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Stormwater and Drainage Master Plan and Formulation of Best Management Practices for Cameron Highlands

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Abstract: ***One of the main ecotourism areas in Malaysia is Cameron Highlands and due to illegal farming and uncontrolled logging, the rivers are being polluted. The main problems lie in Cameron Highlands included stormwater management, water quantity and water quality issues, sedimentation problem, mud flood as well as erosion and landslide occurrence. Therefore, this research is generating the stormwater and drainage Master Plan for the Cameron Highlands. The research aims to minimize the flooding impacts due to inadequacies in stormwater and drainage systems in urban areas and agricultural farms and provide a holistic solution which cultivated a specific guideline for agricultural in hilly areas. The recommended stormwater management master plan is focused on providing quantity and quality control system, sedimentation basins and slope protection work. The master plan also takes into consideration non-structural measures such as public awareness programs and law enforcement scheme. Finally, the research shows the Erosion Induced Landslide Risk Maps for Cameron Highlands Catchment for the stakeholders and farmers. This research thus plays a big role in generating the Erosion and Sediment Control Plan (ESCP) guidelines as one of the stormwaters and drainage master plan component in Cameron Highlands for the relevant authority's agency.***

Keywords: ***Erosion, Drainage, Landslide, Management, Stormwater***

I. INTRODUCTION

United Nations Development Program set 17 Global Goals, which is known as Sustainable Development Goal (SDG). According to one of the goals named as clean water and Sanitation, safe and affordable drinking water for all by 2030 is set. Achievement of this goal requires investing inadequate infrastructure, providing sanitation facilities and encouraging hygiene.

Concisely, protecting and restoring water-related ecosystems is essential [1]. Cameron Highlands is a 'hot spot' for ecotourism. However, due to illegal farming and uncontrolled logging, several rivers have been severely polluted. A study from Environmental Quality Report DOE, 2017, river water quality has been decreased over the past 10 years. The percentage of clean rivers has decreased from 58% to 46% during this period while the percentage of polluted rivers has increased from 8% to 11% in the year 2017 [2].

In the last few decades, the water quality improvements of the river play an important role in the environment [3-7]. The key step of an effective river cleaning process is to identify and quantify the natural and anthropogenic influences. Knowing the contaminant sources well is an essential requirement for the cleanup process planning and mitigation [8-11]. It is being found that the river water quality is more prone to be contaminated in hilly areas. Highly and historically used hilly area such as Cameron Highlands that has a 71,218 square hectors of hilly region known as Titiwangsa Range, thus chosen for this research. The area is famous for Tea Plantation since the British Colonial times, and now become a center for vegetables firm. The government through the Mineral and Geoscience Department has identified 33 critical slopes in Cameron Highlands that are prone to landslide activities [12]. These critical slopes are part of the 517 sites, which have been identified to be prone to landslide activity. The mapping of the dangerous slopes has been carried out since 2014 and involved an area of 275 sq km or 35% of Cameron Highlands total area. Therefore, the Stormwater and Drainage Master Plan for Cameron Highlands offers a holistic approach in an integrated stormwater management system, as well as it captures the sedimentation, erosion, landslide and agricultural aspects.

II. STUDY AREA

Cameron Highlands is one of the smallest districts in Pahang state of Malaysia as illustrated in Figure 1, which is located at North West of the state of Pahang. 712.18 square km is the total area of Cameron Highlands districts, which is closely surrounded by Lipis district on the southeast, Kelantan on the north and Perak on the west. Over the last few years,

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a steady growth of population has faced by the Cameron Highlands, where the rate of inhabitant's increment was underneath 2% per annum. On the other hand, the average national growth rate was about 2.3%.

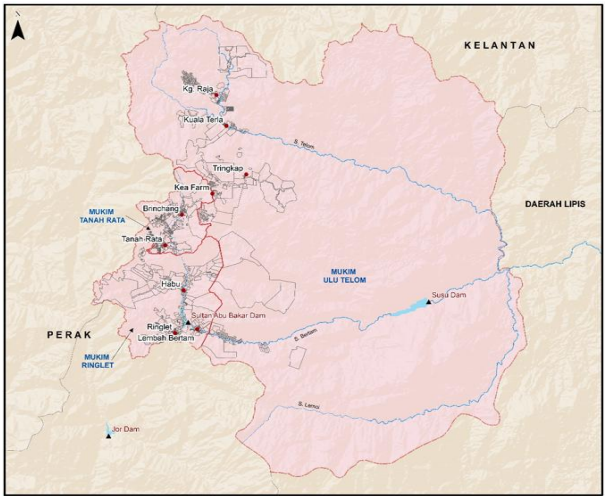

Fig. 1 Location of Cameron Highlands District and its Mukim

There are several issues and problems in the study area. The main issues are on stormwater management are water quantity and water quality (inclusive of environmental aspects). However, there are a few other problems that were identified in Cameron Highlands, which are sedimentation problem, mud flood as well as erosion and landslide occurrence. On 5 November 2014, the muddy floodwaters inundated Bertam Valley when TNB released the water in stages from Sultan Abu Bakar Hydroelectric Dam. More than 20 houses in Ringlet town, Ringlet New Village and Kampung Ulu Merah Ringlet were flooded in knee-deep muddy water. The mud flood and mudslide tragedy resulted in 5 deaths, 5 injuries, 20 houses, and 20 vehicles damaged. 203 people from about 47 families were evacuated at the Ringlet community hall [13].

III. APPROACH OF STORMWATER AND DRAINAGE MASTER PLAN

The primary goal of the study is to deal with the stormwater environment and lessen the effects of development on it. In addition, this study focused on balancing among the social, economic and environmental aspects for attaining sustainable development. As a result, the objectives of this research can be described as follows:

- To form an enduring solution to manage flood water, drainage system and stormwater in the current locations to help people and their properties of getting affected by the adverse scenarios of these issues. In addition, to implement a cohesive stormwater management plan to defend the standing and proposed development.
- To regulate the unnecessary sediment of water channels into a tolerable level, which will control the catchment events by involving the source control procedures during the rate of erosion acceleration
- To prepare an Erosion Induced Landslide Risk Map for Stormwater Management in Cameron Highlands
- To produce Guidelines of ESCP for agricultural activities in highland areas.

The Stormwater and Drainage Master Plan for Cameron Highlands are divided into three (3) major scopes and approach which are Stormwater and Drainage Master Plan Technical Report, Erosion Induced Landslide Risk Map for Agricultural Areas and Erosion and Sediment Control Guidelines for Agricultural Areas. Figure 2 presented the overall concept and scope of the approach for the study.

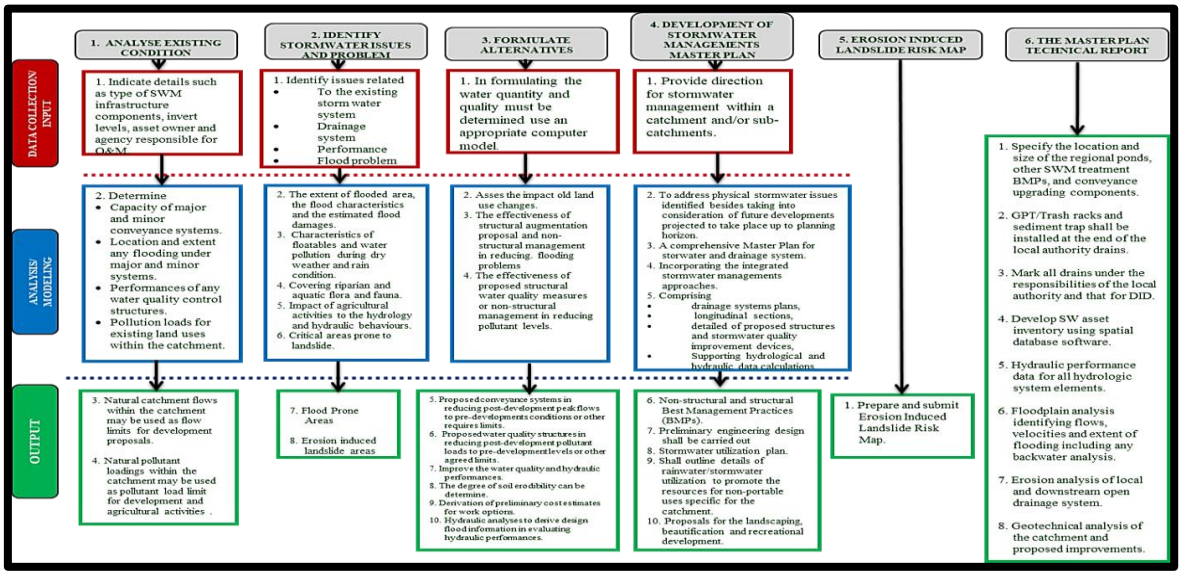

Fig. 2 Overall Scope and Approach for Stormwater and Drainage Master Plan for Cameron Highlands

The execution of this master plan was divided into six (6) phases as shown in Figure 2. Data collection of all relevant data and information such as: reports of past studies relevant to the study area, hydrological data, soil physical properties, survey information, present and future land use, cadastral lots, flooding records, flooding extent, causes of flooding and flood damage, and others were analyzed for further exploration. Apart from that, the conditions and capacity or performance of existing stormwater management infrastructure components comprising conveyance facilities from trunk drain onwards, control structures such as ponds, gates, GPTs etc. were determined.

Proposal of structural augmentation and strategy on non-structural management efficiency is being measured. After that the model proposes a structural and non-structural measurement such water quality and management to reduce flooding and pollutant levels within the catchment areas. The complete stormwater and drainage master plan were then molded based on the proposed structural and non-structural measures that can alleviate the related existing issues and problems in Cameron Highlands.

Erosion Induced Landslide Risk Map (EILRM) for Cameron Highlands catchment was prepared based on the assessment of the level of risk posed by slope failure for a particular area or site involves the consideration of available data. The United Nations (UN) defines natural hazard risk as "the probability of occurrence of a potentially damaging natural phenomenon" [14]. Meanwhile Fell defines hazard risk as "the magnitude of the event times the probability of its occurrence" [15]. Therefore, the principal objective of hazard risk assessment is for the identification of past and present slope failure as well as prediction of the future occurrence.

IV. CAMERON HIGHLANDS STORMWATER AND DRAINAGE MASTERPLAN

In view of the importance of the study area which is to be protected against stormwater flooding and pollution in Cameron Highlands. Therefore, the proposed measures will aim to provide protection for the entire drainage and river system. The adopted criteria for planning the stormwater management measures are generally as follows:

- Compliance with Urban Stormwater Management Manual for Malaysia (MSMA)
- Integration of the stormwater control measures into the existing stormwater drainage system both physically and visually
- Promotion of integrated plan to enhance the benefit of the proposed stormwater management plan
- Safety, maintenance, aesthetic and economy

The catchment management is done within a catchment to reduce existing stormwater and rivers problems and to prevent the occurrence of new problems. It involves the development and implementation of a combination of structural and non-structural measures to mitigate the problems. It also involves the development and implementation of a range of measures, commonly known as Best Management Practices (BMPs), to improve the quality of urban stormwater runoff and existing streams prior to its discharge to receiving waters. It usually involves the following components:

- Reduction of pollutions at/near to the source
- Control at the source for stormwater quantity runoff
- Interception and treatment/removal of remaining pollutants
- Prevention of future pollutions
- Prevention of erosion and sediment issues for agricultural areas

Structural Measures

The establishment of alternative formulation and strategies of any mitigation measures related to stormwater quantity and quality control for agricultural activities are important for rehabilitation and management of the rivers and drainage system in Cameron Highlands which have over the years, been exposed to activities that has caused deterioration in their conditions in terms of pollution, river environment and eco-system.

The recommended stormwater management master plan is focused on providing flood storage, river improvement and beautification/recreational development. The proposed improvement plans that consider overall Cameron Highlands including Brinchang, Tanah Rata, Habu, Ringlet and Lembah Bertam (Bertam Catchment) and Tringkap, Kuala Terla and Kg. Raja (Telom Catchment) are described in this research.

First is the Quantity Control Structures that includes:

- Drainage upgrading plan consisting of 26 km drainage improvement (including new drains)
- Trunk drains from future development lot, consisting of 8 km drainage improvement (including new drains)
- Proposed flood protection works (floodwall / earth bund) with a total length of 47 km.
- Proposed slope protection along the river with a total length of 650 m
- One (1) detention pond with a total surface area of 1.28 ha designed for the 100 yr ARI flood
- Nine (9) no of SABO dams to be installed at the upstream part of the river.

Second is the Quality Control BMPs that includes:

- Twenty-four (24) sediments basins proposed for sediment control measures
- Four (4) wetland proposed for further pollution control (including extended detention pond)
- Twenty-four (24) biorentention basins with a total area of 13.4 ha as alternative pollution control
- Twenty-four (24) no of gross pollutant traps (GPTs) proposed for coarser sediments and floatable control
- Nine (9) no of High-Efficiency Sediment (HESB)

Figure 3 and Figure 4 shows the layout of the proposed BMPs for Brinchang and Tanah Rata catchment respectively.

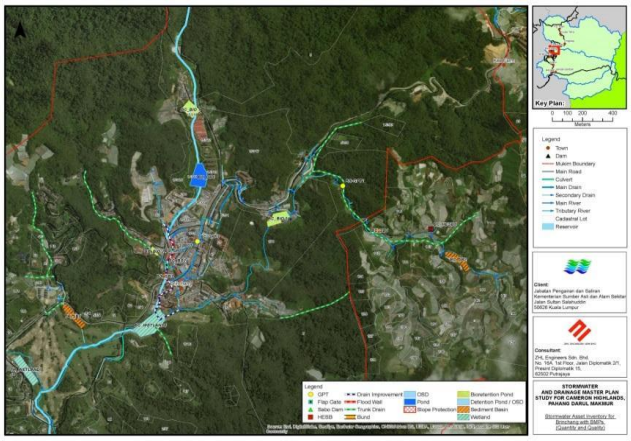

Fig. 3 Layout of the Proposed BMPs for Brinchang

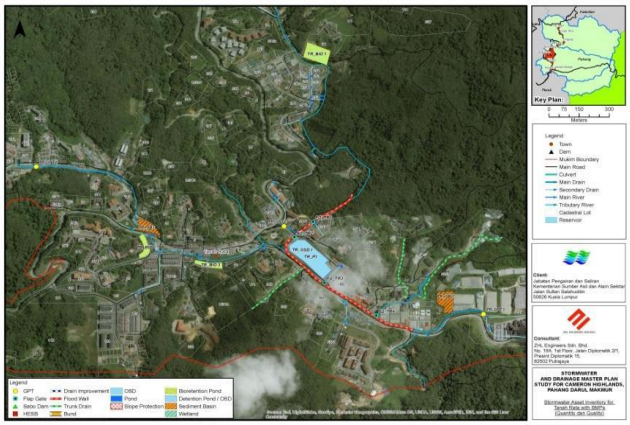

Fig. 4 Layout of the Proposed BMPs for Tanah Rata

The implementation of structural measures to reduce flooding problems, pollution levels and erosion and sediment risk usually will incur the highest capital investment. Due to a large amount of capital investment required, it is prudent that the proposed works to be implemented in stages, based on the urgency and priority of works. Priority factors may include:

i. Current flooding and water quality problems

ii. Population density (those an affected by the flooding problem)

iii. Development trend (in line with the MDCH Structure Plan until the year 2030)

iv. Engineering relationship between consecutive stages of works

It is proposed the works to be executed in two phases in which Phase 1 suggested to be implemented in the year 2019-2023 while Phase 2 suggested being implemented in the year 2024-2028. Phase 1 incorporates the critical works especially in the developed areas around Bertam Catchment (Brinchang & Tanah Rata) and Telom Catchment (Tringkap). However, some suburban areas that experience frequent flooding are also included in Phase 1 implementation. Phase 2 covers the remaining works proposed in the Master Plan. This will include works planned for future development/land use changes, etc.

Non-Structural Measures

The existing setup, scope of work and inter-institutional cooperation of the relevant agencies in Cameron Highlands are capable of handling the water resources management issues if further enhancements are instituted. These enhancements include strengthening inter-institutional cooperation through the setting up of the Cameron Highlands River Committee that eventually reports to the State Secretary's office and later the State EXCO. Apart from the continual program for staff development through training, additional resources (manpower, physical infrastructure, equipment and vehicles) are also recommended at several agencies to boost monitoring and enforcement activities.

Apart from that, programs for environmental awareness in the voluntary organization working towards environmental awareness among community committed to bringing out a movement for the protection of the environment. Public Outreach Program (POP) is a nationwide programmed aiming to motivate community into actions. The objectives of POP are to educate and promote Environmental Awareness to the community. These POP programs can encourage community participation in the Environment Program. Figure 5 shows the POP activities.

Fig. 5 Public Outrage Program in Cameron Highlands

Sustainable land management practices for agricultural areas can be implemented with Good Agricultural Practices (GAPs). In a fashion similar to urban practices, agricultural GAPs can be divided into source controls, hydrologic modifications, reduction of delivery, and storage and "treatment". General techniques can be implemented by farmers to minimize contamination and erosion by agricultural runoff.

V. EROSION INDUCED LANDSLIDE RISK MAP

The principal objective of hazard risk assessment is for the identification of past and present slope failure as well as prediction of the future occurrence. Most of the hazard risk analyses require detailed knowledge of the geo-environmental predisposition factors and initial events that led to failure. The results of these analyses consist of the identification and mapping of all erosion induced landslide phenomenon and are often translated in a form of maps which is the fundamental step of the hazard assessment.

The ranking of areas of susceptibility and delineation of areas of probable failure are among important features relevant to the production of these maps. In this project, the Erosion Induced Landslide Risk Modelling was developed to produce the Erosion Induced Landslide Risk Map. The modeling was done by taking into consideration both landslide susceptibility and soil erosion information for the project area. Firstly, the landslide susceptibility map was produced based on the historical records of a landslide in the project area for 20 years and the frequency ratio model using map overlaying techniques. Then the landslide susceptibility map was overlaid on the soil erosion map of the project area that was developed based on the USLE to produce the Erosion Induced Landslide Risk Map. Figure 6 shows the flow chart of the methodology adopted for the Erosion Induced Landslide Risk Modelling.

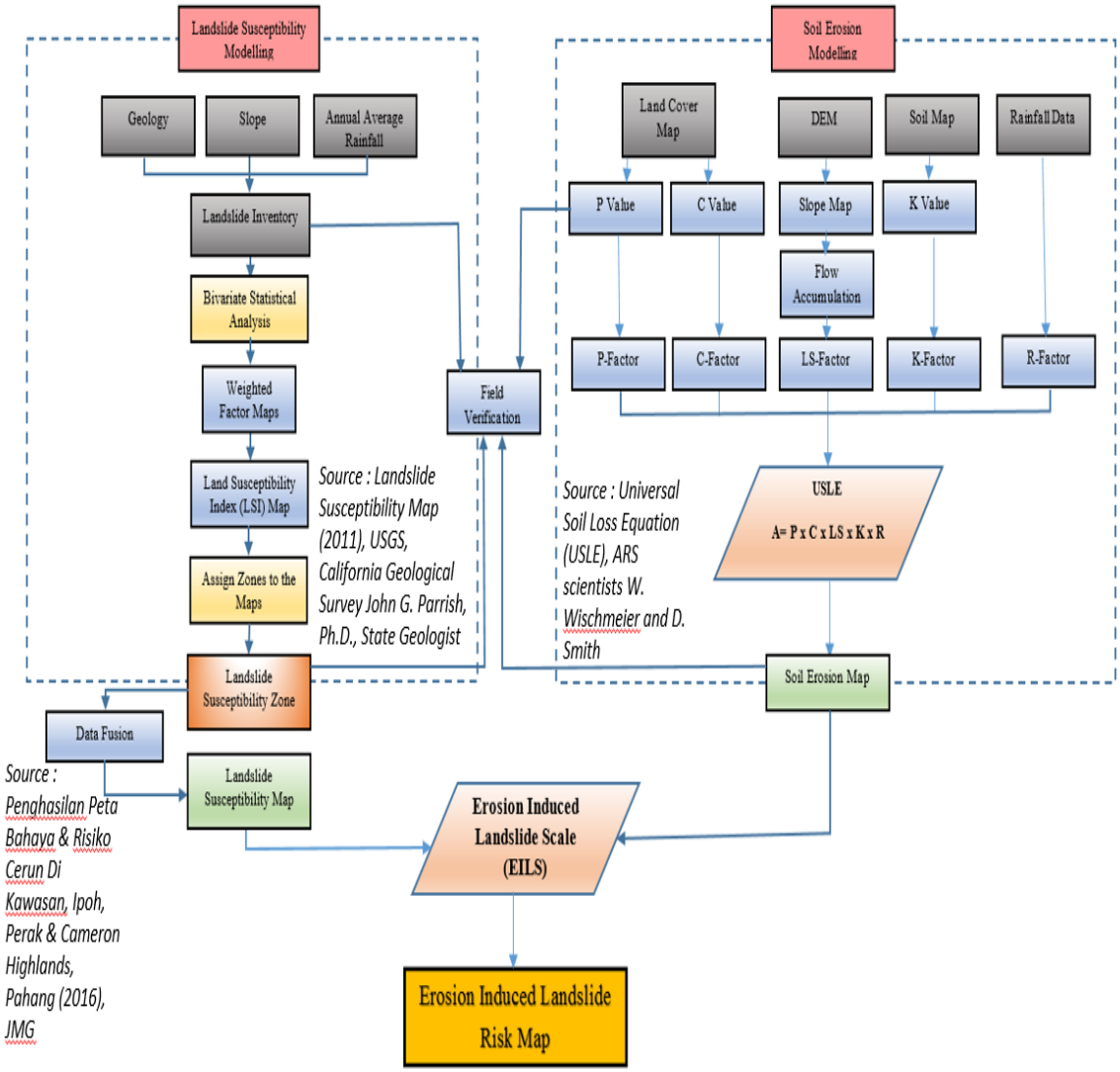

Fig. 6 Flow chart of the methodology adopted for the Erosion Induced Landslide Risk Modelling

In the Erosion Induced Landslide Risk map, the potential event and its probability of occurrence were combined. The hazard risk categories are expressed as a probability in qualitative forms (very low, low, moderate, and high). These categories are based on the soil erosion and susceptibility matrix scale as shown in Figure 7.

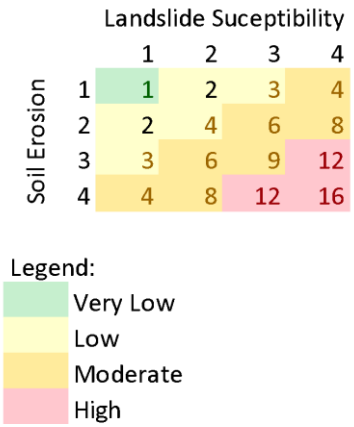

Fig. 7 Erosion Induced Landslide Risk Scale

Distribution of Erosion Induced Landslide Risk within the project area is shown in Figure 8 spatially and in Table 1 numerically. Erosion Induced Landslide Risk layer has been classified to four zones for visual interpretation from very low to high based on the hazard risk categories as shown in Figure 8.

Table. 1 Selected variable parameters and levels

VALUE	COUNT	AREA (km^2)	AREA (%)
Very Low	5010272	362.30	53.4
Low	2862416	291.39	42.9
Moderate	459691	23.77	3.5
High	91556	0.41	0.1

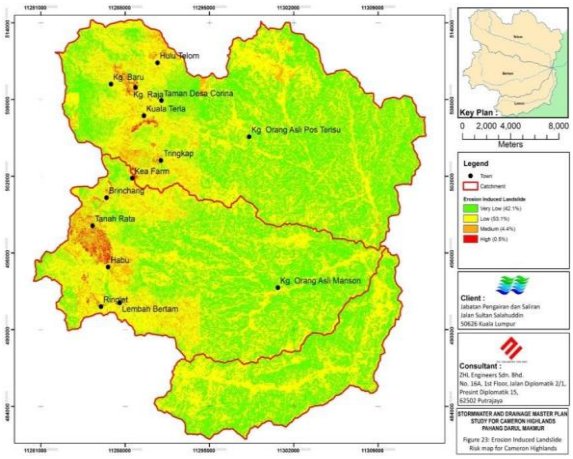

Fig. 8 Erosion Induced Landslide Risk Map for Cameron Highland

VI. CONCLUSION

The implementation of Stormwater and Drainage Master Plan for Cameron Highlands, Pahang were expected to minimize the flooding impacts, sedimentation problems, erosion and landslide incidents due to agricultural activities as well as water quality problems in Cameron Highlands. The proposed master plan incorporated structural and non-structural measures such as water quantity and quality BMPs (on-site detention, new and upgrading drainage system, high-efficiency sediment basin, Sabo dams, etc.), public outreach programs as well as enhancements of the inter-institutional cooperation through the setting up of the Cameron Highlands River Committee. Due to a large amount of capital investment required, it is prudent that the proposed works to be implemented in stages, based on the urgency and priority of works. Therefore, it is proposed that the works will be executed in two phases in which Phase 1 will be implemented in the year 2019-2023 while Phase 2 will be implemented in the year 2024-2028.

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