Environmental Impact Assessment (EIA)

Guidelines for Construction on Hill Slopes

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Foreword

The Environmental Impact Assessment (EIA) has been widely used as a critical tool in managing and clarifying the complex interrelationships between development and the environment. It provides assessment of the environmental consequences of development actions in a systematic, holistic and multidisciplinary way.

In Sabah, the Environment Protection Department is imposing two environmental impact assessment categories namely the EIA or the Proposal for Mitigation Measures (PMM) in managing any development listed as prescribed activities under the Environment Protection (Prescribed Activities) (Amendment) Order 2013.

The purpose of these Guidelines is to provide practical guidance to environmental consultants, developers, planning authorities and any other stakeholders on procedural aspects as well as the processes involved in the preparation of the EIA/ PMM report. It intents to provide a structured framework for the scope of environmental considerations required during the planning, implementation and maintenance stages of any prescribed development activity. Identification of potential environmental issues at the initial stage of development is essential for the selection of realistic mitigation measures. Significance of this approach will ensure that any development activity will be carried out with minimal adverse residual environmental impacts.

It is the Department's hopes that these Guidelines will result in greater consistency and understanding on the basic of environmental requirements, selection of alternatives, identification of environmental issues, preparation of mitigating measures as well as environmental compliance and monitoring to ensure sustainable and profitable activities are achieved.

The Department gratefully appreciate the valuable assistance from government agencies, organizations and individuals in their comments, feedback and inputs on these Guidelines. We welcome comments and suggestions for the continuous improvement of these Guidelines in future.

Yabi Yangkat
Director
Environment Protection Department

Contents

1 Introduction

1.1 Definitions

The aim of this EIA guideline is to provide a framework for the preparation of an Environmental Impact Assessment (EIA) report for construction activities on hill slopes in the State of Sabah, Malaysia. This EIA guideline should serve as an operating manual for the Project Proponents as well as a guide for environmental consultants.

Within Sabah, the construction of buildings or roads on hills with a slope gradient of 20 degrees or more is categorised as a “prescribed activity” under the Second Schedule of the Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005. This requirement therefore subjects the Project Proponent to appoint an environmental consultant registered with the Environment Protection Department (EPD), to conduct an EIA report for submission to, and approval by EPD Sabah prior to project commencement. This EIA guideline will only cover the site preparation and construction stages of these developments under the prescribed activity.

This EIA guideline focuses on the planning and control of hill slope developments and management of impacts on adjacent areas. The main objective of this guideline is to provide environmental consultants, developers, contractors and government agencies involved with commissioning and construction activities on hill slopes with:

i. Information on how to avoid and minimise environmental impact, which is preferable to the more costly option of undertaking remedial action;

ii. Information on the likely impact of construction activities on hill slopes on the environment and how this is to be assessed; and

iii. Suggested best practice environmental measures to meet the performance objectives.

This EIA guideline is not prescriptive or detailed. Each environmental assessment will require the environmental consultant to tailor their assessment to particular site conditions and make their own assessment of measures appropriate to the site.

The content of this EIA guideline may be amended from time to time in order to keep abreast with the latest developments and improvements in techniques and new understanding of the environmental impacts and risk. Such changes may be issued by EPD in a complete revision of this document, or in separate additional guidance notes which address specific issues.

This EIA guideline has been produced in consultation with relevant technical departments, stakeholder representatives, and other interested organizations. Printed copies of this and other EIA guidelines are available from EPD.

1.2 Assessment Procedure – A Quick Reference

The environmental assessment procedure may be divided into seven steps as described in Table 1-1. Of these steps, only steps 3 and 4 are dealt with in this guideline as these include issues particular to construction activities on hill slopes. The remaining steps are standard procedures, common to all EIA reports. These steps are described in detail in the Handbook on Environmental Impact Assessment in Sabah (November 2005) issued by EPD.

Table 1-1: Assessment Procedures

The Seven Steps	Summary of Main Required Activities
Step 1: **Project Screening**	**Project Proponent:** • Check Section 2.3 to see if the project is required to undertake an EIA • Consult with EPD as to whether the project should undertake an EIA • Consult with EPD whether planning documents are sufficient
Step 2: **Selection of Environmental Consultants**	**Project Proponent:** • Select EPD registered consultants to undertake preparation of TOR and the EIA
Step 3: **Project Scoping and Preparation of Terms of Reference**	**Environmental Consultant:** • Undertake scoping activities • Assess initial project description and assist the Project Proponent to make amendments • Perform initial site visit • Prepare a draft TOR • Undertake the public hearing activities required for Special EIA • Participate in review meetings • Finalise the TOR for EIA and obtain final approval from EPD
Step 4: **Undertaking the EIA Study**	**Environmental Consultant:** • Assess the project details • Assess the existing environments • Assess the environmental impacts

The Seven Steps	Summary of Main Required Activities
	• Devise and propose mitigation measures • Devise and propose monitoring programmes
Step 5: **Preparation of the EIA Report**	**Environmental Consultant:** • Adhere to the EPD requirements based on the approved TOR in the preparation of the EIA report • Prepare the EIA report in line with the EPD chapter by chapter recommendations • Discuss with the Project Proponent on the findings and content of the EIA report
Step 6: **Submission of the EIA Report**	**Environmental Consultant:** • Submit the EIA report to EPD • Undertake the public hearing activities required for Special EIA • Participate in review meetings • Submit additional information if required and finalise the EIA report
Step 7: **Preparation of the Agreement of Environmental Conditions**	**Project Proponent:** • Review the draft Agreement of Environmental Conditions (AEC) prepared by EPD • Signing of Letter of Undertaking on AEC • Implement mitigation measures and monitoring programmes • Submission of periodic environmental compliance report as required in the AEC

2 Sabah Context

2.1 Geographical Overview

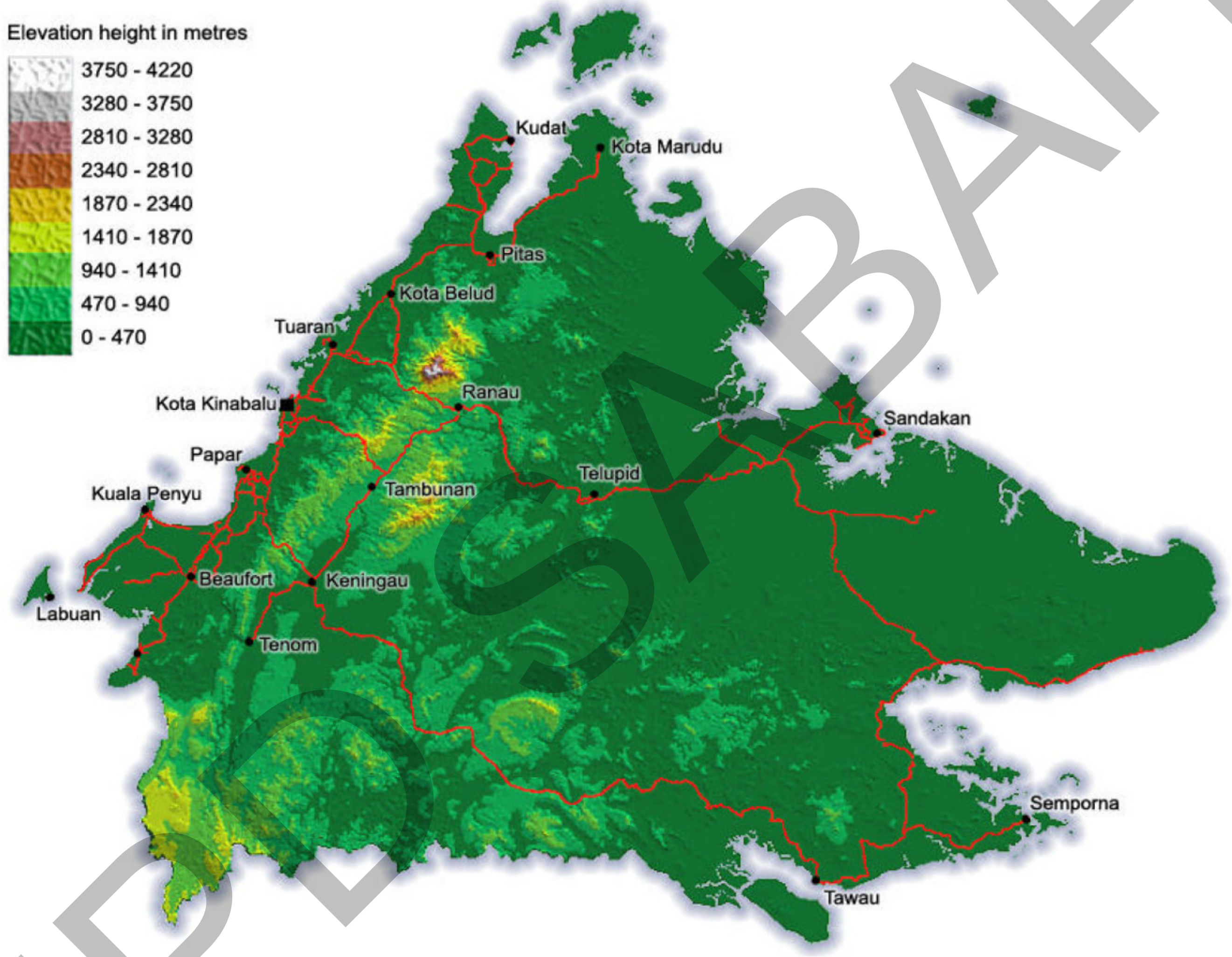
Within Sabah, the natural terrain is generally hilly and mountainous. The western part of Sabah is dominated by the north-east trending Crocker Range, which rises from near the west coast to 50 km inland and stretches from the Sarawak border in the south-western corner of the country to the Kinabalu massif. The range rises up to 1,200 to 1,800 m in height along a central spine. The range culminates at its northern end in Mount Kinabalu (4,095 m). Between the Crocker Range and the sea on the west coast is an extensive, heavily populated coastal plain with hills reaching down to the sea in many places.

On the eastern side of Crocker Range are several less prominent ranges, also trending north-east. This includes Mount Trusmadi, Sabah's second highest mountain with a height of 2,590 m. In the south central and part of east Sabah, the topography is dominated by a series of circular to sub-circular basins ranging from 16 to 50 km across. These basins are defined by curved ridges up to 1,800 m high and valleys. Flat, non-swampy land available for development in Sabah is therefore limited in extent compared to the hilly terrain, which constitutes most of Sabah.

A dissected plateau, the Lokan Peneplain, 65 km wide and 180 to 300 m high occurs between Telupid and Sandakan. The southern part of the Sandakan Peninsula is hilly and terminates in a number of spectacular escarpments facing Sandakan harbour. The Semporna Peninsula is dominated by steep volcanic hills stretching parallel to the south coast. Inland from Tawau and Lahad Datu (Segama - Kuamut areas), the terrain is mountainous, with hills of more than 900 m high. The greater part of the east coast, including the Bengkoka, Sandakan and Dent Peninsulas, consist of low-lying plains and coastal swamps with occasional high ridges.

Five inter-montane plains are located along the west coast and interior; these are the Tenom, Keningau, Tambunan, Patau and Ranau Plains. Each consists of terraces cut into alluvium that was deposited in the steep-sided valleys of the mountain ranges.

With the increasing pressure from population growth, economic development and land conversion activities, it is inevitable that hilly steep areas will continue to be the target for development. However, development on hilly areas requires the application of physical planning criteria that must be clearly observed to ensure it does not endanger the stability, balance and harmony of the natural environment.



Source: Environment Protection Department, 2003

Figure 2-1: General terrain of Sabah

2.2 Current Trends

Construction on hill slopes with a gradient of 20 degrees or more is becoming increasingly evident in Sabah particularly in and around urban areas. This also includes hilly areas with tourism and residential potential such as Kundasang in Ranau, Likas Ridge and Signal Hill in Likas and Bukit Padang in Kota Kinabalu. The type of structures erected on such slopes ranges from residential houses to commercial condominiums/ apartments and chalets. Other structures include roads, temples, water storage reservoirs and telecommunication/ transmission towers. Within urban areas like Kota Kinabalu and Sandakan, commercial condominiums and apartments are the most dominant type of structures erected on hill slopes, while resorts and hotels are most common in areas with tourism potential. Higher elevation areas attract developers as they are preferred sites for potential tourist facilities such as hotels, apartments, condominiums and multi-storey housing.

Among the main reasons for developing hill slopes are:

- Shortage of, or cost of, land in nearby flatter areas;
- Desire to take advantage of panoramic views; and
- Advantages due to elevation (avoidance of flooding and cooler breeze).

2.3 Legal Requirements

Under the Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005, the submission of an EIA is a mandatory requirement for construction activities on hills with a slope gradient of 20 degrees or more in Sabah under the Second Schedule of the Order. Specifically, the prescribed activities are:

Second Schedule: List of Prescribed Activities Requiring Environmental Impact Assessment (EIA) Report

Item 3: Housing, commercial and industrial estates

Para (iii) *Development of housing, commercial or industrial estates on hills with slopes having gradient of 20 degrees or more*

Item 10: Resorts and recreational development

Para (ii) *Development of resorts, recreational or tourism facilities on hills with slopes having gradient of 20 degrees or more*

Item 12: Any other activities which may damage or have an adverse impact on quality of environment

Para (i) *Construction of buildings for public purposes on hills with slope having gradient of 20 degrees or more*

Para (ii) *Construction of major roads or upgrading of major roads involving realignment and widening through settlement, coastal areas or wetland forests, or on hills with slopes having gradient of 20 degrees or more*

There are also other prescribed activities that have an indirect connection to construction activities on hill slopes. These include among others:

First Schedule: List of Prescribed Activities Requiring Proposal for Mitigation Measures (PMM) Report

Item 3: Housing, commercial and industrial estates

Para (i) *Development of housing, commercial or industrial estates covering an area of 10 hectares or more but less than 50 hectares*

Item 6: Resorts and recreational development

Para (i) *Development of resorts, recreational or tourism facilities covering an area of 10 hectares or more but less than 30 hectares*

Second Schedule: List of Prescribed Activities Requiring Environmental Impact Assessment (EIA) Report

Item 3: Housing, commercial and industrial estates

Para (i) *Development of housing, commercial or industrial estates covering an area of 50 hectares or more*

Item 9: Quarries

Para (i) *Quarrying of aggregates, limestone, silica, quartzite, sandstone, sand, marble or stones for commercial or construction purposes within 3 kilometres of:*

(a) *Any existing settlement, residential, commercial or industrial area, major roads, or any buildings for public purposes; or*

(b) Any area for which a license, permit or approval has been granted for development of settlement, residential, commercial or industrial area, major roads, or any buildings for public purposes

Para (ii) Earthwork involving extraction, removal, filling or dumping of earth with a volume of 40,000 cubic metres or more

Item 10: Resorts and recreational development

Para (i) Development of resorts, recreational or tourism facilities covering an area of 30 hectares or more

Under Section 12A of the Environment Protection Enactment 2002, amended in 2012, failure to comply to the requirement for an EIA may result in a fine not exceeding fifty thousand ringgit (RM50,000) or imprisonment for a term not exceeding two years, or both a fine and imprisonment, under the First Schedule. Under the Second Schedule, failure to comply may result in a fine not exceeding one hundred thousand ringgit (RM100,000) or imprisonment for a term not exceeding five years, or both a fine and imprisonment.

For any proposed development that is not on a hill slope, however is adjacent to or in close vicinity to potentially unstable/ sensitive slope areas, prior consultation with the local authorities and EPD is recommended. This is to ensure that the environmental aspect of the development is taken into consideration during the project planning and implementation.

An EIA is an important technique for ensuring that the likely impacts of the proposed development on the environment are fully understood and taken into account, before the commencement of such developments. The main objectives of an EIA for construction on hill slopes are:

- To assess and recommend the most appropriate hill slope development options based on existing site conditions so as to minimise impacts on the environment;
- To identify, predict and wherever possible quantify the significance of any adverse impacts on environments and communities that are likely to be affected by construction activities on hill slopes;
- To formulate and incorporate appropriate and cost effective mitigation and abatement measures into overall planning of construction on hill slopes; and

- To determine a suitable and effective programme for ensuring environmental compliance and monitoring of residual impacts.

Other legal requirements related to construction activities on hill slopes that should be referred to by the environmental consultant during preparation of the EIA report, are:

Legal Requirements	Relevance
Environmental Quality Act, 1974	– Restriction and prohibition of pollution (air emissions, noise pollution, inland waters, soil, waste, hazardous and scheduled substances) – Prohibition of open burning – Management of scheduled waste
Environmental Quality (Sewage) Regulations 2009	– Provision and proper operation of sewage treatment system – Sewage discharge quality
Environmental Quality (Scheduled Wastes) Regulations 2005	– Management and disposal of scheduled waste including storage and labelling
Town and Country Planning Ordinance (Sabah Cap. 141)	– Preparation and approval of schemes for designated landuse of an area (zoning)
Land Ordinance (Sabah Cap. 68)	– Land matters
Explosive Act 1957 (revised 1978)	– Use, storage and transport of explosives
Water Resource Enactment, 1998	– Water conservation areas – Flood plain management areas – River reserves
Cultural Heritage (Conservation) Enactment 1997	– Preservation and conservation of cultural heritage sites
Wildlife Conservation Enactment 1987	– Protection and management of plants and animals
Local Municipal Rules including Earthwork By-Laws	– Requirements for planning submission including earthwork, drainage and general construction

Legal Requirements	Relevance
Sabah Biodiversity Enactment, 2000	– License to access biological resources

In addition to the legal requirements, there are several guidelines related to the environment which should be considered by all construction activities on hill slopes applicants. These include (but are not limited to):

- *Garis Panduan Pembangunan Di Kawasan Tanah Tinggi* (Ministry of Natural Resource and Environment, 2005);
- National Slope Master Plan 2009 – 2023 (Public Works Department, 2009);
- Guidelines on the Prevention and Control of Soil Erosion and Siltation in Malaysia (Department of Environment, 1996);
- Guidelines for Public Safety and Health at Construction Sites (Department of Occupational Safety and Health, 2007);
- Guidelines for Geological Terrain Mapping (Minerals and Geoscience Department Malaysia, 2010);
- Urban Stormwater Management Manual for Malaysia (MSMA 2nd Edition) (Department of Irrigation and Drainage, 2011);
- National Landscape Guidelines (Department of Town and Country Planning, 1995);
- Guidelines for the Environmental Impact Assessment of Highway or Road Projects (Public Works Department Malaysia);
- Guidelines on Highland Development (Federal Department of Town and Country Planning Peninsular Malaysia, Ministry of Local Government and Housing, 2009);
- Environmental Impact Assessment Guidelines for Development of Resort and Hotel Facilities in Hill Stations (Department of Environment, 1995);
- Guidelines on Erosion Control for Development Projects in the Coastal Zone (Department of Irrigation and Drainage, 1997); and
- Guidelines for Erosion and Sediment Control in Malaysia (Department of Irrigation and Drainage, 2nd Edition 2011).

These guidelines should be followed as appropriate (depending on the project concept and site specific issues) by the environmental consultant during preparation of the EIA report for submission to EPD.

The guidelines and legislation above are correct as of November 2012. It is the duty of the environmental consultant at all times to update the list and to apply the latest regulations as issued by relevant government agencies.

2.4 Application and Approving Procedures

Any person who intends to undertake construction activities on hills with a slope gradient of 20 degrees or more in the State of Sabah is required to submit an EIA report to the Director of EPD, Sabah for approval. The contact details for EPD are:

DIRECTOR

ENVIRONMENT PROTECTION DEPARTMENT

Tingkat 1 – 3, Wisma Budaya

Jalan Tunku Abdul Rahman

Beg Berkunci 2078

88999 Kota Kinabalu, Sabah, Malaysia

Telephone Number:	+60 (088) – 251 290/ 251 291/ 267 572/ 268 572
Facsimile Number:	+60 (088) – 238 120/ 238 390
Email Address:	jpas@sabah.gov.my
Website Address:	http://www.sabah.gov.my/jpas

In addition, written approval of the development report/ plan from the relevant City Council/ Municipal Council/ Local District Council is required prior to construction activities on hill slopes.

The procedure for submitting and obtaining approval for the development plan for the construction is shown in Figure 2-2 and summarised as follows:

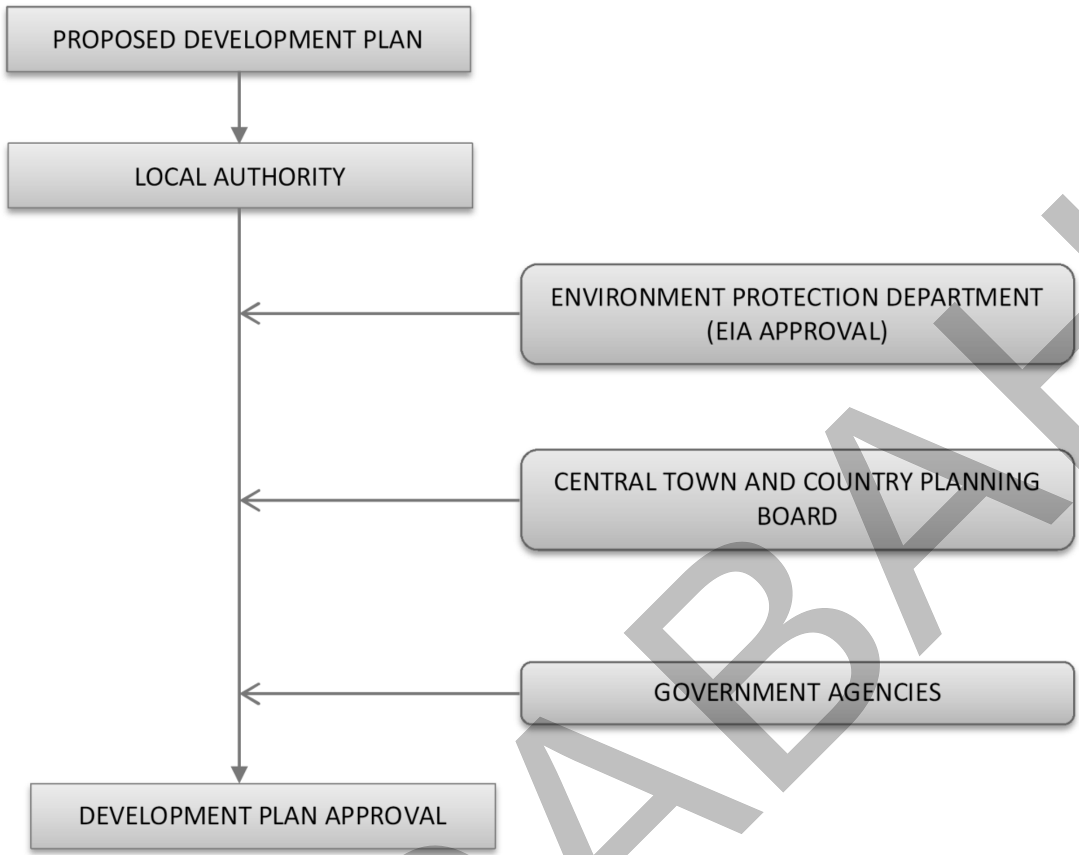


Figure 2-2: Procedure for processing of Development Plan

- The applicant must submit a development proposal report or plan, prepared by a qualified person (s) (most likely an architect/ planner), to the relevant City Council/ Municipal Council/ Local District Council.

- The City Council/ Municipal Council/ Local District Council will refer the development report/ plan to the relevant departments (including EPD), for technical comments and acceptance. If the proposed development is categorised as a “prescribed activity” under the Environment Protection (Prescribed Activities) (Environmental Impact Assessment) Order 2005, an EIA report is required for approval from the EPD.

- In the event that the proposed development involves a change in the land use, approval is required from the Central Town and Country Planning Board of the area where the construction works will be carried out, for rezoning of the land (change of land use). This is in accordance to Part I, Section 3 of the Town and Country Planning Ordinance 1950.

- The City Council/ Municipal Council/ Local District Council may approve the proposed development upon receiving approval from the Central Town and Country Planning Board for rezoning, approval of the EIA report from the EPD, and compliance with all technical comments and acceptance from the relevant departments on the application.

Other applications/ approvals required prior to construction activities on hill slopes include (but are not limited to):

- Mineral clearance approval from the Minerals and Geoscience Department Malaysia, Sabah;
- Use of diesel generator set requires prior approval from the Department of Environment (DOE), Sabah;
- Use and storage of explosives for blasting falls under the jurisdiction of Royal Malaysian Police; and
- License to remove, extract and transport earth material on titled land or lands under Temporary Occupation License (TOL) from the Lands and Surveys Department.

2.5 Key Stakeholders

As part of the environmental assessment procedure, EPD will seek technical comments from relevant departments with responsibilities for specific aspects relating to construction activities on hill slopes. The main responsibilities of these departments in relation to the Environmental Assessment are listed below. However, the departments may also comment on any other aspect of the assessment, if deemed relevant.

Department	Responsibility
Lands and Surveys Department	– Land titles/ ownership
District Offices	– Local settlement issues, i.e. flooding and public complaints
Department of Irrigation and Drainage	– Drainage system, water catchment areas, water supply, riparian reserves
Public Works Department	– Slope concerns, road network
Town and Regional Planning Department	– Landuse planning, zoning
Municipal Council	– Municipality issues, i.e. waste management
Minerals and Geoscience Department Malaysia, Sabah	– Slope stability, geological and soil features

Department	Responsibility
Department of Environment	– General environmental concerns (air, effluent, water, scheduled waste and other)

The list of departments is not exhaustive and may vary depending on the development concept and sensitivity of the location.

EPD is responsible for overseeing the environmental assessment procedure in relation to the prescribed activities and at the same time, requires comments/ concerns/ advice from the key stakeholders for decision making.

3 Typical Project Activities

3.1 Project Plan

An environmental impact assessment is an assessment of an intent, i.e. the assessment of the potential impacts occurring from well described planned activities.

It is therefore important that all activities, which have potential environmental impacts, are planned and described in sufficient detail prior to the environmental assessment. After the initial project information, the EIA report therefore concerns the project description or plan.

The Project Proponent must provide the environmental consultant with a detailed description of all activities; both the main construction activities and the supporting activities.

3.2 Project Stages

Generally, construction activities on hill slopes will involve five (5) main stages, i.e. pre-development; site preparation; earthwork; construction; and post-construction. However, this EIA guideline only specifically covers the site preparation, earthwork and construction (if known during the EIA report preparation) stages of a development.

The activities involved during each stage for construction activities on hill slopes are listed below in Table 3-1:

Table 3-1: Typical Activities for Construction on Hillslopes Projects

Stage	Activities
Pre-development	• Land acquisition and access - Acquire land - Relocation of existing occupants (if any) • Investigation - Detailed site surveying - Preparation of geological and hydrological report, geotechnical report and soil investigation report - Detailed design for development plan, earthwork plan, Erosion and Sediment Control Plan (ESCP) and drainage plan - Environmental Impact Assessment (EIA) study

Stage	Activities
Site Preparation	• Site clearing/ stripping - Construction of temporary access roads - Removal of existing vegetation cover - Demolition and removal of existing structures - Construction of temporary drainage system - Provision for operating equipment (chainsaws, front loader, bulldozers and other) • Temporary occupation - Establishment of site office and workers' quarters - Provision for electricity, water, telecommunication, solid waste and sewage facilities - Employment of workers - Machineries and equipment servicing and maintenance - Pest control
Earthwork	• Earthworks - Earth cutting and filling works (differentiate the volume of earth and rock materials) - Excavation and removal of rock materials (requirement for blasting works onsite must be stated clearly) - Transportation of materials (soil and waste) - Building ground retention structures - Installation of slope protection structures/ close turfing
Construction	• Construction works - Construction of development components and facilities - Transportation of construction materials - Installation of permanent drainage system - Regular drainage and slope maintenance work • Landscaping
Abandonment	In addition, there is also the possibility of abandonment during the course of implementation of proposed construction activities on hill slopes. The types of activities involved during this stage are: - Unsuitable/ surplus soils removal or stockpiling

Stage	Activities
	- Workers' quarters and site office removal - Solid waste disposal - Equipment and machineries removal - Liquid waste disposal - Site rehabilitation works, i.e. planting of cover crops, soil stabilization and other

4 Scoping

This chapter deals with the scoping stage which defines the work scope for preparation of the EIA report (refer to Table 4-1).

Table 4-1: Assessment Procedures - Scoping

The Seven Steps	Summary of Main Required Activities
Step 3: Project Scoping and Preparation of Terms of Reference	Environmental Consultant: • *Undertake scoping activities* • *Assess initial project description and assist the Project Proponent to make amendments* • *Perform initial site visit* • *Prepare a draft TOR* • *Undertake the public hearing activities required for Special-EIA* • *Participate in review meetings* • *Finalize the TOR for EIA and obtain final approval from EPD*

Scoping is the identification of potential environmental impacts and the predicted extent of the impacts. This exercise is an important early stage of the environmental assessment process to ensure that the assessment is carried out properly and appropriately, i.e. that the report is sufficiently comprehensive, while at the same time preventing the assessment from becoming unnecessarily protracted or expensive due to inappropriate focus on issues of only minor concern.

In general, the scoping process is outlined in the EPD's Handbook on Environmental Impact Assessment in Sabah. This section briefly outlines the main steps in scoping, but primarily focuses on providing specific guidance on:

- Identification and preliminary assessment of potential impacts with respect to certain approaches to construction activities on hill slopes and with respect to specific project locations; and
- Selection of appropriate assessment methodologies, based on project sensitivities.

In order to carry out the above, a comprehensive description of the project in terms of location, activities and processes needs to be developed. This is described in the following section.

4.1 Project Information

The first step in scoping is to obtain as much relevant information about the project as possible, to ascertain the scale of the project and its component activities which may result in impacts to the environment.

4.1.1 Description

A description of the project location, activities and potential qualitative and quantitative impacts should be developed at this stage in order to identify the stages, activities or characteristics of the proposed project that are likely to give rise to environmental impacts.

4.1.2 Project Location

A preliminary assessment of the baseline conditions shall be made to identify key sensitive receptors. Consideration should be given to the existing topography and drainage features, soil and vegetation conditions, wildlife, traffic conditions, water, air and noise quality as well as sensitive habitats and land uses.

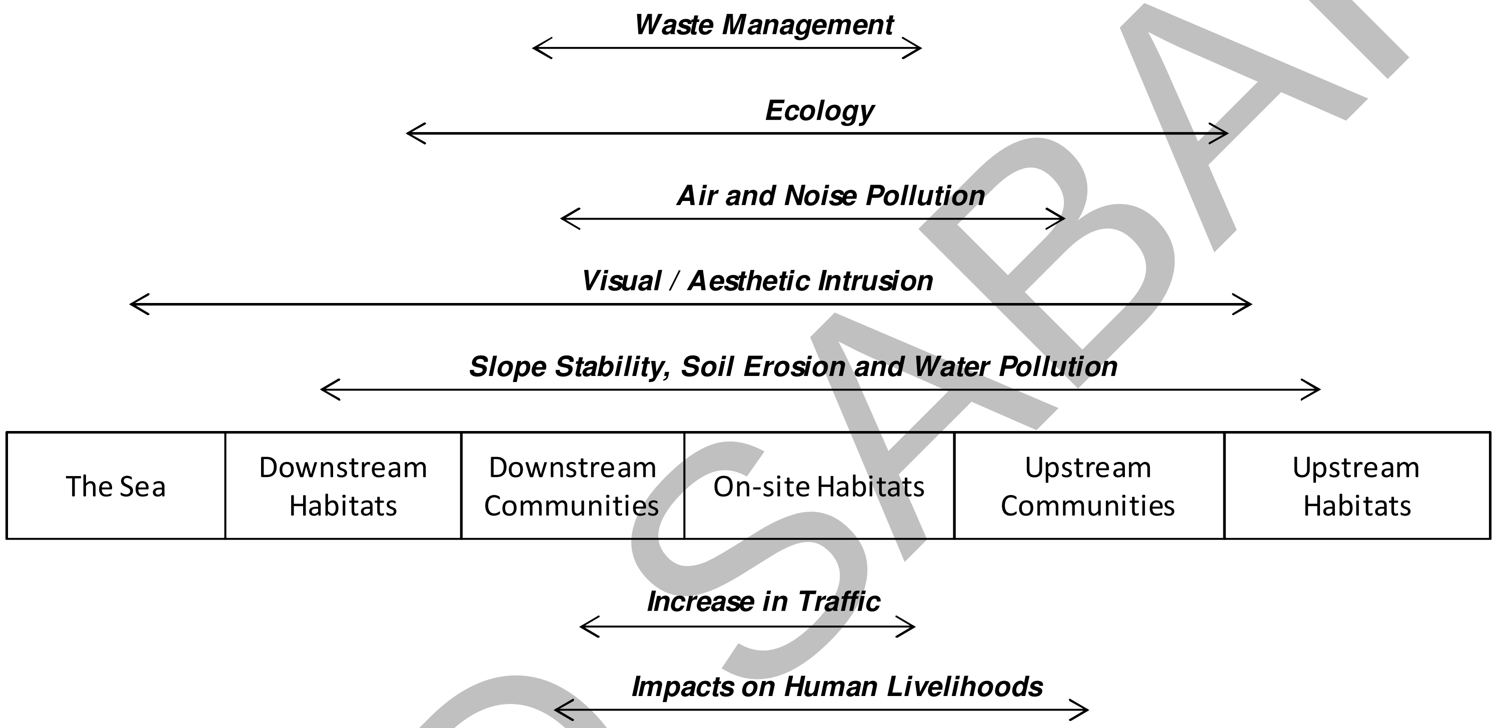
A site visit and preliminary consultations with relevant regulatory authorities must be undertaken during the scoping exercise.

4.1.3 Identification and Prioritisation of Impacts

Based on the previous steps, a list of all potential environmental impacts should be made, with a preliminary estimate of their relative significance. The key impacts are those with the highest potential significance, considering both spatial scale, significance to stakeholders, potential impact severity and mitigation potential. EPD's Handbook on Environmental Impact Assessment in Sabah is a useful resource for this assessment. A prioritised list of impacts shall thereby be established and clearly described.

For each key impact identified, the anticipated zone of impact should be estimated by the expert judgement of the relevant specialists, based on conditions at the site. The zone of impacts may differ depending on the environmental component; the zone of impact for noise impacts for example may be much smaller than the potential river water quality zone of impact, owing to properties of both the polluting and the dispersing agent and the conditions at the site.

Some potential impacts and their zone of impact for construction activities on hill slopes projects are shown in Figure4-1.



Source: Adapted from DOE Malaysia EIA Guidelines for Land Reclamation Projects, 2008

Figure4-1: Main issues and extent of impacts for construction activities on hill slopes projects

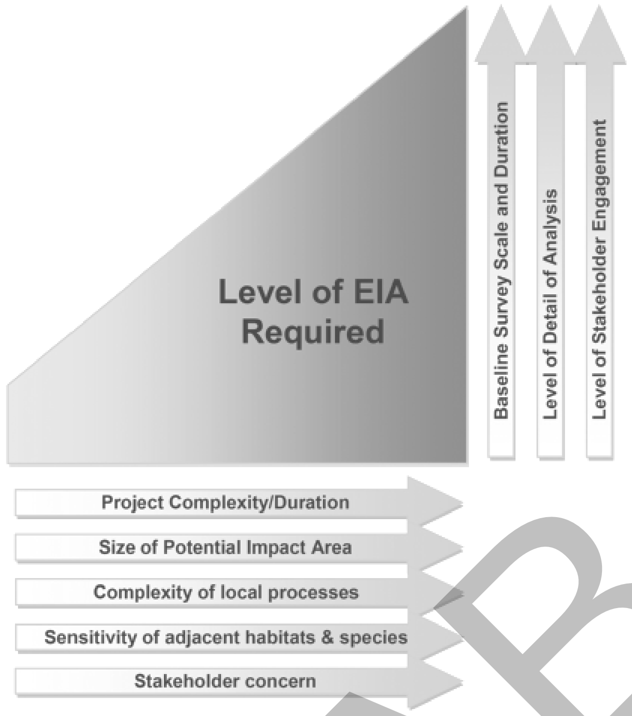
4.2 Types of Impacts

Whereas construction activities on hill slopes can provide significant planning and development opportunities, as well as benefits to the public if properly planned and executed, there are also numerous potential adverse impacts that have to be taken into account. The potential impacts are site and project specific, depending, among other factors, on slope features, topography, drainage patterns, nearby environmental receptors, size and layout.

Whilst the environmental assessment evaluates both positive and negative impacts, the positive impacts are generally site specific, related to the project objectives, whilst the negative impacts can be considered as generic impacts on the physical, ecological, or socio-economic environments. A non-exhaustive list of main potential impacts related to construction activities on hill slopes is provided in Section 5.3; these are also listed in Figure4-1.

4.3 Terms of Reference

The TOR for the EIA shall directly reflect the scoping exercise whereby the environmental consultant should address the identified impacts as fully as practicable. The level of analysis from baseline studies and the sophistication of prediction and evaluation methodologies, shall be tailored to the level of significance of the impacts and hence level of precision required for the evaluation, as illustrated in Figure 4-2. Less attention should be given to those issues which have lesser significance. In practical terms, this means that the level of uncertainty may be higher for these issues.



Source: PIANC, 2010

Figure 4-2: Key factors in determining the level of environmental assessment required

4.3.1 Data Collection Requirements

Collecting existing data is always the first step in the collection of baseline information. It must however be reviewed for its relevance to the proposed site, its accuracy, and used as a basis for determining what primary field investigations may be required to 'fill the gaps'.

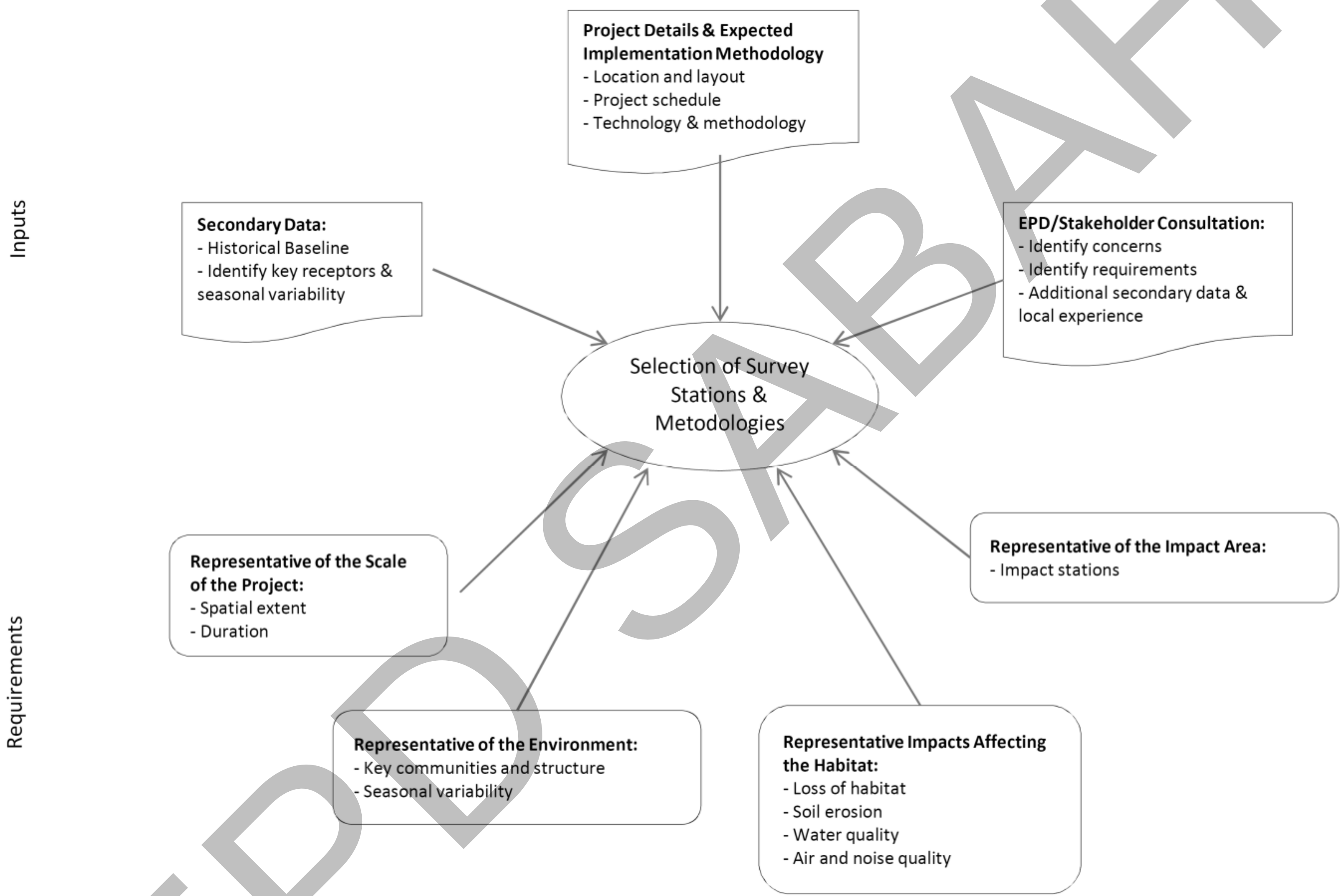
Primary field surveys are almost always required for most aspects of the environment, such as: existing vegetation and habitats, wildlife, water, air quality, noise level, topography, socio-economic and other factors. Field surveys are needed either because published information in Sabah often does not exist at a suitable scale, or is not generally applicable to the project being assessed.

Where primary field surveys are required, careful consideration must be given to the design of the field survey and sampling programme (refer to Figure 4-3). The data collection must focus on the key issues needed to be examined for the EIA (identified during the scoping process), and should be collected at the appropriate time(s) of the year. In Sabah, this may include consideration of rainy and dry seasons, and on the coast, the monsoon and inter-monsoon periods.

It is important to address the temporal scale of the project when designing the baseline survey programme. A long-term hill-slopes construction programme (e.g. three or more years) would require a baseline survey that captures natural seasonal variations within that period; while for a short project (e.g. 1-3 month earthwork phase), capturing a snapshot of the existing conditions can be sufficient.

In addition, the survey programme shall take into account the anticipated zone of impact for the issue in question to ensure that all potential sensitive receptors are included.

It should also be highlighted that a more detailed baseline, capturing seasonal variations, provides more security for the Project Proponent, in the event that natural variations are incorrectly perceived by stakeholders or regulators as project-derived impacts.



Source: Adapted from PIANC, 2010

Figure 4-3: Examples of criteria for selection of baseline survey stations and methodologies

5 Impact Prediction and Evaluation

This chapter deals with the assessment of the impacts that are likely to occur in the existing environment when the project activities are implemented (refer to Table 5-1).

Table 5-1: Assessment Procedures – Description of Impact Assessment

The Seven Steps	Summary of Main Required Activities
Step 4: Undertaking the EIA study	Environmental Consultant: • *Assess the project details* - *Plan assessment* • *Assess the existing environments* - *Physical environment* - *Biological environment* - *Human environment* • *Assess the environmental impacts* - *Soil erosion and water pollution from land clearing works* - *Slope stability due to earth cutting/ filing works on hill slopes* - *Aesthetically unpleasant due to the bared land/ tall structures* - *Hydrological changes* - *Air and noise pollution* - *Loss of terrestrial/ riverine ecology due to removal of vegetation* - *Waste handling (biomass, solid waste, sewage and scheduled waste)* - *Impacts on existing land based traffic* - *Ground vibration from piling works or blasting (if required)* - *Social economic concern/ benefits* - *Potential abandonment* • *Devise and propose mitigation measures* • *Devise and propose monitoring programmes*

This section outlines procedures for identifying the environmental impacts associated with construction activities on hill slopes, as well as proposed methodologies for assessing the scale and extent of the environmental impact.

The magnitude of the impacts depends on the combination of existing conditions and the selected construction technologies and methodologies, while the zone of impact depends on existing environmental conditions such as topography, vegetation, wildlife presence, land use, traffic or nearby settlements. Adverse environmental impacts affect the habitats and livelihoods outside the project area and hence the Project Proponent is responsible to minimise such impacts by adopting mitigation measures. As a general principle, mitigation measures should preferentially focus on addressing the impacts in order to eliminate/ minimise the residual impacts.

The assessment should consider site characteristics, the proposed construction development as well as the cumulative effects with other existing or proposed developments within close proximity to the site. The environmental consultant's approach to assessing these interrelated factors should be clearly described based on the TOR as approved by EPD.

5.1 Description of Plans and Site

Step 4 of the overall environmental assessment process may be divided into four (4) main parts:

i. Description of planned activities and existing environment conditions;

ii. Assessment of environmental impacts;

iii. Devising mitigation measures; and

iv. Formulating of monitoring programme

This chapter deals with the description of plans and the existing conditions within the site and the zone of impact (refer to Table 5-2).

The assessment of the existing environment and thus the activities and associated mitigation will, to a large extent, be based on an analysis of topographic maps combined with knowledge of the field conditions. These maps are based on aerial photo interpretation of dense canopy cover and can only be indicative of terrain contours and smaller features such as creeks and streams. The actual delineation of areas and mitigation measures must be based on the verifiable conditions in the field i.e. be based on field surveys.

Table 5-2: Assessment Procedures - Description of Plans and Existing Environments

The Seven Steps	Summary of Main Required Activities

Step 4:
Undertaking the EIA study
	Environmental Consultant:
	• *Assess the project details*
	  • *Plan assessment*
	• *Assess the existing environments*
	  • *Physical environment*
	    - *Water*
	    - *Air and noise*
	    - *Soils and geology*
	    - *Meteorology*
	  • *Biological environment*
	    - *Flora and Fauna*
	  • *Human environment*
	    - *Public administration*
	    - *Demography*
	    - *Livelihoods and economic activities*
	• *Assess the environmental impacts*
	• *Devise and propose mitigation measures*
	• *Devise and propose monitoring programmes*

The impact assessment is, as mentioned, based on a combined knowledge of the intent and the existing environment.

An assessment must therefore be made of the existing environment, its components and its sensitivity to impacts from the construction activities on hill slopes. In order to provide a basis for comparison during later monitoring, it is important to have a set of baseline data, describing clearly the pre-project conditions. The description provided must be clear and direct to the point being discussed.

5.1.1 Project Options

Hill slope development has inherent risks that do not exist for flatter sites. These risks are usually manageable, but involve increased costs, relative to alternative sites. The decision to develop on a hill slope should be assessed and justified through a discussion of alternative project options.

The justification needs to identify why the proposed functions or objectives of the development can only be achieved by locating the development on a hill slope.

This approach is aimed at preventing inappropriate development on hill slopes; e.g. siting a factory on a hill slope would generally be difficult to justify.

5.1.2 Site Consideration

Consideration on the selection of a hill slope location for development depends primarily on the availability of land and the physical characteristics of the site. The specific requirements, as specified in the guidelines from the Ministry of Local Government and Housing, for proper site selection are:

a. Low risk of slope failure at site and its surrounding:

- Absence of fault zones;
- Absence of slip zones and slope failures;
- Geologically sound bedrock;
- Bedrock or soil with good geotechnical properties; and
- Absence of historical earthquake activity.

b. Does not have conservation value:

- No geological value such as fossils or geological structures which have been identified by the Minerals and Geoscience Department or higher education institute as a site suitable for gazettement as a study area;
- No unique geomorphic features such as limestone peaks;
- Absence of protected plant or animal species; and
- Not within forested ridge areas which have inherent visual qualities.

c. Not gazetted as permanent forest reserve, water catchment, or zoned as having mineral resource, ridge conservation area or high risk area (slope more than 30 degrees);

d. Absence of unique or characteristic features, which are important identities, attached to an area which may not be disturbed.

The following site consideration based on the Green Building Index Assessment Criteria should also be made:

- Compliance to the local plan or structure plan.
- Availability and distance to existing infrastructures and community services, i.e. public transportation access, commercial areas (restaurants and markets), medical services (clinic and hospital), religious institutions (mosque and church).
- Ample allocation of at least 10% of total development area for landscaping.

5.1.3 Project Screening

Screening is recommended to be applied by environmental consultants to determine the aspects that should be covered in an EIA report. The process of screening should be simple and rapid, but effective enough to eliminate major potential environmental impacts that have residual significance, such as destruction of environmentally sensitive areas or priority habitat.

Screening allows for focus on real environmental issues at an early stage of the assessment process and allows for environmentally sensitive planning and early resolution of some issues. This will minimise the possibility of residual impacts. Project screening is conducted by assessing the project details in relation to the existing environment as described in Section 5.1.4 and Section 5.1.5.

5.1.4 Assess the Project Details

In order to be able to propose realistic mitigation measures, the following initial information should be obtained prior to embarking on any field surveys or assessments. This information will provide the scope of work for the assessments to be included in the EIA report.

A more detailed description of the project concept, with all available technical data should be given in the EIA report, in terms of:

i. <u>Project Location and Concept</u>

   - Exact location of the proposed project site and all receptors within 3-km radius, particularly those within the zone of impact. These should be shown on a map with an appropriate scale and coordinate system;

- Description and illustration of the proposed project including all the related components (development plan and cross-sectional views);

- Cross-section profiles of the whole slope should be drawn during the development stage to determine the form of the slope;

- Implementation schedule for site clearing, earthwork and construction activities;

- Local structure plan for the area and its nearby surroundings;

- Details on present traffic conditions and future anticipated conditions (if the proposed project increases the traffic volume significantly); and

- Statement of need for the proposed project.

ii. <u>Site Clearing</u>

- Detailed site survey plan showing ground levels, rivers, existing structures and other features within the site; and

- Description of site clearing method and area involved;

iii. <u>Earthwork Details</u>

- Estimated amount of earthwork (cut and fill) including location of proposed borrow pits/ disposal sites, layout plan and cross sections. The vertical and horizontal scales on all cross sectional **drawings must be 1:1**;

- Earthwork methodology including phasing plan;

- Rock excavation method including blasting details (minimum safe distance), if blasting is necessary;

- Hydrological features including water catchment of the site and proposed drainage layout plan;

- Erosion and sediment control plan detailing out the erosion control measures to be implemented;

- Slope terrain gradient classification including its suitability for development;

- Details on siting of temporary structures such as site office, workers' quarters, workshop, stockpile area, and others, including estimated number of workers to be employed (if available).

iv. <u>Construction Works Methodology</u>

- Site layout plan (including location of proposed structures, material storage area, workers' quarters and site office);
- Seismicity study (if applicable), particularly for projects located on seismic hazard areas;
- Type of piling method adopted for foundation works;
- Drainage plan showing plans for conveying surface and sub-surface water away from the site, to avoid erosion damage to the proposed structure; and
- Landscaping proposal for the proposed project, including vegetative restoration of portions of the site that were disturbed during construction.

5.1.4.1 List of Supporting Documents Required

The following reports/ details (plus other appropriate reference sources) should be made available and incorporated in the EIA report where relevant:

Report/ Study	Details Required
Geological and Hydrological Investigation Report (containing geology, hydrogeology and engineering geology aspect), Soil Investigation and Geotechnical Report prepared by a registered geologist/ professional engineer	– Underlying soil properties (including strength and permeability), geological and slope features including slope failure areas (landslides), structural geology (rock types, landforms, terrain features, joints, bedding, faults, shear zone, etc.), degree of weathering, hydrogeological regimes (groundwater levels, aquifer characteristics)
Erosion and Sediment Control Plan (ESCP) as prepared by a competent party (latest as per submitted to the local authority)	– Layout and design details for erosion control facilities such as sediment basin, silt traps and temporary drainage network mainly for earthwork stage (compulsory) and construction stage (where applicable)

Report/ Study	Details Required
Drainage Report prepared by a professional engineer (latest as per submitted to the local authority)	– Drainage pattern onsite before and after development, water catchment areas, runoff flow direction
Earthwork Plan (in phases) prepared by a professional engineer (latest as per submitted to the local authority)	– Earth cutting and filling areas, comparison between existing and finished ground levels, earthwork implementation in phases detailing out the activities involved in each phase

5.1.5 Assess the Existing Environment

It is necessary to provide sufficient information to give a brief but clear illustration of the existing environmental components. These components include, to the extent applicable (but are not necessarily limited to) the following:

- **Physical Environment**: topography, slope features, soil, geology, seismology, hydrology, climate, surface water, ground water, water catchment areas, air quality and noise level.

- **Biological Environment**: wildlife, forest, rare, protected or endangered species (flora and fauna), fisheries, aquatic biology, wilderness or protected areas, key conservation value habitats or species.

- **Human Environment**: population and communities (including numbers, locations, compositions, employment and other), land use, infrastructural facilities (including water supply, electricity, sewerage, flood control/ damage and others), institutions (such as schools, hospitals and places of worship), transportation (roads, navigation and other), archaeological, historical and cultural values and aesthetic values.

The baseline study for the EIA should concentrate on identifying those environmental components that may be significantly impacted by the proposed project. These may be conducted through ground observation, literature review and stakeholder consultation. The description can be presented in the form of mapping, listing or reports in the EIA report.

5.1.6 Study Area and Zone of Impact

Generally, a study area for the preparation of an EIA report covers a 3 km radius from the project site boundaries. However, the study area should focus on what the environmental consultant deems to be the zone of impact. A clear delineation of the study area based on actual ground survey conducted is important to define the area within which impacts should be considered.

There may be different zones of impact for the physical (such as water quality, terrain features, hydrology, traffic, air emission and noise nuisance), biological (such as wildlife species, habitat and diversity) and human (such as social issues affecting communities, cultural and aesthetic aspect and land use) environment. The environmental consultant should overlap these impact zones and decide which zone is particularly sensitive and where impacts are likely to be of some significance. Such zones may reach far downstream from the site, particularly if there are sensitive areas downstream or locality concerns. The zone of impact can be determined after understanding the concept of the proposed development and conducting ground observations to identify these sensitive areas.

The extent of the study area/ zone of impact must be mapped out, clearly defined and justified in the TOR document and agreed upon with EPD. This will particularly include human settlements that are to be included in the assessment surveys for the preparation of the EIA report.

5.2 Impact Assessment

The EIA for construction activities on hill slopes will assist in the following:

- Planning of site preparation and construction works;
- Identification of environmental impacts and the risk of negative impacts;
- Exclusion or protection of sensitive or vulnerable areas; and
- Protecting environmental components in the immediate site area, in adjacent areas and in the broader environment.

Integrating environment protection at the project planning stage will ensure that measures to avoid and minimise pollution can be built into the project design and work schedule. The EIA should not only consider the environmental impact on a site, but whether or not significant off-site effects are likely. An initial assessment of the site should be conducted to identify sensitive environmental areas or land-uses that require protection. These may include:

- Sensitive or endangered flora and fauna;

- Aquatic plants and animals, if a natural waterway is affected; and
- Historical buildings/ cultural areas that are considered as sensitive.

The first activity to be performed as part of the EIA process is to identify environmental issues which are important and which will need to be studied in detail, and to identify and eliminate issues which are of little or no importance and therefore can be excluded from the EIA study.

5.2.1 EIA Matrix

Impact assessment is not an exact science. The assessment of impacts therefore requires a deep knowledge and understanding of the local environment and the development concept. Therefore, different assessments are likely to come to similar but still somewhat different conclusions.

The environmental consultant should combine their personal experience with recent international and local research results, monitoring reports from neighbouring areas of active construction activities on hill slopes, new survey data and in some cases from the results of modelling.

Literature on the impacts of construction activities on hill slope already exists and in the first instance this should be consulted. A review of known impacts documented for similar environments is likely to provide a good foundation for the basis of the impact assessment.

Results obtained from computerised mathematical models need to be verified against field data. It should be recognised that for the results to be representative, the data requirements are high and limited by the quality of the input data. To enable verification by EPD, actual procedures must be made available. Before using computer models, prior consultation and approval with EPD is advisable.

It cannot be stressed enough that the environmental consultant should take a realistic and site specific view of the project. They shall neither promote nor counter the proposed activities but realistically present, what in their professional opinion is realistic to expect as a result of the plans. In order to have an impact on the planning, the environmental consultant should focus on a limited number of significant key issues supported by literature review and project specific information. In addition to an assessment of the probability (risk) of the impact to occur, each issue shall be described with a view of:

- The magnitude of the projected impact.

- The permanence of the projected impact.
- The reversibility of the projected impact.
- Cumulative impacts over time of the projected impact.

<u>This means that these four points should be represented as sub-headings for each description of an impact.</u>

The summary of results shall be presented in an EIA Matrix, an example of which is shown in Table 5-3. To guide the reader of the EIA report, this summary table is best placed before the descriptions of environmental impacts.

Table 5-3: EIA Matrix (Example)

Impacts	Magnitude	Permanence	Reversibility	Cumulative
Key Environmental Impacts				
Slope Stability	2	3	3	3
Soil Erosion and Water Pollution	2	2	2	3
Air and Noise Pollution	2	2	2	2
Waste Management	2	2	2	2
Ecology	1	3	3	3
Other Environmental Impacts				
Traffic and Transportation	2	2	2	2
Vibration	2	2	2	2
Social Economic	2	3	3	3
Visual/ Aesthetic	2	3	3	3
Abandonment	1	3	2	2

Legend	**Number**		
Criteria	**1**	**2**	**3**
<u>Magnitude</u> *Measure of the importance of the condition in relation to spatial boundaries*	Change/ effect within project site only	Change/ effect to local conditions and/or to areas immediately outside	Regional/ national/ international change/ effect
<u>Permanence</u> *To define whether the condition is temporary or permanent*	No change/ not applicable	Temporary	Permanent

Impacts	Magnitude	Permanence	Reversibility	Cumulative
Reversibility *Measure of the control over the effect of the applied condition*	No change/ not applicable	Reversible	Irreversible	
Cumulative *Measure of whether the effect will be a single effect or a cumulative effect over time or a synergistic effect with other conditions*	No change /not applicable	Non-cumulative/ single	Cumulative	

When scoring the level of impact, the environmental consultant should give justification on how the scoring has been done and what has caused very high or very low assessment scores. This can be done by repeating the table row at the end of each impact description. An example is given in Table 5-4.

Table 5-4: Activity Level EIA Matrix (Example for Slope Stability Impact)

Criteria	Score	Justification
Magnitude of Change/ Effect	2	Impacts extend to the immediate downslope, approximately 500 m away.
Permanence of Impact	3	Permanent - Changes to the slope/ building construction is permanent
Reversibility of Condition	3	Irreversible upon commencement of slope cutting/ filling works
Cumulative Impact	3	Cumulative impact with other surrounding conditions such as adjacent development, increase in traffic density within the area.

5.2.2 Use of Geographical Information System (GIS)

The representation of spatial data by means of a GIS provides an appropriate tool for representing and analysing spatial data sets, particularly for larger, more complex and sensitive projects. GIS therefore offer good opportunities to examine the environmental sensitivity of different environments.

It is a requirement to submit datasets directly to EPD. The GIS used by the environmental consultant should be able to export datasets in a format readable by the EPD's system. The environmental consultant should therefore consult the EPD before the analytic work begins in order to ensure such compatibility.

EPD may from time to time issue a list of map formats including standardised map symbols or spatial data requirement, which must be used in maps submitted as part of an EIA.

5.2.3 Optimisation of Project Plan

The environmental consultant will at several points during the assessment, find that the plan description provided by the Project Proponent is suboptimal seen from an environmental point of view. There may be environmental management issues, which are not included in the plan description, there may be certain parts of the project scope, timing or lay-out, which are not seen as acceptable, or there may be suboptimal choices of technologies or methodologies. The environmental consultant will, when such flaws in the plan description become obvious, advise the Project Proponent on recommendable plan changes so the final plan, which is being assessed by the environmental consultant, is optimised for environmental management, i.e. negative environmental impacts are being minimised through proper choice of scope, technologies and methodologies.

It is unavoidable that the project activities will cause some residual impacts even when all activities are carried out in the best possible manner. The assessment by the environmental consultant will then concentrate on assessing the magnitude and effect of these residual impacts. There will be no more that the Project Proponent can do to minimise them. There will, however, be some mitigation in the form of compensation that can be implemented. Off-set planting or replacement of habitat conservation, cash compensation or substitutes for lost livelihoods or environmental services are among the options for mitigating unavoidable and thus residual, impacts.

Project optimisation option should be thoughtfully considered and reported in the EIA report so that the maximum benefits of the project are clearly understood. These benefits should be considered against any residual impacts that may be identified in the EIA.

5.3 Environmental Impacts

The key environmental impacts associated with construction activities on hill slopes concern:

- Slope stability

- Soil erosion and water pollution
- Aesthetic/ visual
- Hydrological (drainage run-off and peak flows)
- Air Pollution
- Noise Pollution
- Ecological impact
- Waste generation and management
- Traffic and transportation
- Ground vibration impact
- Socio-economic impact
- Potential abandonment

Documented advice should be provided to Project Proponents at an early planning stage on best ways to improve the environmental sustainability of the project. For example, provide site location or design alternatives that reduce the risk of environmental impacts and improve the environmental performance and aesthetics of the project. This may require the environmental consultant to obtain specialist advice from technical specialists (i.e. designer or engineer/ architect) on such matters.

Different activities related to construction on hill slopes cause different impacts, while technologies, methodologies and local, site specific conditions determine the extent of the impacts, i.e. the zone of impact and the severity. As a planning tool, it is important that the EIA gives very clear recommendations to the Project Proponent on how activities should be implemented. The surrounding community, however, is more concerned on where, when and how, impacts will affect their livelihoods; less on why. The definition of impact, particularly residual impact, should therefore be clear and define impacts in terms of time, quantity and quality.

5.3.1 Slope Stability

Slope forms and slope processes are important considerations in land use planning, both from the viewpoint of the environmental constraints they pose and the environmental impacts related to subsequent slope alteration.

The physical landscape is an assemblage of valleys and hill slopes and the dimensions and appearance of slopes give an area its essential morphological character. Various theories have been forwarded to explain the development of slopes.

There is a direct causal relationship between the processes of soil weathering, erosion, transportation and deposition, and the form and gradient of hill slopes. The immense variety of slope form and steepness is due to the fact that processes of erosion operate in varying combinations and with differing relative effectiveness in areas of different rock type, structure, climate, vegetation, relief and so on. The form of any slope is therefore affected by a number of factors, including (but not limited to):

- Chemical composition of the rock;
- Jointing;
- Permeability;
- Angle of dip;
- Strike;
- Rate of erosion of the river at the foot of the slope;
- Climate;
- Nature and rate of weathering;
- Nature and rate of transport processes such as creep and wash; and
- Nature of the vegetation cover and contemporary earth movements

Landforms are the products of the local balance between weathering, erosion and deposition and are continuously evolving. Slopes that are too steep for the weathered material to remain stable are subject to periodic failure. Instability may be associated with moderate to steeply sloping terrain or with land which has been disturbed. There are many factors involved including soil type, geotechnical features (fractures), exposure to saturation, surcharge loading and vibration.

Natural slopes that have been stable years may suddenly fail because of construction activities on hill slopes, which may bring about (a) changes in the slope topography; (b) changes in the groundwater conditions; (c) loss of cohesive strength of soil; (d) Stress changes in the soil underlying the slope; and (e) acceleration of the rate of weathering of rock.

Cut and fill activities change the slope topography and release residual horizontal stresses allowing expansion of the slope. Joints or weak zones may be exposed along which sliding may occur. Overcutting of the toe or over steepening of the slope gradient to create a platform can also induce instability. Placement of surcharge loads, in the form of fill material or heavy machinery, over the slope may also lead to an increase in shear stresses acting on the slope which may lead to slope failure. Stockpiled, or fill material, may also fail if it is not properly designed and constructed to stringent requirements.

Surface and sub-surface drainage patterns on the existing terrain may be altered as a result of the construction activities on hill slopes. The change in groundwater flow patterns may cause detrimental changes to the stability of the newly constructed slope or the existing in-situ slopes that were stable prior to construction works.

According to H.R. Thomas (2002), the following are the seven main factors contributing to slope failure:

i. Overloading slope (weight of building or road);

ii. Increase fill on slope without adequate drainage;

iii. Removal of vegetation;

iv. Increase of slope angle;

v. Increase of slope length by cutting at the bottom of the slopes;

vi. Changes in surface drainage routes; and

vii. Changes in sub-surface drainage routes.

The main causes of slope failures/ landslides at a number of hill slope developments in Malaysia are as follows:

- **Design** – inadequate ground investigation, lack of understanding of engineering analysis and design;
- **Construction** – lack of quality assurance and quality control by contractors and lack of proper site supervision by engineers;
- **Maintenance** – lack of slope maintenance culture from both the public and private sectors; and

- **Communication** – lack of communication amongst various parties involved in construction.

<u>Assessment Methodology</u>:

<u>Description of the Site</u>: The description should include, but should not be limited to, the following aspects: terrain, slope forms (refer to Appendix 6) geology, natural topography, hydrology and natural features. The following consideration should be adopted:

a. Planning of the development should fit the particular conditions of the site: topography, soils, drainage patterns, natural features and vegetation, all of which should be reflected in the site layout plan.

b. Method statement that describes how the major activities that may cause slope instability will be undertaken. These should include appropriate phasing, preservation of green areas and buffer zones (setback) from adjacent lands, site restoration plans and others.

The environmental assessment for construction activities on hill slopes depends on the characteristics of the site itself, and of the upslope and downslope areas. Topographical maps on scale of 1:50,000 or nearest equivalent produced by the Lands and Surveys Department and detailed site topographical map at a scale of 1:1,500 to 1:500 (or larger) should be used to provide detailed information on site characteristics. The characteristics to be considered include:

- Location of site in relation to overall slope system (including slope profile and classification map);
- Geology (including geological map);
- Soil type and depth (including soil map);
- Drainage system (including hydrology map); and
- Vegetation cover.

A geological terrain mapping exercise together with slope stability analysis (determination of safety factor pre and post development) must be conducted prior to any earthwork onsite to determine the suitability of the area for construction works. In addition, this will ensure that the development is only allowed at areas deemed as safe for siting of a structure.

Review of Reports/ Studies: The list of required reports/ plans as mentioned in Section 5.1.4.1 should be assessed and their findings incorporated in the EIA report. These must be detailed out for ensuring a qualitative/ quantitative impact study on the level of the Project's significance on the existing site features.

Field Survey: A field survey should be undertaken to verify the features of the site, including its location in relation to the overall complexity of the slope system, geology, soil type and depth, drainage system and vegetation cover. It should also include geological and instability features. The geological features of interest are joints, fault zones (type and movement), zones of weak rocks, seepages/ springs and scarps. Effort should be made to identify instability features such as tilting trees (refer to Plate 5-1), poles, settlement and subsidence (such as tension cracks – refer to Plate 5-2), recent landslides, old landslides, rock falls/ toppling failure, direction of slide movement, heave and bulge. Information on these, including past instability incidence should also be obtained through consultation with surrounding residents.

Plate 5-1: Tilting of trees and failing boulders are common signs of slope movement

Plate 5-2: Sign of slope movement as suggested by tension cracks

Slope System: Representative cross-section profiles of the whole slope should be drawn to determine the form of the slope. This will aid in assessing the area of influence of the proposed project on the downslope section as well as the area of influence of upslope activities at the site.

Geology: Geology and rock types have an important influence on the types of soils found in an area, the shape of the slope and the stability of the site. Rock structures (bedding planes, folds, joints, faults) are an important factor in the stability of natural hill slopes. For example:

- Steep terrain often has highly fractured rocks exposed, which increase the susceptibility of the area to rockslides and landslides.
- Weak rock types are frequently combined with unfavourable geological structures and active tectonics (changes in the earth crust), creating regions where larger portions of the hill slopes are formed by mass movement processes.

Soil Type: Soils are developed from the weathering of rocks. Different rock types produce different soil types with different chemical and mechanical properties. Erodibility is defined as the resistance of the soil to both detachment and transport and varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical content. The erodibility of soil is one of the factors controlling erosion. Shallow soils normally occur in hill slopes and are very often non-cohesive and tend to be eroded very easily.

Surface and Groundwater Conditions: Any development can have the potential to change the existing surface water and ground water conditions. On hillslopes, these impacts can be critical. Increased impervious areas (roads, pavements, buildings) will decrease the infiltration to groundwater tables, and increase the quantity and rate of surface water runoff. The reduction in groundwater and lowering of water table may cause soils to shrink or crack, with changes to their inherent properties. The increased surface water flow can, if not adequately managed, lead to greater soil erosion, and impacts on downstream slopes and waterways.

Vegetation: Vegetative cover helps to break the impact of falling rain drops and hence, reduces their erosive force. The roots of trees also play an important role in reducing erosion and site stability by binding soil mantles to sub-soils or substrata thus, contributing to the mechanical strength of the soil.

The information shall be assessed and potential slope instability areas identified and transferred to a topographical map of appropriate scale. These should include key findings from the reports/ studies conducted as well as recommendations by the environmental consultant to ensure these are considered during the preparation of EIA report. In addition, there must also be a full time supervision by professional engineers during implementation of hill site development to ensure proper and responsible implementation of the slope protection and strengthening works.

5.3.2 Soil Erosion and Water Pollution

Erosion on slopes occurs when one or more of the following conditions prevail: (i) The slope length is long; (ii) The slope is steep, (iii) The soil is highly erodible and/or the soil cover (vegetation) has been removed and will take some time to re-establish.

Construction activities on hills with slopes having a gradient of 20 degrees or more (steep slopes) invariably involves removal of vegetation cover, slope cutting and filling activities and can therefore, accelerate the process of soil erosion on slopes.

Site clearing: i.e. vegetation removal, involves earthwork to prepare a level platform for the buildings and structures to be constructed. Clearing of the ground surface will make the area vulnerable to the erosive effect of rain. Erosion on exposed slopes starts with rain-splash leading to sheet, rill and gully erosion. Soil loss due to erosion will subsequently be discharged into streams, causing increased in turbidity levels and water quality degradation. Not all eroded material is discharged immediately and much of it can be deposited temporarily or permanently on the land surface where the slope becomes gentler (refer to Figure 5-1 and photos).

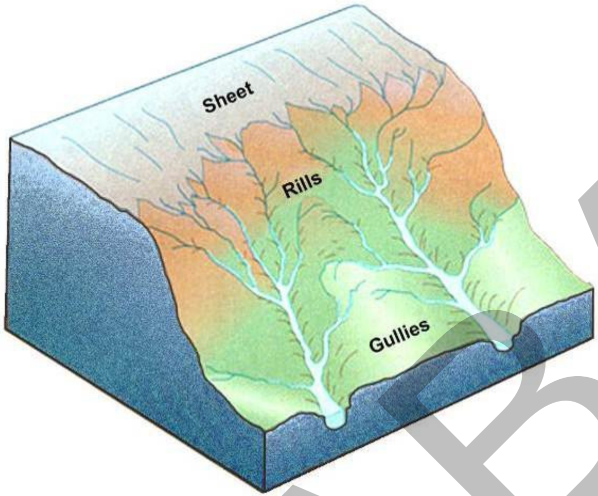


Figure 5-1: Soil erosion diagram

Sheet Erosion

Rill Erosion

Gully Erosion

Cutting and filling changes the slope gradient, often creating steeper slopes. The steeper the slope, the faster the runoff water flows and the more force it will have to move material (refer to Figure 5-2).

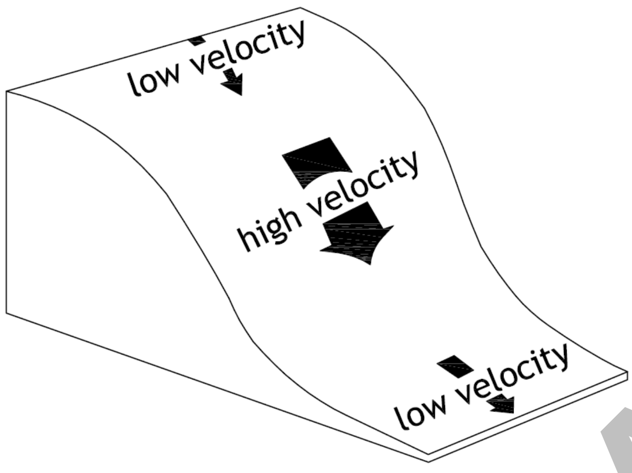


Figure 5-2: Erosion and its resulting flow velocity

Assessment Methodology:

Assessment of Soil Erosion Risk: It is important to assess and identify risk areas where soil erosion will increase during and after the construction period. Erosion risk from construction of access roads leading to the project site should also be considered. The methodology for the assessment of soil erosion risk can involve the following steps:

i. *Examine available topographical data*

This includes topographical, land use, soil and vegetation cover maps within and surrounding the proposed site. It can also consist of satellite imagery, and aerial photographs. Historical aerial photos can provide information on changes over time of river alignments and other geomorphological features. The following features should be identified:

- Drainage features (permanent, intermittent and dry valleys);
- Erosion features such as rills, gullies, mass movement, bank erosion and others;
- Areas of sedimentation including streams;
- Man-made features such as settlements, tracks, roads and others;
- Water users and intake points downstream;
- Type of vegetation cover; and
- Soil type and depth.

ii. *Conduct field surveys*

These should be conducted to verify the features identified in Item (i) and to add additional information such as other erosion sources, location of discharges, current nature of rivers and streams downstream of project site and water users downstream (water intake points, catchment areas, mangroves, swamps and others).

iii. *Prepare a pre-development erosion risk map*

This map should include relevant data gathered in Item (i) to (ii) and provide information on the following:

a) Location of existing areas with high erosion rates within the site and along alignment of access road;

b) Amount (including percentage of total land) of areas with high erosion rates; and

c) Existing areas of sedimentation, including existing drainage. This map will assist in assessing the location, nature and magnitude of change in erosion risk due to the project development.

iv. *Undertake an erosion risk assessment*

Erosion risks are higher during the site preparation and earthwork stage when the land is cleared and exposed for a period of time. The longer the exposure period, the higher the soil loss will be. The seriousness of soil erosion during the these stages will depend on the size and location of land cleared and the period and phasing of exposure. These factors should be studied and described through an overall erosion risk assessment. The soil loss assessment will assist in assessing the mitigating measures proposed in the development plan to control soil erosion during site preparation and earthwork stages.

A best possible approach to assessing overall soil erosion risk, is to conduct a careful assessment of the geomorphological condition of the slope, to provide an indication of whether the project will place the environment at risk. Criteria for environmental assessment therefore should include the following:

- Period of exposure of cleared land and predicted soil loss during the exposed period (use of Universal Soil Loss Equation – USLE, refer to Appendix 8);

- Status of the water quality downstream of the site;
- Amount of earth/rock cutting and filling required and its coverage area onsite (including earthwork phasing);
- Number of beneficial users sensitive to water pollution downstream;
- Extent of sedimentation and damage to property and water intake points downstream; and
- Maximum slope and height for compaction of filling either on flat land and/ or hill slope.

Preparation and Assessment of Conceptual Erosion and Sediment Control Drawings: These scaled drawings should be superimposed onto the topographic map indicating the mitigating measures to be implemented onsite. The drawings should contain the following information:

a) List of all Best Management Practices (BMPs) for erosion and sediment control including their quantities, sizing design/ calculations and locations;

b) Stockpile, overburden and disposal management areas; and

c) Areas to be preserved, critical buffer areas and river reserves.

Review of Reports/ Studies: The list of required reports/ plans as mentioned in Section 5.1.4.1 should be assessed and their findings incorporated in the EIA report. These must be detailed out for ensuring a qualitative/ quantitative impact study on the level of the project's significance on the existing site features

Review of Earthwork Methodology: Information on earthwork methodology including phased clearing and provision for erosion control facilities should be assessed based on site suitability. These include identification of adjacent sensitive areas including key conservation value species. Location of borrow pits/ dumping sites for earth materials including transportation route and number of trips should be made known.

5.3.3 Aesthetic/ Visual

Construction activities on hill slopes will unavoidably bring about a change in the landscape and will thus have a visual impact on landscape quality. Visual/ aesthetic impact is mainly concerned with the direct physical change to the existing landscape features such as removal of vegetation, alteration of topography and erection of buildings and structures. Visual impact is a change to the appearance of the landscape and the subsequent effect on the views of communities, groups and individuals that are exposed to it.

Assessment of visual amenity impact is often difficult to predict and quantify as it is largely subjective. Therefore it is necessary to assess this component in a consultative manner, involving as wide a sample of potentially affected persons as possible. It will also assist to prepare a scale model, or artistic impressions of the expected outcome on completion of development.

Visual impact can vary from overall improvement to degradation. For example; construction of chalets on a hill slope could lead to improvement of the visual quality and enhance the attractiveness of the landscape; erection of a five storey hotel on a ridge top could lead to visual obstruction and blocking of views; a poorly designed four storey bungalow could be visually incompatible with the surroundings and therefore reduce the overall visual quality of the area.

Landscape and visual impact assessment shall be directed towards predicting and judging the significance of the effects that the new development may have on landscape character and visual amenity. The perception and aspiration of the community on particular landscape features must be taken into account. The assessment should also take into account the compatibility of the proposed development with existing local plans and regional planning.

Assessment Methodology:

Step 1: Preparation of Site Inventory: An inventory of the existing landscape and visual characteristics of the site and its surrounding area should be undertaken to identify, classify and record the location of the visual resources and values. The inventory in the form of photographs, maps and images of visual resources can be prepared by examining aerial photographs, desk study and ground survey. The inventory should at least cover the following aspects:

- Physical aspect such as landform, drainage and geology;
- Human environment aspects such as settlements, buildings, cultural heritage features, protected areas, wetlands and the affected people including their perception and aspiration of the particular project's landscape features;
- Aesthetic aspects such as the available views, visual amenity and visual character; and

- Extent of vegetation that will be cleared as per the development plan proposal.

Step 2: Preparation of a visual envelope: A visual envelope is the number and extent of visual receivers. The establishment of the visual envelope should be based on a desk study as well as a site investigation. Visual receivers within the visual envelope should be chosen from a variety of distances and viewpoints. In assessing visual impacts, it is important to cover as many viewpoints as possible. Key viewpoints to be selected include viewpoints from major access routes e.g. roads, footpaths and other and at activity nodes (e.g. residential areas, important public open spaces and landmarks). The number and extent of visual receivers should be described and mapped. The exact location of selected viewpoints used should be specified.

Step 3: Visualization: A visualisation of the proposed development shall be made. Visualisation techniques such as perspective drawings, plans and section elevation diagrams, photomontages and computer imaging can be used to demonstrate how the proposed project will look. The choice of presentation technique for the perspective views will depend on the complexity of the proposed project, number of viewpoints and visual sensitivity of the area. The exact location of selected viewpoints used for visualisation should be specified.

Step 4: Review of Planning and Control Issues: Compatibility of the project to blend into the existing landscape and local/ regional plans should be taken into consideration. In addition, there should be a review of the planning and development control framework (development plan, land lease condition, special design areas, landmarks, monuments, guidelines and control on urban design and others) as these will provide an insight into the future outlook of the affected area and the way the proposed project can fit into the wider context.

Step 5. Overall Assessment of the Project's Impact on the Landscape: The assessment of landscape and visual impacts could include (for example):

- Level of change to the existing landscape condition, which includes direct impacts (relating to physical removal or destruction of features) upon specific landscape elements, as well as more subtle effects upon the overall pattern of landscape elements that give rise to landscape character and local and regional distinctiveness;

- Scale of the proposed works in relation to the overall view;

- Impact upon acknowledged areas of special interest or value, such as landform features with special landscape significance;
- Proximity of sensitive viewpoints to the proposed development; and
- Compliance with existing guidelines, planning and control issues.

Examples of special landscape features that may contribute to the landscape character of a site, area or region include:

- Valued landscape, e.g. national parks, protected coastlines, areas of high landscape value, scenic spots and others;
- Other areas of conservation interest, e.g. protected areas, designated buffer zones, wetlands, historic landscape, sites or buildings of cultural heritage; and
- Specific landscape elements, e.g. mountain and hilltops, ridgelines, coastlines, rivers and waterfalls, and valleys.

An example of an assessment criteria checklist, which can be used for visual/ aesthetic assessment, is shown in Table 5-5.

Table 5-5: Example of Assessment Criteria Checklist

Compatibility with Surroundings	**Yes**	**No**
- Height - Shape - Proportion - Building elements, colours and materials used		
Obstruction of Views	**Yes**	**No**
- Block views from existing key viewpoints towards existing landscape features - Block views from existing/ planned view corridors towards landmarks/ features		
Landscape/ Visual Quality Enhancement	**Yes**	**No**
- Appealing design features that enhance attractiveness of the landscape - Clear visual obstruction of landmarks/ features from existing key viewpoints		
Visual Interference	**Yes**	**No**
- Uncomfortable eye feeling/ glare caused by reflection of sunlight from structures		

- Uncomfortable eye feeling/ glare caused by generated direct light sources
- Reduces sightings of wildlife

5.3.4 Hydrological (drainage run-off and peak flows)

It is very important to characterise the hydrological condition of the site, both surface and underground. Surface and underground hydrological characteristics of importance include:

- Drainage pattern;
- Dimensions and flow of stream and river;
- Natural drainage depressions, basins and sinks;
- Floodplains, both on site and downstream that will undergo change due to grading and construction; and
- Sub-surface condition including depth to water table, flow pattern of groundwater and aquifer type.

Changes in water runoff need to be managed so that they do not contribute to downstream impacts. Also, any potential changes to groundwater need to be carefully considered as these can impact foundation conditions and slope stability.

5.3.5 Air Pollution

Dust can be expected around the project development area, particularly during prolonged dry and windy conditions. Sources of air pollution for construction activities on hill-slopes include:

a) Dust from on-site surface works including site clearing and earth moving operations; transportation of earth and construction materials; and

b) Air pollutants such as Nitrogen Oxides (NO_x), Sulphur Oxides (SO_x), Carbon Monoxide (CO) and smoke from the exhaust emissions of transportation vehicles.

Dust particles are transported by wind and/ or water. Wind borne dust can settle on neighbouring or distant properties, resulting in particle dust on surfaces, which may affect operations or simply represent a nuisance for others. Dust deposition on vegetation can affect photosynthesis, thus impacting affected species.

High levels of dust concentration may occur in the local environment, presenting a health hazard to local people or communities.

Assessment Methodology:

A risk assessment on the level of dust affecting the population living in the area should be undertaken. The risk will be dependent on the number of people exposed to the elevated dust levels and the period of exposure. The risk should be assessed in relation to the predominant wind direction for the area, duration of site activities and length of dry period. Baseline air quality monitoring should be established at the nearest receptors to determine the present level for comparison during the implementation stage of the proposed project.

5.3.6 Noise Pollution

Within construction sites, the main source of noise is semi-mobile and mobile machineries conducting the construction activities. These include excavators, loaders, bulldozers, piling machine and cranes, dump trucks, lorries and graders. These machineries and vehicles operate within the construction site and along the access road. Most of the noise from these sources is inherent and difficult to subdue.

Assessment Methodology:

As the operation of the construction machinery and equipment will result in elevated noise levels, a risk assessment of noise pollution in relation to the surrounding communities should be conducted. This can include (among others) comparison of noise level from different equipment in relation to the distances from the site obtained from published literature, as shown in Table 5-6.

Table 5-6: Example of Typical Noise Level from Construction Machinery

Type of Equipment	Typical Noise level at 30 metres (dBA)
Scrapper at full load	83 – 92
Dozers ripping	80 – 90
Loaders (100 – 200 kW)	77 – 80
Cranes (small mobile)	74 – 77
Dump trucks	65 – 82
Diesel generator sets (250 kVA)	74 – 81
Welding Sets	69 – 75
Concrete trucks	69 – 78

Type of Equipment	Typical Noise level at 30 metres (dBA)
Pile driver (air hammer)	80 – 101
Chipping hammer on steel	63 – 81
Grinder	63 – 68
Air compressor	65 – 67

Source: World Health Organization

Reference should also be made to noise conditions at the project site in relation to the allowable noise limits stipulated by the Department of Environment in the Planning Guidelines for Environmental Noise Limits and Control in the Environment, 2007. In addition, the length of the construction activities should also be taken into consideration in the assessment. Baseline noise level monitoring should be conducted at the nearest receptors to determine the present level for comparison during the implementation stage of the proposed project. Existing sources of noise nuisance should also be properly documented.

5.3.7 Ecology

Construction on hill slopes will change habitats with subsequent impacts on the flora and fauna. The main ecological impacts are related to the clearing of vegetation and water pollution and the main objective of an ecological assessment is to provide sufficient data to allow an identification, prediction and evaluation of the potential ecological impacts. Concerns should be focused on unique or rare plants, or species of major conservation or scientific interest.

Assessment Methodology:

A site inventory of existing flora and fauna is vital in order to determine what, where and in what numbers communities of fauna and flora utilise or occur at or nearby the project site. This is particularly important where the site is within or adjacent to sensitive environments such as mangroves, parks or other protected areas. The site inventory can be prepared through ground surveys with reference to a location base map. If the site is known to accommodate either a permanent or temporary endangered or protected species, data on the distribution and location of these species should be provided. Surveys of aquatic environments is only required if the site is located upstream/ within of known aquatic sensitive areas or habitats.

The ecological impact shall be assessed against the location of the site clearing as indicated in the development plan, potential water pollution, and size of sensitive areas within and surrounding the site and whether it will be destroyed as well as the presence of sensitive aquatic areas downstream.

5.3.8 Waste Management

During construction stage, the main types of waste generated are solid waste and sewage. The release of untreated sewage into any existing waterway will result in discharge of effluent with a high organic and nutrient level, which could lead to eutrophication, and spread of pathogens in the downstream receiving waterway. As for solid waste, it consists mainly of used cement bags, discarded steel bars, planks and others as well as household garbage from the site office and workers' quarters.

Fuel is normally kept on-site for use by construction machinery and transportation vehicles, and normally stored either in skid tanks or steel drums. Accidental spillage or leakage from tanks and drums may contaminate soil/ water and cause pollution. Oily wastes are categorised as scheduled waste and their handling, storage, transportation and disposal are governed by the Environmental Quality (Scheduled Wastes) Regulations, 2005.

Assessment Methodology:

The impact of sewage should be assessed based on the quality of the sewage effluent and its compliance to the Environmental Quality (Sewage) Regulations 2009. As for solid waste, the impact should be assessed based on the predicted amount of garbage produced daily and its management practice onsite. The ability of the temporary disposal area onsite to accommodate this waste should also be assessed.

5.3.9 Traffic and Transportation

Traffic creates noise and dust as well as affecting existing traffic flows, particularly along the access roads. Traffic associated with construction activities on hill slopes are mainly large lorries transporting earth and construction materials to and from the project site. This can create a nuisance in the surrounding area, particularly outside normal working hours, by affecting existing traffic flows, causing dirt to accumulate on the roads and causing damage to the roads.

Assessment Methodology:

Traffic and transportation impacts can be assessed based on the number of houses and population affected by the nuisance created by the traffic movement. The existing road capacity should be assessed together with mapping of the surrounding communities affected by the transportation route. Where available, the location of the borrow pits/ disposal sites for the proposed project should be made known so that the suitability of the transportation route can be assessed.

The longer term impact of increased traffic flow post-development also needs to be assessed. The need for increasing traffic capacity or enhancing traffic management on roads leading to the site must also be assessed.

5.3.10 Ground Vibration

Vibration of structures may occur due to air-borne acoustical waves or solid borne vibration. Ground borne vibration is likely to accompany some construction and other industrial activity. The frequency range of vibration inside buildings which may result in human response is between 1 Hz and 80 Hz, with human sensitivity to acceleration (by vibration effects) decreasing with decreasing frequency.

Structural damage may be caused in industrial areas by vibration-exciting machines, in construction zones by pile driving or other activities, in residential areas from traffic on roads and railroads. In addition, vibration can also have a damaging effect on slope stabilization measures and retaining structures as well as causes discomfort to surrounding residents. Vibration due to pile driving depends on the nature of the soils transmitting the vibration and the distance to the nearest building.

Structural damage due to ground vibration from blasting of rock outcrop within a construction site is related to peak particle velocity. Presently, the Minerals and Geoscience Department recommend a limit of 3 - 5 mm/s for housing areas, depending on site sensitivity. Any proposal for blasting activities requires prior approval from the Minerals and Geoscience Department through submission of a detailed blasting design proposal by a specialist/ mining engineer. Appropriate minimum safe distance from the blasting point should be recommended. Reference should also be made to The Planning Guidelines for Vibration Limits and Control in the Environment (Department of Environment, 2007). In addition, the site's underlying geological and soil features as detailed out in the list of reports/ studies mentioned in Section 5.1.4.1, should be assessed to ascertain the degree of impact in relation to the project details.

Assessment Methodology:

Vibration from pile driving and blasting activities (if any) must be monitored to assess the levels. The impact assessment should be based on the location and distances of the nearby houses/ structures in relation to the source of the vibration within the site. Suitability of piling method adopted should also be discussed based on site characteristics, depth of penetration and proposed development concept. Generally, use of bored piling (see Plate 5-3) is much preferred compared to conventional hammering method as it reduces ground vibration and noise issues significantly.

Plate 5-3: Use of bored piling for foundation works

5.3.11 Socio-Economic

The project planning needs to demonstrate a commitment to the social consideration in land use planning, and a requirement for all development to follow the guidelines in preparing social assessment reports as part of the EIA study process.

Assessment Methodology:

Description of Existing Socio-Economic Conditions: This includes a description of the following from field studies, ground surveys and published reports:

- *Existing and Proposed Land Use*

These include zoning for the area within and surrounding the proposed development and any designated receptors that are found during field visits.

- *Land Status/ Tenure*

  Land issues/ claims should be highlighted, if any.

- *Key Demographic and Economic Characteristics*

  This applies to the surrounding community within the zone of impact and includes:

  - Location of populations within and surrounding the project site (clearly illustrated in a map)
  - Population
  - Gender and age groups
  - Ethnic group and religion
  - Education background
  - Socio-economic status (i.e. economic activities, income, occupation)
  - Sensitive areas (i.e. burial grounds, historical buildings/ artefacts, cultural sites, water catchments, archaeological sites, tourist attractions and others) (clearly illustrated in a map).

- *Infrastructure/ Service/ Facilities*

  Urban Area – within 500 metres radius or 5 – 10 minutes walking distance (i.e. child care centre, kindergartens, schools, clinic or hospital, shops, public transport, recreation centres and others (clearly illustrated in a map).

  Rural Area – within 3 km radius from the site.

- *Perception and Awareness/ Community Engagement*

  Consultation should, at the very early planning stage, provide the community with an opportunity to be informed and to influence decisions which may affect them. The Project Proponent should commit to this consultation by giving opportunity for community to participate in the decision making process as the project may affect the way their local area is developed.

A consultation plan document including the following should be prepared:

- *Objective of the consultation process*
- *Identification of zone of impact (receptors that will be impacted by the development)*
- *Level of communication, i.e. door to door interview, questionnaire distribution, community dialogue and others*
- *Relevant questions that should be posed to the community can include (but are not limited to):*
  - ➢ *Have you heard about the new upcoming project?*
  - ➢ *What are your concerns related to the project?*
  - ➢ *What benefits do you perceive from this project?*
  - ➢ *What is your recommendation for improvement of the project?*
  - ➢ *What is your level of acceptance of the upcoming project?*

  The number of respondents to be consulted within the zone of impact must be determined and justified by the environmental consultant with **locations of those interviewed marked in a map**. Emphasis should be given on consultation with the village head/ local representative.
- *How issues raised in the public consultation are to be handled in the EIA report.*

Brief social survey notes describing the project concept and outlining the social consultation method including list of questionnaire must be prepared and documented in the EIA report.

Prediction of social economic impacts is an inexact exercise. To assess the significance of the impacts, the following general concerns need to be addressed:

- *Nature of the Impact*

Probability of occurrence	-	Likelihood that an impact will occur as a result of the project

People affected	-	Percentage of population affected or how it will affect different demographic groups
	-	What is the likely population change as a result of the development
	-	Will the project likely to give rise to an increase or decrease in employment opportunity in the local area
Zone of Impact	-	The extent of impact in terms of area (show on map)
Duration	-	How long will the impact last, assuming no attempts to mitigate

- *Severity of the Impact*

Local sensitivity	-	To what extent is the local population aware of the impact? Is it perceived to be significant? Has it been a source of previous concern in the community?
Magnitude	-	How serious is the impact? Does it cause a large change over baseline conditions (e.g. will crime rate double)? Will local capacity be exceeded?
	-	Will the project generate demand for increased community services and facilities (schools, health care, road conditions, shops, public transport, parks and others)?

- *Potential for Mitigation*

Reversibility	-	Is the impact reversible? Short or long term?
Institutional capacity	-	The current institutional capacity to address impacts
	-	Existing legal, regulatory structure
	-	Can local government deal with the impact or would it involve the private sector?

In general, many predicted economic impacts are beneficial and encouraged by the local decision makers. However, there are likely to also be negative impacts, particularly for those residing near to the proposed development. The potential local employment benefits of a proposed project can be encouraged through appropriate skills training programmes for local people. In addition, the project may provide business spin-off and contract opportunities to the local service providers and industries.

5.3.12 Potential Abandonment

Even if the possibility of abandonment of the project is unlikely, there has to be a contingency plan in the event of this happening in abnormal circumstances, such as economic collapse or a poor market situation or other unpredicted calamities. The abandonment could take place at any stage of the project.

If the site were to be abandoned at any stage during the project activities period, there is a risk of the following impacts:

i. Cleared areas that are abandoned will become long-term sources of soil erosion, contributing to water quality issues and detracting from future use of the site;

ii. If the site is abandoned following the earthworks stage, an unsightly scar on the landscape may be left, which will impair the aesthetics of the area;

iii. Temporary changes in surface water and ground water conditions, as planned for during the earthwork phase, may become permanent if the site is abandoned. These changed conditions could lead to slope instability in the medium to long term;

iv. Cleared, but abandoned, land may become an area for colonisation by weed species that then spread to adjacent sites; and

v. The site having been cleared and abandoned, may be occupied by squatters with structures constructed in an unplanned, unsanitary, and potentially unsafe manner.

As such, it is important to establish a proper abandonment plan which lists out works to be conducted prior to actual abandonment. These may include assessment of site suitability for other future developments, site cleaning works as well as rehabilitation works.

5.4 Additional Impacts

The list of potential impacts above is non-exhaustive as the environmental consultant should extend or shorten the list of issues depending on local conditions. The discovery of particular key conservation value areas or particular sensitive habitats will require the inclusion of new issues while other issues may not be applicable for that particular project.

6 Mitigation Measures

This chapter covers identification of the major mitigation measures for the environmental impacts identified (refer to Table 6-1).

Table 6-1: Assessment Procedures – Description of Mitigation Measures

The Seven Steps	Summary of Main Required Activities
Step 4: Undertaking the EIA study	Environmental Consultant: • *Assess the project details* • *Assess the existing environments* • *Assess the environmental impacts* • *Devise and propose mitigation measures* - *Provision for slope stability measures* - *Provision for erosion control measures* - *Proposal for landscaping/ aesthetic features* - *Minimizing air and noise pollution impact* - *Provision for habitat and wildlife protection/ conservation* - *Management of waste generated* - *Minimizing ground vibration impact* - *Provision for transportation management* - *Reducing adverse impact on surrounding community* • *Devise and propose monitoring programmes*

The previous section included a description of methods for assessing planned activities and their impact on the environment. It also points out that there may be impacts from necessary and unavoidable activities, which were not included in the project plan and description. Mitigation measures therefore address three different scenarios:

- Proposals for improved technologies or methodologies for planned activities in order to minimise their negative environmental impact, e.g. site selection, site layout orientation, development implementation method or exclusion of high risk areas.

- Proposals for management activities, which are not included in the Project Proponent's original plan of activities but which are necessary in order to control environmental degradation, e.g. waste management, drainage, soil erosion control practices and others. This is mainly related to working practices such as limiting works hours.
- Proposals to compensate for unavoidable, residual impacts, e.g. community development programmes or a specific contribution towards local conservations or offsets.

The environmental consultant should assess the adequacy of the measures to alleviate or mitigate negative environmental impacts planned by the Project Proponent. Where the Project Proponent's measures can be strengthened or where they are seen as insufficient, the environmental consultant should propose mitigation in the form of proposals for alternative technologies, methodologies or scope of work. Addressing the key physical impacts prior to design finalisation is essential to the sustainability of the overall design concept. For residual impacts, the environmental consultant should, where appropriate, propose mitigation measures to compensate for the effects of the impacts. It is important to note that the recommended mitigation measures for a project in the EIA report must be based on the different stages of project implementation such as site preparation, earthwork and construction as well as potential abandonment.

The environmental consultant should, for each foreseen impact and for each proposal for changes to scope, technology or methodology assess the risk level and magnitude of all expected residual impacts and state these clearly in the EIA report.

In addition, there are requirements, which are imposed for administrative reasons. These include employment of an environmental officer, provision of maps and other information, which may be necessary for environmental monitoring.

It is, however, important that the Project Proponent and the environmental consultant together use the latest knowledge and development in the respective fields, in order to devise a project and site specific plan for environmentally sound management and associated mitigation. The pointers included in this guideline should not be seen as a complete, ready-made, direct solutions but rather as principles of mitigation.

At the same time, it must be stressed that any combination of site, technology and methodology will warrant a unique set of mitigation measures.

6.1 Key Mitigation Measures

6.1.1 Slope Stability

The impact of construction works on the stability of slopes and the surrounding environment can be minimised by the provision of slope stabilisation measures. These measures should be carried out even before commencement of construction so that the construction activities will not be hampered by slope movement which may later require costly remedial work.

The mitigation measures that can be considered for slope stabilisation include (but are not limited to):

- **Avoid the risk of slope failure by avoiding high hazard areas** - Where the potential for failure is beyond the acceptable level and not preventable by practical means, i.e. the terrain is subject to massive planar slides or rock and debris avalanches, the hazard should be avoided. Planned development on such slopes or near the base should be avoided and relocated to areas where stabilization is feasible.

- **Protect the site from slope failure** - While it is not always possible to prevent natural slope failures occurring above a project site, it is sometimes possible to protect the site from failed slope material. This is particularly true for sites located at or near the base of steep slopes. Methods include catchment and/ or protective structures such as basins, embankments, diversion or barrier walls and fences.

- **Reduce the hazard to an acceptable level** - For deep-seated slope instability, strengthening the design of a structure is generally not by itself an adequate mitigating measure. Unstable slopes affecting a project can be rendered stable by increasing the factor of safety through the reducing or eliminating of the slope, removing unstable soil and rock materials, or applying one or more appropriate slope stabilisation methods (such as buttress fills, sub-drains, soil nailing, crib walls and retaining walls) (refer to Plate 6-2).

The environmental consultant should evaluate all the proposed mitigation measures to stabilize all cut and fill slopes, structures and unstable zones, as contained in the development plan proposal, for their suitability and effectiveness. In this respect, expert opinion may be sought. If necessary, more effective and suitable mitigation measures should be proposed.

The stabilisation method chosen depends largely on the type of instability anticipated at the project site and surroundings. Often there are multiple contributing factors that cause or could cause slope failure or instability. Frequently, the most economical and effective means of treating slopes consist of a combination of two or more of the stabilisation techniques in conjunction with selecting the most effective and economic stabilisation measures.

Two general techniques used to stabilise slopes are (i) to reduce the driving force for failure; and (ii) to increase the resisting force. These two techniques are described in the following points, which describe potential slope failure mechanisms and propose mitigation measures for each:

(i) Rock and Soil Falls

The principle of this slope failure mechanism is loss of cohesion or tensile strength of the near-surface material on very steep slopes. The mitigation measures that can be considered include (but are not limited to):

- **Reduce the driving force** - This can be achieved by reducing the steepness of the slope through grading, by scaling off overhanging rock, or by diverting water from the slope face;
- **Increase resisting force** - This can be achieved by pinning individual blocks, covering the slope with mesh, net or vegetation, and/ or installing rock anchors or rock bolts. Refer to Plate 6-2 for examples of slope vegetation methods.

(ii) Slides, Slumps and Block Glides

The principle of this slope failure mechanism is loss of shear strength, resulting in sliding of soil or rock mass along a rupture surface within the slope. The mitigation measures that can be considered include (but are not limited to):

- **Reduce the driving force** - This can be achieved by reducing the weight of the potential slide mass (cutting off the head of the slide, or totally removing the landslide), flattening the surface slope angle through grading, preventing water infiltration by controlling surface drainage, or reducing the accumulation of subsurface water by installing sub-drains.
- **Increase the resisting force** - This can be achieved by replacing slide debris and especially the rupture surface with compacted fill, installing shear keys or buttresses, dewatering the slide mass,

pinning shallow slides with rock anchors or bolts, or by constructing retaining structures at the edge of the slide.

(iii) Flows of Debris or Soil

The principle of this slope failure mechanism is fluidization of the soil mass, commonly caused by the addition or increase in water such as when the site is cleared and left exposed for a long period. The mitigation measures that can be considered include (but are not limited to):

- **Reduce the driving force** - This can be achieved by removing potential debris from the site using grading or excavation procedures, or diverting water from debris, by means of surface drains and/ or subsurface drains, so that it cannot be mobilized;
- **Increase resisting force** - This can be achieved by providing buttresses together with subsurface drainage; and
- **Protect site against failure** - This can be achieved by diverting the flow away using barriers or channels or by providing catchment structures to contain the slide material.

Other mitigation measures that can be considered for slope stability include (but are not limited to):

- **Terracing and benching** - This should be carried out and properly maintained. Vegetation should be established on the slopes of the platforms and walls of the terraces immediately after commencement of earthwork onsite.

Plate 6-1: Constructed reinforced soil wall for slope strengthening

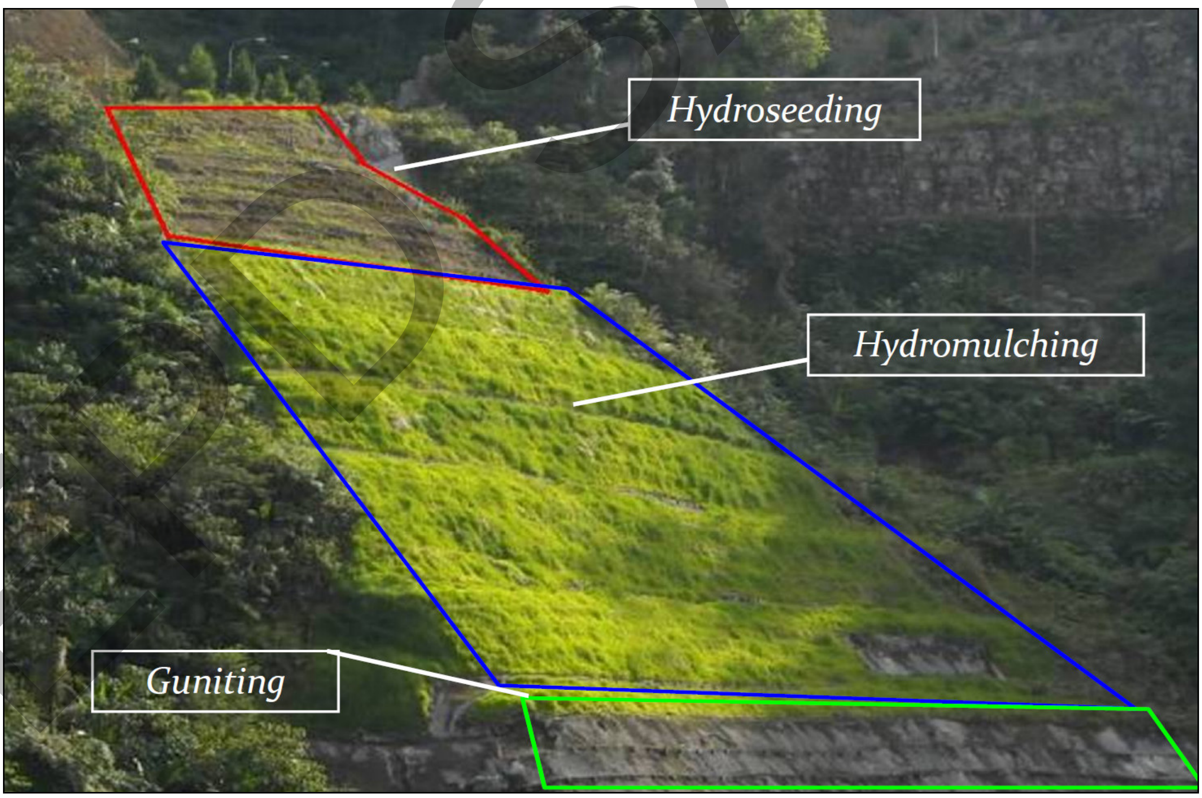


Plate 6-2: Combination of different slope surface treatment

6.1.2 Soil Erosion and Water Pollution

The mitigation measures that can be considered for soil erosion and associated water pollution include (but are not limited to):

- **Appropriate siting and design** - The development should be sited and designed in a manner that presents the lowest erosion risk and minimum land clearance. Where possible, the existing greenery and aesthetic features of the site should be incorporated in the final development layout.

- **Phased development** - Phased development to reduce the amount of exposed land at any one time. Land clearing should be undertaken in phases to keep the area of exposed soil at any one time to a minimum. Only those areas required for development should be cleared. For this purpose, a land clearance plan should be prepared showing the start completion of each phase of development. Clearing, grading and stabilisation operations on one phase should be completed before moving on to the next phase. The construction specifications shall clearly define the maximum length of time that a graded area will be left exposed and what short-term stabilisation methods will be implemented in the event of a lengthy delay. Soil erosion is also minimised by limiting the exposed area to small and discontinuous areas, at a given time.

- **Terracing and maintenance** - Terracing should be carried out and the terraces should be regularly maintained. Vegetation should be established on the slopes of the platforms and walls of the terraces immediately after completion of each phase of earthworks.

- **Stabilisation and protection of exposed areas** - Disturbed exposed areas should be stabilised and protected from rain and runoff as soon as practicable to reduce exposure time. Exposed slopes should be planted with quick spreading grass or other suitable ground cover vegetation as soon as possible so as to keep the interval between clearing and re-vegetation to a minimum. The programme for protecting exposed slopes as contained in the ESCP should be examined and assessed for its effectiveness and practicality. Alternatives include covering the exposed soils with mulches, grasses, matting, plastic sheeting and others (refer to Plate 6-3). This will help protect against the impact of rainfall and the energy of runoff water.

Plate 6-3: Use of canvas sheet as temporary soil erosion control onsite

- **Proper topsoil stockpiling** - Excavated topsoil should be stockpiled at least 30 metres from watercourses, temporarily stabilized and later used for re-vegetation works onsite.

- **Retaining existing vegetation cover** - As far as possible, the existing vegetation cover should be retained as a filter along contours to reduce runoff velocity and capture sediment before it reaches the watercourse.

- **Protection of cut and fill slopes** - Cut and fill slopes should be protected with retention structures or vegetation as soon as possible to minimise erosion of exposed material. The programme of protecting cut and fill slopes as contained in the ESCP should be examined and assessed for its effectiveness and practicality.

- **Construction of sedimentation basins** - Sediment within the construction site should be retained by construction of temporary sedimentation ponds. The location and number of sedimentation ponds as proposed in the ESCP should be assessed against the site erosion assessment. These erosion control measures should be designed in accordance with MSMA requirements by the Department of Irrigation and Drainage in the Urban Stormwater Management Manual for Malaysia. Regular inspection on maintenance works should be conducted to ensure their efficiency.

- **Construction of drainage network** - A network of drains can be installed to regulate runoff within the site and also prevent runoff from adjacent areas from flowing into the site. Perimeter and feeder drains should be designed to cater for peak surface runoff. These drains should be maintained by removing deposited silt at regular intervals. The network and locations of drains as proposed in the ESCP should be assessed before and during construction activities. Additional drains may be required to ensure proper regulation and control of runoff within the site. Particular attention needs to be paid to the drain outlets so that downstream impacts are not initiated or exacerbated. Capacity of receiving drains or waterways needs to be checked for increased flows and the flow concentration at the outlet.

- **Preservation of natural river flow** - The natural flow of rivers and tributaries within the site should be preserved and conserved as much as possible. Efforts should be made to incorporate these into the final development plan layout.

- **Provision of river reserves** - If any river/ stream is found within the site, river reserves should be provided as green buffer in accordance to the requirements by the Department of Irrigation and Drainage.

- **Protection of water catchments** - Ensure that the primary usage and function of water catchments are protected in accordance to the following hierarchy:

  i. water supply;

  ii. drainage;

  iii. power generation;

  iv. flood prevention; and

  v. recreation.

The Department of the Environment publication 'Guidelines for the Prevention and Control of Soil Erosion and Siltation in Malaysia', 1996, should also be referred to.

6.1.3 Aesthetic/ Visual

Mitigation measures for visual/ aesthetic features should include consideration of potential landscape visual enhancement besides reduction of damage caused by the proposed development.

Alternative designs that would avoid or alleviate the identified landscape impacts or that would make the project visually more compatible with the surrounding setting should be thoroughly examined before adopting other mitigating measures to reduce adverse impacts.

The mitigation measures that can be considered include (but are not limited to):

- **Preservation of existing features** - The preservation of trees, green belts, landscape/ ecological/ architectural features of high value and view corridor. Any tree with good amenity value unable to be retained in its current location should be considered for transplanting to another suitable location onsite. In addition, vegetation removal should be minimised.

- **Modification of architectural layout** - The architectural layout can be modified so that the development is compatible with the surrounding environment.

- **Remedial modifications** – Remedial modifications can be made to the development to make it more compatible with its surroundings, including facade treatment, colour scheme and texture of materials used, use of non-reflective material, screen painting and height.

- **Compensatory measures** – Compensatory measures can be implemented, e.g. landscape treatment, compensatory planting, creation of interesting landscape or visual features to enhance the view and green corridors along access roads.

6.1.4 Hydrological (drainage run-off and peak flows)

The mitigation measures that can be considered for the management of hydrological changes include (but are not limited to):

- **Enhancing stream capacity** – Enhancing the capacity of the downstream drainage systems. This may require pipe upgrades, or increasing the size of open channels.

- **Installing water retention systems on site** - These store water from peak flow events and discharge them into the drainage system at a lower rate.

- **Protection of areas susceptible to saturated soil conditions** – These areas include foundations and steep slopes of particular soil types. This can be achieved by diverting surface and groundwater away from these areas.

6.1.5 Air Pollution

The mitigation measures that can be considered for air pollution include (but are not limited to):

a) Dust Control

- **Wheel washing facility** - Provide a wheel washing facility at all site exit points to avoid dirt being carried out of the project area. Water from the washing facility should be changed regularly to ensure clean water (without silt) at all times. The facilities should be connected to the sedimentation basin to treat dirty water, prior to final discharge (refer to Plate 6-4).

- **Water spraying/ sprinkling** - Provide systematic water spraying/ sprinkling along access roads, internal roads and the floor of work sites. The frequency should be determined based on site conditions and number of truck transport trips expected per day.

Plate 6-4: Wheel washing bay with water spraying facilities within a construction site

b) Transportation Control

- **Access road** - Ensure access and internal roads are kept smooth, well graded and clean.

- **Vehicle** - Avoid deployment of poorly maintained old transport vehicles and equipment.

- **Material cover** - Properly cover transported material with canvas or similar covering materials to avoid spillage and to minimise dust emission.

- **Speed** - Reduce vehicles' speed to assist in reducing the dust generated.

c) Barrier

- **Physical barrier** - Construct physical dust barriers such as zinc hoarding or planting of tall trees along project boundaries to create a buffer between the project site and surrounding populated area. The type and design of the physical barrier should be recommended based on the nature, duration and size of the earthwork activities involved

6.1.6 Noise Pollution

The mitigation measures that can be considered for noise pollution include (but are not limited to):

a) Noise Barriers

- **Physical barriers** - Construct physical noise barriers along project boundaries to create a buffer between the project site and surrounding populated areas.

b) Administration

- **Operating hours** - Plan earthwork activities accordingly to take into account noise tolerances at night time and weekends.

- **Notification** - Awareness is an important factor in reducing noise-related annoyance. It leads to preparedness and tolerance. Residents of nearby human settlements should be notified in advance of the earthwork activities and transportation activities.

c) Transportation Control

- **Vehicles** - Transportation vehicles should maintain appropriate traveling speeds along the haul roads and should avoid the running of engines for long periods of time when in a stationary position at the project site.

6.1.7 Ecology

Biological species affected by the project or sensitive biological areas within, or in the immediate vicinity of the project site should be protected. The mitigation measures that can be considered for ecological protection include (but are not limited to):

a) Flora Protection

- **Protected species** - Identify and conserve protected trees (including protected fruit tree species, fig trees and fern flora), "mother or seed" trees, green belts and landscape/ ecological/ architectural features of high value within the project site for preservation purposes.

- **Marking** - Protected floral species or trees should be marked on a map; and marked, painted with red colour, and sign posted on-site.

b) Fauna Protection

- **Wildlife protection** - Provide adequate opportunity for the wildlife to escape and seek refuge in the adjacent or nearby natural habitat areas, by implementing phased development; starting from the center of the project area and progressing to its perimeter. The Wildlife Department should be consulted wherever necessary.

c) Aquatic Protection

- **Timing operations** - Avoid earthwork activities during or immediately after heavy rainfall or during prolonged dry periods to protect aquatic species and habitats.

d) Notification

- **Flora** - Notify Wildlife Department on the discovery of any protected floral species, or any other unique plant species.

- **Fauna** - Notify Wildlife Department on the discovery of any protected or endangered of faunal species or any significant biological habitats.

- **Aquatic** – Notify Fisheries Department on the discovery of any protected or unique aquatic species.

6.1.8 Waste Management

Wastes generated from the project should be handled and disposed of in accordance to Malaysian legislative requirements. The mitigation measures that can be considered for waste management include (but are not limited to):

a) Oily Waste/ Scheduled Wastes

- **Legal requirement** - Handle and dispose of used oil, oily wastes and hazardous waste in accordance to Environmental Quality (Scheduled Wastes) Regulations 2005.

- **Oily waste** - Collect used oil and oily wastes from machinery and transportation vehicles and store and label in proper containers for disposal. A temporary storage facility should be constructed within the project site, and should be fenced, covered, bunded, sign posted, have impervious flooring, and be provided with proper drainage and oil trap. The facility should be sited more than 50 m away from any river, stream or sensitive area.

- **Oil trap** - Construct oil/ water separator to trap and treat oily wastewater on-site (refer to Figure 6-1). Drainage from workshop floor and temporary storage area should be directed to the oil trap, prior to final discharge to public drain, river, stream or other water body. The effluent quality from the oil trap should be able to meet the Environmental Quality (Industrial Effluent) Regulations 2009.

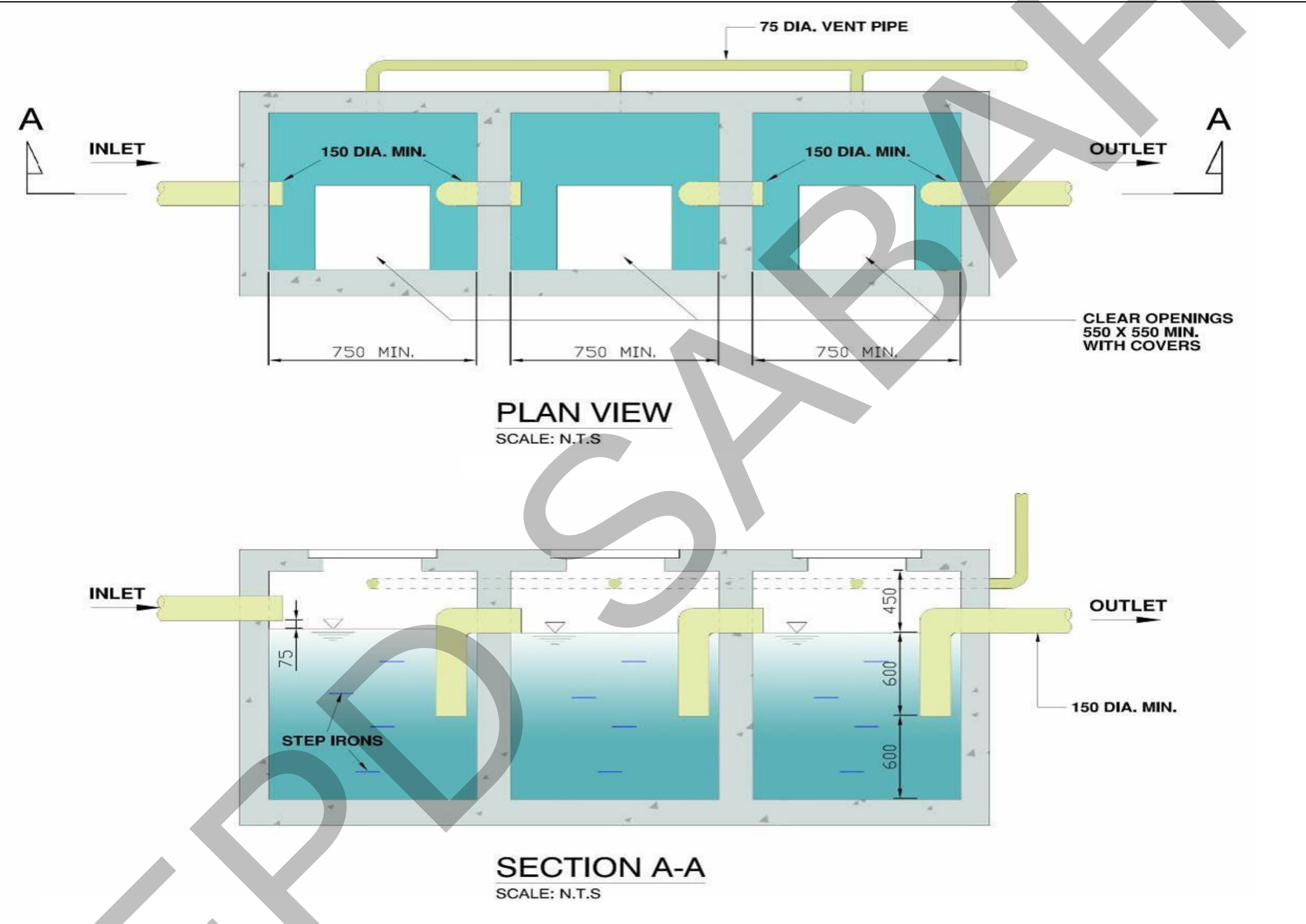


Figure 6-1: Typical design of an oil and grease trap (cast in-situ)

- **Bund** - Construct non-permeable bund surrounding the oil storage facility to ensure that no oil or oily waste enter river/ stream or waterways in case of spillage or leakage. Bund holding capacity should be at least 110% of the largest storage volume on-site.

b) Solid Waste

- **Disposal** – Provide adequate waste bins with covers within site especially at the workers' quarters. These should be regularly disposed off at dumping sites approved by the local authorities.

- **Prohibition** - Prohibit burning of solid waste within the project site, or direct disposal into waterways or onto lower ground.

- **Housekeeping** – Good housekeeping must be practiced throughout the project implementation. These include proper waste disposal at designated areas.

- **Recycling** – Where possible, re-use of building material and products are encouraged. Waste recycling bins should also be provided onsite.

Plate 6-5: Provision for segregated waste recycling bins onsite

c) Sewage

- **Legal requirement** - Handling and disposal of sewage should be done in accordance to Environmental Quality (Sewage) Regulations, 2009.

- **Sewage discharge** - Sewage discharges from workers' quarters and site office should be discharged into an on-site temporary basic treatment facility, such as a septic tank, prior to final discharge. The septic tanks should be regularly de-sludged to maintain its effectiveness and to ensure compliance to the Environmental Quality (Sewage) Regulations 2009.

d) Administration

- **Written approval** - Open burning on-site is not allowed, except as per the requirements of Environmental Quality Act, 1974 and Environmental Quality (Declared Activities) (Open Burning) Order, 2003.

- **Written approval** - The Project Proponent should obtain DOE's Written Approval for use or installation of fuel burning equipment (including generator), and for erection of chimney/ stack or installation of pollution control equipment on-site.

- **Workers' Quarters** – Proper accommodation should be provided to accommodate workers onsite. The structure should be located at least 30 metres from the nearest natural waterway.

6.1.9 Traffic and Transportation

Mitigating measures to control traffic and improve safety include limiting the operating hours, traffic control, provisions of traffic sign and adherence to speed limit. The mitigation measures that can be considered for traffic and transportation control include (but are not limited to):

a) Traffic Site Plan

- **Main access** - Design and construct permanent main access to the project site including all road works, road marking and signage to ensure good road safety.

- **Internal road** - Design and construct internal road system and parking facilities within the project site.

b) Access Control

- **Road access** - Obtain prior approvals from private land owners and Lands and Surveys Department prior to usage of roads or areas not owned or leased by the project proponent.

- **Road junction** - Construct a properly designed temporary access road and road junction at the entrance to the project site, to minimise inconvenience to road users.

- **Maintenance** - Maintain temporary access road regularly and properly, and repair any potholes or damaged sections.

- **Cleanliness** - Ensure temporary access roads are clean at all times, without mud, dry earth, dust or small aggregates.

c) Traffic Control

- **Traffic signage** - Provide proper and adequate traffic signage at road junctions where transportation vehicles ingress and egress, particularly at entrances to the project site and near human settlements to warn other road users of the transportation activity.

- **Speed arrestors** - Provide road humps at strategic locations particularly near human settlements, schools, police stations and houses of prayer to ensure vehicles reduce speed to minimise dust and noise pollution, as well as to improve safety.

d) Transportation Control

- **Vehicle speed** - Reduce vehicle speeds to assist in road safety. Speeds of less than 50 km/hour are considered ideal for transportation activities near populated areas.

- **Material transport schedule** - Plan transportation during earthwork and construction activities to take into account the peak traffic condition and periods of high accident risk.

e) Transportation Safety

- **Transportation** - Control movement of lorries and transportation vehicles so that local traffic activity, nearby human settlements and major road junctions will not be affected by the project.

- **Local authority compliance** - Comply fully and at all times with the requirements of local authorities including Public Works Department for activities on land especially with regards to speed limit and vehicles load.

f) Administration

- **Access control** - Obtain approvals from local authorities, Public Works Department, Road Transport Department and Police, prior to use of any access roads particularly of public roads for the project.

6.1.10 Ground Vibration

Air vibration due to blasting of rock outcrops can be minimised by the use of delay blasting technique. A qualified and licensed shot-firer should be engaged to carry out blasting operations. Blasting design must be approved by the Minerals and Geoscience Department prior to actual works onsite.

Vibration impact from pile driving to establish the base for foundation may give rise to elevated levels of ground vibration. A study on the impact of ground vibration from pile driving should be conducted if these operations occur within 50 metres of an existing building. If vibration is a nuisance, appropriate actions should be taken.

The mitigation measures that can be considered for vibration impact include (but are not limited to):

- **Schedule of Operation** - Conducting the pile driving operation within as short a time as possible. At the same time, surrounding communities should be informed of the schedule of operation for their awareness. Awareness of such operation would make the residents more tolerant and acceptable to the elevated vibration levels.
- **Consideration of Building Design** - Consideration of changes to foundation design and method of pile driving depending on the suitability of the site. Expert opinion may be sought. Bored piling, which hardly produces any vibration, may be an alternative.

6.1.11 Socio-Economic

Consideration should be given to the affected local population by protecting sources of local water supply and recreation area. In addition, effective public relations exercise is importation in ensuring social acceptability of the project.

The mitigation measures that can be considered for socio-economic impacts include (but are not limited to):

a) Protection of Water Resources

- **Local water supply** - Ensure that government potable water supply, local gravity water supply and general livelihood of the local population are not negatively affected by the project.

- **Compensation** - Any monetary, equipment or other assistance to the affected local population should be discussed and agreed by the local council and local leaders.

b) Employment

- **Employment and business opportunities -** Preference for employment and business should be given to local population. This will provide some opportunities to the local people to participate in the development of the project, as well as providing them with an opportunity to earn extra income. In addition, their employment and business participation will prevent social resentment and conflicts, increase their positive feelings towards the project, and create a sense of pride towards the development of their area.

c) Consultation

- **Public relations** - Conduct a proper public relations exercise involving the local authorities. Two-way communications through dialogue help both parties to understand each other, set a forum for understanding, and establish rapport. Information about the numerous benefits of the project and minimum environmental impacts should be made readily available to the public.

- **Dialogue** - Hold regular meetings/ dialogues with the surrounding population and their community leaders. The Project Proponent should explain to the villagers the nature of the project, the extent to which it will affect their villages, and the mitigation measures undertaken to eliminate or minimise environmental problems.

6.1.12 Potential Abandonment

In the event that the works are abandoned during the construction stage, every attempt should be made to reinstate the condition of the site to that which existed prior to commencing construction. Whilst this will not be feasible where large scale excavation works have taken place, as a minimum, the cleared area should be re-vegetated. This will involve breaking up compacted ground, covering with topsoil, and planting/ seeding with selected local tree species and/or cover crops such as *Lycopodium cernuum, Dicranopteris linearis* and *Melastoma malabaththricum.*

Where a structure is partly erected, this should be demolished and removed from the site.

All drainage provisions, including sedimentation ponds should be retained.

All equipment, machinery and waste materials should be removed from the site.

6.2 Residual Impacts

It is unavoidable that there will be some adverse impacts from the construction activities on hill slopes even if these are carried out with every intention of avoiding or minimising such impacts.

There will be a loss of ecological features, in terms of natural wildlife habitat together with surface runoff which pollutes the waterway as a result of land clearing. For such impacts, the risk and the magnitude must be assessed as part of the assessment procedure.

6.2.1 Off-set of Residual Impacts

Residual impacts relating to the loss of biodiversity/ habitat may be countered by off-set activities elsewhere. Particular key conservation value habitats may be protected elsewhere. Such off-set activities may balance the impact in full or partially, but should in all cases be considered.

6.2.2 Mitigation of Residual Impacts

Residual impacts are already minimised through the choice of technologies or methodologies. Mitigation is therefore only possible through compensation or substitution. Compensatory measures in terms of replacement of habitat loss, re-vegetation, alternative access to livelihoods and others are among the available options for mitigation of residual impacts.

7 Monitoring Programmes

This chapter covers the recommended monitoring programmes based on the mitigation measures highlighted for the identified environmental impacts (refer to Table 7-1).

Table 7-1: Assessment Procedures – Description of Monitoring Programme

The Seven Steps	Summary of Main Required Activities

Step 4:
Undertaking the EIA study
	Environmental Consultant:
	• *Assess the project details*
	• *Assess the existing environments*
	• *Assess the environmental impacts*
	• *Devise and propose mitigation measures*
	• *Devise and propose monitoring programmes*
	  - *Compliance monitoring*
	  - *Impacts monitoring*

Environmental monitoring provides feedback on the actual environmental impacts of a project. Monitoring results will assist in the judgement of whether the environmental mitigation measures proposed are successful in reducing or eliminating negative environmental impacts. An environmental monitoring programme is also used to ensure compliance to the recommended mitigation measures and environmental standards stipulated by EPD, Sabah and other relevant agencies.

Generally, an environmental monitoring programme will involve collecting data for one or more of the following purposes (Everitt, 1992):

i. To establish a baseline, that is, gathering information on the basic site characteristics prior to development or to establish current conditions;

ii. To establish long term trends in natural undisturbed systems to establish natural baselines;

iii. To estimate inherent variation within the environment, which can be compared with the variation observed in another specific area;

iv. To make comparison between different situations (for example, pre-development and post development; upstream and downstream) to detect changes; and

v. To make comparisons against a standard or target level.

Without monitoring system, there is no mechanism for ensuring that the specified mitigation measures are being implemented and for evaluating the success of the mitigation measures undertaken.

7.1 Compliance Monitoring

The environmental consultant should, in the EIA report, propose means and schedules for monitoring whether the technologies and methodologies applied in the project comply with the recommended measures and methods. This compliance monitoring plan will then, by the EPD, be used as a basis for an Agreement of Environmental Conditions (AEC), which is an agreement between the EPD and the Project Proponent on how environmental management of the project shall be optimised.

The environmental consultant must, for each of the mitigation measures proposed in relation to the environmental issues that have been identified, recommend how, when and where monitoring can be implemented to verify that the recommendations have been followed.

EPD has also established a standardised monitoring system. The system is linked to a database within EPD. This database will store all future monitoring data from all monitoring of construction on hillslopes activities.

The frequency of environmental monitoring and reporting may be varied depending on the stages of the project and sensitivity of the area, i.e. erosion prone area, social concerns and will be specified by the EPD through the AEC issued with the EIA approval.

There are requirements for submission of maps and photos to support compliance monitoring. Maps must follow standard cartographic requirements of showing geo-references, scale and north arrow, while photos must have dates and be geo-reference.

7.1.1 Monitoring Techniques

Compliance monitoring will be undertaken primarily by means of the techniques listed below. This information should be submitted to EPD based on the agreed frequency of monitoring until the project is completed.

Photographs. Photographs to provide evidence of the implementation of the recommended mitigation measures. Photographs should, for example, be used to verify compliance with the following mitigation measures:

- Provision for slope strengthening and protection structures, i.e. retaining walls, close turfing and others.

- Provision for erosion control facilities onsite, i.e. sedimentation pond, silt trap and drainage network, re-vegetation works on exposed areas.

- Provision for dust and noise suppression facilities, i.e. wheel washing facilities, planting of trees, installation of zinc hoarding, condition of access roads.

- Changes to the landscape of the area.

- Proper waste management practice onsite, i.e. provision for collection bins, general site conditions at the workers quarters, site office, storage area, workshop, sewage facilities and others.

- Proper transportation management including utilisation of approved routes, allowable vehicle load and others.

- Provision of buffer zones or protected area management.

- Phased clearance.

When photographs are submitted for compliance monitoring, the exact location should be clearly marked on a map together with a GPS reading and a direction bearing. The date and time should be noted.

Field checks. Periodic field checks at appropriate stages of the construction activities should be undertaken in order to ensure compliance with the following mitigation measures:

- Earthwork and construction methodology (earthwork area; period and timing of operations; volume of materials extracted and equipment and methods used).

- Improved working practices/ management procedures.

- Man-made items such as slope protection and drainage system (cracks or spalled concrete surface and support; debris, undesirable vegetation growth and other obstruction to water flow; erosion; unstable trees and others).

- Landscaping works.

- Reducing dust and noise problems.

- Provision of buffer zones or protected area management.
- Proper waste handling.
- Phased clearance.
- Proper transportation management.

Records. Records of earthwork and construction activities to ensure compliance with the following mitigation measures:

- Planned schedule and actual completion for construction of slope strengthening/ protection.
- Maintenance of erosion control facilities, i.e. sedimentation pond, silt trap and drainage network.
- Daily working hours.
- Type of foundation design, blasting works conducted and duration of implementation.

Maps/ layout plans. Maps/ layout plans to indicate locations of key mitigation measures during implementation. These should, for example, be used to verify compliance with the following mitigation measures:

- Provision for slope strengthening and protection structures, i.e. retaining walls, close turfing and others.
- Provision for erosion control facilities onsite, i.e. sedimentation pond, silt trap and drainage network, re-vegetation works on exposed areas.
- Provision for dust and noise suppression facilities, i.e. wheel washing facilities, planting of trees, installation of zinc hoardings.
- Phased site clearing works including areas that will be retained/ incorporate in final layout for aesthetic/ ecological conservation purpose.
- Transportation route for vehicles to/ from disposal site/ borrow pit (if any).
- Proper waste management practice onsite, i.e. provision for waste bins, general site conditions at the workers quarters, site office, storage area, workshop, sewage facilities and others.

Scheduling and responsibilities. As the EIA report covers construction activities on hill slope, therefore the need for images and other monitoring requirements should be planned accordingly. The monitoring programme should be formulated in advance by the environmental consultant in collaboration with the Project Proponent in accordance with the schedule of implementation, and be approved by the EPD through the Agreement of Environmental Conditions.

The EIA report should clearly state the responsibilities and actions to be taken in relation to compliance monitoring, as follows:

- Allocate institutional and administrative responsibilities for planning, management implementation and monitoring of the environmental requirements; and

- Allocate responsibilities to execute mitigation measures, including the detailed design of the mitigation measures.

Non-compliance will normally be followed by the issuance of an order to comply and a simultaneous and immediate compounding of the non-compliance offence according to the Environment Protection Enactment 2002.

The Project Proponent and/ or environmental consultant should consult the EPD for advice if there are difficulties in implementing the approved mitigation measures and monitoring programmes.

In some cases EPD may request a “re-assessment” of specific aspects of the operation related to the mitigation measures found to be in “non-compliance”.

7.2 Impacts Monitoring

Impacts monitoring is concerned with the monitoring of the residual impacts or the effectiveness of the mitigation measures. The EIA report will have provided baseline data showing the situation as it was before the construction activities took place. All subsequent impact monitoring will relate to this baseline data. It is therefore important that the environmental consultant plans sampling points and parameters for baseline sampling to coincide with points and parameters for impact monitoring.

7.2.1 Slope Stability

Impacts monitoring for slope stability control could include (but is not limited to) the following:

- Visual inspection for any signs of slope failure within the site, i.e. cracks on slope protection structure, tilting of trees, blockage of waterway, slips and others.

7.2.2 Soil Erosion and Water Pollution

Impacts monitoring for soil erosion and water pollution control could include (but is not limited to) the following:

- Visual inspection for signs of erosion within the site.
- Water quality analysis particularly for turbidity and total suspended solids at suitable locations to determine the amount of siltation generated from the site. Additional parameters may be recommended depending on site characteristics.
- Visual inspection on the functionality of the erosion control measures onsite, i.e. sedimentation pond, silt traps and others.

7.2.3 Air and Noise Pollution

Impacts monitoring for air and noise pollution control could include (but is not limited to) the following:

- Visual inspection for excessive dust or noise level generated from the site.
- Air quality (total suspended particulates) and noise level monitoring at suitable locations to determine the level of dust and noise nuisance generated from the site.
- Visual inspection on the condition of public access road utilised for the project's transportation activities.

7.2.4 Others

Impacts monitoring for other environmental issues identified could include (but is not limited to) the following:

- Visual inspection for general cleanliness and good management practises within the site.
- Any incidents or complaints related to earthwork, construction and transportation activities.
- Discovery of protected or unique floral, faunal or aquatic species within the project site.
- Discovery of historical sites/ artefacts/ burial grounds within the project site.

7.2.5 Monitoring Frequencies

Frequencies of monitoring depend upon the timing and schedule of project activities. The monitoring frequency can be varied. If the environmental consultant finds there is a particular parameter, which should be monitored more frequently due to increased activity levels, an increased monitoring frequency should be proposed in the EIA report. On the other hand, if little activity is on-going, and the operation is in compliance over an extended period, the Project Proponent may request a less intensive monitoring schedule. Changes in the monitoring frequency will be decided on a case-by-case basis by EPD.

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Appendix 1: Glossary of Terms

Activity – basic element of a project or plan that has the potential to affect any aspect of the environment. Projects are composed of activities. Activities are often called actions.

Building – any building, erection or structure on any land and where the context so permits, includes the land on which the building is situated.

Central Board – the Central Town and Country Planning Board constituted under the provisions of Section 3 of the Town and Country Planning Ordinance.

Development – any land development that involves infrastructures and other structural construction activities together with related activities or changes the land's natural condition.

Discontinuity – interruptions, usually of a planar nature, to the homogeneity of a rock mass, i.e. joints, faults.

Effluent – any discharge either sewage or industrial effluent by an operation to the receiving environment.

Environment – physical factors of the surroundings of the human beings including land, water, atmosphere, climate, sound, odour, taste, the biological factors of animals and plants, and the social factor of aesthetics.

Environmental Impact – an estimate or judgement of the significance and value of environmental effects on physical, biological, social or economic environment.

Factor – basic element of analysis used in any method. In most methods, factors relate to some form of environmental impact.

Factor of Safety – ratio of average available strength of the soil along the critical slip surface to that required to maintain equilibrium.

Fault – a fracture in rock along which there has been an observable amount of displacement.

Foundation – a system or arrangement of foundation units such as footing, raft or pile through which the loads from a building or structure are transferred to the supporting soil or rock.

Green Lungs – a type of physical landscape on an area that is covered with vegetation or water for recreational features. Examples are parks, open space, swamps, and hilly areas.

Landslide/ Landslip – rapid movement of earth materials separated from the underlying stationary part of the slope by a definite surface.

Matrix Method – identifies interaction between various project actions and environmental parameters and components.

Natural Resources – air, biological diversity of resources, oil, gas, forest and forest product, land, rocks, soils, animals, birds, plants, marine or aquatic life, and water of the State of Sabah.

Pollutants – any natural or artificial substances, whether in solid, semi-solid or liquid form, or in the form of gas or vapour, or in a mixture of at least two of these substances, or any objectionable odour or noise or heat emitted, discharged or deposited or is likely to be emitted, discharged or deposited from any source which can directly or indirectly cause pollution and includes any environmentally hazardous substances.

Pollution – any direct or indirect alteration of the physical, thermal, chemical, or biological properties of any part of the environment by discharging, emitting, or depositing wastes so as to affect any beneficial use adversely, to cause a condition which is hazardous or potentially hazardous to public health, safety or welfare, or to animals, birds, fish or aquatic life, or to plants.

Residual Impact – the potential environment impact remaining after mitigating measures have been adopted into a project plan.

Rockfall – movement of blocks of solid rock.

Soil Creep – shallow, slow-moving form of an earth flow involving thin layers of near-surface soil.

Topography – shape of the ground, formed by highlands, slopes, rivers, swamps, coasts and river network which have their own aesthetic values.

Zone of Impact – an extent of area which will receive the greatest effect from an activity.

Appendix 2: List of Abbreviations

ACLR	Assistant Collector of Land Revenue
AEC	Agreement of Environmental Conditions
BMP	Best Management Practice
DID	Department of Irrigation and Drainage
DOE	Department of Environment
EIA	Environmental Impact Assessment
EPD	Environment Protection Department
ESCP	Erosion and Sediment Control Plan
FOS	Factor of Safety
GIS	Geographical Information System
IUCN	International Union for Conservation of Nature
LSD	Lands and Surveys Department
MSMA	Manual Saliran Mesra Alam
NWQSM	National Water Quality Standards for Malaysia
PMM	Proposal for Mitigation Measures
RM	Ringgit Malaysia
Sg.	Sungai (River)
TSS	Total Suspended Solids
WHO	World Health Organization
WWF	World Wildlife Fund
ZOI	Zone of Impact

Appendix 3: Contact Details

Contact details for other key government agencies related to construction activities on hill slopes are as following:

Department	Address	Contact Details	
Lands and Surveys Department	Wisma Tanah dan Ukur, Jalan Perwira, Beg Berkunci No. 2044, 88576 KOTA KINABALU	Tel No.:	088 - 527600/ 527601
		Fax No.:	088 - 413626
		Email:	-
Sabah Forestry Department	Ibu Pejabat, Jabatan Perhutanan, Beg Berkunci No. 68, 90009 SANDAKAN	Tel No.:	089 - 660811/ 660125/ 660824
		Fax No.:	089 - 672579/ 671303
		Email:	htan@sabah.gov.my
Sabah Wildlife Department	Tingkat 5, Blok B, Wisma MUIS, 88100 KOTA KINABALU	Tel No.:	088 - 215167/ 214515
		Fax No.:	088 - 222476/ 254767
		Email:	jhl@sabah.gov.my
Department of Irrigation and Drainage	Aras 5, Wisma Pertanian, Jalan Tasik, Luyang, Off Jalan Maktab Gaya, Beg Berkunci 2052, 88767 KOTA KINABALU	Tel No.:	088 - 280500
		Fax No.:	088 - 242770
		Email:	did@sabah.gov.my
Public Works Department	Bangunan KPI, Jalan Sembulan 88582 KOTA KINABALU	Tel No.:	088 - 244333
		Fax No.:	088 - 237234
		Email:	-
Town and Regional Planning Department	Tingkat 3, 4 dan 5, Blok B, Wisma Tun Fuad Stephens, KM 2.4, Jalan Tuaran 88646 KOTA KINABALU	Tel No.:	088 - 222336/ 222337/ 222031
		Fax No.:	088 - 222557
		Email:	-
Minerals and Geoscience Department Malaysia, Sabah	Jalan Penampang, Beg Berkunci 2042, 88999 KOTA KINABALU	Tel No.:	088 - 260311/ 252494/ 252496
		Fax No.:	088 - 240150
		Email:	jmgsbh@jmg.gov.my
Department of Environment, Sabah	Aras 4, Blok A, Kompleks Pentadbiran Kerajaan Persekutuan Sabah, Jalan UMS-Sulaman, 88450 KOTA KINABALU	Tel No.:	088 - 488166
		Fax No.:	088 - 488177/ 488178
		Email:	sabah@doe.gov.my

Appendix 4: List of Environmental Consultants/ Study Team

The following list includes the expertise, which in most cases should form part of the assessment team for construction on hill slopes EIAs depending on site characteristics and environmental issues identified. Some team members may cover two or more of these fields of expertise:

- Geology/ Slope Stability
- Soil Erosion
- Hydrology
- Ecology/ Flora and Fauna
- Air Quality and Noise
- Socio-Economic
- Waste Management

Each member of the team, involved for their specialist subject(s), should be involved in the entire environmental assessment cycle from scoping, baseline data collection, impact prediction and evaluation, and identification of mitigation measures.

The list of registered environmental companies related to environmental report preparation can be referred to on the website of EPD: http://www.sabah.gov.my/jpas/

Appendix 5: Standard List of Content

The content of the EIA report shall consist of the following:

CHAPTER 1:	**EXECUTIVE SUMMARY**
	Project Description
	Findings
CHAPTER 2:	**GENERAL INFORMATION**
	Project Title and Project Proponent
	Environmental Consultant
	Public Hearing (for Special EIAs)
CHAPTER 3:	**PROJECT DESCRIPTION**
	Statement of Need
	Concept and Phases
	Description of Location
	Project Status
CHAPTER 4:	**IMPACT PREDICTION AND EVALUATION**
	Significant Environmental Impacts
	EIA Matrix
	Impact Assessment
CHAPTER 5:	**RECOMMENDED MITIGATION MEASURES**
	Recommendations
	Additional Mitigation Measures
CHAPTER 6:	**RECOMMENDED MONITORING PROGRAMME**
	Compliance of Mitigation Measures
	Residual Impacts
ANNEXES	Annex 1: Baseline Environmental Data and Information
	Annex 2: Methodologies and Analysis of Data
	Annex 3: List of References
	Annex 4: Terms of Reference

Appendix 6: Slope Development and Forms

Four main types of slope forms recognised. These include: cliffs, concave slope, rectilinear slopes and convex slopes (see Figure A6-1).

Cliffs are developed on slopes in deeply cut river valleys, on escarpment faces (long steep slopes at the edge of a plateau), in massive rocks and on faulted landscapes. Cliffs are steep, often with faces of 40 degrees or more and the products of weathering for the most part fall immediately to the base. A talus or screed slope will develop at an angle controlled by the size and shape of the weathered fragments (Figure A6-1(A)).

The lower part of a slope profile will commonly exhibit a concave section (Figure A6-1(C)) due, in some cases, to deposition processes. However, it is more usual to find slopes covered only by a thin layer of soil or exposing bare rocks with marked basal concavities. Many slopes display rectilinear sections (Figure A6-1(E)), which normally form the steepest part of the whole profile. It is quite common to find such a major rectilinear section leading down to the very bottom of the valley. On other slopes, the rectilinear section is restricted to the central part of the profile where it separates a broader convexity above from a large concave section below.

Convex sections (Figure A6-1(D)) are common to many slopes and usually develop on the upper part of the slope (summital convexity) due to erosional processes and are rarely covered by more than a thin layer of soil.

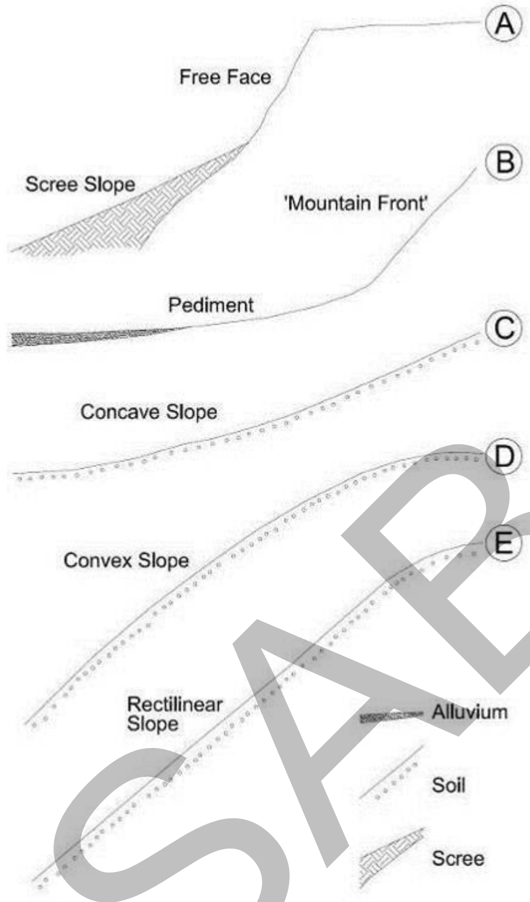


Figure A6-1: Common simple slope forms

Most slopes, however, are not made up of these simple forms but rather are composite resulting from a combination in one profile of two or more of these simple forms. A convexo-rectilinear-concave slope comprises an upper convexity, a central rectilinear section and a lower concavity, the three grade into each other to give a smoothly curving profile, (see Figure A6-2(A)). Such slopes typically form on weak rocks. In areas where the rock type is varied, comprising alternating resistant and less resistant strata there may be a whole sequence of convexities, rectilinearities and concavities, giving a 'complex slope form'.

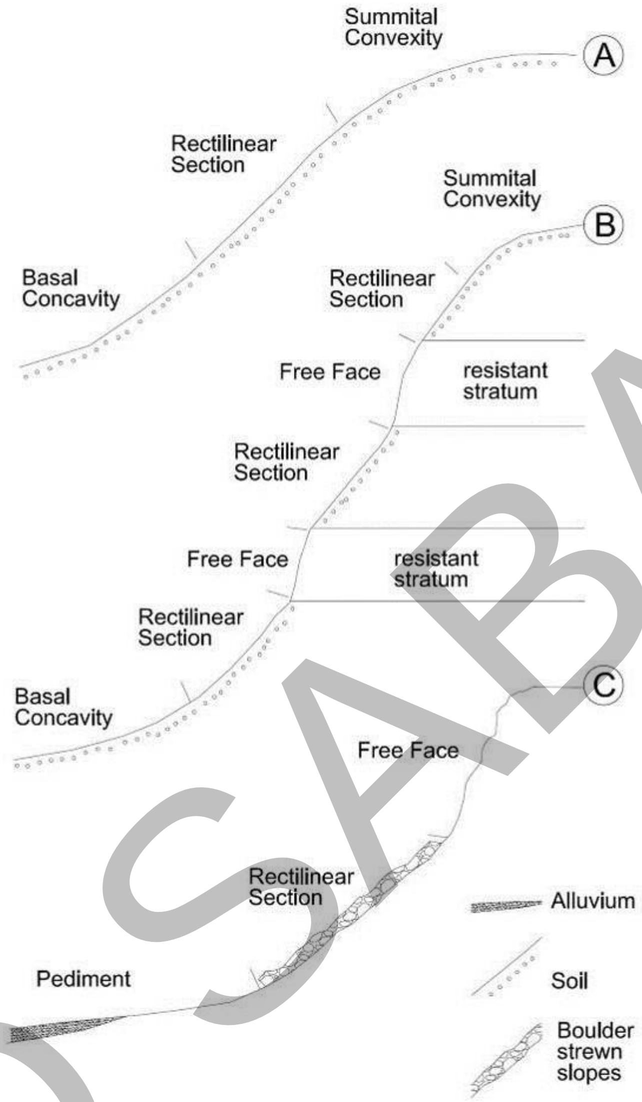


Figure A6-2: Complex slope forms

In an area of alternating massive and thinly bedded weak strata, where the relief/ lack of tension is considerable, valleys are deeply incised/cut and where active weathering is taking place, the slope profile may comprise of numerous free faces (associated with massive strata) and rectilinear debris-controlled slopes (in the more easily weathered thinly bedded rocks) and summital convexities and basal concavities may be very limited in extent or absent altogether (Figure A6-2(B)).

In areas of hard crystalline rock, a composite slope form may be developed with an upper free face (at an angle of 40 degrees or more), a central boulder-controlled slope (at over 25 degrees) and a lower concave slope (the pediment at less than 7 degrees) (Figure A6-1 (B) and Figure A6-2(C)).

Appendix 7: Measurement of Slope Gradient

Area of Influence: To determine whether a proposed development is located on a slope with gradient of 20 degrees or more, representative slope profiles must be drawn from a contour map. The slope profiles should include the area of influence to the first sharp break in slope above and below the site or at least a minimum 500 m upslope and downslope of the site whichever is applicable. Topographic features may however indicate modifications to this general axiom.

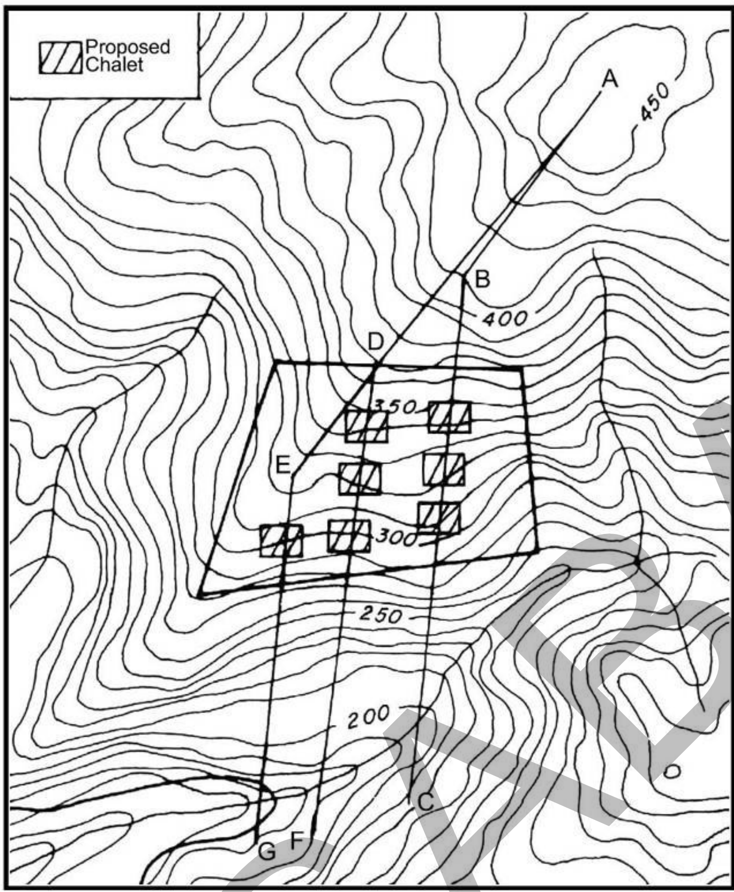
Map Scale: The accuracy of slope measurement is very dependent on the map scale and contour intervals. A detailed topographical survey of the proposed development is normally carried out as part of the planning process. Such detailed site topographical is produced on scales ranging from 1:1,500 to 1:500. These maps should be used in conjunction with the 1:12,500 (contour intervals of 10 m) or nearest equivalent for the upslope and downslope areas produced by the Lands and Surveys Department to construct slope profiles, where available.

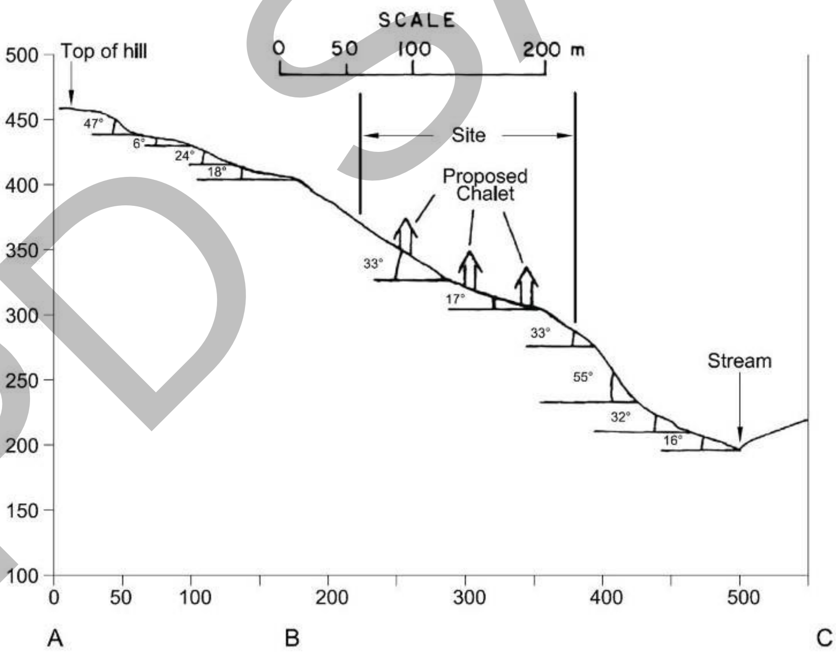
Section Lines: Critical section lines of representative profiles should be selected so that they intersect the locations of all the proposed structures to be erected on the site and also existing land use features, i.e. road, houses, telecommunication tower upslope and downslope of the site. The section lines should be orientated perpendicular to the steepest slopes. The number of section lines will be dependent on the proposed development and existing land use in the vicinity.

Suggested Method: Construction of slope profiles involves plotting the elevation of contour lines where they intersect with the section lines. The suggested method of slope profile construction is as follows:

a. Determine the alignment of the section lines. The section lines should start from the area of influence upslope and follow the steepest gradient onto the site and across the proposed constructions at the site and onto the area of influence downslope of the site. It is recommended to construct multiple slope profiles, each profile across each proposed construction at the site.

b. A line is drawn on the contour map from upslope of the site and across the proposed construction at the site and onto the downslope area as shown in the slope profile figure attached. This line provides the baseline ABC (attached example) for the graph; the length of this baseline is equivalent to the length of the area of influence as defined above.





SLOPE PROFILE

c. The points at which contour lines intersect the baseline are marked and their elevations recorded. The vertical axis of the graph is scaled for elevation and constructed perpendicular to the baseline; preferably, the vertical and horizontal scales should be similar to show the true gradient of the slope. Points of elevation may now be plotted at the appropriate distances along the baseline. For precise plotting, intersecting lines may be drawn from the corresponding values on the distance and elevation scale. Connecting the points, a line profile of the slope is produced. The site boundaries, location of each proposed construction on the site and existing construction on the upslope and downslope areas, are marked on the profile.

d. The profile may show sections of the slope with varying gradients. The gradient of each slope section should be measured. This can be easily determined by measuring directly with a protractor the gradient of each slope section at the point of each slope break along the profile.

e. Repeat steps b-d to plot the slope profiles of the other section lines, in this example, ADF and ADEG.

f. If any of the slope section of the profiles has gradient of 20 degrees or more, then it is concluded that the site is located on slope with gradient of 20 degrees or more.

Computer Analysis: Calculation of slope angle is straight forward using computer software. The topographical base map can be converted into digital form and using computer software such as SURFER, AUTOCAD, Geographic Information System (GIS), representative slope profiles can be created.

Appendix 8: Universal Soil Loss Equation (USLE) Estimation

8.1 Background

The Universal Soil Loss Equation (USLE) predicts the long term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion. This erosion model was created for use in selected cropping and management systems, but is also applicable to non-agricultural conditions such as earthwork/construction sites. The USLE can be used to compare soil losses from a particular field with a specific crop and management system to "tolerable soil loss" rates. Alternative management and crop systems may also be evaluated to determine the adequacy of conservation measures in farm planning.

Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions. Therefore, the values obtained from the USLE more accurately represent long-term averages.

$$\mathbf{A = R \times K \times LS \times C \times P} \qquad \text{(Wischmeier et al., 1978)}$$

- **A** represents the potential long term average annual soil loss in tons per hectare per year. This is the amount, which is compared to the "tolerable soil loss" limits.

- **R** is the rainfall and runoff factor by geographic location. The greater the intensity and duration of the rain storm, the higher the erosion potential.

- **K** is the soil erodibility factor. It is the average soil loss in tons/ha per unit area for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 22.1 metres and slope steepness of 9%. K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute.

- **LS** is the slope length-gradient factor. The LS factor represents a ratio of soil loss under given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 22.1 metres. The steeper and longer the slope, the higher is the risk for erosion.

- **C** is the crop/ vegetation and management factor. It is used to determine the relative effectiveness of soil and crop management systems in terms of preventing soil loss. The C factor is a ratio comparing the soil loss from land under a specific crop and management system to the corresponding loss from continuously fallow and tilled land. The C Factor can be determined by selecting the crop type and tillage that corresponds to the field and then multiplying these factors together. The C factor resulting from this calculation is a generalised C factor value for a specific crop that does not account for crop rotations or climate and annual rainfall distribution for the different agricultural regions of the country. This generalised C factor, however, provides relative numbers for the different cropping and tillage systems; thereby helping you weigh the merits of each system.

- **P** is the support practice factor. It reflects the effects of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of erosion. The P factor represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope. The most commonly used supporting cropland practices are cross slope cultivation, contour farming and strip-cropping.

- All values of parameters in this equation will be obtained using data that has been obtained for Malaysia condition.

- All the relevant data can be referred in the “Guideline for Erosion and Sediment Control in Malaysia” published by Ministry of Natural Resources and Environment and Department of Irrigation and Drainage Malaysia (October 2010).

- The soil loss tolerance rate from erosion risk map of Malaysia (Department of Environment, 2003) is shown in Table A8.1 below.

Table A8.1: Soil Loss Tolerance Rates from Erosion Risk Map of Malaysia

Soil Erosion Class	Potential Soil Loss (tonne/hectare/year)
Very Low	<10
Low	10 – 50
Moderate High	50 – 100
High	100 – 150
Very High	>150

8.2 Procedure for Using USLE

1. Determine the R Factor.

2. Based on the soil texture determine the K value. If there is more than one soil type in a field and the soil textures are not very different, then use the soil type that represents the majority of the field. Repeat for other soil types as necessary.
3. Divide the field into sections of uniform slope gradient and length. Assign an LS value to each section.
4. Choose the crop type C factor and select the P factor based on the support practice used.
5. Multiply the 5 factors together to obtain the soil loss per tonne per hectare per year.
6. Determine the soil erosion class.

<u>**EXAMPLE OF SOIL LOSS ESTIMATION FOR A PROJECT SITE USING USLE**</u>

A =R x K x LS x C x P

1. Rainfall and Runoff Factor (R)

   The sample field is in Tawau, Sabah. Therefore the R Factor is obtained in from the Tawau meteorological station.

   R Factor = 702.40 MJ.mm/ha/yr

2. Soil Erodibility Factor (K)

   The sample field consists of fine sandy loam soil with an average organic matter content. Refer to table for soil erodibility factors for Malaysian soil series.

   K Factor = 0.18

3. Slope Length-Gradient Factor (LS)

   The sample field is 250 meter long with a 3% slope. Refer to table for slope length and steepness factor

   LS Factor = 0.275

4. Crop/Vegetation and Management and Support Practice Factor (CP)

   - Scenario 1: Assuming the condition at site is bare land without erosion and sediment control measures (newly cleared area)

     CP Factor = 1.00

   - Scenario 2: Assuming the condition at site is covered with rangeland (grass and shrubs) for a medium density residential area as part of the erosion and sediment control measures

     CP Factor = 0.23 x 0.15 = 0.0345

5. Therefore, A = R x K x LS x C x P
   - Scenario 1: 702.40 x 0.18 x 0.275 x 1.00 = 34.767 tons/ha/year
   - Scenario 2: 702.40 x 0.18 x 0.275 x 0.0345 = 1.200 tons/ha/year

6. Soil Erosion Class

   - Thus, by applying certain cover management and proper erosion control practice to control soil loss at a specific site, the average annual predicted soil loss can be reduced up to 96%. Therefore, the soil erosion class is considered very low for this site.