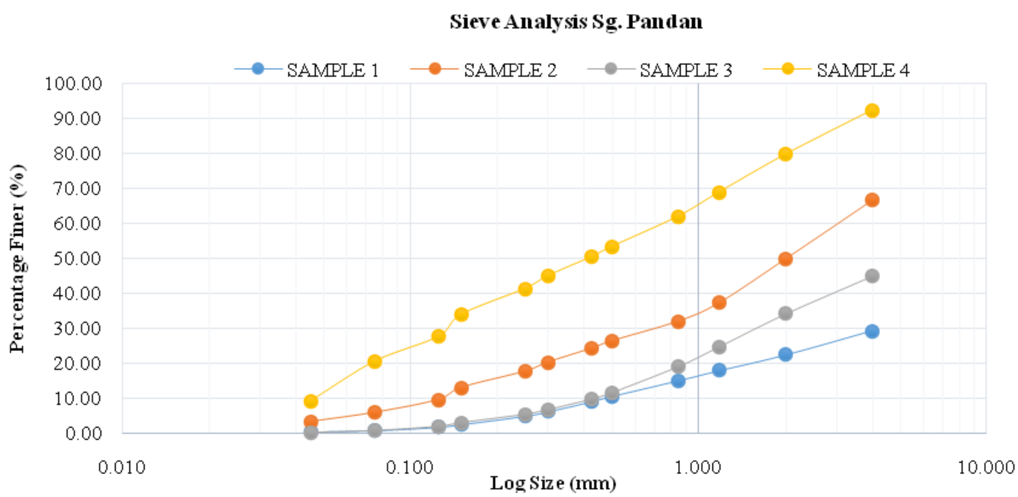
Chainage 0		Chainage 1828		Chainage 2810		Chainage 4031	
Station	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**
-9.9	37.966	-8.9	41.795	-6.85	41.843	-1.55	45.367
-5.8	35.966	-5.4	37.795	-2.95	40.843	-1.25	43.367
5.8	35.966	5.4	37.795	2.95	40.843	1.25	43.367
12.7	37.966	11.1	41.795	10.15	41.843	13.25	45.367
Chainage 4606		**Chainage 6491**		**Chainage 3206**		**Chainage 4968**	
Station	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**
-4.85	47.196	-6.5	73.323	-9.75	41.71	-5.5	72.933
-4.15	45.196	-2.5	72.323	-4.95	38.71	-3.5	71.933
4.15	45.196	2.5	72.323	4.95	38.71	3.5	71.933
9.15	47.196	6.5	73.323	9.45	41.71	15.5	72.933
Chainage 5939		**Chainage 6408**		**Chainage 7258**		**Chainage 5525**	
Station	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**	**Station**	**Elevation**
-7.4	240.268	-5.45	79.943	-8.15	81.248	-9.2	58.912
-4.4	239.268	-4.55	78.943	-3.25	79.248	-3.6	57.912
4.4	239.268	4.55	78.943	3.25	79.248	3.6	57.912
8.1	240.268	6.15	79.943	9.85	81.248	8.1	58.912
Chainage 6549							
Station	**Elevation**						
-6.95	70.19						
-2.85	69.19						
2.85	69.19						
13.05	70.19						

Table 5b: Manning's roughness coefficient

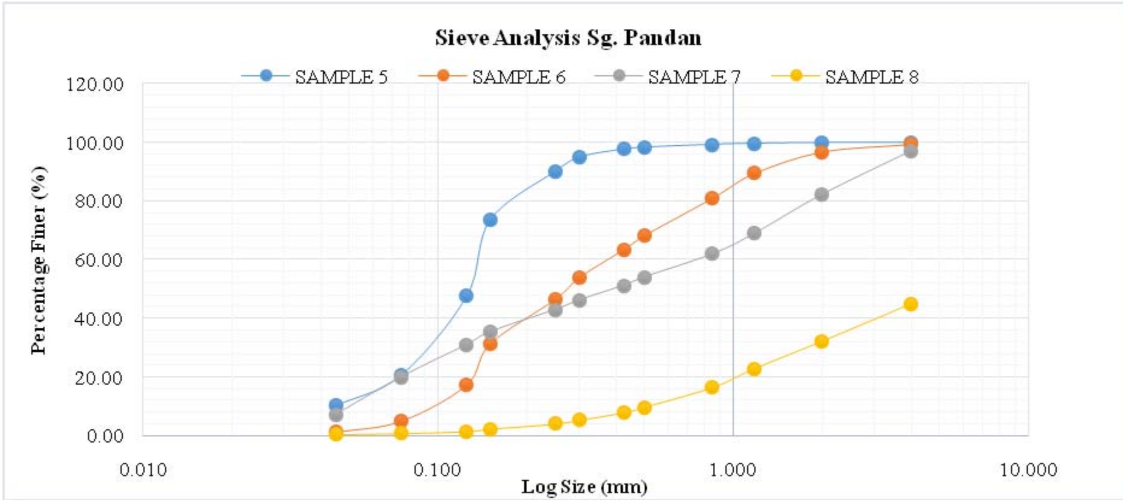
Surface Cover	Suggested n Values
Natural Channels	
Small streams	
Straight, uniform and clean	0.033
Clean, winding with some pools and shoals	0.045
Sluggish weedy reaches with deep pools	0.080
Steep mountain streams with gravel, cobbles, and boulders	0.070
Large streams	
Regular cross-section with no boulders or brush	0.060
Irregular and rough cross-section	0.100
Overbank flow areas	
Short pasture grass, no brush	0.035
Long pasture grass, no brush	0.050
Light brush and trees	0.080
Medium to dense brush	0.160
Dense growth of trees and brush	0.200

Sieve Analysis

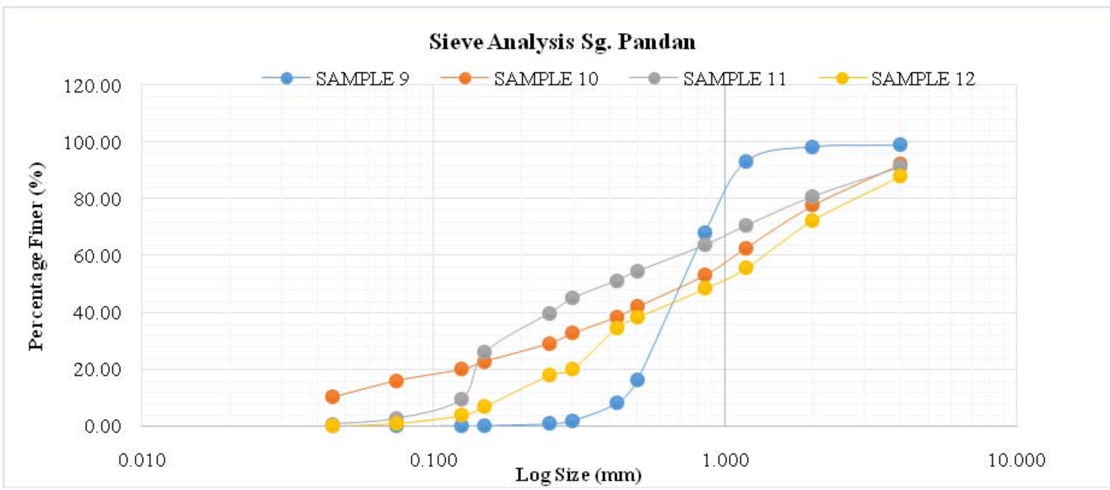
In order to study the sediment transport capacity of Sg. Pandan, sieve analysis data is required. Sieve analysis results from 13 samples located at 13 different point located on every chainage are used in HEC-RAS (see Figure 2 (a)-(d). Below are graphs displaying the result of sieve analysis on the entire soil sample used in this research.



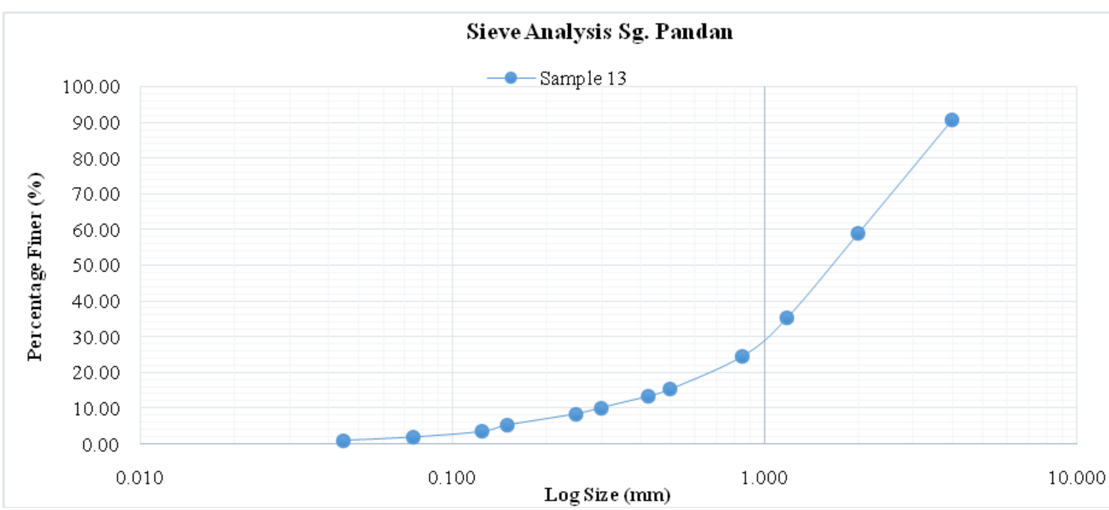
(a)



(b)



(c)



(d)

Figure 2: (a)- (d) Sieve analysis graph of 13 type of samples

Results and Discussion

The analysis of the results will be divided into four parts according to the research objective. The analysis is only focus on peak discharge, velocity, depth, and sediment transportation capacity.

Peak Discharge

The flow rate value for each catchment area were determined by using HEC-HMS modelling. It is consist of flow rate value for pre-development and post-development. The development area is located within sub-basin 3, sub-basin 4, sub-basin 5, sub-basin 6, and sub-basin 7. The representation of each sub-basins for the project development area in HEC-HMS model is shown Figure 3(a)-(e). Every sub-basins plotted in the HEC-HMS will drains toward main river which is Sg. Pandan. The model in HEC-HMS was designated in order to determine flow rate for 5 year, 50 year, and 100 year event for pre and post-development. Example list of each elements flow rate value that would be diverted into Sg. Kuantan is shown in Figure 3b and Figure 3c.

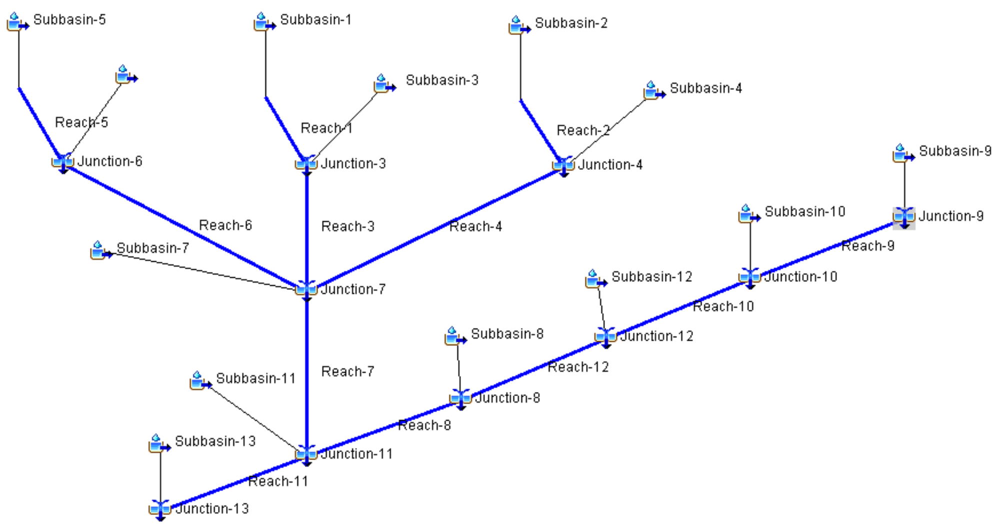
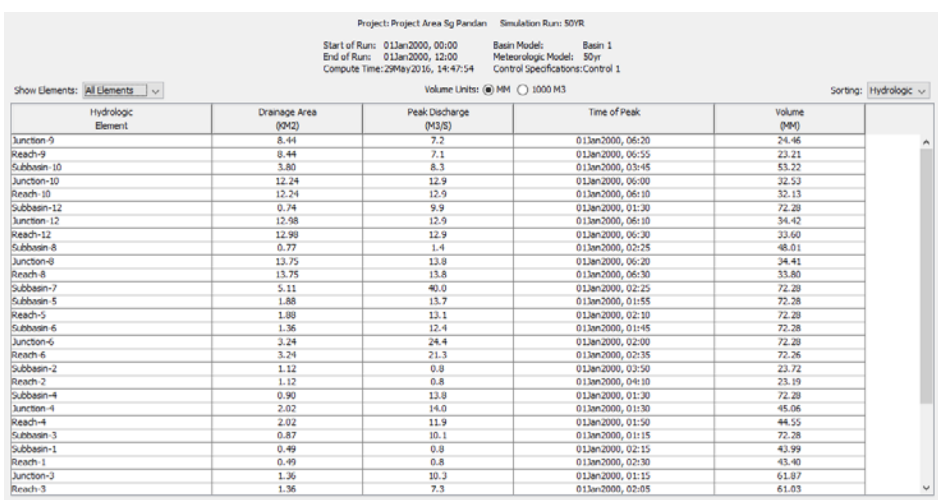


Figure 3a: Basin model



Project: Project Area Sg Pandan   Simulation Run: 50YR

Start of Run: 01Jan2000, 00:00   Basin Model: Basin 1
End of Run: 01Jan2000, 12:00   Meteorologic Model: 50yr
Compute Time: 29May2016, 14:47:54   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: MM 1000 M3   Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Junction-9	8.44	7.2	01Jan2000, 06:20	24.46
Reach-9	8.44	7.1	01Jan2000, 06:55	23.21
Subbasin-10	3.80	8.3	01Jan2000, 03:45	53.22
Junction-10	12.24	12.9	01Jan2000, 06:00	32.53
Reach-10	12.24	12.9	01Jan2000, 06:10	32.13
Subbasin-12	0.74	9.9	01Jan2000, 01:30	72.28
Junction-12	12.98	12.9	01Jan2000, 06:10	34.42
Reach-12	12.98	12.9	01Jan2000, 06:30	33.60
Subbasin-8	0.77	1.4	01Jan2000, 02:25	48.01
Junction-8	13.75	13.8	01Jan2000, 06:20	34.41
Reach-8	13.75	13.8	01Jan2000, 06:30	33.80
Subbasin-7	5.11	40.0	01Jan2000, 02:25	72.28
Subbasin-5	1.88	13.7	01Jan2000, 01:55	72.28
Reach-5	1.88	13.1	01Jan2000, 02:10	72.28
Subbasin-6	1.36	12.4	01Jan2000, 01:45	72.28
Junction-6	3.24	24.4	01Jan2000, 02:00	72.28
Reach-6	3.24	21.3	01Jan2000, 02:35	72.26
Subbasin-2	1.12	0.8	01Jan2000, 03:50	23.72
Reach-2	1.12	0.8	01Jan2000, 04:10	23.19
Subbasin-4	0.90	13.8	01Jan2000, 01:30	72.28
Junction-4	2.02	14.0	01Jan2000, 01:30	45.06
Reach-4	2.02	11.9	01Jan2000, 01:50	44.55
Subbasin-3	0.87	10.1	01Jan2000, 01:15	72.28
Subbasin-1	0.49	0.8	01Jan2000, 02:15	43.99
Reach-1	0.49	0.8	01Jan2000, 02:30	43.40
Junction-3	1.36	10.3	01Jan2000, 01:15	61.87
Reach-3	1.36	7.3	01Jan2000, 02:05	61.03

Figure 3b: Flow rate for pre-development for 50 years

Project: Project Area Sg Pandan Post   Simulation Run: 50YR

Start of Run: 01Jan2000, 00:00   Basin Model: Basin 1
End of Run: 01Jan2000, 12:00   Meteorologic Model: 50yr
Compute Time: 29May2016, 14:49:50   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: MM / 1000 M3   Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Junction-9	8.44	7.2	01Jan2000, 06:20	24.46
Reach-9	8.44	7.1	01Jan2000, 06:55	23.21
Subbasin-10	3.80	8.3	01Jan2000, 03:45	53.22
Junction-10	12.24	12.9	01Jan2000, 06:00	32.53
Reach-10	12.24	12.9	01Jan2000, 06:10	32.13
Subbasin-12	0.74	9.9	01Jan2000, 01:30	72.28
Junction-12	12.98	12.9	01Jan2000, 06:10	34.42
Reach-12	12.98	12.9	01Jan2000, 06:30	33.60
Subbasin-8	0.77	1.4	01Jan2000, 02:25	48.01
Junction-8	13.75	13.8	01Jan2000, 06:20	34.41
Reach-8	13.75	13.8	01Jan2000, 06:30	33.80
Subbasin-7	5.11	44.9	01Jan2000, 02:20	81.71
Subbasin-5	1.88	15.4	01Jan2000, 01:55	81.71
Reach-5	1.88	14.7	01Jan2000, 02:10	81.71
Subbasin-6	1.36	13.9	01Jan2000, 01:45	81.71
Junction-6	3.24	27.4	01Jan2000, 02:00	81.71
Reach-6	3.24	23.9	01Jan2000, 02:35	81.69
Subbasin-2	1.12	0.8	01Jan2000, 03:50	23.72
Reach-2	1.12	0.8	01Jan2000, 04:10	23.19
Subbasin-4	0.90	15.3	01Jan2000, 01:25	81.71
Junction-4	2.02	15.4	01Jan2000, 01:25	49.26
Reach-4	2.02	13.2	01Jan2000, 01:50	48.75
Subbasin-3	0.87	11.2	01Jan2000, 01:15	81.71
Subbasin-1	0.49	0.8	01Jan2000, 02:15	43.99
Reach-1	0.49	0.8	01Jan2000, 02:30	43.40
Junction-3	1.36	11.4	01Jan2000, 01:15	67.91
Reach-3	1.36	8.2	01Jan2000, 02:00	67.07

Figure 3c: Flow rate for post-development for 50 years

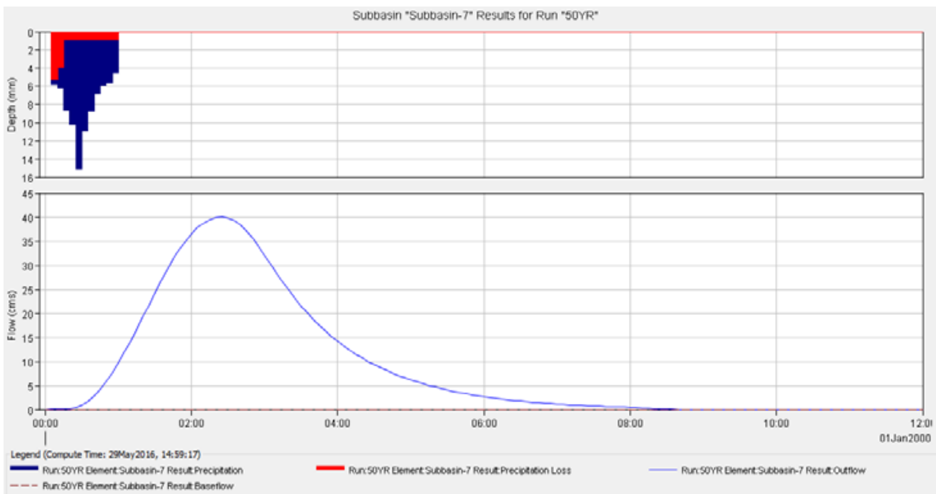


Figure 3d: Sub-basin 7 for pre-development for 50 years

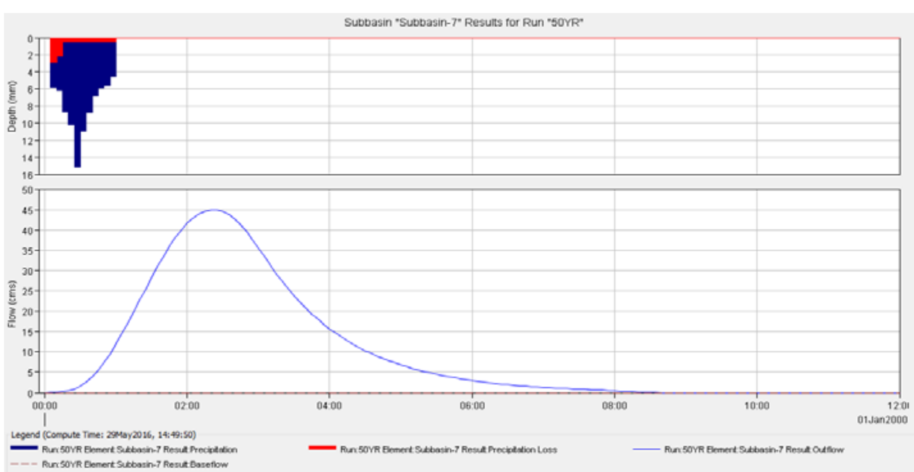


Figure 3e: Sub-basin 7 for post-development for 50 years

Table 6: Peak discharge result

Hydrological Element	Flow Rate (m3/s)						Percentage change
	5YR Pre	50YR Pre	100YR Pre	5YR Post	50YR Post	100YR Post	
Junction-10	6.7	12.9	15.5	6.7	12.9	15.5	0%
Junction-11	45.2	86.9	104.2	54.2	96.2	113.6	13%
Junction-12	6.7	12.9	15.5	6.7	12.9	15.5	0%
Junction-13	55.2	106	127.1	63.5	114.7	135.9	10%
Junction-3	5.4	10.3	12.3	6.5	11.4	13.4	13%
Junction-4	7.4	14	16.7	8.8	15.4	18.1	12%
Junction-6	12.8	24.4	29.2	15.6	27.4	32.2	15%
Junction-7	39.8	76.4	91.6	48.9	85.8	101	15%
Junction-8	7.2	13.8	16.6	7.2	13.8	16.6	0%
Junction-9	3.7	7.2	8.6	3.7	7.2	8.6	0%
Reach-1	0.4	0.8	0.9	0.4	0.8	0.9	0%
Reach-10	6.7	12.9	15.5	6.7	12.9	15.5	0%
Reach-11	42.2	80.9	97	50.4	89.5	105.7	13%
Reach-12	6.7	12.9	15.5	6.7	12.9	15.5	0%
Reach-2	0.4	0.8	1	0.4	0.8	1	0%
Reach-3	3.8	7.3	8.8	4.7	8.2	9.7	15%
Reach-4	6.2	11.9	14.2	7.5	13.2	15.5	14%
Reach-5	6.9	13.1	15.7	8.4	14.7	17.3	15%
Reach-6	11.1	21.3	25.5	13.6	23.9	28.2	15%
Reach-7	38	72.9	87.4	46.7	82	96.6	15%
Reach-8	7.2	13.8	16.6	7.2	13.8	16.6	0%
Reach-9	3.7	7.1	8.5	3.7	7.1	8.5	0%
Subbasin-1	0.4	0.8	0.9	0.4	0.8	0.9	0%
Subbasin-10	4.3	8.3	9.9	4.3	8.3	9.9	0%
Subbasin-11	1	2	2.4	1.3	2.3	2.7	19%
Subbasin-12	5.2	9.9	11.8	5.2	9.9	11.8	0%
Subbasin-13	13.2	25.3	30.4	13.2	25.3	30.4	0%
Subbasin-2	0.4	0.8	1	0.4	0.8	1	0%
Subbasin-3	5.3	10.1	12	6.4	11.2	13.2	14%
Subbasin-4	7.3	13.8	16.5	8.7	15.3	18	13%
Subbasin-5	7.2	13.7	16.4	8.8	15.4	18.1	15%
Subbasin-6	6.5	12.4	14.9	7.9	13.9	16.3	14%
Subbasin-7	20.8	40	47.9	25.6	44.9	52.9	15%
Subbasin-8	0.7	1.4	1.7	0.7	1.4	1.7	0%
Subbasin-9	3.7	7.2	8.6	3.7	7.2	8.6	0%

The result of peak discharge for all hydrology elements is tabulated in Table 6. It is includes the value of peak flow for 5 years, 50 years, and 100 years. Meanwhile, the value of percentage describes how many percent of flow rate changed due to development of palm oil plantation. The data describe that the flow rate in the area is either increase or remain constant. The entire flow rate which is related to the sub-basin 3, 4, 5, 6, and 7 will increase due to palm oil plantation project. The highest percentage of flow rate changes is 19% which is sub-basin 11. This is due to the location of sub-basin 11 itself that makes to receive flow rates from sub-basin 3,4,5,6, and 7.

Depth

In HEC-RAS, the result of river depth for 5 years, 50 years, and 100 years were plotted in a profile that starts from upstream to downstream of every reach. If all the reach is combined, it can show the increment of the water in the channel. Figure 4(a)- (f) of profile plot of every reach in the Sg. Pandan's HEC-RAS model. The blue region shows the water level for 5 years event, and the blue line shows the 50 and 100 years event. For example, in Figure 4a the depth of 5 years event is remain inside the river bank but for 50 and 100 years event, the water level surpass the river bank which means flooded. Overall increment of water level is about 1-1.5 meter away from normal but still flooded due to the shorts height of river bank. The difference between pre-development and post-development are small which is +0.2m increment.

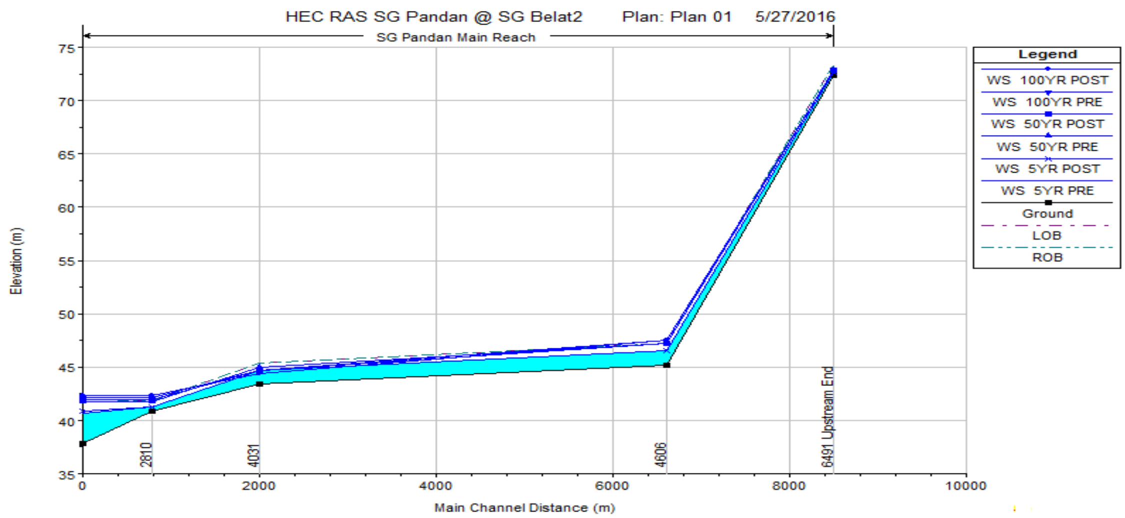


Figure 4a: Profile plot for Reach 9, 10, 12, and 8

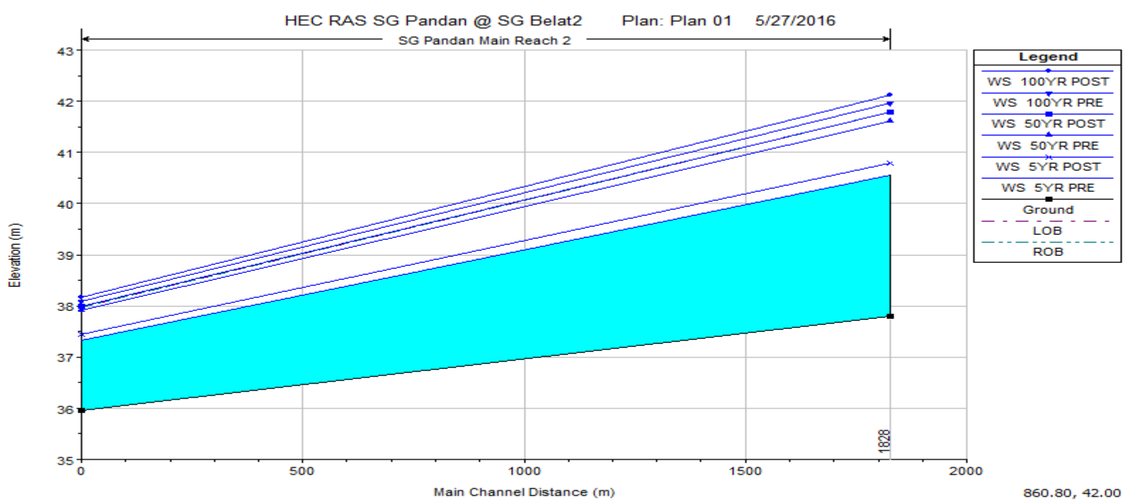


Figure 4b: Profile plot for Reach 11

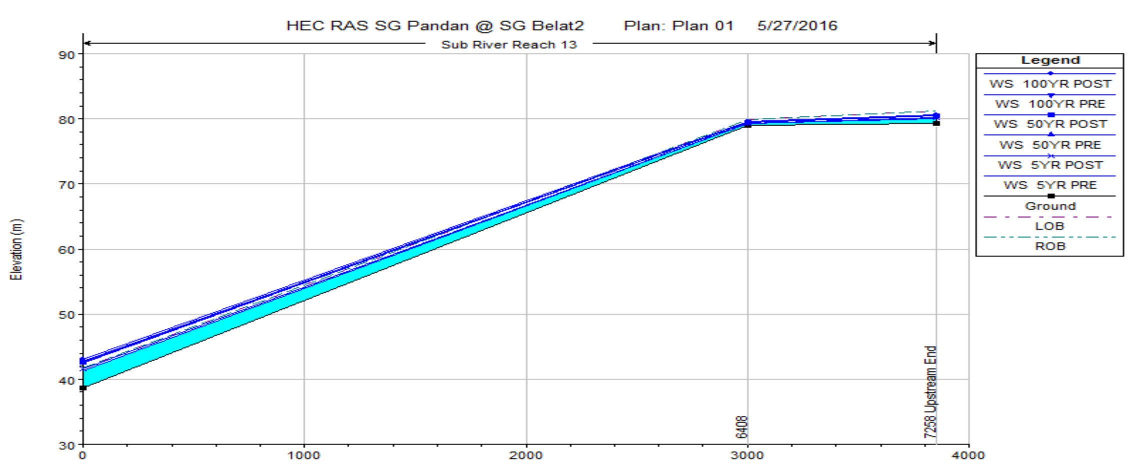


Figure 4c: Profile plot for Reach 1 and 3

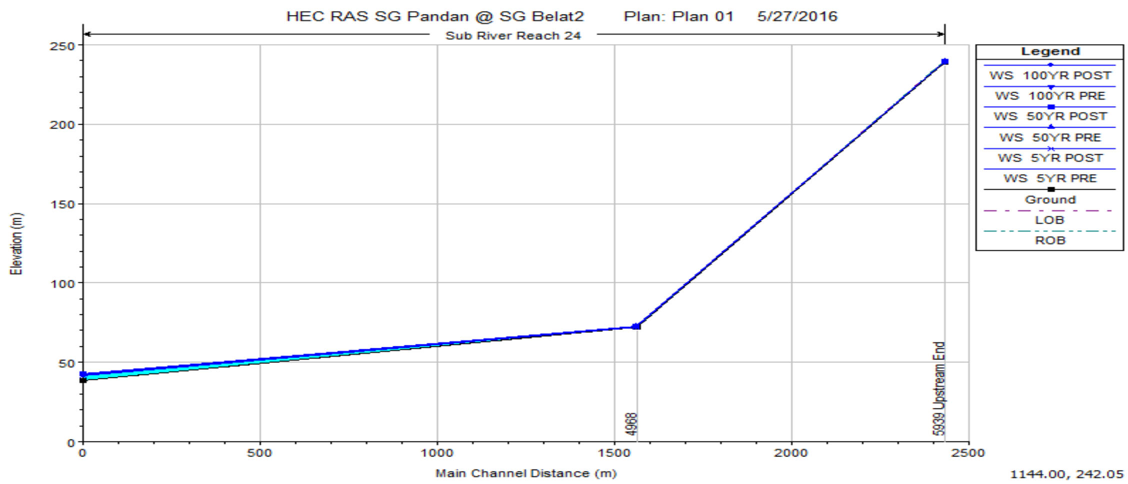


Figure 4d: Profile plot for Reach 2 and 4

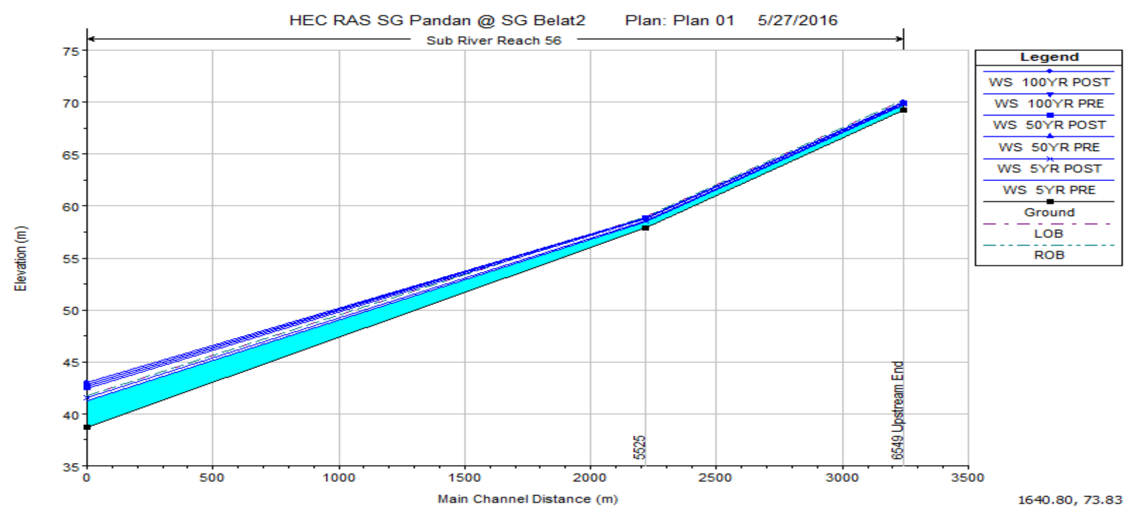


Figure 4e: Profile plot for Reach 5 and 6

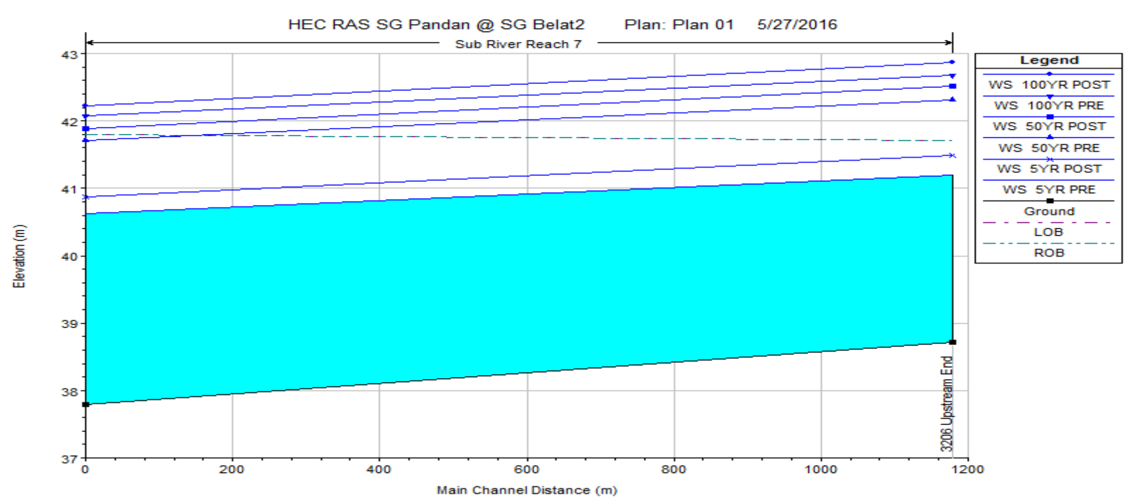


Figure 4f: Profile plot for Reach 7

Velocity

Table 7 shows the velocity of all nodes modelled in HEC-RAS. The velocity data consist of 5, 50 and 100 years event for pre and post-development. The percentage describes the changes in velocity that happened between pre-development and post-development. Main River is named as Sg. Pandan meanwhile Sub-River is named as Sub River. The highest velocity recorded is 3.51m/s which is during 100 years post-development event at the downstream of Sg. Pandan and it is the lowest point and the output for all catchment. Meanwhile the highest percentage difference happens at the Sg. Pandan-Reach 12-4081 which is 25% and the point is not affected by the development. This is probably due to channel cross section between Station 4031 and the upstream station, Station 2028, is quite big which is 2.2m. However, it is proven that project development cause velocity to increases. All the channel which are affected by project development shows positive increment while others shows negative increment or remain constant.

Table 7: Channel velocity result

River	Reach	River Station	Velocity (m/s)						Percentage Changes
			5YR Pre	50YR Pre	100YR Pre	5YR Post	50YR Post	100YR Post	
Sub River	Reach 2	5939	0.75	0.97	1.06	0.76	0.95	1.04	-1%
	Reach 4	4968	1.79	2.08	2.16	1.87	2.12	2.2	3%
	Reach 4	3406	0.17	0.21	0.22	0.18	0.21	0.23	3%
Sub River	Reach 1	7258	0.05	0.07	0.07	0.05	0.07	0.07	0%
	Reach 3	6408	1.75	2.14	2.27	1.86	2.21	2.33	4%
	Reach 3	3406	0.11	0.13	0.14	0.11	0.13	0.14	0%
Sub River	Reach 5	6549	1.34	1.67	1.77	1.44	1.74	1.83	5%
	Reach 6	5525	2.13	2.48	2.59	2.23	2.54	2.65	3%
	Reach 6	3406	0.31	0.37	0.39	0.33	0.39	0.41	6%
Sub River	Reach 7	3206	1.16	1.38	1.47	1.24	1.45	1.53	5%
	Reach 7	2028	0.95	1.22	1.3	1.06	1.29	1.38	8%
SG Pandan	Reach 9	6491	1.67	1.98	2.07	1.67	1.98	2.08	0%
	Reach 10	4606	0.47	0.57	0.59	0.47	0.56	0.57	-2%
	Reach 12	4031	0.77	1.11	1.75	0.77	1.42	2.58	25%
	Reach 8	2810	1.87	1.44	1.02	1.87	1.05	0.87	-14%
	Reach 8	2028	0.18	0.23	0.24	0.16	0.21	0.23	-8%
SG Pandan	Reach 11	1828	1.17	1.5	1.6	1.27	1.57	1.67	6%
	Reach 11	0	2.65	3.22	3.43	2.76	3.3	3.51	3%

Sediment Transport Capacity

The results of sediment transport capacity, as shown in Table 8, is a results calculated by HEC-RAS modelling based on sieve analysis and hydraulic characteristic data for each reaches in the studied river. The sediment transport capacity displayed its value in tones per day and is analyzed for 5 years event only. The table shows the difference of sediment transport capacity both before and after project development, significantly determine the condition of channel in whether it is eroded or sediment surplus. The positive value of percentage difference shows that the point at the reach is being eroded and negative value means sediment surplus. The highest capacity of sediment transport is in the station 0 which is the output point of the river by 1624 tonnes per day.

Table 8: Sediment capacity result

River	Reach	River Station	Sediment Transport Capacity (Tonnes/day)		Sediment Difference (Tonnes/day)	Percentage of Changes
			5YR Pre	5YR Post		
Sub River	Reach 2	5939	60	66	-6	10%
	Reach 4	4968	1259	1595	-336	27%
	Reach 4	3406	0	0	0	0%
Sub River	Reach 1	7258	0	0	0	0%
	Reach 3	6408	125	164	-39	31%
	Reach 3	3406	0	0	0	0%
Sub River	Reach 5	6549	635	949	-314	49%
	Reach 6	5525	3475	4476	-1001	29%
	Reach 6	3406	0	0	0	0%
Sub River	Reach 7	3206	247	363	-116	47%
	Reach 7	2028	75	141	-66	88%
SG Pandan	Reach 9	6491	25	25	0	0%
	Reach 10	4606	0.2	0.2	0	0%
	Reach 12	4031	244	244	0	0%
	Reach 8	2810	113	113	0	0%
	Reach 11	2028	0	0	0	0%
SG Pandan	Reach 11	1828	51	81	-30	59%
	Reach 13	0	6131	7755	-1624	26%

In HEC-RAS, the results of sediment transport capacity are displayed in the form sediment rating curve plot and sediment profile plot. Figure 5a shows the sediment rating curve which is the plot of total cross section flow versus sediment capacity, meanwhile Figure 5b shows the sediment profile that is the plot of sediment capacity versus distance in main channel.

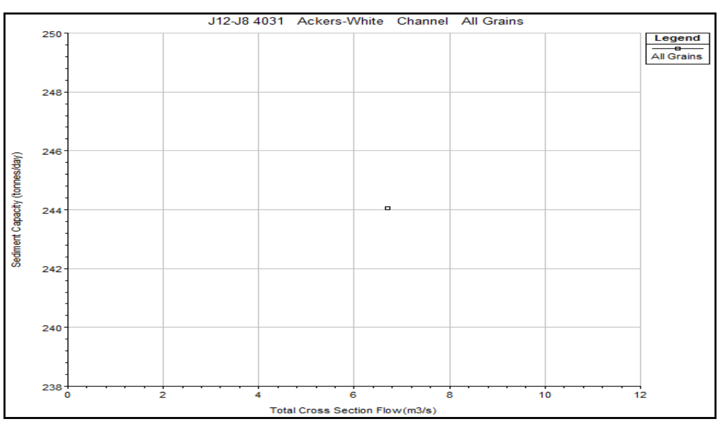


Figure 5a: Sediment rating curve for Station 4031

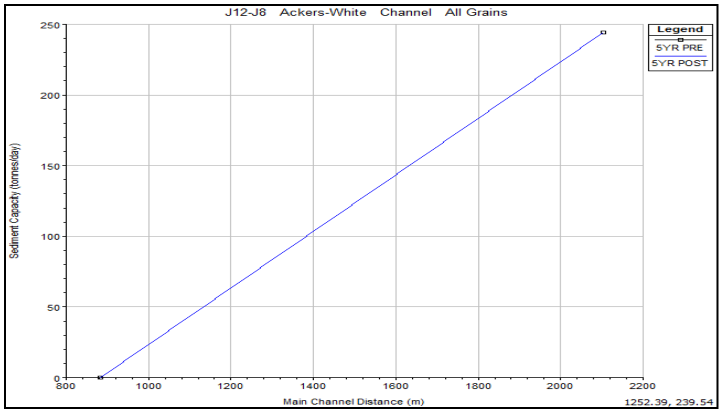


Figure 5b: Sediment profile for Station 4031

Conclusion

In this study, results obtained by using HEC-HMS and HEC-RAS modelling is sufficient enough in order to determine the effect of change in land usage towards Sungai Pandan. From the results, we could tell that the change of land usage do alters the natural hydrological characteristics of the river. It can be justified by compares the results of peak discharge, depth, velocity, and sediment transport capacity, both before and after project development. Based on the analyzed results, the value of peak discharge, depth, velocity, and sediment transport capacity of the river are increasing. The average peak discharge, velocity, and sediment transport capacity shows increment about 7%, 3%, and 20% respectively. The depth of water level is increasing and for 50 years and 100 years event, most of the water level is passing the side bank level of the river, which means it is flooding. Therefore, the change of land usage in the river basin of Sungai Pandan, which is once is a natural forest then turn to oil palm plantation, will make the river lost its efficiency to deliver water to the downstream.

References

[1] Axel, B., Daniel, N. and Gerd, B., Effects of Climate and Land-Use Change on Storm Runoff Generation: Present Knowledge and Modelling Capabilities, Hydrology Process. 16 2002 509-529.

[2] Harbor, J.M., A Practical Method for Estimating the Impact of Land Use Change on Surface Runoff, Groundwater Recharge and Wetland Hydrology, *Journal of The American Planning Association. 60 (1) 1994 95-108.*

[3] Leopold, L.B. (1968). Hydrology for Urban Land Planning – A Guidebook on The Hydrologic Effects of Urban Land Use.

[4] Harbor. J. M., A Practical Method for Estimating the Impact of Land Use Change on Surface Runoff, Groundwater Recharge and Wetland Hydrology, *Journal of The American Planning Association. 60(1) 1994 95-108*