State Environmental Conservation Department (ECD), Sabah, Malaysia

EIA Guideline for Construction on Hillslopes

Final Draft

January 2001

Abbreviations

DID	Department of Irrigation and Drainage
DOE	Department of Environment (Malaysia)
ECD	Environmental Conservation Department (State of Sabah)
EIA	Environmental Impact Assessment
ha	hectare
km	kilometre
m	metre
m^3	cubic metre
mg/L	milligram per litre
RM	Malaysian Ringgit
TSS	Total Suspended Solids

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Prepared Lim Peng Siong, Vitalis Moduying, Yabi Yangkat, Tony Greer, Carsten Hollænder Laugesen, Eric Juin

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Publication contact

The Environmental Conservation Department
2th & 3th floor, Wisma Budaya
Jalan Tunku Abdul Rahman
88999 Kota Kinabalu
Sabah, Malaysia
Phone: 088 251 290
Fax: 088 238 120
E-mail: jkas@sabah.gov.my
Homepage: www.sabah.gov.my/jkas

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Preface

Hills with slopes having gradient of 20 degrees or more are prone to excessive topographical changes, landslides and slope failures. Development on hillslope increases the prospect of slope failure, or landslides, the problem becoming critical during the wet season. Indiscriminate or uncontrolled construction on hillslopes could thus bring about dire consequences, including severe damage to property and can also lead to loss of life.

Construction activities on hillslopes in Sabah, particularly in the urban centres and tourist resort areas, have been on the increase in the last few years, sometimes with detrimental results. These include the destruction of landscape, increased soil erosion, slope failures and loss of lives.

In Sabah, the Environmental Conservation Department is, effective September 1999, charged with regulating the construction on hills with slopes having gradient of 20 degrees or more to ensure that development on hillslopes are conducted in an environmentally responsible manner.

This guideline is produced to provide guidance on the scope of environmental considerations required during the planning, pre-construction, construction and operations and maintenance stage of construction on hillslope activities.

Through use of this document it is intended that the key environmental considerations will be identified in the planning of construction on hillslope activities. Early identification of potential environmental considerations will ensure that subsequent developments will be carried out with minimal adverse environmental impacts.

ECD would like to express their appreciation to the Danish Co-operation for Environment and Development (DANCED) for overseeing and assistance in preparation of these Guidelines through ECD's Capacity Building Project. Appreciation is also extended to all government agencies, organisations and individuals for their contribution and support in formulation of this Guideline.

Eric Juin
Director
Environmental Conservation Department

Introduction

The aim of this Guideline is to provide a framework for the preparation of EIA for construction on hillslope activities under the requirements specified in the Sabah's *Conservation of Environment Enactment 1996* and *Conservation of Environment (Prescribed Activities) Order 1999*. The Guideline is therefore intended for use by project proponents, environmental consultants and approving authorities when initiating, assessing and approving the EIA for construction on hillslope activities in the State of Sabah. The Guideline can, however, also be used as a guideline for the development and control of other hillslope developments not covered by the EIA regulations.

The Guideline should be regarded as complementary to the *Handbook for Environmental Impact Assessment (EIA) in Sabah*, published by the Environmental Conservation Department.

The Guideline provides an easy to follow and practical means for assessing environmental impacts, recommending mitigation measures and proposing monitoring programmes for:

- Construction of buildings for commercial purposes
- Construction of buildings exceeding 4 storeys high for residential purposes
- Construction of parks
- Construction of resorts
- Construction of other recreational facilities.

Construction on hills with slopes having gradient of 20 degrees or more is defined as the erection or assembly of structures (such as buildings), recreational facilities (such as parks and resorts), and related access roads on hills with natural slopes having gradient of 20 degrees or more. Throughout this Guideline, *construction on hillslope* is used as an abbreviated form to cover all of the above activities. The method of determining whether the natural slope have gradient of 20 degrees or more is stated in Annex A.

Specifically excluded from this Guideline is construction of major roads on hills with slopes having gradient of 20 degrees or more; this activity will be covered by other guidelines.

This Guideline should be used in conjunction with the following documents:

- *Handbook for Environmental Impact Assessment (EIA) in Sabah*, published by the Environmental Conservation Department, Sabah (ECD)
- *Environmental Impact Assessment Guidelines for Development of Resort and Hotel Facilities in Hill Stations* – EG8/95 published by the Department of Environment Malaysia (DOE).

Newspaper clippings


Photo 0.1 Residential buildings on slopes of Signal Hill, Kota Kinabalu Photo 0.2 Resort on hillslope at Kundasang


Photo 0.3-0.4 Condominiums/apartments on crest and slopes of Likas Ridge



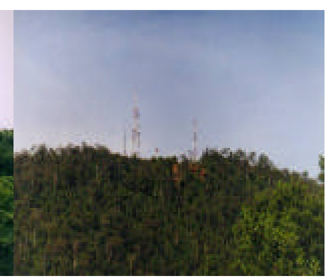


Photo 0.5 Observation Tower at Signal Hill Kota Kinabalu Photo 0.6 Chinese Temple sited at top of Sandstone cliff, Sandakan Photo 0.7 Transmission Towers at crest of ridge

Photo 0.8 University campus built on hillslope

1 Sabah Context

1.1 Geographical Overview

The terrain of Sabah is generally hilly and mountainous. The western part of Sabah is dominated by the northeast trending Crocker Range, which rises from near the west coast to 50 km inland and stretches from the Sarawak border in the southwestern corner of the country to the Kinabalu massif. The range rises up to about 1,200 to 1,800 m in height along a central spine. The range culminates at its northern end in Mount Kinabalu (4,093 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.

East of the Crocker Range are several less prominent ranges, also trending northeast. One of these ranges is the Trusmadi Range; the second highest mountain, Mount Trusmadi (2,590 m), is located on this range. 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.

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.

Flat, non-swampy land available for development in Sabah is thus limited in extent compared to the hilly terrain, which constitutes most of Sabah. As pressures from population growth, economic activities and landuse activities grow, it is inevitable that parts of the hilly areas will be developed.

Construction on hillslopes with gradients exceeding 20 degrees is becoming increasingly evident in urban centres around Sabah. This also includes hilly areas with tourism potential such as Kundasang and Gunung Emas in Penampang. The types of structures erected on such slopes range from residential houses to commercial condominiums/apartments and chalets; other structures include temples, water storage reservoirs and telecommunication/transmission towers. In and near the urban areas of Kota Kinabalu and Sandakan, commercial condominiums and apartments are the dominant type of structures erected on hillslopes while resorts and hotels are most common in areas with tourism potential.

In Sabah, the total area, which has been utilised for hillslope development, is estimated to be in the region of 3 to 5 per cent. In Kota Kinabalu alone, hillslope development projects are estimated to make up about 10 per cent of the developed area while in Sandakan the figure would be less.

It is anticipated that construction on hillslope will increase in the near future as pressures from population growth, economic activities and land in use pressure continue to increase. The continued growth in the tourism industry has prompted several proposed high-rise projects mainly in the form of apartments for sale to the public and hotels for tourism purposes.

Construction on hills with slopes having a gradient of 20 degrees or more is normally carried out for five purposes, namely:

- Personal requirements - individuals who own land on such slopes may want to construct buildings for their own use
- Commercial requirements - land developers may construct condominiums and apartments for sale to the public
- Tourism requirements - buildings such as hotels, resorts, parks and recreational facilities may be constructed by both the public and private sector for tourism or recreational purposes
- Religious purposes - religious bodies may want to erect places of worship
- Public Utilities - construction of major water storage/distribution reservoir and telecommunication/ transmission towers.

Table 1.1 Examples of areas where construction on hillslopes already have taken place

District	***Area***
Kota Kinabalu	• Likas Ridge - Condominium, Apartment and Bungalow • Signal Hill - Condominium, Flats, Observation Tower, Bungalow • Shangrila-La Height - Condominium, Bungalow, Water Storage Reservoir • Inanam Laut - University
Sandakan	• Taman Merah - Bungalow • Observation Platform • Chinese Temple
Ranau	• Kundasang Perkasa Hotel • Kinabalu Pines Resort • Zen Garden Resort • U-Merlin Resort
Penampang	• Gunung Emas - Resort • Beverly Hills - Housing
Tambunan	• Gunung Alap - Resort
Tenom	• Tenom Town - Perkasa Hotel
Tuaran	• Tengihilan - Buddhist Retreat Centre

Figure 1.1. Overview of key areas with existing construction on hillslopes in Sabah

1.2 Geology in Relation to Instability/Landslides

The geology of Sabah is dominated by sedimentary formations. About 70 per cent of this underlying geology is made of sedimentary rocks with about 10 per cent of rock types being Terrace and Recent deposits. The remainder of the geology is intrusive and extrusive igneous and metamorphic rocks.

The sedimentary formations comprise of a variety of rocks including interbedded sandstone and mudstone, shale, siltstone, limestone, calcareous sandstone, chert, tuffite and slump breccia. They are in varying degrees of consolidation. The sedimentary rocks which form the mountain and hill ranges along the west coast of Sabah belong to the Crocker and Trusmadi Formations; the rocks are strongly folded, faulted and fractured. The sedimentary rocks composing the east coast of Sabah are poorly consolidated, gently folded and tilted. Some of the formations consist predominantly of mudstone.

Terrace deposits are found in the Pinosuk Plateau, the Keningau-Sook Plain and along the coastal areas. These consist of gravel, sand, silt and mud. The Pinosuk deposits are of glacial origin, poorly sorted and consolidated and consist of blocks as much as a few metres across.

Intrusive igneous rocks form mountains and hills in the Kinabalu and Segama areas, including the Mount Kinabalu. Volcanic rocks are mainly found in the Semporna Peninsula where they form mountainous country along the spine of the Peninsula; associated with these volcanic rocks are some intrusive rocks.

Weathering of the sedimentary formations is frequently severe, often reaching a depth of 30 m. A completely weathered zone of 1 to 10 m thick has developed in most formations. The erodibility of soils developed from the weathering of these sedimentary formations depends on soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical content. Soils with high silt content are highly erodible.

Instability and landslides are recurrent problems associated with hillslope development affecting excavation for building sites and road cuts (Table 1.2), particularly on the hilly terrain underlain by sedimentary rocks along the west coast, Kundasang and Sandakan areas. Landslides are also common in steep terrain underlain by igneous intrusive rocks, particularly the ultrabasic rocks, in the Lahad Datu and Telupid areas. The landslides may occur both in bedrock and in overburden. Slides may also occur in fill material.

Bedrock slides are most common where planes of structural weakness such as bedding or major joint planes dip towards the cut. Overburden slides occur mainly on semi-hemispherical slip surface.

Table 1.2 Major landslides in Sabah

Date	Locality	Loss of life/injury	Property	Remarks
Feb. 8., 1999	Kg. Gelam, 2 km from Sandakan	17 dead, 2 injured	4 houses destroyed	-
Jan. 6, 1999	Kg. Garib, Inanam	1 dead	1 house damaged	-
Feb. 16, 1996	Kg. Pinosuk, Ranau	-	4 houses damaged	Many landslides along Ranau-Telupid and Ranau-Tamparuli Roads during the same period
Aug. 28, 1995	KM. 25 Tambunan-Penampang Road	1 dead	1 lorry damaged	Disruption of water supply in the Penampang area
Dec. 7, 1980	Tenom-Pangi Hydroelectric Power Project area	3 buried, several injured	-	-
Dec. 8, 1980	Kg. Kimanis, Papar	3 dead	1 house damaged	House slipped 50 feet down the slope with the slide
Oct. 10, 1979	Bayview Heights, Mile 3, Tuaran Road	-	4 houses damaged	Slide on fill material

Note: All affected houses were located on hillslopes and landslides occurred after periods of continuous rain.

1.3 Legal Requirements

Effective September 1999, Environmental Impact Assessment (EIA) is a mandatory requirement for construction on hills with slopes having gradients of 20 degrees or more in Sabah under the *Conservation of Environment Enactment 1996* and the *Conservation of Environment (Prescribed Activities) Order 1999*. Construction on hillslope is a Prescribed Activity, which requires an EIA approval prior to project commencement. The development falls under two categories:

> *Section 3: Development of Commercial, Industrial and Housing Estates. Paragraph (vi): construction of buildings for commercial purposes or buildings exceeding 4 storeys high for residential purposes on hills with slopes having gradient of 20 degrees or more; and*
>
> *Section 7: Any other activities, which may damage or have an adverse impact on quality of environment or natural resources of the State. Paragraph (i): construction of parks, resorts or other recreational facilities or major roads on hills with slopes having gradient of 20 degrees or more.*

Failure to observe this directive, the authority, body or person in default shall be guilty of an offence and shall, on conviction, be liable to a term of imprisonment for 5 (five) years and a fine of RM 50,000.00 (Malaysian Ringgit fifty thousand only).

1.4 Application and Approving Procedures

Effective September 1999, construction on hills with slopes having a gradient of 20 degrees or more in the State of Sabah is subjected to an EIA requirement. This is in addition to the approval of the development plan by the relevant City/Municipal/Local District Council and rezoning (change of land use) of the land by the Central Town and Country Planning Board.

Any person who intends to undertake construction on hills with slopes having a gradient of 20 degrees or more in the State of Sabah shall submit to the Director of the Environmental Conservation Department (ECD) an ***EIA Report***. A copy of the development plan proposal should also be submitted to ECD. The Department contact is:

The Director
Environmental Conservation Department
Tingkat 2 & 3, Wisma Budaya
88000 Kota Kinabalu, Sabah

Attention: Environmental Assessment Section
Tel: 088-251290/1
Fax: 088-238120
E-mail: jkas@sabah.gov.my
Homepage: *www. sabah. gov.my/jkas*

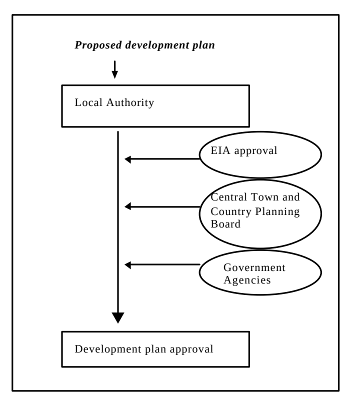
Approval of the development plan is required from:

- The relevant City/Municipal/Local District Council for written approval of the Development Plan.

Where the development involves a change in the land use, approval is required from:

- The Central Town and Country Planning Board for approval to rezone (change of landuse) the land on which the construction will be carried out under Part I, Section 3 of Town and Country Planning Ordinance 1950.

The procedure for submitting and obtaining approval for the development plan of the construction is shown in Figure and summarised below:



- Applicant must prepare a development proposal report or plan by qualified person(s) and submit it to the relevant City/Municipal/Local District Council. The report/proposal shall include the details as required under the Guidelines for Development on Hillside area adopted by the State Ministry of Local Government and Housing (refer to Annex B)

- The City/Municipal/Local District Council shall refer the development report/proposal to the relevant departments for technical comments and acceptance, which include EIA approval for such construction from ECD (under Section 4 of the Conservation of Environment Enactment)

- If the land has to be rezoned for different land use other than specified in land title, the City/Municipal/Local District Council shall submit the application to the Central Town and Country Planning Board for approval to rezone the site

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

The project proponent has to be aware of the requirements of a development plan proposal to avoid unnecessary delays in the application procedures. The development plan proposal report must contain all the required details as listed in Annex B.

The list of required details implies that the site on a hillslope should be carefully selected during the feasibility stage to ensure that the proposed site is environmentally acceptable. The proper selection of site avoids problems that are often obvious and which may have adverse impacts on the project. A proper site selection, when thoroughly undertaken, will eliminate obstacles to the project that may affect its viability as a result of impacts to the environment that may be costly to mitigate or control besides the other factors of acceptability for economic or technical reasons. The characteristics of the site should influence the development plan.

Consideration on the selection of a location on the hillslope for construction 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, slope failures
- Geologically sound bedrock
- Bedrock or soil with good geotechnical properties
- Absence of historical earthquake activity

b) Does not have a conservation value

- No geological value such as fossils or geological structures which have been identified by higher education institutions or the Department of Mineral and Geoscience 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
- Not within forested ridge areas which have inherent visual qualities

c) Not gazetted as permanent forest reserve, water catchment, or zoned as an area having mineral resource, ridge conservation area

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

1.6 Typical Project Activities

A typical hillslope construction operation involves activities, which can be grouped into three phases as follows:

- Pre-construction – Activities carried out during this phase include site access and track development, site surveying, geological/geotechnical investigation, including a study of the stability of the site and surrounding area
- Site preparation and construction - Activities at this phase include access road development, base camp construction, site clearing, earthworks, drainage works, development of utilities, construction of buildings and facilities, transportation of construction materials, equipment and machinery operation, waste disposal and abandonment
- Operations and Maintenance – Wastewater treatment, solid waste management, traffic management, labour force management, conservation works, general maintenance works and visitor management are the main activities in this phase.

A summary of a typical construction activity is shown in Table 1.3.

1.7 Key Stakeholders

Key stakeholders in construction on hillslopes activities in Sabah include:

- *City/Municipal/Local Councils* to issue written approval for the development plan
- *Environmental Conservation Department (ECD)* to approve EIA to carry out construction on hillslopes within the State
- *Central Town and Country Planning Board* to approve application for rezoning *Government Agencies* to give technical comment in relation to the development plan
- *Housing Developers Association* - the association for housing developers
- *Land owners* to construct buildings of more than 4 storeys for their own use
- *Corporations* construct buildings for their own use or for commercial purposes
- *Public agencies* construct public facilities and other governmental structures
- *Private land developers* construct apartments, condominiums, housing, resorts, hotels, chalets either as a company or as an individual

A list of experts and other relevant contacts is given in Annex C.

Table 1.3 Construction Activities

Phase	***Locality***	***Activity***
Pre-Construction	Construction Site	• Site surveying • Geological/geotechnical investigation, including stability of site and surrounding area
	Access	• Site access track development
Site Preparation and Construction	Construction Site	• Development of access road • Setting up of base camps • Site clearing • Earthworks • Drainage works • Development of utilities • Construction of buildings and facilities • Transportation of construction materials • Equipment and machinery operation • Waste disposal • Abandonment of site
	Access Road	• Upgrading of access track
Operations and Maintenance	Construction Site	• Wastewater treatment • Solid waste management • Traffic management • Conservation works • General maintenance works • Visitor management
	Access Road	• Maintenance of road and slopes



Photo 1.1 Clearing of project site Photo 1.2 Laying of pad footing Photo 1.3 Micropiling

•

2 Environmental Impacts

Steps	Activities	Issues
Step 1	Assessment of Impacts	Key environmental impacts include: • Slope Erosion • Slope Stability Problems • Landscape Alteration
Step 2	Mitigation Measures	
Step 3	Monitoring	

The purpose of this chapter is to outline procedures that can help identify the environmental impacts associated with construction activities on hillslopes. Methodologies are suggested for assessing and evaluating the scale and extent of the impact.

The general consensus is that it is difficult to quantify the environmental impacts arising from construction on hillslopes and hence an exact assessment cannot be made regarding all impacts and related mitigation measures. Furthermore the assessment must consider the cumulative impact of the construction, particularly regarding other existing developments.

An overall and integrated assessment should therefore be conducted on the slope of the intended development. An integrated assessment of a slope's sensitivity to change will help evaluations to be more compatible with the protection of the environment i.e. that the activity does not jeopardise the sustainability of other appropriate land and water users.

2.1 Impacts Assessment based on site characteristics

Environmental assessment for construction activities on hillslope depends on the characteristics of the site itself and also that of the upslope and downslope areas. Topographical maps on scale of 1:12,500 or nearest equivalent produced by the Lands and Survey Department and detailed topographical map on scales of between 1:1,500 and 1:500 or larger should be used in obtaining information on site characteristics. The characteristics to consider include:

- Location of site in relation to overall slope system
- The geology
- Soil type and depth
- Drainage system
- Vegetation cover.

2.1.1 Slope Development and Forms

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

The physical landscape is no more than an assemblage of valley- and hillside 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.

The slope evolution approach is concerned with tracing the historical development of the slope from its initiation to its present-day form. Under this approach, slopes tend to decline in steepness as the cycle of erosion proceeds towards the stage of old age. Thus steep slopes are designated as 'youthful' and gentle ones as 'old'. However, it has been observed that the rate of slope development varies from area to area and from one type of rock to another. Modern-day geomorphologists, however, contend that time may not be an important factor in slope modification, but that the slope form is merely 'adjusted' in response to changes in controlling factors.

There is therefore a direct casual relationship between the processes of weathering, transportation, erosion and deposition and the form and gradient of slopes. The immense variety of slope form and steepness is due to the fact that processes of erosion operates 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

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

The main types of slope forms recognisable are cliffs, concave slope, rectilinear slopes and convex slopes (see Figure 2.1).

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, with faces often 40 degrees or more and the products of weathering for the most part fall immediately to the base. A talus or scree slope (depositional feature) will develop at an angle controlled by the size and shape of the weathered fragments (see Figure 2.1.A).

The lower part of a slope profile will commonly exhibit a *concave* section (see Figure 2.1.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 (see Figure 2.1.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 (see Figure 2.1.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.

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 grading into each other to give a smoothly curving profile, (see Figure 2.2.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'.

In an area of (i) alternating massive and thinly bedded weak strata, (ii) where the relief/lack of tension is considerable, (iii) valleys are deeply incised/cut and (iv) 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 (see Figure 2.2.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 (see Figure 2.1.B and 2.2.C).

In the assessment of impacts of construction activities on hillslope, representative cross-section profiles of the whole slope should be drawn (such profiles should be drawn during the development planning stage) to determine the form of the slope. This will aid in assessing the area of influence of the project on the downslope section of the slope and also the area of influence of upslope activities on the project site itself.

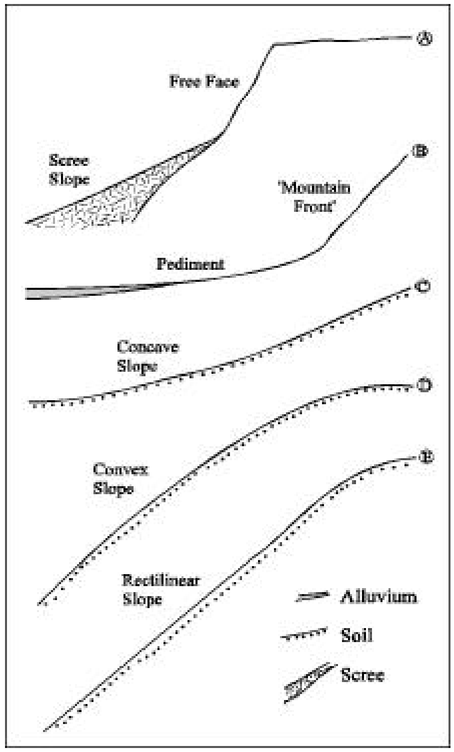


Figure 2.1 Simple Slope Forms (after Small, 1983)

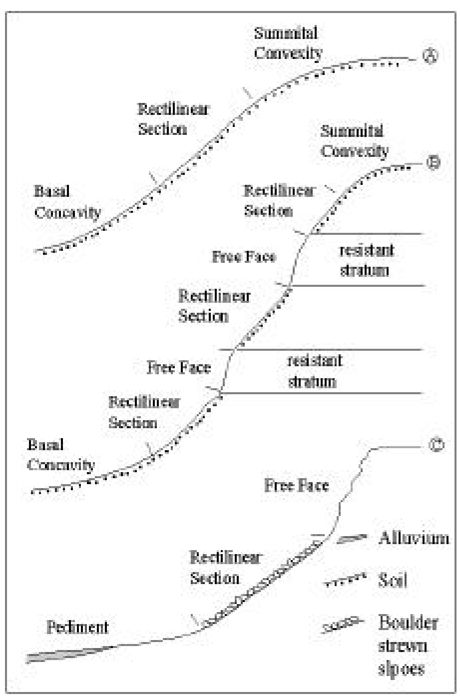


Figure 2.2. Complex Slope Forms (after Small, 1983)

2.1.2 Geology

Geology and rock types exert 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 hillslopes. 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 geologic structures and active tectonism (changes in the earths crust), creating regions where large portions of the hillslopes are formed by mass movement processes.

2.1.3 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 hillslopes and are very often non-cohesive and tend to be subjected to erosion very easily.

2.1.4 Drainage System

Eroded material will be transported downstream by streams and into rivers polluting them. It is thus important to characterise the hydrological condition at the site, both surface and underground. Surface and underground hydrological characteristics of importance include:

- Drainage pattern
- Dimensions and flows of stream and rivers
- Springs and wells, including flow
- Natural drainage depressions, basins and sinks
- Floodplains, both on site and downstream that will undergo change due to grading and construction
- Subsurface conditions including depth to water table, flow pattern of groundwater and aquifer type.

2.1.5 Vegetation

The role of vegetation in reducing erosion has been well documented. Vegetation cover helps to break the impact of falling rain drops and hence reduces the erosive force of the raindrops. The roots of trees also play an important role in reducing erosion and site stability by binding soil mantles to subsoils or substrata thus contributing to the mechanical strength of the soil.

2.1.5 Mapping

Maps used for the description of site characteristic include for example topographical, slope, geological, land use and geomorphological maps. Examples are shown in Figure 2.3-2.7.

2.3 Major Environmental Impacts

The major adverse environmental impacts of construction on hillslope activity are:

- **Slope erosion** and siltation due to (i) removal of vegetation creating bared surfaces and (ii) cutting of the hillslope creating steeper slope and increasing surface runoff
- **Slope stability** problems due to (i) removal of footslope, (ii) changes in stress conditions of rock underlying slope, (iii) change in groundwater conditions and (iv) increasing load on slope section where structure will be sited
- **Landscape impacts** due to (i) the direct physical change to existing physical features such as removal of vegetation, alteration of topography and erection of buildings and structures.

Other adverse environmental impacts of construction on hillslope activity include:

- Loss of ecological habitat
- Objectionable noise levels from construction and transportation activities
- Dust and atmospheric pollutants from machinery and transport vehicles
- Vibration associated with piling, vehicular movement and blasting
- Traffic and transportation
- Wastewater and solid waste disposal.

The above assessment of what constitutes major and minor impacts is based on a holistic and integrated approach. The criteria used are shown in Annex D.

2.3.1 Slope Erosion

Erosion on slopes takes place when one or more of the following conditions exist: (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 be re-established.

Construction on hills with slopes having a gradient of 20 degrees (steep slope) invariably involves removal of vegetation, the creation of cuts and fills and can therefore accelerate the process of soil erosion on slopes.

Clearing of the site involves earthworks in the preparation of the siting of structures. This will inevitably result in the removal of vegetation and the creation of cleared surfaces, which then become vulnerable to the erosive effect of rain. When a raindrop falls, it is usually absorbed into the pore spaces of the soil. However, when these pore spaces are saturated, the raindrops will either stand on the surface as a puddle or more likely flow downhill. As the water flows downhill, it will carry with it bits of debris and soil particles. The greater the rainfall intensity the greater the available run off to remove material. Erosion on exposed slopes starts with rainsplash leading to sheet, rill and gully erosion and the creation of badland if the site is abandoned. Soil loss due to erosion will subsequently be discharged into streams. Not all eroded material is discharged immediately and much of it is deposited temporarily on the land surface where slopes become gentler (see Figure 2.3 and photos).

Cuts and fills change the slope angle, often creating steeper slopes. The steeper the slope the faster the runoff flows and the more force it will have to move material downslope.

Photo 2.1 Sheet erosion

Photo 2.2 Rill erosion on artificial slope

Photo 2.3 Gully erosion

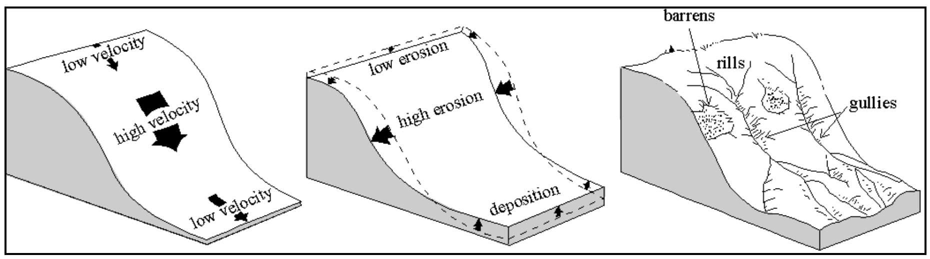


Figure 2.8 Erosion and resultant geomorphic features (after Marsh 1969)

Assessment Method for Slope Erosion

It is important to assess and identify high erosion risk areas where soil erosion risk will increase during the construction period and the anticipated erosion risk after completion of project. Erosion risk from construction of access road should also be considered. The methodology for the assessment of soil erosion risk can involve the following steps:

1. Examine available maps, which includes for example topographical, land use and vegetation cover maps, all including the surroundings (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). Maps on a scale of 1:12,500 or nearest equivalent produced by the Lands and Survey Department would serve and such maps exist for most parts of Sabah. The following features should be identified:

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

2. Examine aerial photographs, when available, of the proposed site and surroundings including alignment of access road, and again if available, examine photographs of different dates as they record changes in land use over time. Aerial photographs of scale 1:5,000 or 1:

12,500 should be used. Plot detail of erosion features such as rills, gullies alongside related factors such as land use and vegetation cover. The information obtained should be transferred to the base map of scale 1:12,500 or nearest equivalent.

3. Carry out field surveys to verify the features identified in (1) and (2) and to add additional information such as other erosion sources, discharges, nature of river/stream water downstream (clean or already sedimented) and water users downstream/slope (e.g. water intake, mangrove swamp, etc.).

4. Prepare a pre-erosion risk map. This map should include relevant data gathered in step (1)-(3) and provide information on for example (i) location of existing areas with high erosion rates within the site and along alignment of access road with high erosion rates, (ii) amount (including percentage of total land) of areas with high erosion rates and (iii) 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 construction and development.

5. Make a post-erosion risk assessment, including a post-erosion risk map. Erosion risks are higher during the construction stage when the land is cleared and exposed for a period of time. The longer the exposure period, the more serious the soil loss. The seriousness of soil erosion during the construction stage 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 post-erosion risk/hazard assessment.

This assessment should include the preparation of a post-erosion risk map, which is overlaid the pre-erosion risk map. The post-erosion risk map shall show the soil erosion risks during construction stage, taking size, location, phasing and period of exposure into consideration. The post-erosion risk map should include the site and the surrounding areas.

This soil loss assessment will assist in assessing the mitigating measures proposed in the development plan to control soil erosion during construction stage.

As no exact quantifiable erosion criteria exist, a ‘best possible’ assessment of the significance of the overall soil erosion risk alongside a careful assessment of the geomorphological condition of the slope should provide indication as to whether or not the project places the environment at risk. Criteria used for the environmental assessment should include for example:

- Period of exposure of cleared land and predicted soil loss during the exposed period
- State of water quality downstream of the proposed site
- Number of beneficial users sensitive to water pollution downstream
- Extent of sedimentation and damage to property downstream.

2.3.2 Slope Stability Problems

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 by man. Natural slopes that have been stable for years may suddenly fail because of construction activities on hillslope, which may bring about:

- Changes in the slope topography
- Changes in ground water conditions
- Loss of cohesive strength of soil
- Stress changes in the soil underlying the slope
- Acceleration of the rate of weathering of rock.

Accelerated weathering. Changes to the terrain and hydrology through construction, earthworks or removal or vegetation cover may cause erosion which create conditions conducive to mass movement if exposed surfaces are not protected within a short period. Exposed rocks will be weathered at a faster rate and the weathered material is susceptible to movement especially when saturated with water. Such conditions are commonly found in denuded and eroded exposed slope surfaces of delayed or abandoned development projects in Sabah.

Cut-and-fill. Cut-and-fill platforms are usually created to site the structures. Slope cutting changes the slope topography and releases residual horizontal stresses and cause expansion of the slope. Joints or weak zones may be exposed along which sliding may occur. Overcutting the toe or oversteepening of the slope gradient to create a platform can therefore induce instability. Placement of fill will also lead to increase in shear stresses acting on slopes and may lead to slope failure. The fill may fail if it is not properly designed and constructed to stringent requirements.

Hydrological change. Drainage patterns of an existing terrain may be altered as a result of construction. The change in groundwater flow patterns may cause changes detrimental to the stability of the newly constructed slopes of the existing in situ slopes that were stable prior to construction.

Assessment Method for Slope Stability

The following dimensions are suggested as guideline for defining the area of influence upslope and downslope of the project site. In general, the area of influence is 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. It should be borne in mind, however, that topographic features might indicate modifications to this general axiom. The area of influence will be finally agreed upon between the ECD and the EIA consultant during the preparation of the TOR for the EIA study. When dealing with slope stability assessment, previous geological and geotechnical experience in the area of interest is valuable especially if a particular type of slope failure has been established for a previous failed slope in the same area.

The methodology for the site assessment of slope stability can involve the following steps:

1. Collating information from existing records/reports. Geotechnical and geological information from records of development of area (site investigation, boring, piling, foundation, slope stability studies) should be obtained and compiled from relevant government agencies (e.g. JKR, Department of Mineral and Geoscience) and from consulting architects and engineers. The data shall be assessed (expert opinion may be necessary) and potential slope instability areas identified and transferred to map of appropriate scale; topographical maps on a scale of 1:12,500 or nearest equivalent covering most parts of Sabah would serve as a good base. Examining geomorphic and drainage patterns from the topographical maps also give an indication of materials likely to be found at site

2. Studying aerial photographs, when available. The study of aerial photographs in the assessment of slope erosion should incorporate the identification of geological and geomorphological features including features, which suggest instability. Aerial photographs of about 1: 25,000 are widely available while some areas are covered by larger scale aerial photographs. When available, aerial photographs of different time intervals should be studied to build up a history of development in the area. Data from aerial photograph interpretation should be transferred onto a map of 1:12,500 or nearest equivalent scale

3. Field survey assessment of the site characteristics. A field survey should be conducted to verify the features interpreted from aerial photograhs and information from existing geological and geotechnical reports of the site. The field survey of site characteristic should include the location of site in relation to overall complexity of the slope system, the geology, soil type and depth, drainage system and vegetation cover. It should also include geological and instability features. Geological features of interest are joints, fault zones, type of fault and movement, zones of weak rocks, seepages/springs and scarps. Efforts should be made to identify instability features, including tilting of trees, poles, settlement, recent landslides, old landslides/slips, rock falls/topples, direction of slide movement, heave and bulge. Information from local residents, in particular on past landslides, should also be noted and recorded.

Information on the subsurface condition (type and extent of rock/soil underlying site, relevant properties such as permeability, strength, and groundwater regime) of the site can be obtained from geotechnical investigation reports. These data should be correlated with the field survey surface data.

4. Preparation of a slope sensitivity map. Data obtained from step (1)-(3) should be transferred and plotted onto a slope sensitivity map. This map should identify and clearly mark stability features of the site and surroundings, including slope sensitive areas (unstable areas) with potential instability problems. Sensitive areas should be avoided or if affected by the proposed development, should be properly stabilised.

5. Analysing and mapping the run-out zone in the event of a landslide originating from the site. The effects of landslides extend downslope, and there therefore is a need to estimate the extent and nature of landslide runout based on available data in the event that the assessment of site characteristics shows that there is a potential for a landslide to originate at the site. The assessment should, at least result in a map identifying locations where delivery of slide debris is most likely, where the slide is likely to initiate and the potential downslope/downstream impacts on property and life. Similarly, if a potential slide zone has been identified upslope of the site, the runout zone should be estimated and delineated on a map and the impact on the proposed development assessed.

5. Assessing and mapping the type of development and the potential for increased future instability. Given the proposed development and the anticipated changes in surface and subsurface conditions at the site, an assessment of the increased potential for future slope stability problems in the area should be made. The type of structures to be erected and the specific locations of these structures as per the development proposal are critical in this assessment. The assessment should map and evaluate the type of development and siting of structures and whether or not this raises the risk of slope instability, particularly where these structures are to be sited on or close to sensitive areas as identified earlier.

The assessment of slope stability may be based on an overall evaluation of slope stability conditions of the site and its immediate surrounding. The assessment should consider the short- and long-term stability of the site and that of the surrounding environment, possibility of landslides involving natural or engineered slopes, type and scale of development, surrounding landuse and proposed mitigating measures. The use of 2nd opinion of the assessment might be included.

Photo 2.5 Debris avalanche from a landslide on steep slope. Photo 2.11 Landslide affecting road built on slope Photo 2.7 Active slide as suggested by the slanting of trees

Photo 2.8 Slope movement as indicated by tilted oil palm tree Photo 2.10 Sign of slope movement as suggested by tension cracks Photo 2.9 Sliding of rocks along a bedding plane Photo 2.6 Bulging of toe of a failed slope.

2.3.3 Landscape

Landscape is defined (Hill and Revell, 1989) as " the outdoor environment, natural or built, which can be directly perceived by a person visiting and using that environment". The term landscape focuses upon the visual properties or characteristics of the environment including natural and man-made elements, and physical and biological resources, which could be identified visually. The impact on landscape is therefore a direct physical change to existing landscape features such as vegetation, topography, open space and recreational facilities as well as buildings and structures. Visual impact is a change to the appearance of the landscape and the subsequent effect on the views of groups of people at particularly sensitive viewpoints.

Visual impact can vary from overall improvement to degradation. For example; construction of chalets on a hillslope could lead to improvement of the visual quality and enhance the attractiveness of the landscape, erection of a 5 storey hotel on a ridge top could lead to visual obstruction and blocking of views, a poorly designed 4 storey bungalow could be in visual incompatibility with the surroundings, because the design features are not appealing and reduces the overall visual quality of the area.

Constructions on hillslope will unavoidable bring about a change in the landscape and will thus have a visual impact on landscape quality.

Assessment Method for Landscape

Landscape and visual impact assessment shall be directed towards predicting and judging the significance of the effects 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.

The methodology for the site assessment of landscape impacts can involve the following steps:

1. Preparation of inventory. For an assessment of the landscape, an inventory of the existing landscape and visual characteristics of the area is necessary. The purpose is to identify, classify and record the location and quality of visual resources and values. The inventory can be prepared by examination of aerial photographs, desktop study and site inspection. A photographic record of the site shall be prepared. The inventory shall at least cover the following aspects:

- Physical aspects such as geology, landform, drainage
- Human aspects such as cultural features, buildings and settlements, people affected and their perception of the landscape character
- Aesthetic aspects such as the views available, visual amenity and visual character
- The extent of vegetation that will be destroyed as per the development plan proposal.

Maps, photographs and imageries of visual resources of the area will be produced. The inventory of the landscape and visual resources of the area shall be appraised and shall focus primarily on the quality, sensitivity of the landscape and its ability to accommodate change.

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 desktop study as well as 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 includes viewpoints from major routes e.g. roads, footpaths, 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 given.

3. Visualisation. 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 given.

4. Review of planning and control issues. It is important to review the planning and development control development framework (development plan, lease conditions, special design areas, landmarks, monuments, guidelines and control on urban design, landscape-related zoning etc.) as these will provide an insight into the future outlook of the area affected and the ways the construction project can fit into the wider context.

5. Make an overall assessment of the landscape impact. The assessment of landscape and visual may be based on the type and extent of the construction impact on the environment, and could include assessment of 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 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
- Impacts upon acknowledged special interest or values such as areas of high landform with special landscape significance
- Proximity of sensitive viewpoints to the proposed development
- 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:

- *Areas of distinctive landscape character,* e.g. characteristic combinations of land coverage creating a sense of place
- *Valued landscape*, e.g. country parks, protected coastline, areas of high landscape value, woodland, scenic spots
- *Other conservation interest,* e.g. protected areas, designated buffer zones, wetlands, historic landscape, sites or buildings of cultural heritage
- *Specific landscape elements,* e.g. hilltops, ridgeline, coastline, river valleys and woodlands.

Photo 2.11 Condominiums and apartments rising from the slopes and top of Likas Ridge Photo 2.12 a + b Slope of ridge stripped of vegetation and replaced by cut slopes and buildings

A checklist of assessment criteria such as shown in Table 2.1 can be used.

Table 2.1 Example of assessment criteria checklist

Item	Compatibility with surroundings	Yes	No
1	Height		
2	Shape		
3	Proportion		
4	Building elements, colours and materials used		
	Obstruction of views		
5	Block views from existing key viewpoints towards existing landscape features		
6	Block views form existing/planned view corridors towards landmarks and features		
	Landscape/visual quality enhancement		
7	Appealing design features that enhance attractiveness of the land-scape		
8	Clears visual obstruction of notable landmarks/features from existing key viewpoints		
	Visual interference		
9	Uncomfortable eye feeling/glare caused by reflection of sunlight from structures faced with mirror		
10	Uncomfortable eye feeling/glare caused by direct light sources gener-ated from proposed development		
11	Reduces sightings of wildlife		

2.4 Additional Impacts

2.4.1 Ecological Impact

Construction on hillslopes will change habitats thereby impairing 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 ecological data to allow an identi-fication, prediction and evaluation of the potential ecological impacts. A site inventory is vital in order to determine what, where and in what numbers communities of fauna and flora 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.

As required under the Guidelines for Construction in Hilly Areas (see Annex A), the project pro-ponent has to incorporate into his development plan proposal a report on the vegetation found at the site. These data should serve as an initial inventory of the flora and fauna found at the site and should be reviewed and verified by carrying out site inspection.

A useful inventory for management purposes is a habitat map. This can be produced by site surveys alone, using the location base map and by sketching in habitat types. . If it is known that the site is either a permanent or temporary home for endangered species data should be collected on these species, and the distribution and location of endangered or protected species should be recorded. Surveys of aquatic environment need only be carried out if the site is located upstream of aquatic sensitive areas.

The ecological impact should be assessed against the location of site clearing as indicated in the development proposal plan, the possible water pollution, the size of sensitive areas in and around the construction site that will be destroyed and the presence of sensitive aquatic areas downstream.

2.4.2 Noise

The sources of noise in construction activity on hillslope are mainly construction noise generated by semi-mobile machinery, which includes excavators, loaders, bulldozers, piling machine and cranes, and mobile machinery, which includes dump trucks, lorries and graders. The machinery and vehicles operates along the access roads and at the construction site. Most of the noise from these sources is inherent and difficult to subdue.

Since the operation of most construction equipment and machinery will result in elevated noise levels, a risk assessment of noise pollution on the population living in the area should be made. The risk assessment should be based on the number of people exposed to high noise levels and considered against the length of the construction period.

2.4.3 Dust

Dust is a cause of concern for residents living along and near the access roads and project site during the site clearing and construction stage. Dust can be generated by earth-moving lorries, grader along the access road under construction, movement of overburden, wind blowing upon the cleared site. In addition, vehicles and earth moving equipment will emit exhaust and fumes.

A risk assessment of dust pollution on the population living in the area should be made. The risk will be dependent on the number of people exposed to elevated dust levels and the period of exposure. The risk should therefore be assessed based on the number of people exposed to high dust levels, length of construction and length of dry periods.

2.4.4 Vibration

Constructional operations such as blasting, pile driving or the movement of heavy machinery can cause ground vibrations and possibly air vibrations. Ground vibrations may have a damaging effect on nearby buildings, slope stabilisation measures and retaining structures and can cause discomfort to residents. Vibration due to pile driving depends on the nature of soils transmitting the vibration and the distance to the nearest building.

Structural damage due to ground vibrations from blasting (e.g. of rock outcrops) is related to peak particle velocity. Currently, the Department of Mineral and Geoscience recommends a limit of 5 millimetres per seconds for housing. Any proposal for blasting needs approval from the Department of Mineral and Geoscience. Assessment of the proposed blast design will give an indication of the level of vibration. Ground vibrations can be controlled by the use of an effective blast design.

It is important that the vibration from blasting be monitored to ensure that the blast design is suitable and the vibration levels are within acceptable limits. Vibration from pile driving must also be monitored to assess the level of vibration. The vibration impact assessment should be based on the number of houses and people and the distances of the houses from the source.

2.4.5 Traffic & Transportation

Traffic creates noise and dust as well as affecting existing traffic flows, particularly along the access roads. Traffic associated with construction stage is mainly large lorries transporting overburden and constructional materials. Nuisance associated with traffic will be mainly in the form of vehicle movement to and from the project site, particularly during the night, dirty roads and damage to existing roads.

The impact from traffic can be assessed based on the number of houses and population affected by the nuisance caused by traffic movement. Traffic impact on the road capacity can be assessed by considering the changes in average traffic density against the capacity of the existing roads.

2.4.6 Wastewater and Solid Waste

Wastewater and solid waste are generated during the construction and operation stages. The release of untreated wastewater would result in discharge of effluent high in organic and nutrient level, which could lead to eutrophication, and spread of pathogens. The impact would be on the quality of receiving water downstream of the site. The impact should be assessed based on the quality of sewage effluent and should comply with the limits of Standard B of DOE's Sewage and Industrial Effluent Regulations 1979.

Solid wastes, such as used cement bags, discarded steel bars, plank, etc. will be generated from construction activities. Household garbage will also be produced from the staff quarters and site office during the construction phase and also from households during the operation phase. Solid waste should be properly disposed off at approved sites. The impact should be assessed based on the expected amount of garbage produced and ability of the disposal system to cope with the solid waste produced.


Photo 3..3 Reinforced Concrete wallprotecting cut slope Photo 3.4 Soil slope protected by creepers


Photo 3.5 Combination of gunite and turfing Photo 3.6 Cement motar renderedslope protection


Photo 3.7 Anchored bored-pile wall Photo 3.8 Slope protected by gunite wall

Photo 3.9 Slope failure

Photo 3.1 Soil Nailing

Photo 3.2 Rock slope protection using anchored tie wall

3. Mitigation Measures

Steps	Activities	Issues
Step 1	Assessment of Impacts	
Step 2	Mitigation Measures	Key mitigation measures include: • Controlling slope erosion • Slope stabilisation • Proper landscaping
Step 3	Monitoring	

The purpose of this chapter is to assist in determining possible preventive, remedial or compensatory measures for each of the adverse impacts evaluated as significant.

Mitigation will consist of a number of related actions and can take many forms, including the following:

- Preventive - to be addressed during the pre-feasibility study and includes site selection, orientation of layout and method of construction and landscaping
- Control - to be addressed during development and operational phases and relates to working practices such as control of runoff and discharges
- Compensatory - whereby it is recognised that there will be an adverse impact and that some compensation for the loss is to be made. This could include, for example, a specific contribution towards local community improvement projects.

This chapter covers

- Identification of the major mitigation measures for the key environmental impacts and suggests implementation methodologies to be used to help minimise or eliminate the impacts
- Description of other mitigation measures, including secondary, compensatory, rehabilitation measures.

3.1 Key Mitigation Measures

Key mitigation measures for construction activity on hillslope include:

- **Slope erosion control measures**
- **Slope stabilisation measures**
- **Landscaping measures.**

Other relevant mitigation measures include:

- Air quality control
- Noise control
- Vibration control
- Wastewater and solid waste control.

3.2 Slope Erosion Control Measures

An erosion and sedimentation control plan (ESCP) is required to be submitted together with the development plan proposal. The mitigating measures outlined in the ESCP should be assessed for their effectiveness and practicality based on the assessment made during the EIA study. Additional or more appropriate mitigating measures should be proposed to effectively reduce the impact of slope erosion, particularly during the construction stage. Emphasis should be given to mitigation measures that control at source rather than measures intended for control of already eroded material.

Key mitigating measures to control slope erosion include:

1. Phased development. The project should be implemented in phases to keep land clearance to a minimum. Only those areas required for development should be cleared. For this purpose, a land clearance plan has to be drawn up showing the completion of each phase of development and all clearing, grading and stabilisation operations 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 lengthy delay. Where possible, all excavated topsoil shall be stockpiled away from watercourses where they will not contribute to erosion, temporarily stabilised and later used for revegetation. Phased development will reduce the amount of exposed land at any one time.

An assessment should be made of the proposed phased development and amendments/improvements should be made where appropriate.

2. Stabilisation and protection of exposed areas. Disturbed exposed areas should be stabilised and protected from raindrop and runoff as soon as practicable to reduce exposure time. Exposed slopes should be turfed as soon as possible so as to keep the interval between clearing and revegetation to a minimum. The programme of protecting exposed slopes as contained in the ESCP should be examined and assessed for its effectiveness and practicality.

3. Retaining existing vegetation cover. As much as possible of the existing vegetation cover should be retained. Existing vegetation should be maintained as a filter along contours to reduce velocity and improve water quality. When retained in construction sites, they break up the length of long slopes and act as a buffer to minimise erosion. Stream buffers shall be retained for rivers, the width of the buffers shall follow the existing Department of Irrigation and Drainage (DID) regulations.

4. Timing of operations. Land clearing and cutting operations exposing bare slopes should be carried out, wherever possible, during dry periods to minimise the impact of slope erosion. The schedule of land clearing as proposed in the ESCP should be examined and appropriate amendments/recommendations proposed.

5. 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.

6. Construction of sedimentation ponds. Sediment within construction site should be retained by the construction of temporary sedimentation ponds. The location and number of sedimentation ponds as proposed in the ESCP should be assessed against the assessment of soil erosion of the site. Ponds should be properly designed according to DID's (1975) specifications to sufficiently trap and accommodate sediments transported by surface runoff. The ponds should be regularly maintained by removing the deposited material at appropriate intervals. Sediments removed from the ponds should not be placed or disposed near waterways.

7. Construction of drainage network. A network of drains should 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 the deposited silt at regular intervals. The network and locations of drains as proposed in the ESCP should be assessed and additional drains might be proposed to ensure proper regulation and control of runoff within the site.

8. Terracing and maintenance. Terracing should be carried out and the terraces properly maintained. Cover crops should be established on the slopes of the platforms and walls of the terraces immediately after commencement of earthworks.

The details of erosion and sedimentation control measures for a hillslope construction project (after Guidelines for Construction in Hilly Areas, 1997) are stated in Annex E.

Table 3.1. Indicative rates for selected drainage works in Sabah

Control Measures	Unit	Rates (RM)

Roadside concrete drain 12" X12"	m	60-85
Roadside concrete drain 18" X 18"	m	80-100
Unpaved drain	m	7-22
Culvert, 3 ft (900 mm) diameter	m	280
Lined Sediment trap with gabions	m^3	600-800
Close turfing	m	4
Geotextile layer	m^2	15-22

Table 3.2. Indicative rates for selected slope stabilisation works in Sabah

Control Measures	Unit	Rates (RM)
RC Retaining wall	m	100-300
RC Retaining wall with anchors	m	500-1000
Reinforced earth	m	200-600
Anchored grid	m	200-450
Removal of soil	m^3	6-12
Gunite wall	m^2	60-100
Gunite wall with anchors	m^2	250-600

3.3 Slope Stability Measures

The impacts of construction on the stability of slope 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 that may subsequently incur unnecessary costly remedial works later.

The following criteria are considered applicable:

- *Avoid the failure hazard.* Where the potential for failure is beyond the acceptable level and not preventable by practical means, as in terrain 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 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 the runout of failed slope materials. 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.* Unstable slopes affecting a project can be rendered stable by increasing the factor of safety through the elimination of the slope, removing unstable soil and rock materials, or applying one or more appropriate slope stabilisation methods (such as buttress fills, subdrains, soil nailing, crib walls etc.). For deep-seated slope instability, strengthening the design of structure is generally not by itself an adequate mitigating measure.

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

The stabilisation method chosen depends largely on the type of instability, which is anticipated at the project site, and its surrounding. Often there are multiple contributing factors that cause or could cause slope failure or instability. Failure to identify the contributing causes could render the stabilisation work ineffective and recurrence of slope failure. The cost for implementing such measures should also be considered; the most expensive method is not always the most effective and vice versa. 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 economical stabilisation measures. Economy of time and money are frequently key factors in the selection of stabilisation and mitigation methods.

The two general techniques used to stabilise slopes are (i) to reduce the driving force for failure, and (ii) to increase the resisting force.

1. Rock and Soil Falls. The principal failure mechanism is loss of cohesion or tensile strength of the near-surface material on very steep slopes. Stabilisation methods include:

- Reduce the driving force by reducing the steepness of slope through grading, or by scaling off overhang rock, diverting water from the slope face etc.
- Increase resisting force by pining individual blocks, covering the slope with mesh or net, or installing rock anchors or rock bolts on dense spacing.

2. Slides, Slumps, Block Glides. The principal failure mechanism is loss of shear strength, resulting in sliding of soil or rock mass along a rupture surface within the slope. Mitigating measures include:

- Reduce the driving force 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 subdrains
- Increase the resisting force, 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.

3. Flows of debris or soil. The principal failure mechanism is fluidization of the soil mass, commonly caused by the addition or increase water such as when the site is cleared and left exposed for a long period. Reduction of this hazard include:

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

Table 3.2. Indicative rates for selected slope stabilisation works in Sabah.

Control Measures	Unit	Rates (RM)
RC Retaining wall	m	100-300
RC Retaining wall with anchors	m	500-1000
Reinforced earth	m	200-600
Anchored grid	m	200-450
Removal of soil	m^3	8-20
Gunite wall	m^2	60-100
Gunite wall with anchors	m^2	250-600

3.4 Landscape

Mitigating measures for impacts on the landscape should not only be concerned with damage reduction but should include consideration of potential landscape visual enhancement. Wherever possible design and layout that would enhance the landscape and visual quality should be adopted.

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

Based on the impact assessment the EIA consultant should propose mitigation measures and compare these with the proposed measures as stated in the development plan proposal. In this respect, visualisation techniques can be used to make the comparison.

Possible mitigating measures include:

1. Preservation, e.g. preserving trees, green belts, landscape/ecological/architectural features of high value and view corridor. Any tree with good amenity value unable to be retained should be considered for its suitability for transplanting.

2. Architectural layout e.g. modifying the architectural layout so that the development is compatible with the surrounding environment.

3. Remedial, e.g. facade treatment, colour scheme and texture of materials used, use of non-reflective material, screen painting and height.

4. Compensatory, e.g. landscape treatment, compensatory planting, creation of interesting landscape of visual features to enhance the view and green corridor along access road.

3.5 Additional Mitigation Measures

3.5.1 Air Quality

If air quality is assessed to be a problem, the mitigation measures to control air pollution could include:

- *Dust Control*: Systematic water spraying along access road under construction and at construction site area. For normal days, water spraying frequency of two to four times a day and for windy/dry days, frequency of more than six times a day
- *Transportation control*: Haul roads during the construction stage should be kept smooth, well graded and cleaned. Avoid overloading and transported materials to be sheeted. Wheel washing facilities should be provided at the entrance.

3.5.2 Noise

Where it is identified that noise is a problem, the following mitigation measures can be implemented to reduce noise:

- *Operating hours*: Consideration should be given to controlling the times of construction operations. Activities shall be planned accordingly to take into account of the sensitive noise tolerance at night time (resting and sleeping period) and at day time (schooling period)
- *Notification*: Awareness is an important factor in reducing noise-related annoyance. It leads to preparedness and tolerance. Residents surrounding the construction site and along the access road should be notified in advance of the operational activities
- *Design control*: Noisy semi-mobile and mobile machinery should be well maintained to reduce noise emission. Installation of silencers should be considered. Baffle mounds or fencing can be used to screen noisy operations at the construction site
- *Transportation control*: Transportation vehicles shall maintain appropriate travelling speeds along the access road. Trees should be planted along the access road at the start of its construction. Besides beautifying the road, they also function to reduce noise from traffic.

3.5.3 Vibration

Air vibration due to blasting of rock outcrops can be minimised by the use of delay blasting technique. A qualified shot firer should be engaged to carry out the blasting operation the design of which must be approved by the relevant government authority.

Impact pile driving to establish a base for foundations may give rise to high levels of ground vibration. A study on the impact of ground vibration from pile driving should be conducted where these operations occur within 50 metres of a building. If vibration is a nuisance, appropriate actions should be taken. These include:

- Conducting the pile driving operation within as short a time as possible. At the same time, the residents should be informed of the schedule of operation so that they are prepared and aware. Awareness of such operation would make the residents more tolerant of the elevated vibration levels

- Considering a change in the foundation design and method of pile driving. Bored piling, which hardly produces any vibration, may be an alternative.

3.5.4 Wastewater and Solid Waste

Mitigation measures to prevent the discharge of untreated wastewater include:

- Installing temporary on-site septic tank system during the construction stage
- Permanent wastewater treatment system should be designed and built to comply with the Ministry of Health Guideline/Recommendation for Sewerage Requirements for Housing in Malaysia April 1983 and Code of Practice for Design and Installation of Sewerage System Standard MS 1228:1991 and should comply with the limits of Standard of DOE's Sewage and Industrial Effluents Regulation 1979.

Mitigation measures for solid waste disposal include:

- Providing sufficient bins to collect solid waste
- The solid waste bins should be regularly emptied and the solid waste collected should be disposed off at sites approved by the Local Authority.

3.6 Secondary Rehabilitation Measures

In circumstances when it is not possible to restrict the scope of the development impact, mitigation measures can be employed off site to partially offset the adverse impact.

Possible secondary mitigation measures for construction activities on hillslope could include, for example, community development projects e.g. playground or hiking trails for the benefit of the people in the area.

Picture

4. Monitoring

Steps	Activities	Issues
Step 1	Assessment of Impacts	
Step 2	Mitigation Measures	
Step 3	Monitoring	Environmental monitoring includes: • Compliance monitoring • Impact monitoring.

This chapter includes the following:

- Monitoring requirements to ensure compliance of the recommended mitigation measures
- Procedures for monitoring residual environmental impacts.

4.1 Compliance monitoring

Compliance monitoring is the one-time or periodic gathering of evidence to ensure that approval conditions are observed and complied with.

4.1.1 Slope Erosion Control

Compliance monitoring of approval conditions on slope erosion control could for example include the submission of the following evidence:

- Land clearing plan
- Revegetation plan
- Map showing locations of sedimentation ponds and drainage system
- Maintenance schedule of sedimentation pond and drainage system
- Photographs showing land clearing, revegetation, the installation of sedimentation ponds, drainage system. The photographs should be taken from the same reference point.

These information should be submitted to ECD upon the completion of each phase of the development until the project is completed.

4.1.2 Slope Stabilisation Control

Compliance monitoring of approval conditions on slope stabilisation control could for example include the submission of the following evidence:

- Layout plan showing areas that need to be stabilised and the type of stabilisation work
- Planned schedule of stabilisation work constructions
- Date of completion of each stabilisation work
- Photographs showing the installation of stabilisation structures.

4.1.3 Landscape Mitigation Measures

Compliance monitoring of approval conditions on landscape impact could for example include the submission of the following evidence (upon completion of each phase of the landscaping plan):

- Map showing locations where vegetation and landscape/features of high value are preserved
- Map showing areas where replanting has taken place
- Photographs of changes in landscape.

The same fixed reference points as used during the impact assessment should be used.

4.2 Impact Monitoring

Based on the assessment of the environmental impacts of the project, the EIA consultant can if feasible recommend impact monitoring, including locations where monitoring is to take place. Impact monitoring involves the pre-measurement of environmental parameters during project construction so as to detect changes in these parameters, which can be attributed to the project.

4.2.1 Slope erosion and water quality

The impact of slope erosion may be monitored by reference to erosions pins or to water quality, particularly turbidity and total suspended solids content. The amount of the total suspended solids of water from drainage lines would indicate the amount of silt being eroded from the site and into the natural drainage system. Visual site checks can also be recommended, especially during rainy periods, for signs of water quality deterioration that could be attributed to the project.

4.2.2 Slope Failure

Visual on-site checks or other methods for determination of slope failure can be recommended. This would include recommendation on the number, timing, technique and location of the proposed method.

Annex A: Measurement of Slope Gradient

Area of influence. To determine whether a proposed site is located on a slope with gradient of 20 degrees or more, representative slope profiles should 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 might however indicate modifications to this general axiom.

Map scale. The accuracy of slope measurement is very dependent on map scale and contour interval. A detailed topographic survey of the proposed site is normally carried out as part of the planning process. Such detailed site topographical maps are 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 Survey Department to construct slope profiles. Such Lands and Survey maps are available for most parts of Sabah.

Section Lines. Section lines of representative profiles should be selected so that they intersect the locations of all proposed structures to be erected on the site and also existing land use features (e.g. road, houses, telecommunication tower, etc.) 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 site development and existing land use in the vicinity.

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

1. 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 on to 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

2. 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 figure below. This line provides the baseline ABC (attached example) for the graph; the length of this baseline is equivalent to the length of area of influence as defined above

3. 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

4. The profile may show sections of 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

5. Repeat steps 2 to 4 to plot the slope profiles of the other section lines, in this example, ADF and ADEG

6. 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 straightforward 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 constructed.

Annex B: Development Proposals

Contents of the development proposal report for construction on hill slope projects (after Guidelines for Construction in Hilly Areas, Ministry of Local Government and Housing, 1997)

Item	Particulars	Investigation Results
1	Development concept and justification	Useful to the local planning authority in considering the proposal. It also assists the applicant in determining proposal, which is suitable and viable
2	Location plan and site plan	To indicate the actual location of the site to be developed, its condition, present use, surrounding development including available facilities
3	Land ownership details and limitation of the land	To prove ownership of the land and the exact location including information about the land for the purpose of application to develop the land
4	Soil and environmental condition of the land in respect of the following: a) physical topography b) landscape c) geology and geotechnical d) contour e) water catchment area and the runoff pattern f) natural shape of the land	Present the natural conditions of the proposed development area, including its topographical condition, vegetation, drainage etc. A slope map should also be prepared.
5	Studies on trees and all vegetation which will be damaged by the development	To present information on the trees and vegetation existing on the land including investigation on how far the development will impact on the flora and fauna of the area
6	Details of the existing buildings which may be damaged by the development	To evaluate the existing buildings in the surrounding area including the location and condition of these buildings which may have historical or architectural values
7	Land use analysis and the impact of the development on the surrounding	To evaluate how far the proposed development is compatible with the present development on the surrounding area
8	Layout plan with the following details: a) Development to any land:	How development activities incorporate steps to protect and beautify environment.
	i) protection and beautification to the environment	
	ii) protection to the natural topographical condition	Explanation on how earthworks of the proposed development can be implemented with protection measures to the natural topographical condition as per the present *Guidelines on Topographical Protection*
	iii) landscape proposal	Evaluation of the necessary landscaping measures

		with the aim of enhancing the comfort of the environment
	iv) the protection and replanting tree proposal on the proposed development	Evaluation of how activities take into account steps to protect and replant trees which may be damaged as per current *Guidelines for Tree Protection*
	v) location and type of trees and plants having a circumference exceeding 0.8 m on the proposed site	Identification of trees classified under section 35H of the Town and Country Planning Act (Amendment 1995) A 933. Under this section, all trees with circumference exceeding 0.8 m shall not be cut unless written approval has been given by the local authority
	vi) provision for open space	Evaluate provision of open space in accordance with current standard
	vii) proposal for earthworks	Clarification on steps to control earthworks to prevent excessive soil erosion
	viii) details of works programme	Explanation on what steps to be taken to control earthworks to prevent excessive soil erosion, especially during the operation phase which may impact on the physical environment
	b) development in conjunction with buildings having architectural or historical value i) particulars to identify the building • its uses • its condition • its characteristics • its looks • its construc tion • its shape ii) particulars on the following steps: • protection • beautification • maintenance	Evaluation of the importance of existing buildings in the vicinity of the development area. This is to determine if the buildings should be preserved as per guidelines for Building Protection, Historical and Architectural Sites
	c) development which affects buildings, details on characteristics and looks of buildings in the area surrounding the site	Evaluation of suitability of proposed development with that of the current development in the surrounding area as per current planning guidelines
	d) any other conditions set by local planning authority	The local planning authority may request for any other matters which may be useful for consideration in the approval application

Annex C: Information on Experts

List of Relevant Expert Organisations and Useful Contacts

Organisation	Address	Contacts
Environmental Conservation Department, Sabah (ECD)	Tingkat 2 & 3, Wisma Budaya, Jalan Tunku Abdul Rahman, 88000 Kota Kinabalu	088-251290 (t) 088-238210 (f)
Jabatan Alam Sekitar, Malaysia (DOE)	Tingkat 7, Blok E, Bangunan KWSP, 88000 Kota Kinabalu. Sabah	088-250122 (t) 088-241170 (f)
Drainage and Irrigation Department, Sabah (DID)	Tingkat 5 & 6, Menara Khidmat, Jalan Belia, 88000 Kota Kinabalu	088-280531 (t) 088-242770 (f)
Department of Mineral and Geoscience	Km. 3, Jalan Penampang, 888300 Kota Kinabalu	088-260311 (t) 088-240150 (f)
Public Works Department	Bangunan Jabatan Kerja Raya, Jalan Sembulan, Peti Surat 128, 88582 Kota Kinabalu	088-244333 (t) 088-237234 (f)
Forestry Department	Ibu Pejabat, Jabatan Perhutanan, Beg Berkunci 68, 90009 Sandakan	0889-660811 (t) 089-669170 (f)
Wild Life Department	Tingkat 5, Blok B, Wisma MUIS, 88100 Kota Kinabalu	088-214317 (t) 088-222476 (f)
Department of Town and Regional Planning	Tingkat 3,4 dan 5, Menara S.D.B, Blok B, Wisma Tun Fuad Stephens, Km. 2.4, Jalan Tuaran 88646 Kota Kinabalu	088-222031 (t) 088-222557 (f)

Annex D: Impact Assessment Matrix

The classification of impacts requires an integrated environmental assessment of each environmental issue. The criteria used for the impact assessment are:

- The *magnitude* of change/effect, which is a measure of the importance in relation to the spatial boundaries
- The *permanence* of the impact, which defines whether the condition is temporary or permanent
- The *reversibility* of the condition, which defines whether the condition can be changed and is a measure of the control over the effect of the condition
- To what extent the impact is *cumulative*, which is a measure of whether the effect will have a single direct effect or whether there will be a cumulative effect over time, or a synergistic effect with other conditions.

A summary impact matrix for construction on hillslope activity is shown below.

EIA Matrix for Construction Activities on Hillslope

Project stage	Major Environmental Impacts	Magnitude	Permanence	Reversibility	Cumulative
Development/ Operation	Slope Erosion	2	3	3	3
	Water Quality	2	2	2	3
	Natural Habitats	1	3	3	2
	Landscape	2	3	3	3
	Air Quality	2	2	3	2
	Noise	2	2	1	1
	Vibration	2	2	2	2
	Traffic	2	2	3	2
	Socio-Economic	2	3	3	2

Magnitude of change/effect: 1:within project site; 2:local conditions; 3: regional/national/international
Permanence: 1:no change/not applicable; 2: temporary; 3: permanent
Reversibility: 1: no change/not applicable; 2: reversible; 3: irreversible
Cumulative: 1: no change/not applicable; 2: non-cumulative/single; 3: cumulative/synergistic

Annex E: Control Measures of Slope Gradient

Details of erosion and sedimentation control measures (after Guidelines for Construction in Hilly areas, 1997, Ministry of Local Government and Housing with slight modifications)

No. & Subject Related Issues	Details
1. Minimising soil erosion	
i) Before construction	Preventive measures shall be put in place to minimise erosion through the preparation of: (i) Preliminary site evaluation, (ii) Erosion and Sediment Control Plan
ii) Reducing work area	The working area for various facilities within a construction site should be kept to less than twice the plinths of the building
iii) Regulate phase of development	Development schedule must be clearly defined. Completion date for each phase of development shall be indicated and all clearing, grading and stabilisation operations shall be completed before moving onto the next phase
iv) Timing of construction activities	Timing of construction activities shall, wherever possible, be spread evenly over the development timescale to ensure that the deleterious effects arising from construction activities are minimised
v) Hydrological and climatic conditions	Construction activities shall take into consideration the hydrological and climatic conditions experienced in the area, in particular the rainfall and runoff patterns
vi) Existing vegetation	Existing vegetation shall be maintained as filters along contours to reduce velocity and improve water quality. When retained in construction sites, they break up the length of long slopes and act as buffers to minimise erosion
vii) Stream buffer	Stream buffers shall be retained for rivers, the width of the buffers shall follow the DID regulations. For small streams within the construction site, the following could be used as guide: (i) Undulating to moderate water course with and average Grade of Basin < 15 degrees: Intermittent stream buffer from 10-20 m; (ii) Steep to very steep water course with and average Grade of Basin > 15 degrees: Permanent stream buffer from 20-30 m
2. Preserving the topsoil and other assets	
i) Sensitive ecological area	Sensitive ecological areas within a construction site such as salt licks, natural springs, unusual rock outcrops etc. shall be demarcated and preserved
ii) Archeological sites	All known archeological sites within the construction site shall be demarcated and preserved. Advise from the Curator of Museum should be sought
iii) Flora and fauna	All known rare and endemic flora and fauna areas or niches within the construction site shall be demarcated and preserved
iv) Topsoil	All excavated topsoil and nutrients shall be stockpiled and later used for revegetation. Topsoil should be stockpiled in areas where it will not contribute to erosion and sedimentation. Temporary stabilisation is necessary for exposed stockpiles.

v) Trees	All trees that are rare shall be fenced and preserved or carefully uprooted and transferred to a nursery/another site for replanting. Expert advice should be sought from the Department of Forestry or Forest Research Institute of Malaysia
3. Access routes	
i) Right-of-ways	a) All right-of-ways or access routes shall be shown on the ESCP and it shall be the responsibility of the Project Proponent to ensure that all vehicular traffic stay within the designated right-of-ways. b) Access roads should be kept to a minimum with other areas off limit to traffic
ii) Roads and permanent storm drains	Roads and permanent storm drains should be installed as early as possible so that they can control runoff during construction. However, they should be temporarily connected to the sediment basins until stabilisation of graded areas is achieved
iii) Road shoulders	Road shoulders are to be protected mechanically or vegetatively against erosion
iv) Construction of all new main and secondary timber extraction roads	Construction of all main and secondary timber extraction roads and any such access must be carried out with the written permission of the enforcement authority and in accordance with specifications laid down by the said authority. These accesses should as far as possible follow natural contours
v) Movement of construction vehicles over unsurfaced roads	All movement of construction vehicles over unsurfaced roads and areas should be kept to a minimum. Haul roads should be sprayed with water to reduce dust pollution during dry periods
vi) Paving of access road	All access roads to the site shall be paved for a distance of 10 metres where these access roads join the existing roads
vii) Exit points	All vehicles should enter and leave the construction site at a limited number of points. The exit points should provide for the washing of vehicles as they leave. The washing bay should be the full width at the exit
4. Drainage control at construction sites	
i) Principles	Runoff water should be directed so that it does not run across disturbed and unstable areas
ii) Hydraulic characteristics of the drainage system	Locate and study the hydraulic characteristics of the drainage system which include: i) overall drainage pattern, ii) dimensions and flow of rivers and streams, iii) springs and wells including flow and well logs, iv) subsurface conditions including aquifer type and capacity, depth to water table and location of perched water table and flow pattern of groundwater, v) salt water intrusion areas, vi) natural drainage depressions, basins and sinks, vii) flood plains, both on-site and downstream, that will undergo change due to grading and construction
iii) Drainage routes and channels	Construct drainage routes and channels in such a way that the beds do not themselves degrade and so contribute to the sedimentation problems
iv) Removal of accumulation of sediment loads	Remove the sediment load accumulated in channels during the dry season to avoid downstream sedimentation
v) Slope drains	For hillside areas, slope drains must be constructed or extended

	as work progresses. Such drains include berm drains, cascading drains and sumps at the toes of the cascading drains to reduce velocity. Diversion banks may be necessary to intercept runoff from higher areas and to divert it away from exposed areas. The longitudinal slope of the bank must not be excessive or the bank itself will erode
vi) Culverts and cross drains	For unsealed roads, culverts and cross drains have to be constructed where the route of a road intercepts a stream, depression or natural drainage channels. The practice has been to lead the runoff from the table drains into upstream end of the culverts. To reduce erosion, it is better to locate table drain culverts some 20-30 m from the watercourse, so that it provides a natural filter for the runoff before it enters the stream
viii) Temporary interceptor ditches and berms	Temporary interceptor ditches and berms with filters as inlets should be constructed to direct runoff from the construction area into the sediment basin
ix) Deviation of mainstream and watercourses	The drainage and deviation of mainstreams and natural watercourses, including provisions of bunds and culverts shall be carried out wherever appropriate
x) Watercourse and its reserves	No watercourse and the reserves along the watercourse shall be disturbed until full plan details of the proposed works have been submitted to and approved by DID. A system shall be maintained that water quality with respect to total sediment load at the downstream be maintained at the original or improved values subject to the satisfaction of the authorities concerned. The silt traps that are provided together with the drainage works shall be approved by the authorities concerned.
xi) Sediment or silt trap xii) Non mechanically stabilised drains	Permanent drains when constructed shall have sediment or silt traps of adequate capacity and other conservation measures to be decided by the authorities concerned. The silt traps shall have the capacity to hold not less than 10 cm of silt at any time, the silt, in the silt traps, if removal is required, shall not be placed in such a way that it becomes a source of siltation of the drains downstream Drains that are not mechanically stabilised shall be grassed and maintained
xiii) Ineffective drainage	Ineffective drainage should be noted especially during wet weather and promptly corrected
5. Earthworks and erosion control	
i) Topography map	A topography map defining the physical features and having a scale of 1:500 with contour intervals of 2 m. The map shall extend beyond the site to be developed far enough so that any impact of erosion from the site and its deposition on adjacent properties can be assessed.
ii) Construction specifications	The construction specifications shall clearly define the maximum length of time that a graded area will be left exposed and shall state what short-term stabilisation practices will be performed in the event of lengthy delay.
iii) Adequate conserva-	The authorities concerned may at any time before the earthworks

tion measures	may be continued to the next phase requires adequate detailed conservation measures. The standards and specifications of such conservation measures shall be in accordance with the specifica-tions of DID.
iv) Extraneous runoff	Extraneous runoff shall be directed away from the exposed soils by drains
v) Contour plough or deep-rip	Contour plough or deep rip so as to leave a rough surface to in-crease infiltration
vi) Protection cover	Provide protection covers such as vegetation and plastic sheets on exposed areas
vii) Earthworks	Earthworks should be confined to periods of low expected precipi-tation
viii) Exposed area	As small an area as practical should be exposed and graded at a time. The size of the area will depend on the potential erodibility of the soil and the time required to stabilise the area after grading is completed
ix) learing and grading	Clearing and grading should be done with care to protect and maintain the previously installed temporary control measures
x) Fills	Fills should be placed in horizontal layers and the faces of the fill slopes should be maintained as filling progresses. The materials to be used and the degree of compaction shall be clearly specified
xi) Landscape	Where it is intended that cleared ground is to be planted, then the area should be landscaped and the planting carried out as soon as possible even prior to the completion of the whole work
xii) Cutting of trees	Trees and other vegetation should not be cut or cleared until the earthwork site is ready to be worked. The cleared ground shall be revegetated (turfed) within three months after commencement of earthworks during the dry season and within one month after commencement of earthworks during the wet season
xiii) Gradient of cutting	Maximum gradient of cuts shall vary with soil texture. However, measures taken should ensure that slumping shall not occur
xiv) Land clearing and soil cultivation	Land clearing and soil cultivation shall only take place in the dry season. Immediately after clearing, conservation measures shall be installed. This shall include silt traps and the maintenance and/or establishment of a vegetative belt of at least 2 chains away from he edge of permanently flowing waterway. There shall be no obstruction whatsoever to flow of water by felled timber or other debris
xv) Disposal of unsuit-able materials and sur-plus earth	Unsuitable materials and surplus earth shall be disposed off in designated spoil tips. In the event additional disposal areas (spoil tips) are required, the contractor shall be responsible for identifying theses disposal areas to be approved by the Site Officer
xvi) Deposit of cleared vegetation and debris	On no account should cleared vegetation and debris be deposited or pushed into watercourses, streams and rivers
xvii) Backfilling of holes and cavities	Holes and cavities resulting from the clearing, grubbing, destump-ing and derooting shall be backfilled with acceptable materials and compacted to approximately densities of adjacent areas
xviii) Design of batters	Batters or terraces represent a special and severe case of ex-

	posed surface after earthworks. The resistance of the batter to erosion will be determined primarily by the engineering design. Batters must be designed to satisfy criteria. For stable soils, a batter slope of 2H : 1V is recommended
6. Sediment prevention and control	
i) Sediment ponds	Wherever feasible, sediment retention ponds, basins or sediment ponds shall be installed. They should be adequately sized and constructed prior to start of earthworks
ii) Silt traps	Small temporary silt traps operate by slowing of stopping runoff at some point on its route, causing it to deposit its sediment load. These shall be constructed across drainage lines near the plinths of building. Allowance must be made for sediment removal and the sediment must be deposited in a suitable area in such a manner that it will not slide back into the traps
iii) Infiltration and ponding basins and stormwater ponds	Infiltration ponding basins and stormwater ponds can be temporarily used as sediment basins, provided they are satisfactorily maintained and cleaned out after construction to ensure efficient operation as designed
iv) Temporary control measures	Silt traps and other temporary control measures should only be removed and dismantled when the permanent vegetative cover and control measures are satisfactorily established
v) Mitigatory measures	Where necessary, mitigating measures such as silt traps, water bars and side drains shall be constructed in all hauling roads in order to reduce siltation into natural waterways
7. Slope stabilisation	
i) Critical areas along streams	All critical areas along streams and gullies must be marked on the ESCP and the recommended methods of stabilisation indicated
ii) Stream stabilisation	Stream stabilisation shall be scheduled during periods of dry weather flow whenever possible
iii) Stabilisation of waterways	The stabilisation of waterways shall be defined giving both temporary and permanent practices, which state where and when sodding, temporary seeding and permanent seeding are to be used. The specifications shall include ground preparation, sod quality, seed type and quality, fertilisation and mulching
iv) Temporary retaining structure	In cases where permanent retaining structure or stabilisation of slopes are exempted by the authorities concerned, there shall be provided temporary retaining structures or stabilisation of slopes during the continuance of such earthwork
v) Protection of slope	Slopes are to be protected against erosion
vi) Irrigation of cut and fill slopes	Cut and fill slopes should be regularly irrigated and fertilised to encourage faster growth. Development should proceed with minimum disturbance of the planted areas and temporary control measures
vii) Protection for walls of cuts	Walls of cuts are to be protected with vegetation and/or chemical stabilisers and/or approved retention structures. Wherever necessary, non-permanent retention structures need to be maintained in order to ensure that erosion shall not aggravate. Vegetation, if used, shall establish complete cover

viii) Interference of natural waterways	There shall be no obstruction or interference with the natural waterways. Where a road is to be cut across a river or stream, bridges and culverts as prescribed by the enforcement authority shall be constructed and maintained according to specifications
ix) Terracing of hilly land	For hilly land, terracing shall be done and maintained. Cover plants shall be established on the slopes of the platforms and walls of the terrace immediately after commencement of earthworks
x) Raising the top of spillways	No person shall employ any means of temporarily raising the top of any spillways without the sanction of the authority concerned

Annex F: Statutory Controls

Annex Table 1. Legislation

Legislation	Controlling Authority
Conservation of Environment (Prescribed Activities) Order 1999	Environmental Conservation Department, Sabah
Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987	Department of Environment Malaysia
Land Ordinance 1930	Lands and Survey Department, Sabah
Water Resources Enactment 1998, Sabah	Drainage and Irrigation Department
Water Supply Ordinance 1961	Jabatan Air, Sabah
Town and Country Planning Ordinance 1950	Town and Regional Planning Department, Sabah
Local Government Ordinance 1961	Local Authorities

Conservation of Environment (Prescribed Activities) Order 1999. Section 3: Any person who intends to undertake any of the prescribed activities shall submit to the Director a report, which is to be prepared by such expert or authority as may be approved by the Director – (a) On the impact of such activities on the environment and on the sustainable utilisation, preservation and management of the natural resources of the State; and (b) On the measures being preventive, mitigating or abatement to be taken for the protection and enhancement of the environment. Section 4: Such report shall be submitted to the Director and shall be in the approved Form as specified in the Second Schedule hereto, which may be used with such modifications as may be required, depending upon the circumstances of each particular case. First Schedule – Prescribe Activities: Section 3 (vi): construction of buildings for commercial purposes or buildings exceeding 4 storeys high for residential purposes on hills with slopes having gradient of 20 degrees or more; Section 7 (I) construction of parks, resorts or other recreational facilities or major roads on hills with slopes having gradient of 20 degrees or more.

Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987. Section 2: The activities specified in the Schedule are prescribed to be prescribed activities. Schedule, Section 17 (b): Hill station or hotel development covering an area of 50 hectares or more.

Land Ordinance 1930. Part I, Section 26(2): The Government also has power to reserve such portion of land as may be deemed advisable along the banks of rivers, streams or creeks, or along the seashore above high water mark, or along the ridges of hills. Such reservations shall be shown on all documents of title.

Water Resources Enactment 1998. Part IV, Section 17(1): No person shall, unless authorised by a licence for a water activity or otherwise authorised in accordance with this Enactment, engage in a water activity, meaning to – (a) take or use water from a water body; (b) return water to a water body directly or indirectly by artificial means; (c) control, divert or mitigate flood waters outside a floodplain management area referred to in Part VI of this Enactment; or (d) carry out a water body alteration activity. Part VI, Section 38 (1): This section applies where, on the recommendation of the Council, the Yang di-Pertua Negeri is satisfied that it is necessary to control, limit or modify activities within an area of land, to prevent the pollution or degradation of surface water or groundwater, or the loss of its availability, or to protect a water body or an aquifer for which a catchment management plan or other investigation has identified that protection is required. Part VII, Section 40(1): From the date of the commencement of this Enactment, river reserves and shore reserves are established on land, which is – (a) in the case of river reserves, within twenty metres of the top of the bank of every river, including its estuary, where the river channel is not less than three metres in width; and (b) in the case of shore reserves, within twenty metres of the bed of all coastal waters. Part VII, Section 41(1): Within a river reserve or shore reserve or on, in or above a water body it is an offence to undertake, without the approval in writing of the Director, any activity, which involves – (a) the removal of natural vegetation or the removal or deposition of material; (b) the erection of a structure or building; or (c) the carrying out of a commercial or agricultural activity, unless the activity is of a type, which the Director has declared in writing, does not require approval.

Water Supply Ordinance 1961. Part VII, Section 25 (1): Any person who deposits or allows to be deposited any earth, material or liquid in such manner or place that it may be washed, fall or be carried into any waterworks shall be guilty of an offence and shall be liable to a fine of five hundred ringgit.

Town and Country Planning Ordinance 1950. Part I, Section 3 (2): The duties of the Board shall be to consider all schemes submitted to it by Local Authorities, to make recommendations thereon to the Yang di-Pertua Negeri, to advise the Yang di-Pertua Negeri generally on the development of land and to supervise and control Local Authorities in the exercise of the powers and duties conferred and imposed upon them by this Ordinance. Part III, Section 15(1): Subject to the succeeding provisions of this section, as from the material date no person shall, within the jurisdiction of any Local Authority, carry out any development of land or any construction, demolition, alteration, extension, repair or renewal of any building until six months after an approved scheme takes effect for the area containing such land or building. Part IV, Section 19 (1): Subject to the provisions of this section, the Local Authority may at any time – (a) remove, pull down or alter so as to bring into conformity with the provisions of an approved scheme, any building or other work which does not conform to those provisions, or the removal, demolition or alteration of which is necessary for carrying an approved scheme into effect, or in the erection or carrying out of which any provision of an approved scheme has not been complied with; or (b) where any building or land is being used in such manner as to contravene any provision of an approved scheme, prohibit it from being used; or (c) where any land has since the material date been put to any use which contravenes any provision of an approved scheme, reinstate the land;

Local Government Ordinance 1961. Section 49 (6): take all necessary measures for the prevention of soil erosion and the protection of crops; Section 46 (23): regulate and control all buildings and building operations and the repair and removal of ruinous and dangerous buildings and subject to any written law relating to town planning, prohibit the erection of a building of a particular class, design or appearance in particular districts, localities or streets or portions of streets;

Annex G: Glossary of Terms

building means any building, erection or structure on any land and where the context so permits, includes the land on which the building is situate

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

dB(A) means decibel-A-weighted, a unit of measurement of sound level corrected to the A-weighted scale using a reference level of 20 micropascals

development means any land development which involve the construction of infrastructure activities, any structure and any related action or disturbance to the natural earth conditions

discontinuity means interruption, usually of a planar nature, to the homogeneity of a rock mass (i.e. joints, faults)

effluent means any discharge either sewage or industrial effluent by an operation to the receiving environment

environment means the 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

factor of safety means the ratio of average available strength of the soil along the critical slip surface to that required to maintain equilibrium

fault is a fracture in rock along which there has been an observable amount of displacement

foundation means 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

landslide or landslip is a rapid movement of earth materials separated from the underlying stationary part of the slope by a definite surface

Local Authority means any District Council, Town Board or Municipal Council established under the provision of Section 3 of the Local Government Ordinance 1961

Local Plan means the local plan for an area, and any alteration of the plan for the time being having effect in the area by virtue of sub-clause (11) of Clause 10 of the Town and Country Planning Ordinance

mudflow or earthflow is mass movement involving high water content

natural resources means air, biological diversity of resources, oil, gas, forest and forest produce, land, rocks, soils, sub-soils, animals, birds, plants, marine or aquatic life, and waters of the State of Sabah *pollutants* means 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 means any direct or indirect alteration of the physical, thermal, chemical, biological, or radioactive 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 means the potential environmental impact remaining after mitigating measures have been adopted into a project plan

resort means a place fequented ususally for specified purpose or quality e.g. health, holiday, mountain, seaside.

river reserve means a reserve within twenty metres of the top of the bank of every river, including its estuary, where the river channel is not less than three metres in width

rockfall means movement of blocks of solid rock

soil creep is a shallow, slow-moving form of an earth flow involving thin layers of near-surface soil

sound level means ten times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals

visual receivers means groups of people who are sensitive to changes in their views

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