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Implementation SMK3L Using HIRARC Method on the Drainage Project in the City of Samarinda

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Abstract – The Semani Drainage Works Project (Sentosa-Remaja-A. Yani) is an initiative in the development of waterways in Samarinda City. The large-scale development and the high level of risk of work accidents on the project require close monitoring of the Environment-Based Occupational Health and Safety Management System (SMK3L). This study aims to identify potential hazards and analyze the risks of potential hazards and design improvements to reduce the impact of risks using the Hazard Identification Risk Assessment and Risk Control (HIRARC) method. The result of this research is the discovery of 117 potential hazards on projects located in three different locations. Where the drainage work on Jalan Pemuda 1 has a low risk level (low) of 21%, a moderate risk level (moderate) of 38%, a high risk level (high) of 41%, and an extreme risk level (extreme) of 0%. For drainage work on the D.I. Pandjaitan road, it has a low risk level (low) of 18%, a moderate risk level (moderate) of 31%, a high risk level (high) of 51%, and an extreme risk level (extreme) of 0%. And for the level of risk in drainage work on Sentosa road has a low risk level (low) of 18%, a moderate risk level (moderate) of 36%, a high risk level (high) of 46%, and an extreme risk level (extreme) of 0%. Risk control or improvement design focuses on Engineering Control and administration as well as Personal Protective Equipment (PPE).

Keywords: Drainage, OSHMS, HIRARC

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1. Introduction

The Flood Control Project is a drainage cahnnel construction project [1]. The Flood Control Project is a drainage cahnnel construction project [2]. This is what makes the East Kalimantan Public Works Office of Spatial Planning and Public Housing in the Water Resources Management Division hold a Flood Control Project and renovate drainage channels.

The Ministry of Public Works in Permen PU 05/PRT/M/2014 defines the Environment-Based Occupational Health and Safety Management System (SMK3L) as an element of the organization's system management in the implementation of construction works [3]. Occupational Health and Safety (OHS) is very important, especially in construction. OHS is a crucial aspect, especially for construction workers. The implementation of OHS risk management is able to prevent or minimize the potential for work accidents. Even if an accident occurs, the impact can be minimized thanks to the application of risk management [4].

According to data from the International Labor Organization (ILO) in 2018, there are 1.8 million deaths per year caused by work in the Asia and Pacific region. This figure is two-thirds of the world's total work-related deaths [5]. At the global level, there are more than 2.78 million deaths per year due to ACC and PAK. In addition, there are 374 million cases of occupational diseases and serious injuries per year [6] [7] [8].

BPJS Employment data shows an upward trend in work accident cases. In 2017, there were 123,041 cases, increasing to 173,105 cases in 2018 with Work Accident Insurance (JKK) claims reaching Rp. 1.2 trillion. In 2019, it decreased to 114,000 cases, but again increased dramatically in 2020 with 177,000 cases. From January to September 2021, there were 82,000 cases of work accidents and 179 cases of occupational diseases, with 65% of them caused by Covid-19 [9].

In response to this situation, it is important to make efforts to prevent work accidents. One way is to conduct a study on the characteristics of work accidents. This study can help understand the patterns and causes of work accidents, so that prevention and mitigation efforts can be carried out with the right approach. Hazard identification is a vital first step in building an effective risk management system. By systematically identifying and assessing hazards, companies can minimize the potential for accidents and occupational diseases, and create a safe and healthy work environment [10]

Research on potential risks related to Occupational Health and Safety on the production floor of PT Coca Cola Bottling Indonesia Semarang unit analyzes risks using the HIRARC method to determine the level of risk. The initial stage in this analysis is the identification of potential risks of accidents and health problems on the production floor of PT Coca Cola Bottling Indonesia Semarang unit. After that, for each risk, the likelihood of occurrence (likelihood) and the severity if the risk results in an accident or health problem (severity) are assessed. The final stage is to assign a risk score and its ranking. The highest-ranked risks are recommended to be prioritized for handling [11].

One approach that can be used in this study is (HIRARC). It differs from (HIRADC) in that the risk assessment also considers the controls already in place at the company. In the absence of existing controls, the HIRARC method is an appropriate choice to apply in this company context. HIRARC is a series of steps to identify risks that can occur in daily and unscheduled activities in the company, then assess the risks associated with the hazards, and design a control program to reduce the risks to fewer with the aim of preventing accidents. The main purpose of using HIRARC is to conduct a systematic review of processes within an organization to determine if there are potential risks that could lead to unwanted events or accidents. Through identification using the HIRARC method, the level of risk in an activity can be found, evaluated, and allows for improvements to be made in the Occupational Health and Safety (OHS) system to control the risks that arise. Finally, this research provides suggestions for OHS improvements based on the findings of the problems identified..

2. Theoretical Basis

A work accident is an unexpected and unwanted event, which disrupts the smooth running of activities and can cause losses to people and property. This research was carried out in a systematic and structured manner, ensuring that the whole process went well.

2.1 Risk Identification Procedure

Risk identification is an effort to recognize or find potential risks that may arise in activities carried out by the company [12]. Company managers are responsible for identifying risks by investigating the possibility of loss, evaluating the frequency and level of risk, selecting the most effective risk anticipation methods, and managing risk management programs. Information about risks can be obtained from internal documents such as financial reports, standard operating procedures, human resource documents, and other sources of information

The risk identification process needs to be done comprehensively or thoroughly to minimize the chance of undetected risks [13].

1. Problem Identification
2. Identification of Potential Hazard
3. Risk Assesment
4. Risk Control

2.2 Hazard Identification Risk Assesment and Risk Control (HIRARC)

The HIRARC method is an approach used to reduce risks and minimize hazards in the workplace. It aims to eliminate or reduce the risks associated with various hazards present in the workplace through a structured and phased approach [14] [15].

Risk assessment is the process of evaluating the level of risk that may lead to occupational accidents and work-related diseases. This assessment is carried out on sources of danger in the work area [16]. Risk assessment is the process of evaluating the risk of hazards that arise by calculating the risk value and determining which risks are acceptable and which are not [17]. The calculation of risk values in the AS/NZS 4360:2004 Australian and New Zealand standard uses two main elements [18].

The likelihood in risk assessment indicates how often a work accident is likely to occur. Table 1. shows the likelihood criteria consisting of five levels, starting from the highest "almost certain", followed by "likely", "possible", "unlikely", and the lowest "rare". An explanation of these levels can be seen in Table 1 as follows.

Table 1 Likelihood Criteria

Tingkat	Kriteria	Keterangan
5	*Almost Certain*	Every time an accident occurs
4	*Likely*	Frequent accidents
3	*Possible*	Accidents may occur
2	*Unlikely*	Accidents are rare
1	*Rare*	Very rare ar no accidents occur

Source : HIRARC Method

After assessing the likelihood of a hazard, the next step is to assess the severity of the accident that may occur. Severity describes how severe the impact of the accident is. Severity levels with five levels, namely (insignificance), followed by (minor), (moderate), (major), and the highest (catastrophic) can be seen in Table 2 below).

Table 2 Severity Criteria

Tingkat	Kriteria	Keterangan
1	*Insignification*	No injuries, minor, loses, activities do not stop
2	*Minor*	There are injuries that are handled only by firs aid, small losses
3	*Moderate*	There are injuries that require medical attention, losses are substantial
4	*Major*	The onset of injury leading to disability and substantial losses
5	*Catastrophic*	Deaths and major losses leading to work stoppages

Source : HIRARC Method

After determining the likelihood and severity, the next step is to calculate the risk value using the Risk Matrix. Risk Matrix is a table that shows the level of risk based on the combination of likelihood and severity. Risk matrix values indicate risks that may occur at low, medium, high, or extreme levels. The risk matrix can be seen in Table 3 as follows

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Table 3 Risk Matrix

Likelihood	*Severity*				
	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Source : HIRARC Method

Table 3 above shows the value of the risk matrix which has the lowest value of 1 and the highest value is 25.

Green (low) risks at low levels can be overcome by routine After identifying the source of the hazard and conducting a risk assessment, the next step is risk control. The data or values obtained from the risk assessment are used as a guide in assessing the results of risk control. Risk control is the steps in managing possible hazards and monitoring regularly to ensure that work activities can be carried out safely. The risk control hierarchy can be shown in Figure 1 bellow.

Picture 1. Risk Control Hierarchy

The risk control hierarchy is a systematic method for minimizing the potential for workplace accidents. Designed in order of priority, this method helps companies and organizations choose the best measures to create a safe and healthy work environment [19] [20] [20] [21] [22] [23].

3. Research Method

Observations are made directly at the job site to identify potential hazards from a variety of sources, including the workplace situation, physical hazards, and work environment conditions. Information can also be obtained from the experiences of others. The u-ditch drainage works at the Semani project used precast concrete and involved steps such as traffic engineering, excavation measurement, excavation, excavation disposal, backfilling with selected backfill soil, and finishing**.** The job description can be seen in Table 4 as follows

Table 4. Job Description

No		Pekerjaan
1	Traffic Engineering	- Manage road traffic affected by disruptions due to project implementation
2	Measurement of Excavator Area	- Measure the area where the u-ditch drainage channel will be constructed
3	Land Excavator	- Excavation of soil using heavy equipment, namely excavators
4	Disposal of Excavator Soil	- Dumping most of the excavated soil out - Leaving excavated soil fot backfilling
5	Work Floor Creation	- Make the ground flat so that the elevation of each u-ditch is the same
6	U-ditch Lifting Process	- The u-ditch is lifed with an excavator and carried to the excavation site
7	U-ditch installation	- After the u-ditch transportation process, it is placed in the excavation that has been made
8	Backfilling Process	- Performing the backfill process with an excavator
9	Finishing/Housekeeping	- Perform finishing work and tidy up and clean up the work area

Data were collected directly at the Semani (Sentosa-Remaja-A. Yani) Flood Control project. The data processing included the following steps: a) understanding the sequence of the drainage project work process; b) identifying potential hazards from the beginning to the end of the project work; c) observing deviations that could cause work accidents; d) completing the HIRARC criteria on the worksheet; and e) ranking the identified potential hazards. Furthermore, the data was processed using Microsoft Excel. The research was conducted at Jalan Pemuda 1, Jalan D.I Pandjaitan and Jalan Sentosa, Temindung Permai Village, Sungai Pinang District, East Kalimantan Province during the project.

4. Result and Discussion

4.1 Identification of Potential Hazard in Drainage Work at Semani (Sentosa-Remaja-A. Yani)

In the first stage of HIRARC, hazards and risks were identified during the construction of the Semani drainage (Sentosa-Remaja-A. Yani). The identification of hazards and risks is sorted according to the stages of work activities in drainage construction. The following are the results of hazard identification in work activities in drainage construction wich can be seen in Table 5 as follows.

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Table 5. Identification of Potential Hazards in Drainage Work SEMANI Using the HIRARC Method

No	Job Description		Hazard	Risk
			1. Traffic Engineering	
a	Traffic Engineering Process	1	Exposure to heavy rain and sunlight	Headache/ Fever
	Tools used :			
	1. Traffic Signs	2	Direct exposure to sunlight	Headache/ Fever
	2. Street Lighting Equipment	3	Noise	Disturbed Ear
			2. Measurement of Excavation Area	
a	Excavation Area Measurement Process	1	Exposed to sharp objects in the field	Injury to body parts
	Tools used :			
	2. Meter	2	Exposure to vehicle dust	Infection of the eyes and nose
			3. Land Division	
a	Soil Excavaton Process	1	Danger due to landslide excavation slope	Buried, fall, slip, fracture, death
	Tools used :			
	1. Excavator PC 55	2	Excavator upside down	Injury to body parts
		3	Exposure to heat and excessive workload	Fatigue resulting in work stress, heat stress due to hot working temperatures
		4	Exposure to dust from excavated materials	Respiratory system disorders, skin and eye irritation
		5	Vibration when the excavator breaker is working	Tremor, pain and sensory nerve impainment
			4. Disposal of Excavated Soil	
a	The process of transporting excavated products	1	Hit by excavator swing arm shile loading material into dump truck	Falls, injuries to body parts, broken bones, property damage
	Tools used:			
	1. Excavator PC 55	2	Spilled material on public roads	Harm to road users, falls, slipd, injuries
	2. Dump Truck	3	Accident caused by being hit by a dump truck	Severe inuries, broken bones, death
		4	Exposure to dust from transported materials	Respiratory system disorders, skin and eye irritation
		5	Dump truck overturned while loading materials	Falls, injuries to body parts, broken bones, property damage
			5. Work Floor Creation	
a	Working Floor Manufacturing Process	1	Exposed to sharp objects in the field	Injury to body parts
	Tools used:			
	1. Hammer	2	Exposed to sharp objects in the field	Injury to body parts
	2. Spikes	3	Exposed to sharp objects in the field	Injury to body parts
			6. U-ditch Transportation	
a	U-ditch Transportation Process	1	Wire sling disconnected	Severe inuries, broken bones, death
	Tools used :			
	1. Crane	2	Bimping into existing due to being hit by other object	Severe inuries, broken bones, death
		3	Hit by a passing vehicle	Severe inuries, broken bones, death

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No	Job Description		Hazard	Risk
		4	Concrete U-ditch drop	Severe inuries, broken bones, death
		5	Crane overtuned due to overload	Harm to road users, falls, slipd, injuries
			7. U-ditch Installation	
a	U-ditch Concrete Installation Process Tools used : 1. Crane	1	Wire sling disconnected	Severe inuries, broken bones, death
		2	Bimping into existing due to being hit by other object	Severe inuries, broken bones, death
		3	Hit by a passing vehicle	Severe inuries, broken bones, death
		4	Concrete U-ditch drop	Severe inuries, broken bones, death
		5	Crane overtuned due to overload	Harm to road users, falls, slipd, injuries
	2. Excavator PC 55	6	Excavator rolled over	Harm to road users, falls, slipd, injuries
			8. Backfilling of Work Area	
a	The process of backfilling the work area Tools usee : 1. Excavator PC 55	1	Exposure to dust from transported materials	Respiratory system disorders, skin and eye irritation
		2	Excavator rolled over	Injury to body parts
		3	Exposure to heat and excessive workload	Fatigue resulting in work stress, heat stress due to hot working temperatures
		4	Vibration when the excavator breaker is working	Tremor, pain and sensory nerve impainment
	2. Dump Truck	5	Accident caused by being hit by a dump truck	Severe inuries, broken bones, death
		6	Dump truck overturned while loading materials	Falls, injuries to body parts, broken bones, property damage
			9. Finishing/ Housekeeping	
a	Housekeeping Tools used : 2. Water Pump	1	Dust exposure	Respiratory system disorders, skin and eye irritation
		2	Exposure to heavy rain and sunlight	Headache/ Fever
		3	Direct exposure to sunlight	Headache/ Fever
		4	Noise	Disturbed

In Table 5, the stages of the Semani (Sentosa-Remaja-A. Yani) drainage works include 9 work items, namely: traffic engineering work, measurement of excavation area, excavation of soil, disposal of excavation results, construction of work floor, transportation of u-ditch, installation of u-ditch, backfilling of work area, and finishing/housekeeping work.

4.2 Risk Assessment Analysis Before and After Control Using HIRARC

In this risk assessment, it is conducted prior to the implementation of risk controls. Risk assessment is performed on every potential hazard identified in the drainage work activities found in the Semani (Sentosa-Remaja-A. Yani) project. Below in Table 6 is a summary of the risk level values obtained from data processing.

Table 6 Total Risk Level Values Before Control

No	Drainage Activities	Risk Level				Total
		Low	Moderate	High	Extreme	
1	Pemuda 1	6	2	13	18	39
2	D.I. Pandjaitan	2	4	12	21	39
3	Sentosa	2	4	17	16	39
	Total	10	10	42	55	117

In Table 6 above is a summary of risk level values based on each stage in the drainage work process in

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Semani (Sentosa-Remaja-A. Yani). There are 117 risk assessments for each potential hazard identified at three different locations. In the table above, risk assessments and risk levels are sorted or categorized according to the stages of work listed in Table 4 earlier. The summary result of risk assessments from the drainage work process is as follows.

1. Low Risk Level

At this risk level, there are 10 risk values at different locations, including 6 risk values on Youth Road 1, 2 risk values on D.I. Pandjaitan Road, and 2 other risks on Sentosa Road.

2. Moderate Risk Level

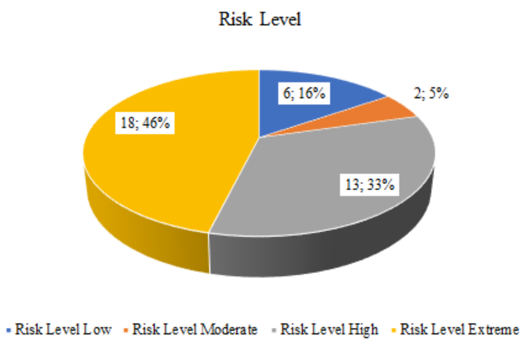
At this risk level, there are 10 risk values at three different locations, namely 2 risk values on Youth Road 1, 4 risk values on D.I. Pandjaitan Road, and 4 risk values on Sentosa Road.

3. High Risk Level

At this risk level, there are 42 risk values at different locations, including 13 risk values on Youth Road 1, 12 risk values on D.I. Pandjaitan Road, and 17 other risks on Sentosa Road.

4. Extreme Risk Level

At this risk level, there are 55 risk values at three different locations, with 18 risk values on Youth Road 1, 21 risk values on D.I. Pandjaitan Road, and 16 risk values on Sentosa Road. The following percentage of risk value can be seen in Figure 2 bellow.



Picture 2. Percentage of Risk Values Before Control

Based on Table 5 and the explanation in the paragraph above, it can be determined that the average work activity is at an extreme risk level. The percentage of risk values before control is as shown in Figure 2 above, with 46% at the extreme risk level, 33% at the high risk level, 16% at the moderate risk level, and 5% at the low risk level. The number of risk level values after control can be seen in Table 7 as follows

Table 7 Total Risk Level Values After

No	Drainage Activities	Risk Level				Total
		Low	Moderate	High	Extreme	
1	Pemuda 1	8	15	16	0	39
2	D.I. Pandjaitan	7	12	20	0	39
3	Sentosa	7	14	18	0	39
	Total	22	41	54	0	117

In Table 7 above is a summary of the risk level values after controls based on each stage in the drainage work process at Semani (Sentosa-Remaja-A. Yani). There are 117 risk assessments for each hazard potential identified at three different locations. In the table above, risk assessments and risk levels are sorted or divided based on the stages of work found in the previous Table 6. The summary result of risk assessments from the drainage work process is as follows.

1. Low Risk Level

At this risk level, there are 22 risk values at different locations, including 8 risk values on Pemuda 1 road, 7 risk values on D.I. Pandjaitan road, and 7 other risks on Sentosa road.

2. Modarate Risk Level

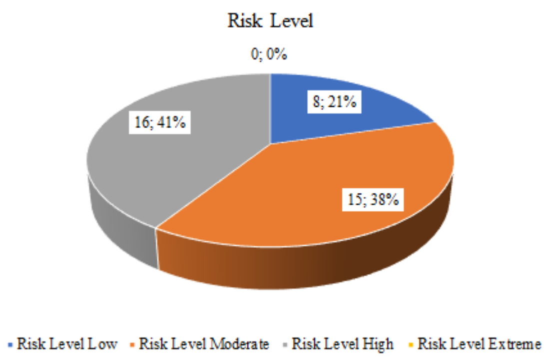
At this risk level, there are 41 risk values at three different locations, including 15 risk values on Pemuda 1 road, 12 risk values on D.I. Pandjaitan road, and 14 risk values on Sentosa road..

3. High Risk Level

At this risk level, there are 54 risk values at different locations, including 16 risk values on Pemuda 1 road, 20 risk values on D.I. Pandjaitan road, and 18 other risks on Sentosa road.

4. Extreme Risk Level

At this risk level, there are 55 risk values at three different locations, including 18 risk values on Pemuda 1 road, 21 risk values on D.I. Pandjaitan road, and 16 risk values on Sentosa road. The following percentage of risk value can be seen in Figure 3 bellow



Picture 3. Percentage of Risk Values After Control

Based on Table 7 and the explanation in the paragraph above, it can be understood that the average work activity after risk control is at a high-risk level. The percentage of risk values before control is as shown in Figure 2 above, with 41% at the high-risk level, 38% at the moderate-risk level, and 21% at the low-risk level. The graph of risk

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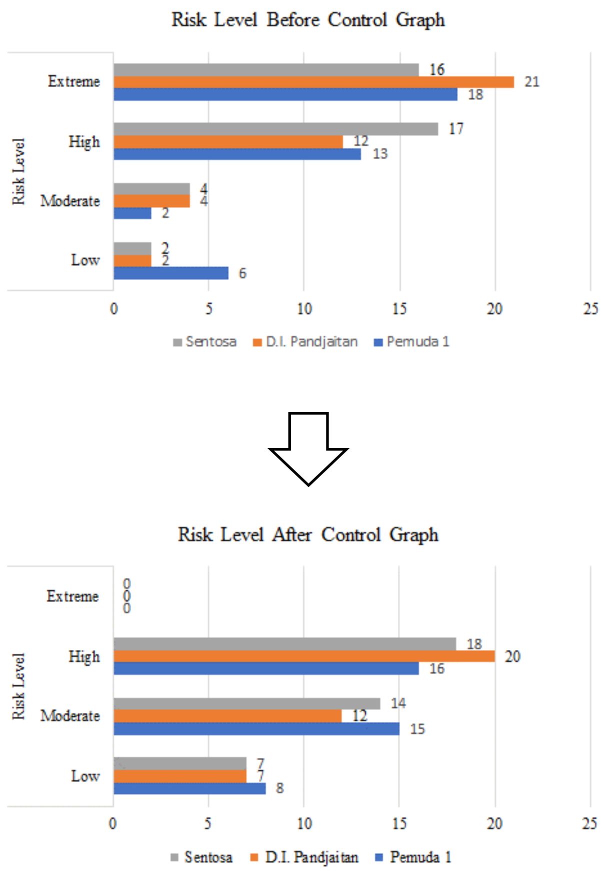
levels before and after control can be seen in Figure 4 as follows.



Picture 4. Percentage of Risk Values After Control

Figure 4 above shows a graph comparing the risk level values before and after risk control measures were implemented. It can be seen from the graph above that there is a decrease in risk level values for identified hazards in the drainage work activities at Semani (Sentosa-Remaja-A. Yani). Before control measures, there were 55 extreme risk level values at three different locations, which decreased to zero after control measures were implemented. At the high-risk level, there were 42 risk values before control measures and 54 risk values after control measures. At the moderate-risk level, there were 10 risk values before control measures and 41 risk values after control measures. Lastly, at the low-risk level, there were 10 risk values before control measures and 22 risk values after control measures were implemented

4.3 Analysis of Risk Level Comparison After Control

Based on the assessment results of risk levels after controls at three different locations, the next step is to compare the risk levels. For drainage work on Pemuda 1 road, the risk levels are as follows: low risk level is 21%, moderate risk level is 38%, high risk level is 41%, and extreme risk level is 0%. For drainage work on D.I. Pandjaitan road, the risk levels are: low risk level is 18%, moderate risk level is 31%, high risk level is 51%, and extreme risk level is 0%. Finally, for drainage work on Sentosa road, the risk levels are: low risk level is 18%, moderate risk level is 36%, high risk level is 46%, and extreme risk level is 0%

5. Kesimpulan

After risk control measures were implemented in the drainage work activities at Semani (Sentosa-Remaja-A. Yani), the values at extreme risk level changed from 55 to 0, high risk level from 42 to 54, moderate risk level from 10 to 41, and low risk level from 10 to 22.

Based on the assessment results of risk levels after controls at three different locations, for drainage work on Pemuda 1 road, the risk levels are as follows: low risk level is 21%, moderate risk level is 38%, high risk level is 41%, and extreme risk level is 0%. For drainage work on D.I. Pandjaitan road, the risk levels are: low risk level is 18%, moderate risk level is 31%, high risk level is 51%, and extreme risk level is 0%. Finally, for drainage work on Sentosa road, the risk levels are: low risk level is 18%, moderate risk level is 36%, high risk level is 46%, and extreme risk level is 0%

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