COMPETENT EROSION AND SEDIMENT CONTROL INSPECTOR

16 – 19 JULAI 2012

INSTITUT ALAM SEKITAR MALAYSIA (EiMAS)
JABATAN ALAM SEKITAR

LAMPIRAN B

CERTIFIED EROSION AND SEDIMENT CONTROL INSPECTOR (CESCI)
16-19 JULAI 2012

MASA / TARIKH	16 JULAI 2012 (ISNIN)	17 JULAI 2012 (SELASA)	18 JULAI 2012 (RABU)	19 JULAI 2012 (KHAMIS)
8.30 - 9.00 am	Registration	Attendance & Breakfast	Site Visit **Fasilitator : Dato Ahmad Fuad Embi** **Fasilitator : Nor Razzaman Hamzah**	Pembentangan Kumpulan **Fasilitator : Dato' Fuad Embi**
9.00-9.30 am	Breakfast			
9.30 – 10.00 am	Opening Session Welcome Remarks Overview and Objectives of Workshop	Chapter 4 : Inspection procedure and Sequence **Penceramah : Dato' Fuad Embi**		
10.00 - 11.00 am	Preamble **Penceramah : Dato' Fuad Embi**			
11.00 – 11.30 am	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK
11.30 am – 12.30 pm	Chapter 1: Fundamentals of Erosion and Sedimentation **Penceramah : Dato' Fuad Embi**	Chapter 5 : Best Management Practices (BMPs) **Penceramah : Dato' Fuad Embi**	Site Visit **Fasilitator : Dato Ahmad Fuad Embi** **Fasilitator : Nor Razzaman Hamzah**	Samb... Majlis Penutup dan Penyampaian Sijil **Pn. Rahani Hussin** Pengarah EiMAS
12.30 pm – 2.00 pm	LUNCH	LUNCH	LUNCH	LUNCH
2.00 pm – 3.30 pm	Chapter 2 : Acts and Regulations **Penceramah : Dato' Fuad Embi**	Chapter 6 : Erosion and Sediment Control Plan **Penceramah : Dato' Fuad Embi**	Penyediaan Pembentangan	
3.30 pm - 4.00 pm	TEA BREAK	TEA BREAK	TEA BREAK	TEA BREAK
4.00 pm – 5.00 pm	Chapter 3 : Safety, Communications and Attitude / Ethics of an Inspector **Penceramah : Dato' Fuad Embi**	**Samb.**	Penyediaan Pembentangan	
5.30 pm - 8.00 pm	DINNER	DINNER	DINNER	DINNER

MODULE DEVELOPMENT ON *COMPETENT ESC INSPECTOR* (CESCI) FOR DEPARTMENT OF ENVIRONMENT

PREAMBLE

1. Background

Rapid land development for urbanization, logging, sand mining, plantations as well as agriculture has resulted in most rivers and coastal areas in Malaysia having heavy sediment loads throughout the year. Except for sand mining, all these sectors involve large scale earthworks beginning with the stripping of all vegetation that covers the soil and turning over of stabilized earth into loose, easily erodible soil. Precious top soil is almost always lost and the loose subsoil is usually left exposed to be carried away by heavy rainfall. Large areas of soil reworked into new platform levels and left exposed for long periods became the normal practice for housing developers. The practice is similar for the other sectors like logging and agriculture. It was only in 2005 that Erosion and Sediment Control Plans (ESCP) were made part of the requirements for earthwork applications on new developments. They are still not effective in tackling the problem, mainly due to a lack of expertise in preparing the plans, both on the part of consultants for developers as well as regulators on the government side. There is still a long way to go to achieve the level of systematic and routine action required to stabilize the problem.

It is time that as the nation grows to achieve developed nation status, measures be taken to stop further deterioration of the quality of the environment. People want our rivers and beaches to have cleaner waters and not have the brown color of the soil. Not only that, the economic cost of cleaning up the waters will be too high for the government (and consequently, the tax payers), if action is not taken now to control the sources of erosion and sedimentation.

Status of River Water Quality

In 2006, a total of 1,064 water quality monitoring stations located within 146 river basins were monitored. See Fig.1 below which shows the trend of water quality in the stations over the years. Out of these 1,064 monitoring stations, 619 (58%) were found to be clean, 359 (34%) slightly polluted and 86 (8%) polluted. Stations located upstream were generally clean, while those downstream were either slightly polluted or polluted. In terms of river basin water quality, 80 river basins (55%) were clean, 59 (40%) slightly polluted and 7 (5%) were polluted.

The major pollutants were Biochemical Oxygen Demand (BOD), Ammoniacal Nitrogen (NH3-N) and Suspended Solids (SS). In 2006, 22 river basins were categorized as being polluted by BOD, 41 river basins by NH3-N and 42 river basins by SS. High SS were mostly from earthworks and land clearing activities.

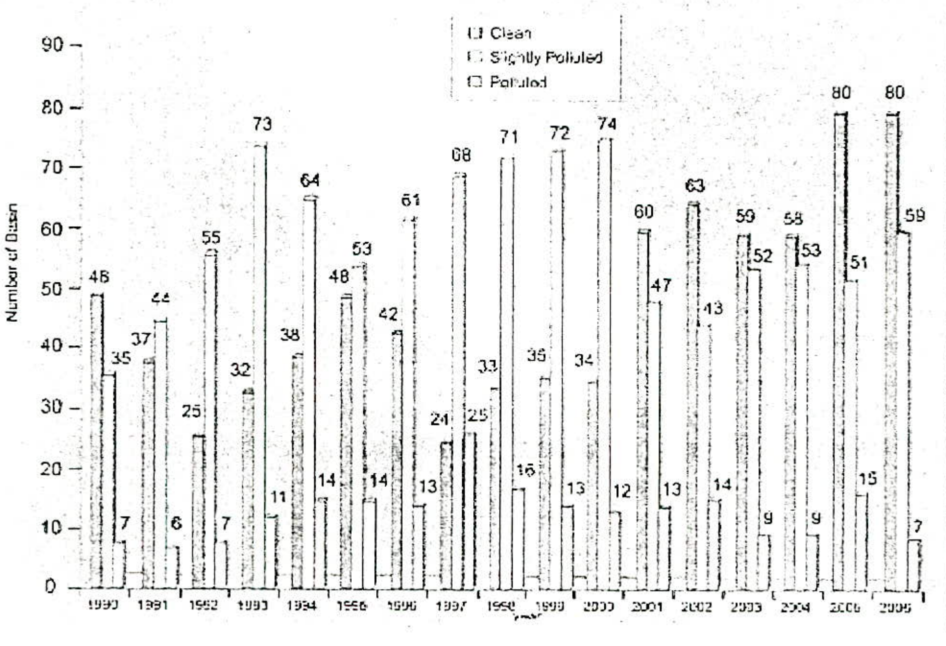
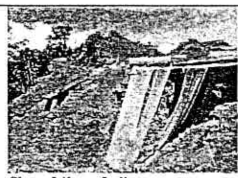
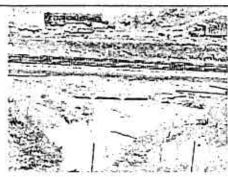
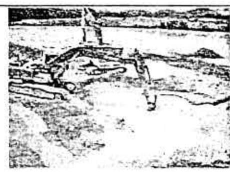
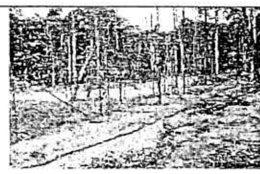


Fig.1 River Basins Water Quality Trend, 1990-2006 (Source: EQR 2006)

Table 1: Impact of Erosion and Sedimentation

RECEPTOR	IMPACT	PHOTO
River	Flooding Bank erosion Low water quality Ecology loss Fish life loss	 *Heavily sedimented stream in Kuala Lumpur*  *Flash flood in Taman TTDI Jaya due to Sg Damansara overflow*

	Other Aquatic life loss Recreation loss Tourism loss	 *Eroding river banks in upstream Sg Klang, the result of intensive development in the upper catchment*
Adjacent property	Damage Flooding Land slides	 *Slope failure, Lojing Highlands, Kelantan*
Drainage way / water way	Clogging Flooding High Mtce Costs	 *Federal Highway culvert completely clogged up with sediment*
Lakes and ponds	Low water quality Ecosystem deterioration Aquatic life loss Recreation loss Eutrophication Storage loss	 *Hill sand mining in the foothills of Melaka; with ponding of extremely sedimented water from sand washing*  *Severely damaged lake from sedimentation in Melaka*
Public drinking water /Water resources	High operation and mtce costs Low water quality	 *Intake at Sg Kinta waterworks as a result of Highland Highway development*
Estuaries, coastal and sea	Fisheries loss Aquatic life loss Ecology loss Low water quality Recreation loss	

	Coastal area degradation Beach degradation Tourism loss	*Sediment plume from Klang valley rivers exiting into the sea*

Activity	Average Erosion rate	Impact to river
Forest	10 ton/km^2/yr	1
Grassland	95 ton/km^2/yr	10 times
Abandoned Mine (with proper closure)	938 ton/km^2/yr	100 times
Cropland	1,875 ton/km^2/yr	200 times
Harvested Forest	5,000 ton/km^2/yr	500 times
Active Surface Mining	18,750 ton/km^2/yr	2,000 times
Construction Sites	19,000 ton/km^2/yr	2,000 times

Table 2: Comparative rates of erosion

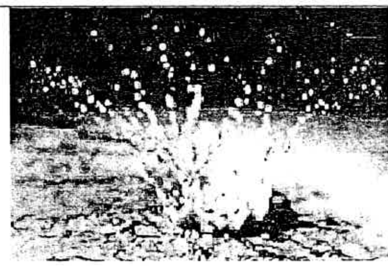
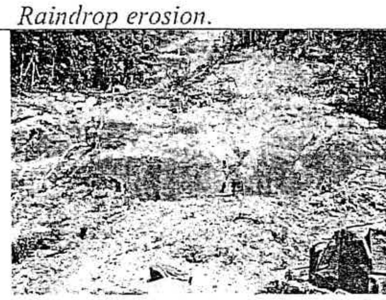
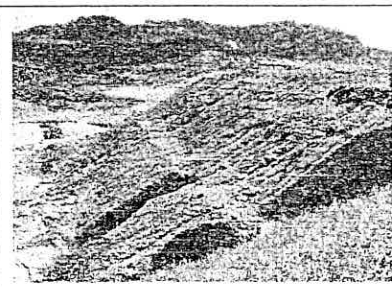
CHAPTER 1 : FUNDAMENTALS OF EROSION AND SEDIMENTATION

1.1 Learning outcomes

On successful completion of this module participants will be able to:
1. Identify type of erosions
2. Explain process of erosion and sedimentation

1.2 Erosion

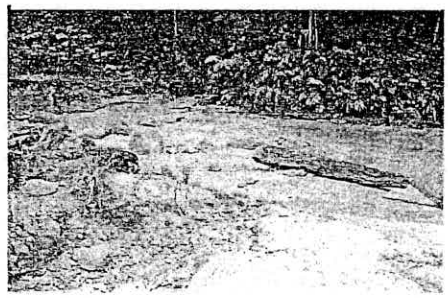
*1. **Raindrop** erosion leads to **sheet** erosion.*
*2. **Sheet** erosion leads to **rill** erosion.*
*3. **Rill** erosion leads to **gully** erosion.*
*4. **Gully** erosion leads to **channel** erosion.*

Raindrop Erosion Raindrops detach soil particles and splash them into the air. These detached particles are then vulnerable to stormwater runoff.	 *Raindrop erosion.*
Sheet Erosion. Sheet erosion is the uniform removal of soil in thin layers by the forces of raindrops and overland flow. It can cover large areas of sloping land and can be recognized by either soil deposition at the bottom of a slope, or by the presence of light - colored subsoil appearing on the surface. If left unattended, sheet erosion will gradually remove the nutrients and organic matter which are important to agriculture and eventually lead to unproductive soil.	 ***Sheet erosion***
Rill Erosion As the flow changes from a shallow sheet to a concentrated flow, the velocity and turbulence of the flow increases. The energy of the concentrated flow is able to detach and transport soil particles. This action begins to cut into the soil mantle and form tiny channels. Rills are small, but well-defined channels that are only a few inches deep.	 ***Rill erosion***

Gully Erosion Rills gradually come together to form gullies. Whereas rill erosion can be eliminated or repaired fairly easily, gully erosion requires major work to regrade and stabilize	 *Gully erosion*
Channel Erosion As runoff in rills and gullies moves downstream, it enters channels that are also susceptible to erosion through bank cutting and degradation. Channels continually adjust and change, degrading and widening, in response to increased runoff from urbanization.	 *Channel erosion*

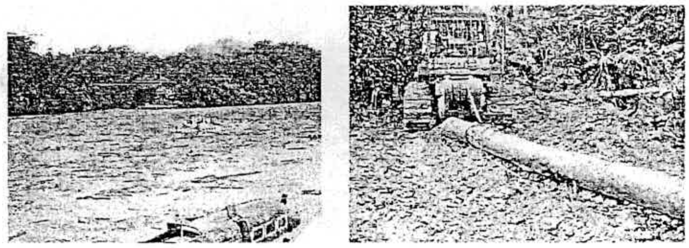
1.3 Sedimentation

Wind and water pick up soil particles to deposit them elsewhere. This is the process of sedimentation. In a river, sediment moves slowly downstream especially during high flows following rainfall. This can cause property damage, increase maintenance costs, impair habitat and water quality. In lakes and reservoirs it can accelerate eutrophication and loss of storage.



Heavy sedimentation in upstream waters can wipe out aquatic habitat like in this stream from Lojing Hills

No erosion control plan can be 100 percent effective; therefore, ESCPs must also put in place measures designed to capture eroded sediments before their conveyance off site.



Poor control of logging operations and illegal logging has led to serious river damage as shown in Sg Rajang

CHAPTER 2 : ACTS AND REGULATIONS

2.1 Learning Outcomes

On successful completion of the module, participants will be able to:

1. Explain the relevancy of Section 21 of EQA, 1974 on erosion and sediment control
2. Explain on the EIA Approval Conditions on erosion and sediment control

2.2 Environmental Quality Act (1974)

Sections in the *Environmental Quality Act* 1974 (Part IV) relevant to erosion and sedimentation are:

Section of EQA	Offence	Penalty
21	Emission or discharge of pollutants from prescribed premises not in compliance with regulations set	fine up to RM 10,000 or imprisonment up to two years or both and to a further fine of RM 1,000 for every day that the offence is continued
25	unlicensed discharge of hazardous substances, pollutants or wastes into any inland waters in contravention of the acceptable conditions.	fine up to RM 100,000 or imprisonment up to 5 years or both, and a further fine of up to RM 100,000 a day for every day that the offence is continued after a notice by the Director General

For construction sites, Section 21 will be the relevant section to prosecute should there be discharge of pollutants or sediments which exceed the amounts specified in the regulations.

2.3 *Environmental Quality Act, 1974 (Amendment, 1985) Section 34a*

The EQA (1974) was amended in 1985 to include section 34A which requires any person intending to carry out any prescribed activity to submit a report on the impact on the environment to the DOE.
Other details on this amendment are:

i. The Minister of Environment is given the power to order any activity which can have significant environmental impact to be a 'prescribed activity'.
ii. Any person intending to carry out a 'prescribed activity' shall have to submit an environmental impact assessment (EIA) report, for approval. The report shall also have proposed measures to be undertaken to reduce the adverse impact on the environment.
iii. The Director General of DOE is given the power to approve the report if it is found to fulfill the requirements.
iv. The person carrying out the prescribed activity, shall be responsible for carrying out the measures.

The relevance of this amendment can be seen in the context of erosion and sediment control (ESC) which is absolutely essential if there is to be no serious impact to the environment from earthworks activities. Hence an ESCP should now be an essential part of the EIA report for any earthworks activity.

2.4 Issues And Challenges

There are many issues and challenges to regulators in trying to control erosion and sedimentation in Malaysia. It needs a lot more effort in promoting awareness at all levels. Among them are:

No ESCP

Many local authorities still do not require a mandatory ESCP before earthworks. Some still accept the old 'earthworks plan'(EP) as sufficient. An EP only shows final levels and areas of cut and fill of earthworks. It does not show where and what measures are to be used to control erosion and sedimentation (i.e. BMPs) at any phase. Inspectors must know the difference between the 2 Plans.

Inadequate/incompetent ESCP

Even when an ESCP is required and presented, it is often poorly done, but accepted anyway. These arise from consultants and regulators having inadequate expertise in the subject of ESC.

Lump sum provision / BQs not itemized

When the contract only provides a lump sum provision for ESC, contractors provide the minimum they can terms of BMPs; or materials of inferior quality (e.g. turf reinforcement mats, TRM, of poor strength) to cut costs.

SHEO not experienced in ESC

Most safety and environmental officers are only experienced in health and safety but not ESC. ESC is a new subject. It is not a part of the curricula of most professional undergraduate courses.

EO no control over CM

Inspectors will have to be aware of such situations as environmental officers (EO) would have their regular reports documented.

Acceptance to the existing situation

This can be said to be the situation up to around 2004 when authorities simply accepted whatever way developers chose to do earthworks. The public too, in general, have poor awareness of the relationship between rivers and earthworks.

Approaches to earthwork

Contractors have for too long been practicing large scale earthworks, which are difficult to control, due to the need to minimize costs.

Poor maintenance practices

Grass cutting everywhere in Malaysia is following the wrong practice of cutting down to the lowest level, to minimize costs. Grass should never be cut down to below 50 mm as this would lead to erosion of the soils in between; now commonly seen on slopes all over Kuala Lumpur.

Flower beds everywhere are also not covered with mulch at the roots which are often left bare.

Legislation / institutional constraints

There needs to be a water resources agency in all states which safeguards rivers and water quality, overall. There are far too many loopholes which are not being attended to; e.g. sand mining in rivers and at the foothills of rivers.

CHAPTER 3: SAFETY, COMMUNICATIONS AND ATTITUDE/ETHICS OF AN INSPECTOR

3.1 Learning Outcomes

On successful completion of the module, participants will be able to:

1. Explain the role and conduct of an Inspector
2. Explain safety measures required during earthworks inspections

3.2 Inspector duties

As an Inspector, your job is to determine whether a site is in compliance with regulations. To do that, you must ensure that you collect comprehensive and accurate information on the site. At the same time, remember that you are also:

Representative On-Site

You are the official representative of a government agency or the private company doing the site development with the job of accurately recording areas of non-compliance.

The Record Keeper

Your records should be clear and systematically kept. Remember, your documentation may be used in a court of law.

Instructor in Erosion and Sediment Control (ESC)

You should have excellent knowledge of the BMPs you inspect, their correct installation and maintenance. Besides observing and documenting, you should also educate site people involved in earthworks on ESC.

3.3 Inspector Ethics

Always practice ethical behavior to be respected as a professional:

Thorough

Your inspection and documentation should be comprehensive and precise. Do not rush the job or be careless.

Show Integrity

Integrity is of utmost importance for an Inspector. Enforcement agencies are always exposed to corruption. *There should be no unofficial contact or socializing with inspected parties that can lead to suspicions of corruption.*

Resolve Conflict

Inform the site people that you have a responsibility to protect public interest in carrying out your job. It is the developer/contractor's responsibility to correct the problem. Be professional in any conflict.

Communicate

Inform all relevant persons on site problems. Give warnings before proceeding with penalties. Be in communication with site staff as the correct strategy is to get them in as part of the ESC team.

3.4 Safety Measures during inspection

An Inspector should adopt proper safety and health measures at all times. There will be many hazards on site.

3.4.1 Insects

Wear long sleeves to protect against mosquitoes, bees and other insect bites. There is the threat of Dengue fever and Chikungunya diseases brought about by Aedes mosquitoes which breed in stagnant waters around construction sites.

3.4.2 Dangerous animals

Be careful of snakes, monitor lizards etc on construction sites. Many of these are drawn by the presence of rodents in the areas. While walking in perimeter areas make enough noise to scare them away first.

3.4.3 Exposure to the elements

Anticipate sudden thunderstorms and lightning. High areas such as hill-tops are susceptible to lightning strikes. *No safe options exist outside.* Run to your car or a safe building as soon as you hear thunder. Full-size buildings work best. Stay away from sheds or open shelters. Keep all windows and doors closed.

In view of our strong tropical sun, always:

1. Drink plenty of water.
2. Use sunglasses with UV protection for your eyes.
3. Wear a hat and protect your skin against the sun. White colors absorbs least heat, i.e. are cooler compared to dark clothing, although dark colors are better at UV protection.

Do not conduct your inspections from your vehicle. Walk the site.

3.5 Physical Hazards

3.5.1 Vehicle and Equipment

On construction sites equipment operators may not be aware of your presence because of noise etc.

- Report to the site office before entering the site.
- Park away from areas where earth machines are moving
- Wear a safety vest to make yourself visible.
- Do not go behind machines where the operator cannot see you

3.5.2 Scrapes, Scratches and Cuts

There are physical risks of scrapes and cuts during inspection. Be aware of your surroundings and avoid high risk areas such as debris and brush piles. Wear safety shoes to avoid puncture from nails and sharp objects.

3.5.3 Slips, Trips and Fall Hazards

Be very careful of steep slopes, loose soil and open excavations where you may lose your footing and fall. Open manholes and other dangers should be reported to the site superintendent.

3.5.4 Falling Objects

Be careful of falling objects from buildings under construction. Wear a hard hat and watch out for suspended equipment. Be aware of your surroundings at all times.

3.5.5 Utilities

Watch out for exposed electrical wires. Be careful of slides when walking near trenches for utility installations.

3.5.6 Confined-Space Inspections

Never work alone when inspecting confined spaces like tanks and underground installations.

3.5.7 Excessive Noise

Loud noise from can lead to long term hearing damage. Wear ear plugs where there is excessive noise. When wearing hearing protection, watch out for moving vehicles or equipment.

3.5.8 Dust

Dust can carry contaminants, block visibility and is a health hazard. Ensure that there are measures to minimize dust from wind or equipment. Use protective eye-ware where there is excessive dust.

3.5.9 Hazardous chemicals

Avoid exposure to hazardous chemicals like herbicides and pesticides. Look out for open containers and spills which can contaminate people.

3.6 Verbal and Written Communication

Understanding how to properly communicate with people will determine your degree of success as an Inspector: Be known as one who deals in a fair & consistent manner

3.6.1 Arrival Introductions

Inform the site manager of your purpose when you arrive at the site. Include the following in your introduction:

- Your credentials and identification
- Purpose of the visit
- What they can expect at the end of the visit
- When follow-up will occur

3.6.2 Working with Contractors

Communicate effectively with contractors. Build a trust relationship and work as a team:

- Be consistent.
- Be reliable and on time, if not call ahead.
- Respect other's opinions.

Use his experience to get more creative and economical solutions, but especially to get everyone to take 'ownership' of the site's erosion and sediment program.

3.6.3 Dealing with Difficult People

You will meet people who are difficult to work with. In those situations remember to:

Be professional

When you notify individuals of regulatory violations, be professional:

- Be friendly but *firm.*
- Express concern for the problem and confidence that the person can solve it.
- Don't show anger in arguments. Keep calm.

Be sensitive

Do not accuse any party. Discuss and maintain a professional tone:

- Be conscious of your body language and facial expression.
- Express empathy and acknowledge their issues.
- Apologize if you are wrong and correct YOUR error only.

How you say it, is as important as what you say

Use questions to clarify

Ask specific questions about the problem. Never make it personal.

- Allow the person to explain his problem.
- Be sure that all parties understand the real problem

Get joint solutions

Explore alternatives in looking for solutions

- Agree on how the solution will be handled.
- Specify the steps that will be taken

CHAPTER 4 : INSPECTION PROCEDURE AND SEQUENCE

4.1 Learning Outcomes

On successful completion of the module, participants will be able to:

1. List out the stages and actions involved in an inspection of ESC at site
2. Explain the critical areas for inspection
3. Explain the details of good reporting

4.2 Stages of Inspection

A proper inspection requires planning and a systematic approach. Basically Inspection can be broken into 3 stages:

i. Pre inspection
ii. Inspection and sampling
iii. Report and compliance

4.3 Pre inspection

Review the plans to identify potential problems and weaknesses in the ESCP:

1. Check contour maps to see how the water flows through the site. Note where water enters and leaves the site. Determine the direction of flow, the watershed where the project is located, and the receiving water(s).
2. Note critical or sensitive areas. These areas should be protected and buffered.
3. Space should be provided throughout construction for BMPs
4. BMPs should be installed in sequence, completed for one phase before the next phase begins.
5. If there are long periods between phases of construction, soil should be stabilized.
6. Check that the plan requires open ground/slope to be stabilized within seven working days. It should also state the preferred method.
7. Final discharge points should be installed with sedimentation BMPs as final measure to prevent pollutants from impacting receiving waters.
8. Maintenance plans should be present with the contractor's performance-monitoring procedures specified. For example, the person doing the inspection for them should be identified.
9. Borrow, stockpile, and waste storage areas should have BMPs to control erosion.
10. Make a list of specific items in the plan that you want to inspect closely when visiting the site. Highlight potential problem areas before leaving the office.
11. Identify areas of the ESCP that may need to be strengthened and parts that may need extra maintenance.
12. Before you leave for the construction site:

   i. *Take the time to review the plans thoroughly before you go to the site, even if you have already reviewed them when they were first submitted.*
   ii. *Outline your approach for each inspection. It is necessary to know in detail the erosion control system specified.*
   iii. *Always take a copy of the approved plans with you to the site for quick referral.*
   iv. *Always bring the project file and necessary reporting forms.*
   v. *Always take equipment for measuring (tape measure, turbidity sampling kit, etc.) and documenting (camera, camcorder).*

vi. *Be sure to have all necessary personal protection equipment with you, such as boots, hard hat, sun and insect protection, rain gear, water, first aid kit, radio, etc.*

You need to be able to read topographic maps to determine the effects of a project on the surrounding area. Reviewing the construction plan provides information needed for the next step of the inspection process, the preconstruction meeting.

4.4 Preconstruction Meeting

A preconstruction meeting will enable you to establish contact with involved parties and inform them of the importance of the ESCP working well.

Cover the following at the meeting:

i. *Clarify the objectives of ESC and requirements for compliance in this project. Discuss inspection schedule.*
ii. *Designate contact person for compliance issues.*
iii. *Inform that the ESCP need to be updated regularly. Clarify procedures for changing the ESCP.*
iv. *Walk the site together. Evaluate the Plans to determine whether the measures are adequate.*
v. *Discuss the schedule for clearing and grading. ESC measures should be installed before the actual grading begins. Stabilize surfaces between phases.*
vi. *Clarify who is responsible for inspecting, cleaning, and repairing the BMPs.*

4.5 Inspection of Site

Once you have successfully completed the Pre-Inspection process, you should be ready to commence inspecting the site.

At the construction site, get an overall picture first:

i. Are BMPs installed as shown on the approved plans?
ii. Is erosion being controlled onsite?
iii. Is sediment being contained onsite?
iv. Are internal inspections being recorded and available for review?
v. Are previous noncompliance issues addressed within seven days of their occurrence?
vi. Are other potential sources of pollution being controlled?

If the answer to ALL of these questions is YES, then the site is in compliance. File an inspection report stating that the site is in compliance and take field notes to support it. Sites where the ESCP work well should be used as examples of good sites.

If the answer to ANY of the above questions is NO, then the site is not in compliance. File an inspection report listing the items that are not in compliance. Your field notes should describe each noncompliance issue and its location.

The following can be used to guide your inspection:

i. *Walk the perimeter of the site. Check for impact to the neighboring areas and offsite water.*
ii. *Take detailed, orderly field notes. (they may be needed as evidence in court).*
iii. *Start from the lowest point and work your way upstream. You can see the amount of sediment leaving the site and locate its source.*
iv. *If sediment is flowing offsite, go far enough downstream to see the extent of the damage. Photograph, date and document the damage. Estimate the sediment volume.*

v. *If turbidity is present in waters, sample upstream and downstream of the discharge point for evidence of non-compliance.*
vi. *Check that basins and traps are sized according to the Plans, that channels and diversions have the proper grade, and that contributing areas for the control devices are no larger than those used in the design.*
vii. *Check critical items (see 4.5.1) .*
viii. *Always fill out the inspection report while you are **at site** so that you can recheck doubtful items.*

4.5.1 Critical Inspection Items

Run-Off Control Areas
BMPs such as swales, traps, sediment basins, channels, and diversions operate by either conveying or impounding storm water. Check that inlets and outlets are unobstructed, not eroding or damaged.
Bare Soil or Disturbed Areas
Bare soil, especially on slopes, that are insufficiently protected will have rills and gullies. These should be repaired and a BMP put in to prevent recurrence.
Stabilized Areas
Check that areas stabilized (e.g.with mulch or turfing) have sufficient coverage and have been put in within desired timeframes to protect underlying soil from erosion.
Construction-Site Entrances/Exits
Entrances/exits for construction traffic should be stabilized and maintained to prevent sediment entering the street, where they can create dust issues or enter the drains. Outlet streets should be cleaned after storm events.
Contamination
Check for contaminated runoff i.e. colored or have odors. Locate and remove sources.
Discharge Points
Discharge points, i.e. locations where runoff leaves the site, should be protected from erosion damage. Check for pollutants at these points.
River crossing/Diversion
Erosion from overflow of culverts/crossing indicates sizing is inadequate.
Borrow, stockpile, and waste storage areas
BMPs should be in place to control erosion and runoff from these sites

4.6 Sampling for Pollutants

Steps to take:
1. ***Collect samples and assign laboratory analysis in accordance with requirements***
Specifications for proper sample collection, handling and analysis should be provided by the Plan.
2. ***Verify chain of custody***
Samples should be accounted for at any given time. Custodians should sign for them throughout the process.
3. ***Non visual pollutant sampling***
Exact methods used to determine which methods were used to arrive at certain conclusions, should be documented to enable it to be used in a court of law. This includes calculations made, or tests performed.
4. ***Sampling equipment and calibration***

Note the make and model of equipment used in sampling including the date and method of last calibration.

4.7 Causes of Noncompliance

ESC problems on sites generally fall into the following four categories:

i. *The responsible party has made little or no effort to comply.*
ii. *There are design errors in the erosion control system or the site conditions have changed.*
iii. *The installation or maintenance of a measure is faulty or inadequate.*
iv. *Severe weather has occurred.*

The responsible party has made little or no effort to comply.
In the inspection report, ensure that the responsible party has been informed of the law. Appropriate enforcement action should be taken.

There are design errors in the erosion control system or the site conditions have changed.
The plan needs to be revised and approved. Look for changes in the site conditions and construction plan. Check the following:

i. *Are the planned measures retaining the sediment onsite?*
ii. *Are there modifications to the plan?*
iii. *Is the perimeter protected?*
iv. *Have the contributing drainage areas changed significantly?*
v. *Are additional control measures needed?*

Again, appropriate enforcement action should be taken.

The installation or maintenance of a measure is faulty or inadequate.
Most noncompliance occurs because measures were not installed correctly or maintained properly. Notify for compliance.

Severe weather has occurred.
Occasionally, there may be very heavy rainfall over a few days which results in non-compliance. Check whether there were efforts to repair damage to BMPs before taking enforcement action.

4.8 The Report

The details of your inspection should be recorded in a standard document. At minimum, a good report form should include:

i. ***The name of the Inspector and all qualifications/credentials.*** Certifications such as CPESC, CPSWQ, or CESSWI should be included into the report. Your qualifications will add more credibility to your inspections.
ii. ***Date of each inspection.*** Verify that the inspections are being performed within the scheduled timeframe.
iii. ***Points of contact or key individuals on-site.*** Create continuity, should a new Inspector be assigned to this site.
iv. ***Inspection frequency.*** Most jurisdictions require weekly or every two week inspections. There should be storm event inspections for every phase of the development if possible.
v. ***Rainfall data.*** Generally, data from the last 24 hours of a storm event should be required.
vi. ***Weather and soil conditions at the time of inspection.***

vii. ***Project name and the project location.*** Identify the site in case of a regulatory visit or audit. Be consistent with the project name from inspection to inspection.

viii. ***The specific site area, phase and type of construction activity.*** Indicate the potential exposure during this inspection, and which BMPs are installed.

ix. ***All relevant BMPs and their operating condition at the time of the inspection.*** Identify the compliance issue and location of BMPs that are not installed properly, in need of maintenance or repair. Identify locations where additional BMPs may be required and inform the Plan designer.

x. ***Evidence of previous or ongoing discharges.*** Describe the discharge, and identify the location.

xi. ***Corrective Action report.*** Specify a time by which corrective actions are to be completed. The information in your Corrective Action reports provides a history of compliance or non-compliance with the site.

xii. ***Signature and Date.*** By signing and dating the report you create a historical timetable.

xiii. ***Photographs or analytical reports.*** These may be used to aid in documentation of site conditions with the inspection report.

4.8.1 Good Practices for Reporting

Complete and factual records
Reports should reflect the actual situation on site. The impact of good or bad practice should be reported on all areas of the site.
Support potential enforcement action
The information in your report should be clear and factual; enough for an enforcement case in court. Do not make statements that cannot be defended in court.
Facilitate
Use simple, direct language. The inspection report should copied to the site manager and other responsible parties to implement corrective action. Inspection reports needs to be filed systematically for easy retrieval.
Document what you see, do not speculate
Do not speculate without proof. Document what you see. Avoid assumptions, especially those you cannot verify.
Do not make personal observations about people
Only report observations about the site, not site personnel.

4.9 Corrective Actions

There should be a process for corrective action in place.
Address entire site
Avoid complexity in the report. Use general statements for general issues or problems on site.
Be specific for violations
If a violation exists on site, include specific information about location, actual conditions and the urgency to make repairs.
Don't give solutions
Avoid giving solutions. There can be many causes of poor site conditions and there

can be many remedies. Proposing a solution could place you in a liability situation.
Do not propose brand names
Do not propose any particular product, by name, as a remedy. Avoid entering this information in your reports.

4.10 Evaluate process for improvement

Periodically evaluate your inspection process. Learn from your colleagues.
Try inspecting in reverse or moving across your site differently, as this may help you see something you missed from previous inspections.

4.11 Compliance Problems

Ten of the greatest compliance problems at construction-sites are listed below. Keep these in mind as you conduct your inspections.

1. Too much soil exposed at one time
2. Missing and/or misunderstood sediment controls
3. Poor management of temporary stockpiles
4. Inadequate BMP maintenance
5. No BMPs to minimize vehicle tracking onto the road
6. Improper solid or hazardous waste management
7. Dewatering and other pollutant discharges
8. Poorly managed washouts (concrete, paint)
9. Inadequate self inspections of BMPs
10. Inadequate maintenance of ESC Plan

(Source: U.S. Environmental Protection Agency)

4.12 Post Inspection Process

Send copies of the inspection report to all required locations/persons.

4.12.1 Verification of Corrective Action

Note corrective actions at every inspection and whether they have been carried out within the required time frame. Communicate problems to the responsible party, the site contact that will initiate corrective actions on-site.
Third Party Inspectors should notify proper regulatory authority where required.

CHAPTER 5 : BEST MANAGEMENT PRACTICES (BMPs)

The list of Best Management Practices (BMPs) can be cross-referenced to DOE publication 'Manual Pemeriksaan BMPs' where BMPs are listed together with situations where they are best applied to.

5.1 Learning Outcomes

On successful completion of the module, participants will be able to:

1. Distinguish between erosion control and sedimentation control
2. Identify and illustrate the use of various BMPs (Best Management Practices) in controlling erosion and sedimentation on site
3. Plan a combination of BMPs for effective erosion and sediment control at a particular site

5.2 Types of Best Management Practices:

Standard Code and Identifier.
The code and number of BMPs as shown in 'Manual Pemeriksaan BMPs' can be used in ESCP drawings, entitled 'Standard Notes and Details'. In the ESCP drawing, BMPs are then indicated by the symbols and code numbers.

Type of Control.
Controlling erosion at its early stages is the most effective way to manage construction site erosion and sedimentation. Therefore, an effective ESC Plan will focus on the following:

- Controlling erosion potential by limiting the area and duration of disturbance.
- Timely restabilization of disturbed areas.
- Providing an adequate drainage network throughout the site in all stages of construction to ensure that stormwater runoff has a defined place to go.
- Designing all drainage conveyances, from small swales to larger drainage channels, to be noneroding and stable.

Here BMPs are categorized into 4 general types:

- Site planning and management. These BMPs are related to planning and management measures.
- Erosion control. These BMPs are used to limit the amount and extent of erosion.
- Sediment control. There BMPs are designed to capture eroded sediments before they can be carried outside the site
- General construction controls. These are general 'housekeeping' measures including storage and maintenance.

Phase of Construction.
The BMPs listed apply to one or more of the following construction phases. All BMPs shall be indicated in the ESCP drawings as being part of the Initial Stage, Interim Stage or Final Stage of construction. This is to help clarify when each BMP is to be installed.
Initial Stage.

These BMPs shall be installed at the outset of construction, before the Preconstruction Meeting and any land-disturbing activities. Initial controls are to be placed on existing grades, but shall be based in part on proposed grading operations.

Interim Stage.

These BMPs shall be based on proposed grades and drainage features and are installed after initial site grading. For some BMPs such as Inlet Protection, interim controls are installed after the construction of site infrastructure.

Final Stage.

BMPs shown in the Final Stage ESC drawing shall be installed as one of the last steps in the construction process, such as final seeding and mulching

5.3 Site Planning and Management

Preserve Vegetation

Existing vegetation should be maintained for *as long as possible* to assist in erosion and sediment control. Grassed buffer strips at the perimeters can remove a lot of sediment. The buffer strips should be regularly maintained:

- Remove sediment buildup
- Replant areas where concentrated flows erode channels through
- Remove all trash, debris, branches, rocks, etc.

Mature trees should be protected during construction by fencing or boarding of the trunks. Trees reduce erosion by protecting soil from rainfall and by holding soil with their roots.

Scheduling/Sequencing

Scheduling/sequencing of BMPs and construction activities aims at minimizing the amount and duration of exposed soil. It includes:

- Developing timetables for certain activities (clearing, grubbing, grading, etc.)
- Stabilizing areas that are inactive

5.4 Runoff Control

Hydromulch

Thick, sticky mix of fiber and wood that can be sprayed onto bare soil, especially on slopes, to protect it from erosion. Worked areas that will be inactive for some time and stockpiles are typical places to hydromulch. They need curing time and need to be reapplied when damaged by traffic or activity.

Hydroseed

Similar to Hydromulch except that it contains seeds and fertilizers; and can be used for final stabilization. Patches where seed germination is poor need respraying. Repair needed where damaged by activity.

Mulching

Covering bare soil with a layer of coconut fiber, wood, bark, or other mulching material to reduce the impact force of rainfall, reduce runoff and retain soil moisture.

Diversions

Channels to intercept and divert site water and off site runoff to areas where it can be controlled. Usually built above cut or fill slope to protect it. Has a supporting ridge on the lower side. Can be lined with RECP, rock or preferably, vegetation.

Gabions

Wire baskets filled with stone to build walls or line channels for protection. Need geotextile layer underneath to stop soil merging into gabion over time.

Inlet Protection at Grade

Normally sediment collection sacks hanging inside inlet, meant to protect inlets that are flush with the ground, or at grade (drop inlets), from sediment.

Inlet Protection- Block & Gravel

Concrete blocks placed around inlets with gravel layer outside them to enable water to pool and settle sediment.

Inlet Protection – Filter Fabric

Filter fabric inlet protection with stakes at corners, used on drop or curb inlets to pool water allow sediment to settle.

Inlet Protection – Gravel Bag

Bags filled with gravel to pool water and settle sediment while allowing clean water to overtop and enter drain.

Inlet Protection- Stone Collar

Ring of stone or crushed rock inside wire mesh ringing the inlet, to pool water and allow sediment to settle. Clean water can overtop and flow into the drain.

Outlet Velocity Protection

Rip-rap aprons or energy dissipater blocks to minimize downstream erosion by slowing water velocity. TRMs may also be used.

Pipe Slope Drain

Pipe used to convey flow down a slope without causing erosion damage to the slope. Need sediment protection at inlet of pipe and scour protection at outlet.

Retaining Walls

Permanent wall built against a slope or bank to prevent slope failure. May be constructed from stone, concrete or wood.

Rip-Rap

Large, coarse rock, underlain with filter fabric to protect soil from concentrated flow e.g. in channels; stabilize slopes with seepage, increase infiltration or slow down runoff.

Rock Check Dam

Aggregates placed in channel to capture sediment in runoff and slow the velocity to prevent erosion.

Swales

Channels lined with vegetation or rock, to slowly convey runoff downstream. Need to have stabilized sides.

Wet Ponds

Permanent pool of water to remove pollutants from post construction run-off. During construction they can be used as sediment basins.

5.5 Erosion Control

Erosion control BMPs protect the exposed soil from stormwater erosion.

Rolled Erosion Control Products (RECPs)

Blanket-type products that can be rolled out to cover soil. Normally made from natural materials like straw or coconut husk. Permanent RECPs are made of natural materials jute or coir, or synthetic material such as polypropylene, and referred to as Erosion Control Mats (more durable than blankets).

Close turfing

Labour intensive practice in Malaysia of laying grass by clumps. Frequently left dry without watering. Also always applied direct onto laterite soils without topsoil, hence always showing poor growth. Needs compost mulched into top layer of laterite before application.

Another common bad practice locally is 'Spot turfing' which should not be allowed unless the soil underneath has been protected with a blanket layer.

Soil binders

Temporary coatings sprayed onto open soils. They need curing time to be fully effective and have to be reapplied if traffic breaks up the surfaces.

Surface Roughening

Temporary scarification or roughening of the surface of graded soils to dissipate velocity of runoff and trap sediment. Usually applied to slopes using bulldozers to leave track markings parallel to the slope contours.

Note: The ongoing use of backhoes to cut slopes leaving 'downslope' teeth marks should be stopped as this practice quickens gully formation, increasing erosion of the slopes.

Tackifiers

Adhesives used to stick mulch materials to the soil surface. Need to be reapplied regularly.

5.6 Sediment Control

Sediment control BMPs trap the sediment carried by stormwater discharge from the site. Sediment accumulation needs to be regularly excavated out to maintain the efficiency of the BMPs.

Baffles

Temporary structures built into sediment basins / traps to lengthen the flow path, thus allowing sediment to settle; can be solid (wood, silt fence etc) or porous (jute, coir etc.)

Fiber Roll

Temporary structures made of straw, coconut husk etc. packed and placed into rolls that can be placed on slopes to capture sediment, reduce flow velocity and slope length. RECPs may also be used as fiber rolls.

Sediment Bags

Large porous bags to trap sediment from site discharge. Does not however, trap all sediment, hence must be used with other methods e.g. placed in grass area to allow the grass to further capture sediment from the outflow.

Sediment Basin

Temporary, structural BMP to store site runoff so that sediment can settle. Needs a large area and a riser pipe arrangement to discharge water. Sediment needs removal when pond is more than half full.

Sediment/Silt Trap

These are small sediment basins serving smaller areas. Outlets are stone weirs (stone size: 100 – 500 mm) lying on geotextile fabric. They generally remove larger sediments.

Sediment Tube Check dam

These are temporary BMPs made of compacted rolls of coconut husk, wood mulch or geotextiles placed in channels or swales to capture sediment and reduce flow velocity.

Silt Fence

Geofabric stretched across wooden stakes in the ground. Used to divert sediment laden waters to areas where they can be controlled e.g. silt traps.

Reinforced silt fence has small gauge wire to strengthen the fabric, and metal stakes.

Super silt fence has large gauge wire (chain-link fence material) with metal stakes.

Skimmers

Floating devices meant to dewater a basin or pond from flexible pipe outlet floating at the surface. Gets cleaner water than perforated riser pipe outlet.

Stabilized Construction Entrance/Exit

Temporary tracking pads, rumble strips or washes at the entrance/exit of the construction site to reduce the tracking of sediment onto public roads by construction vehicles.

Temporary Stream Crossing

Culvert or bridge that spans a waterway to provide crossing for construction traffic. It reduces damage and sediment load to the stream channel.

Turbidity Curtain/Barrier

Floating curtains/barriers around a disturbed area to reduce sediment transport into the main body of water. Made of completely impervious polyester or have about 20% filter fabric material to reduce water pressure on it.

5.7 Other Controls (General Construction Control)

Concrete Washout Area

Excavated pits to wash out concrete from vehicles/equipment to stop it from entering drains or waterbodies.

Dust Control – Watering

Watering the ground with hoses or trucks to eliminate dust from construction activities.

Equipment Maintenance & Cleaning

Special areas for the repair and maintenance of equipment so that petroleum products can be trapped and prevented from entering waterways.

Materials Management

Proper storage, use, and disposal of materials by to prevent pollutant release to runoff. Training is required for staff and sub-contractors.

Rubbish Containment

Collection and containment of rubbish from the construction site to prevent it entering waterways.

Sanitary Waste Management

Proper collection and removal of sanitary waste to prevent it being carried away by stormwater e,g, portable toilets.

Secondary Containment

Containment for vessels of petroleum products to trap spills and leaks.

Stockpile Management

Covering with tarpaulin or protection of stockpile material to prevent erosion/seepage and pollution entering stormwaters

Street Cleaning

Removal of sediment that have escaped the construction site to prevent it entering the drains.

CHAPTER 6 : EROSION AND SEDIMENT CONTROL PLAN

6.1 Learning Outcomes

On successful completion of the module, participants will be able to:

1. Discuss and describe an ESCP, its stages and its purpose in development activities involving earthworks
2. Identify unresolved ESC problem areas in the ESCP
3. Evaluate adequacy of BMPs proposed and propose changes if necessary
4. Plan inspection visits to assess impact of major earthwork activities

The Universal Soil Loss Equation

This semi-empirical equation is developed for long-term assessments of soil losses (sheet and rill erosion rates) under different cropping systems and land management practices.

$A = R.K.LS.C.P$

Where
A is Annual soil loss, in tonnes ha-1 year-1.
R is Rainfall erosivity factor, An erosion index for the given storm period
K is Soil erodibility factor, the erosion rate for a specific soil
LS is Topographic factor which represent the slope length and slope steepness.
C is Cover factor, which represents the protective coverage of canopy and organic material in direct contact with the ground.
P is Management practice factor which represents the soil conservation operations or other measures that control the erosion, such as contour farming, terraces, and strip cropping.

The simple structure of the USLE formula makes it easy to formulate scenarios by changing the land use types (C and P factors) under given ecological conditions (R, K, L, and S factors).

Maps for the rainfall erosivity factor, R have recently been developed for Peninsular Malaysia.

Modified Universal Soil Loss Equation (MUSLE)

The Modified Universal Soil Loss Equation (MUSLE) is used for sediment yield estimation for a specific storm event. This empirical relationship (from Texas) is expressed by the following equation:

$Y = 89.6\,(VQ_p)^{0.56}\ (K.\ LS.\ C.\ P)$

Where *Y is* Sediment yield for the storm event (tonnes)
V is Runoff volume in cubic meter
Qp is peak discharge in m3/s

In the absence of more reliable locally developed formulae, this formula can be used to get estimates of sediment yield for design storm events

Example Calculation - Soil Loss Estimation For Project Site

Problem

Development Area in Tanah Rata, Pahang with a catchment area of 38,500 sq m, average slope of 1:10.

i. Calculate soil loss for area totally cleared without vegetation.
ii. Calculate soil loss for a particular design storm.

Annual soil loss from this case area estimated using Universal Soil Loss Equation, USLE:

A = RKLSCP

All values of parameters in this equation can be obtained using the DID publication ' Guideline for Erosion and Sediment control in Malaysia' (2010). The step by step calculations of soil loss for the area are as follows.

(1) Catchment Area

Total Catchment Area for area = 38,500 m2
= 3.85 ha

(2) Determination of Rainfall Erosivity, R Factor

From the charts of Rainfall Erosivity for Pahang, consider the area of Tanah Rata, and by interpolation, the R factor for the area is 16,000 MJ.mm/ha.hr.yr

(3) Determination of Soil Erodibility, K Factor

The K factor of the proposed development can be estimated from the soil map charts.

(4) Determination of LS Factor

The averaged slope steepness in the area, s = 10.0%, and slope length, λ = 60.0 m. Hence, From the LS Table:

LS = 1.935

(5) Determination of CP Factor

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

CP Factor = 1.00

(6) Determination of Soil Loss

The estimation of soil loss for the area using USLE equation for Malaysian conditions is as follows:

A = R.K.LS.CP

For Plot 1 : A = R x K x LS x CP
= 16,000 x 0.0266 x 1.935 x 1.00
= 824 tonne/ha/yr

Sediment Yield Estimation

The sediment yield from the area can be estimated using MUSLE equation:

$Y = 89.6\ (VQ_p)^{0.56}\ (K.\ LS.\ C.\ P)$

In estimating the sediment yield for the area, the peak discharge, Qp, was determined based on Rational Method (DID, 2000), as recommended in the Urban Stormwater Management Manual, MSMA (DID, 2000).

(1) (a) Design storm event for area

Design Storm = 3 month ARI
Catchment area = 38,500 m2
Overland flow length = 500 m
Duration of storm = 16.2 min

Intensity of design storm, I = 104.8 mm/hr
Runoff Coefficient, C = 0.74

(2) Calculation of Sediment Yield using MUSLE

In this case, the value of K, LS and CP factors are assumed the same as for soil loss estimation above.

Sub Catchment area, A (m^2)	Runoff Volume, V (m^3)	Peak flow Discharge [$Qp = C.I.A$] (m^3/s)	K Factor	LS Factor	CP Factor	Sediment Yeild, Y (tone)
38,500	806.15	0.829	0.0266	1.935	1.00	176.14

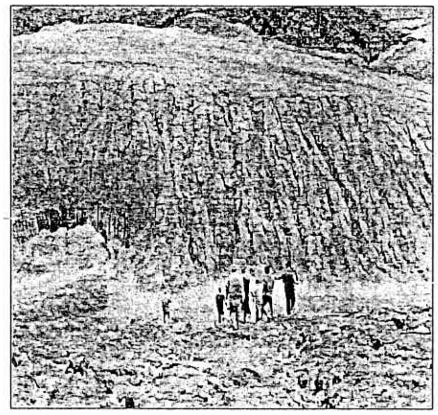
Thus, the Total Sediment Yield for area: **Y = 176 tonnes per storm event**

MODULE 1 : FUNDAMENTALS OF EROSION AND SEDIMENTATION

1

EROSION

- Occurs when soil particles are displaced by raindrops, moving water, or wind
- Detachment, entrainment and transport of soil particles from their place of origin by the agents of erosion.



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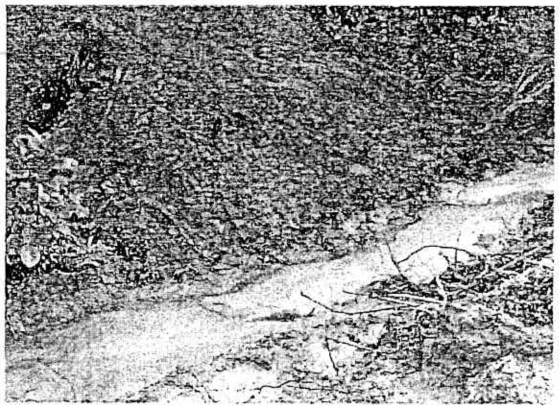
DETACHMENT

- ❑Removal of soil particles from soil surface
- ❑Adds to the sediment load
- ❑Sediment load: Rate sediment is transported downslope by runoff



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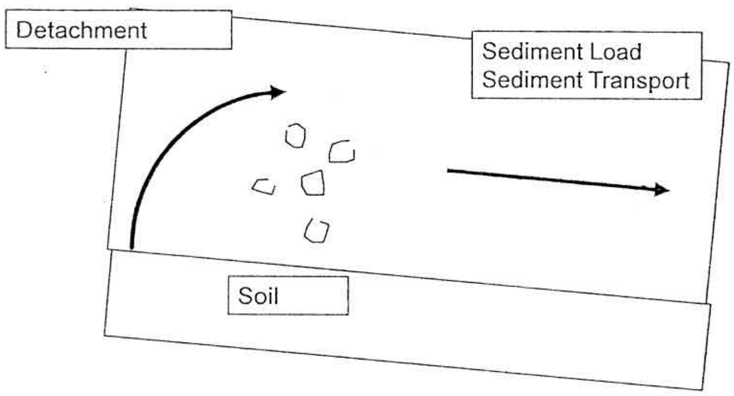
DETACHMENT



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SEDIMENTATION

- It is the the build-up (aggradation) of sediment on the land surface or the bed of a watercourse

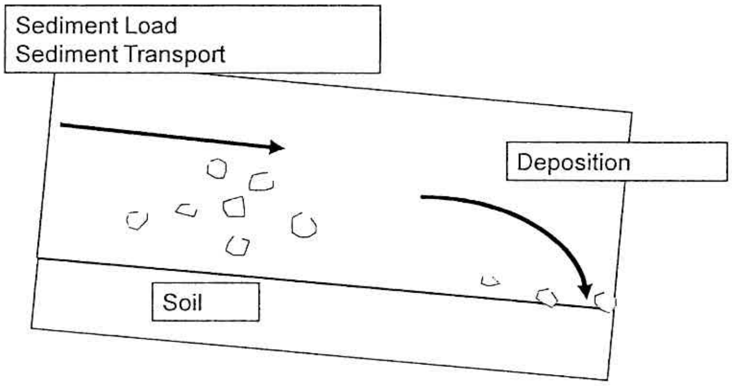
5

DEPOSITION

- Reduces the sediment load
- Adds to the soil mass
- Local deposition
  - Surface roughness depressions
  - Row middles
- Remote deposition
  - Concave slope
  - Strips
  - Terraces

6

DEPOSITION



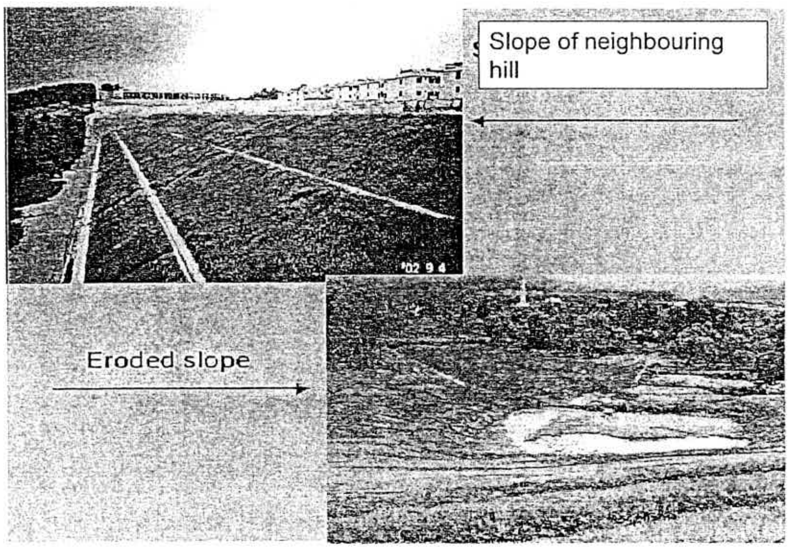
EROSION POTENTIAL

- SOIL ERODIBILITY?
- THE TENDENCY FOR SOIL PARTICLES TO BECOME DETACHED BY ACTIONS OF WATER/WIND
- SILT & VERY FINE CLAY (MOST ERODIBLE)

EROSION POTENTIAL

- VEGETATIVE COVER?
- PROTECTS SOIL FROM EROSIVE FORCES OF RAINDROPS
- GRASSES

9



EROSION POTENTIAL

- TOPOGRAPHY?
- LONG SLOPES DELIVER MORE RUNOFF
- STEEP SLOPES INCREASE RUNOFF VELOCITY

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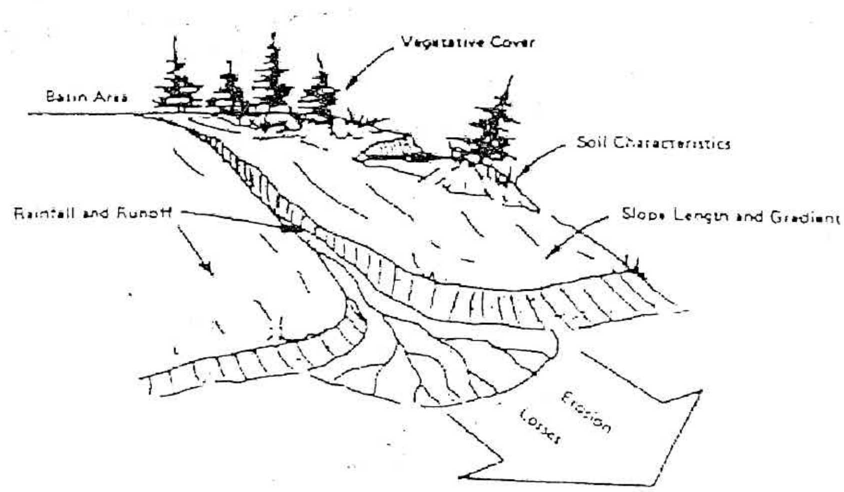


Characteristics Which Affect Erosion Losses

EROSION POTENTIAL

- RAINFALL CHARACTERISTICS?
- FREQUENCY, INTENSITY AND DURATION

13

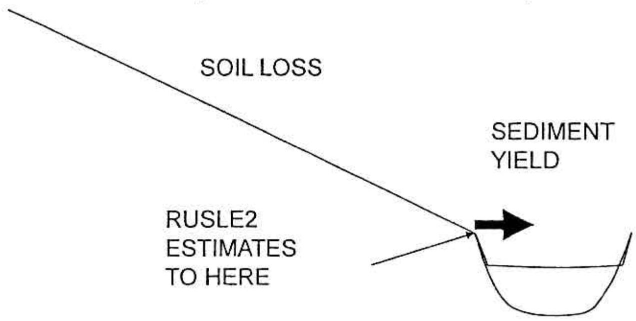
TYPES OF EROSION

- Interrill and rill (sheet-rill)
- Ephemeral gully
- Permanent, incised (classical) gully
- Stream channel
- Mass movement
- Geologic

14

DEFINITIONS

Simple Uniform Slope



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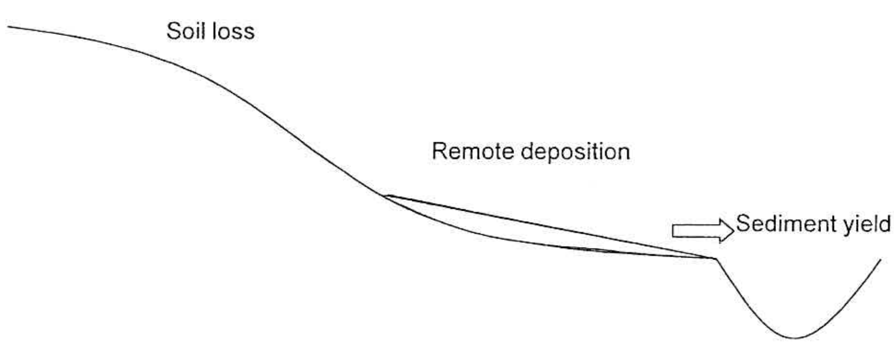
DEFINITIONS

Complex Slope



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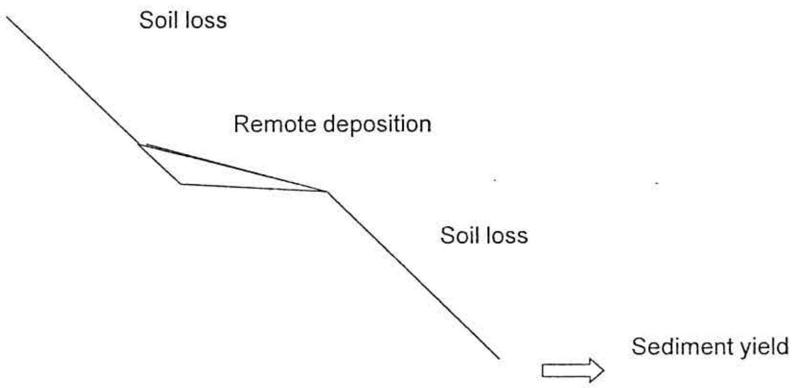
DEFINITIONS

Complex Slope



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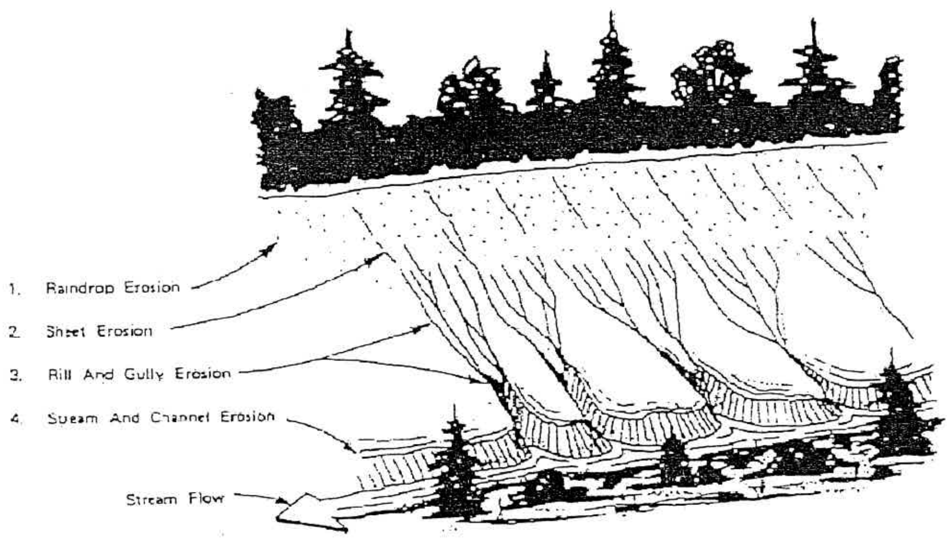
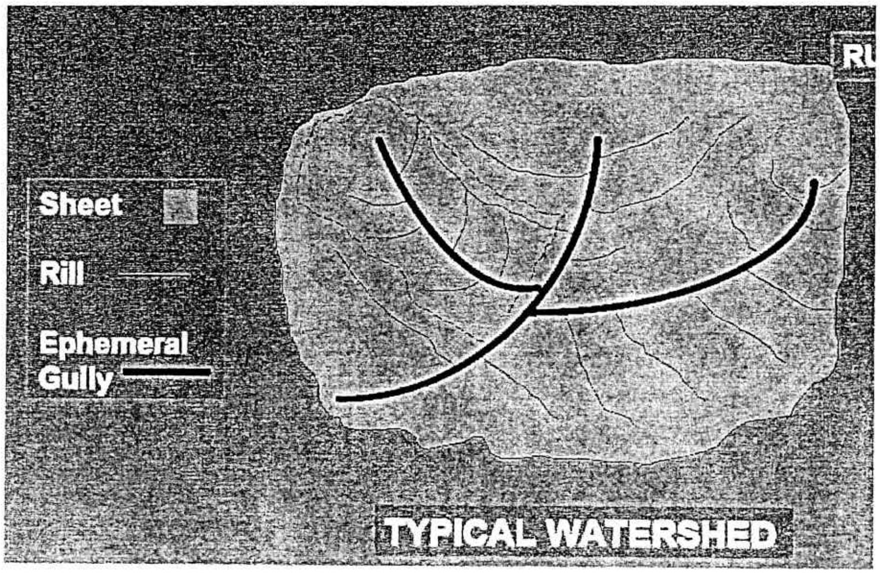


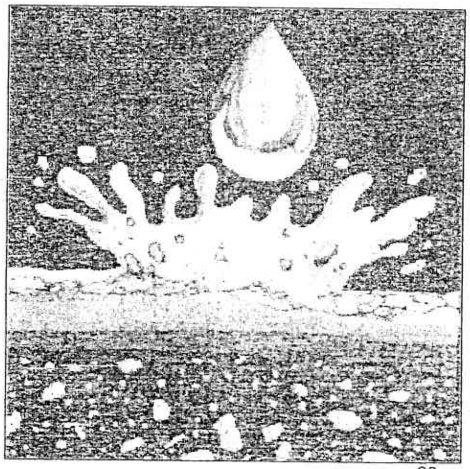
Types of Erosion



MECHANICS OF EROSION

SPLASH EROSION

- ❑DISLODGING OF SOIL PARTICLES BY RAINDROP IMPACTS, RESULTING IN THE DISPERSAL AND MOBILISATION OF THE SOIL PARTICLES



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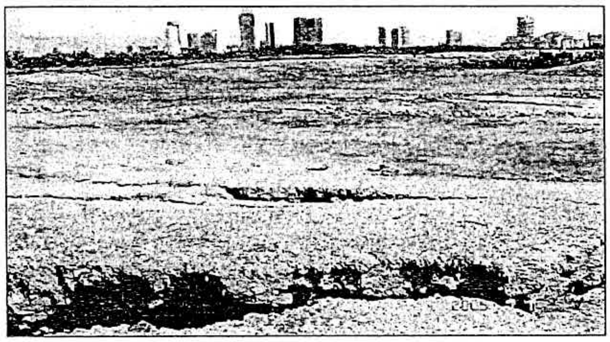
MECHANICS OF EROSION

- SHEET-FLOW EROSION
- UNIFORM REMOVAL OF SATURATED SOIL PARTICLES CONVEYED IN RUN-OFF WATER



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MECHANICS OF EROSION

RILL EROSION

- ❑LONG NARROW DEPRESSION OF SOIL INCISION CAUSED BY INCREASED TOPOGRAPHIC RELIEF AND HIGHER RUNOFF VELOCITIES

- ❑USUALLY< 30CM DEEP BUT METRES-LONG

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MECHANICS OF EROSION

GULLY EROSION

- INCISED CHANNELS BEGAN AS RILLS
- DEEP AND WIDE DEPRESSION CAUSED BY CONCENTRATED FLOWS
- HIGHLY EFFECTIVE AS CONVEYORS OF SEDIMENTS

23

MECHANICS OF EROSION

- MAXIMUM EROSION RATE?
- WHEN RAIN DROP SPLASH AND SHEET FLOW OCCUR SIMULTANEOUSLY

24

MECHANICS OF EROSION

- IMPACTS OF STORM EVENTS?
- EROSION PRODUCING POWER OF RAINDROPS = KINETIC ENERGY X 30-MIN. MAXIMUM RAINFALL INTENSITY
- SUM OF THESE IN AN AREA DURING AN AVERAGE YEAR =RAINFALL EROSION INDEX

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EROSION & SEDIMENT CONTROL

- TEMPORARY SOIL STABILISATION PROCESS
- TEMPORARY RUN-OFF CONTROL PRACTICES
- TEMPORARY SEDIMENT CONTROL PRACTICES

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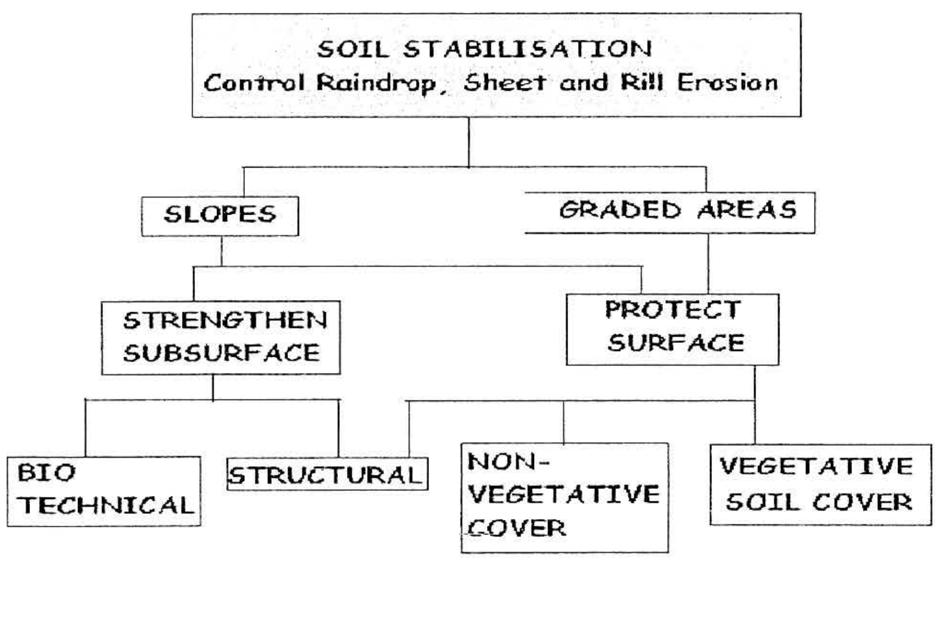
EROSION & SEDIMENT CONTROL

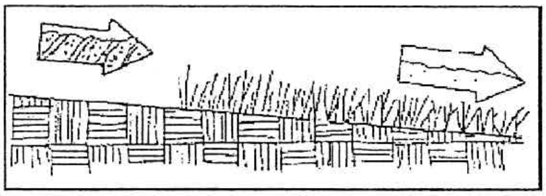
- SOIL STABILISATION REDUCES THE EROSIVE IMPACT OF RAIN ON EXPOSED SOIL

27

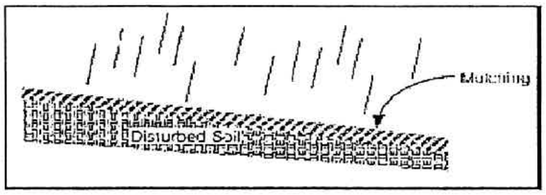


Vegetative Stabilisation

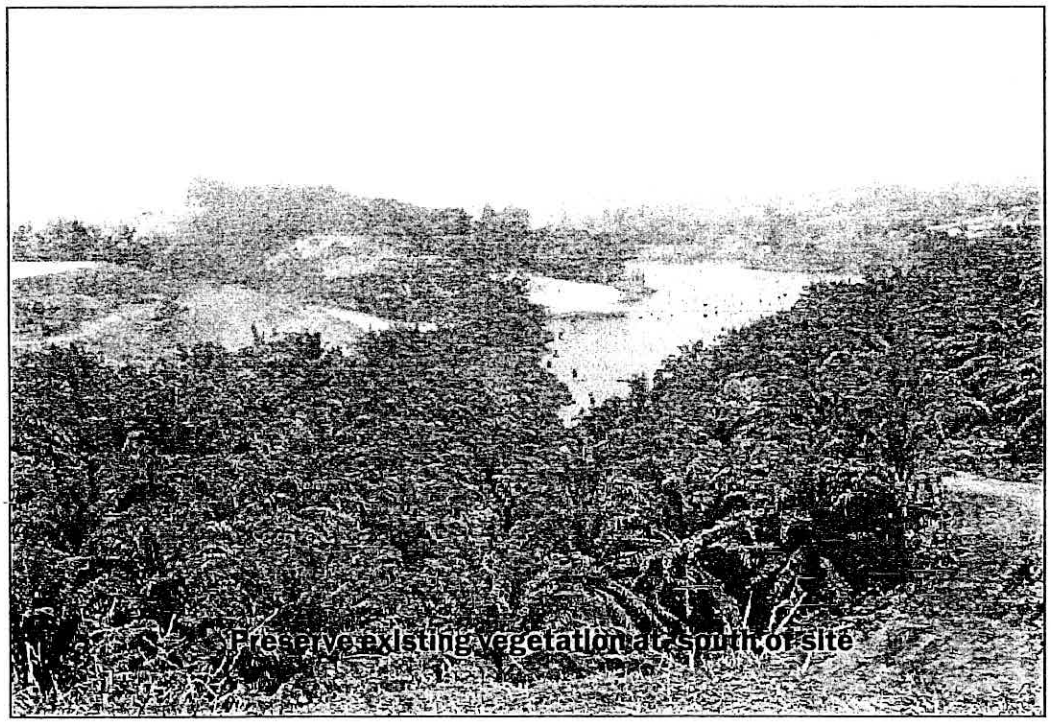
- ←Seeding and Planting

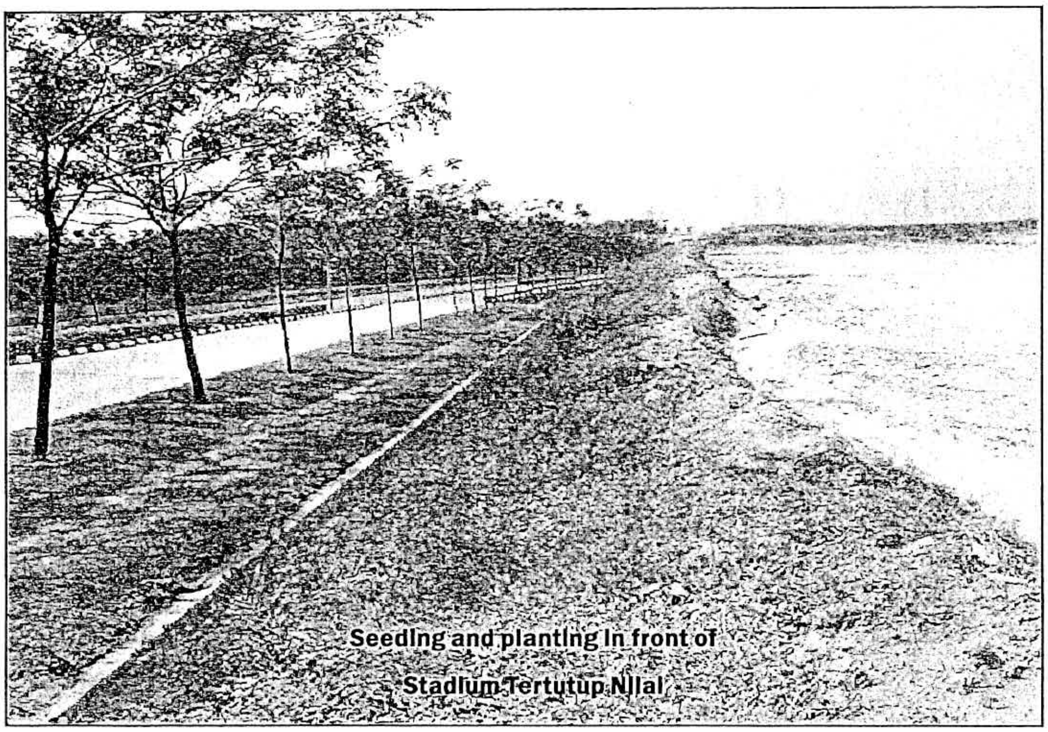


- ←Mulching



29



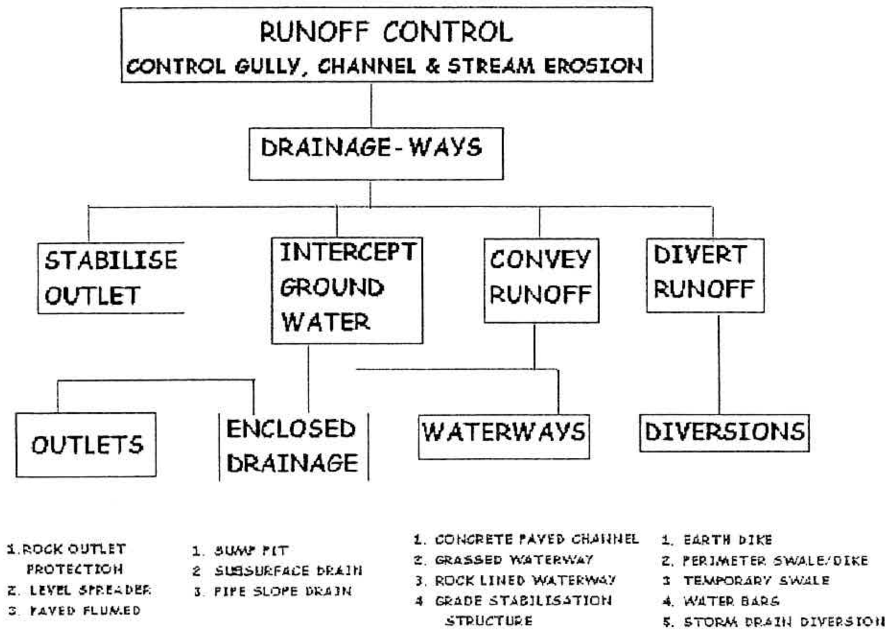


Seeding and planting in front of Stadium Tertutup Nilai

EROSION & SEDIMENT CONTROL

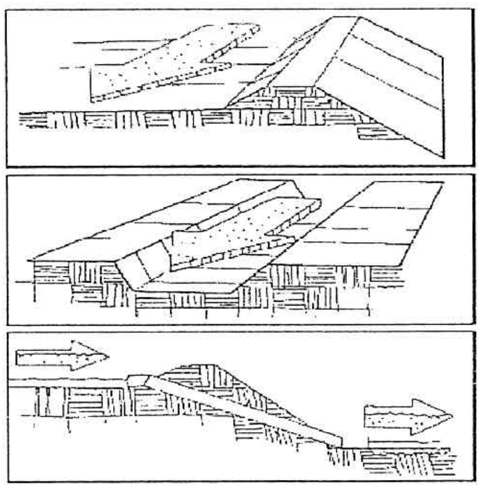
- RUN-ON CONTROL PRACTICES
- PREVENTING STORMWATER FLOWS FROM CONTACTING DISTURBED SOIL AREAS

32

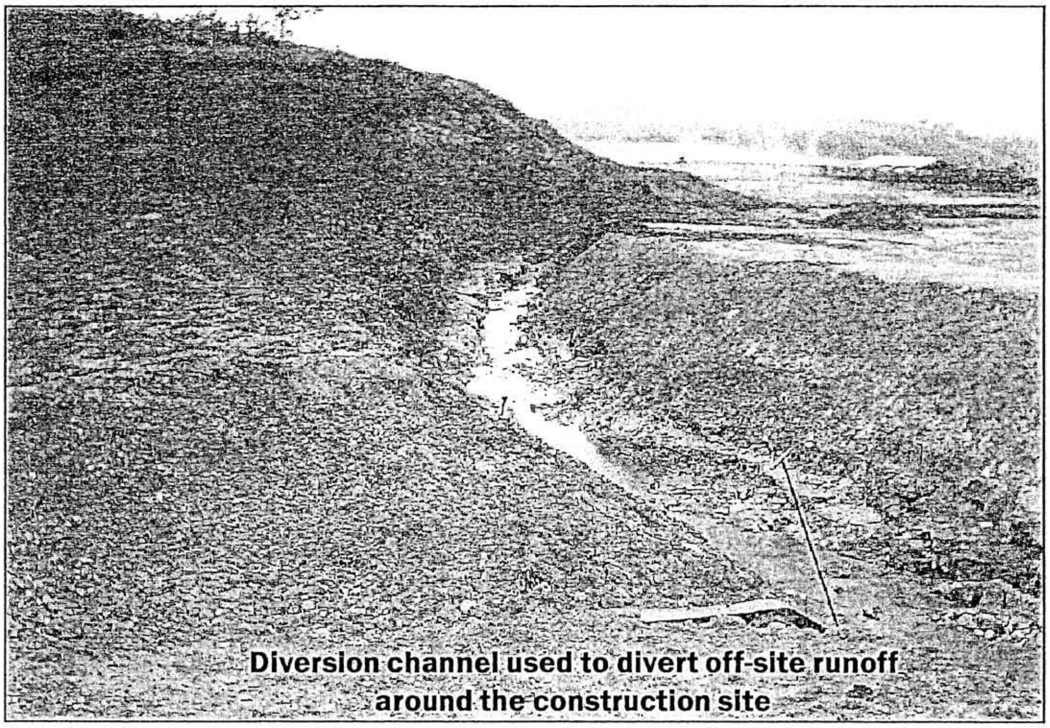


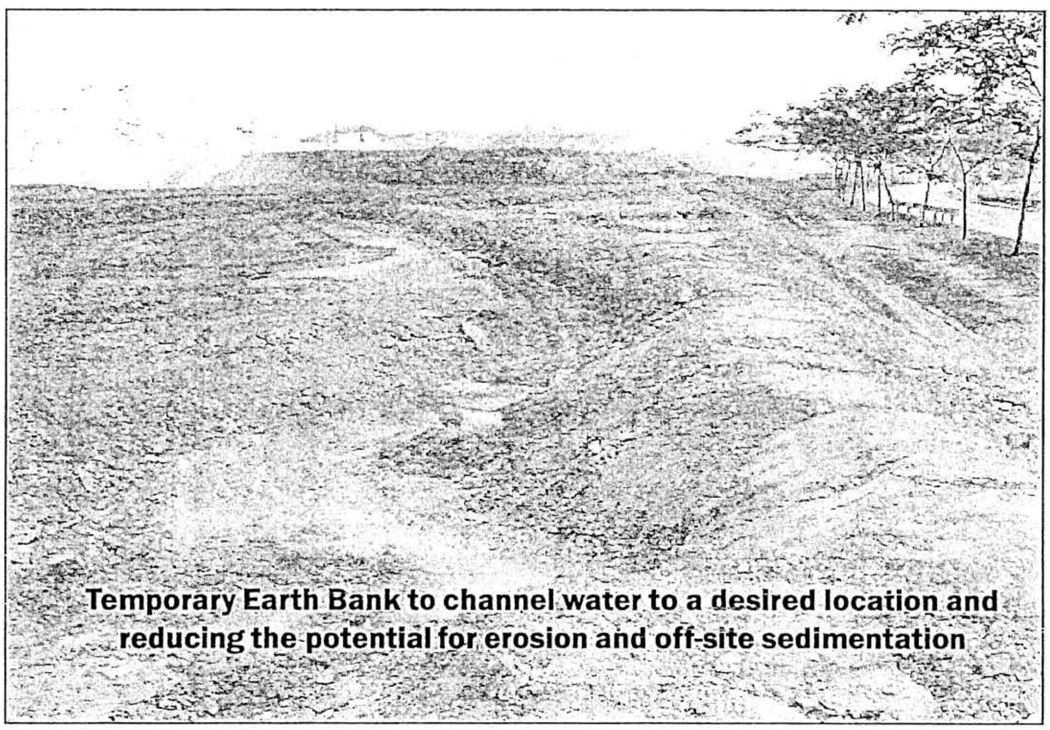
Diversion of Runoff

- Earth Bank
- Diversion Channel
- Slope Drain



34

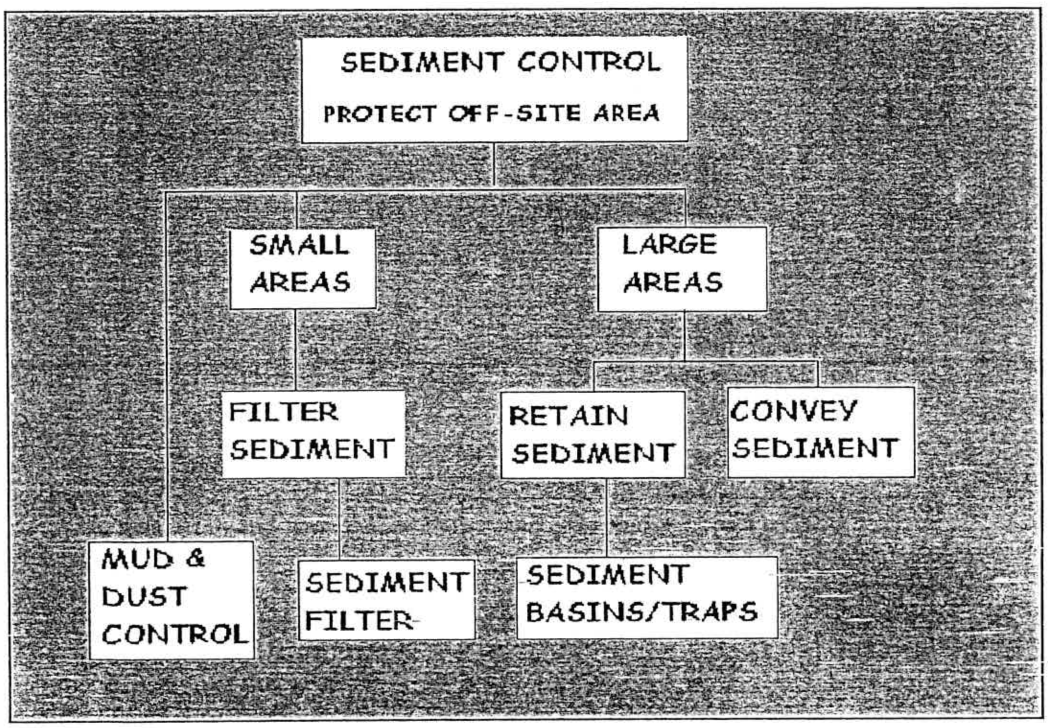

Diversion channel used to divert off-site runoff
around the construction site


Temporary Earth Bank to channel water to a desired location and
reducing the potential for erosion and off-site sedimentation

EROSION & SEDIMENT CONTROL

- SEDIMENT CONTROL
- REMOVE SEDIMENT FROM STORMWATER BY PONDING & SETTLING

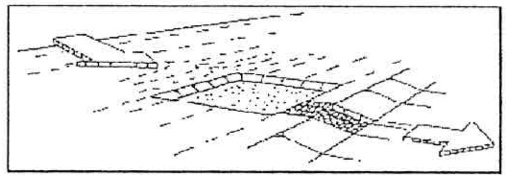
37



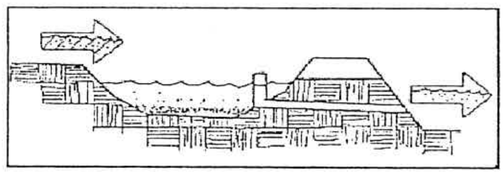
Sediment Trapping

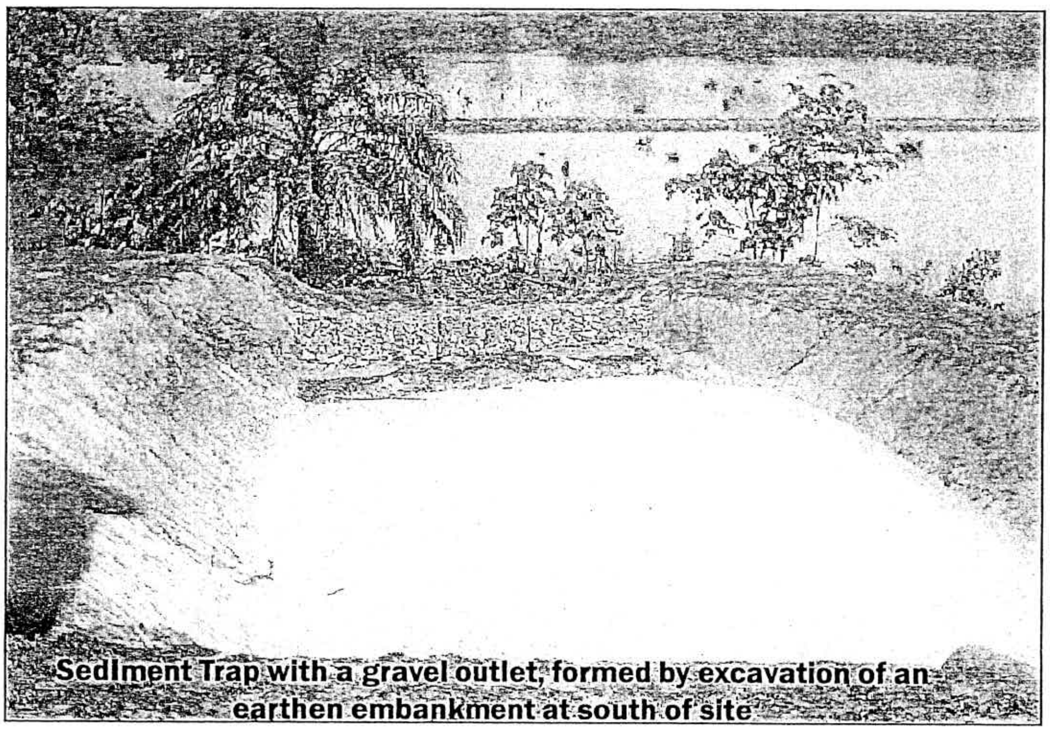
- Drainage Inlet Protection

- Sediment Traps

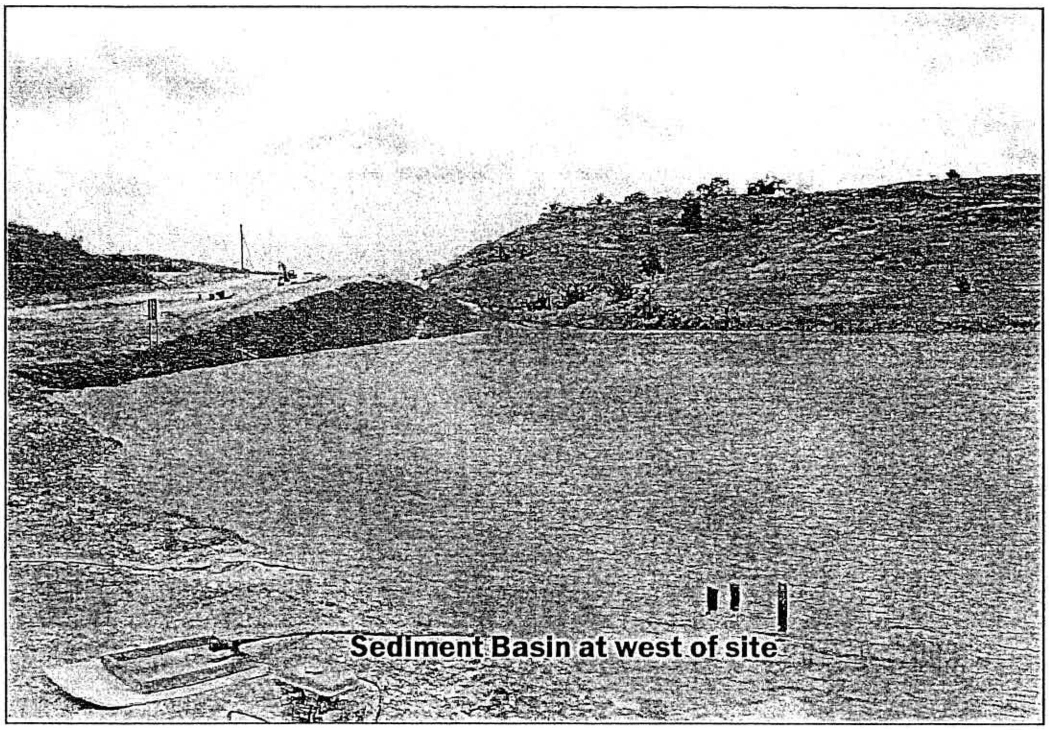


- Sediment Basins





Sediment Trap with a gravel outlet, formed by excavation of an earthen embankment at south of site


Sediment Basin at west of site

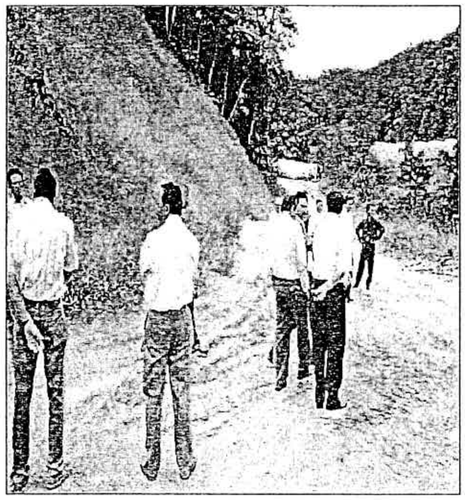
CHAPTER 3

SAFETY, COMMUNICATIONS AND ATTITUDE/ETHICS OF AN INSPECTOR

INSPECTOR DUTIES

Inspector duties

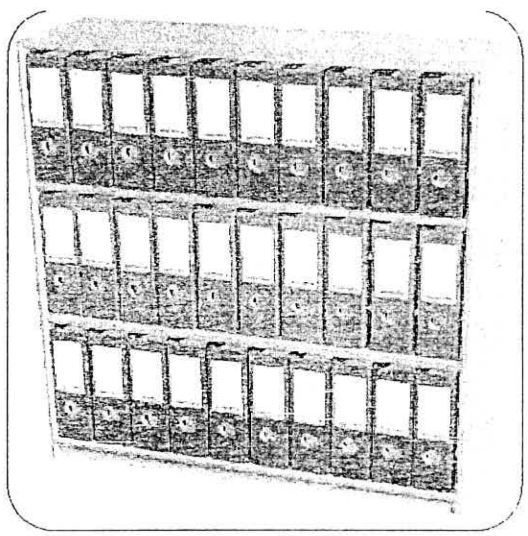
1. Representative On-Site



Inspector duties

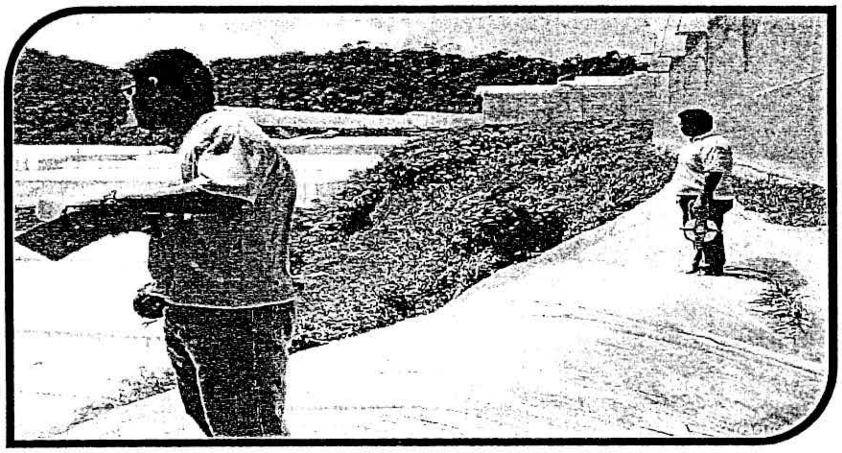
2. The Record Keeper

Clear and systematically kept



Inspector duties

3. *Instructor in Erosion and Sediment Control (ESC)*
   Excellent knowledge of the BMPs

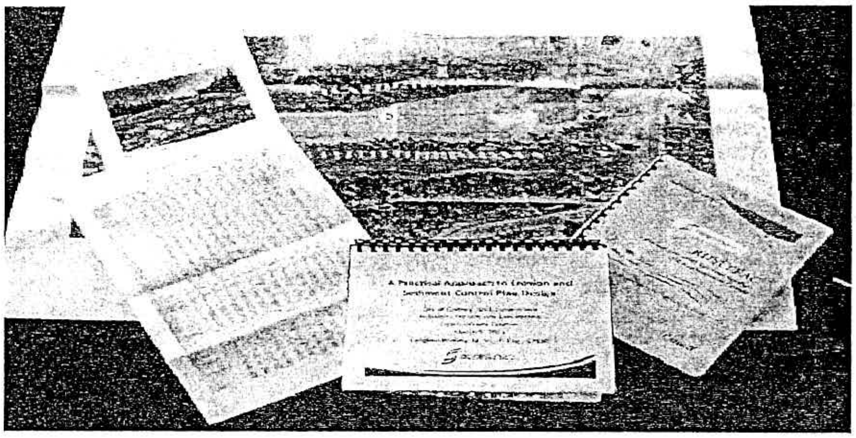


INSPECTOR ETHICS

Inspector Ethics

1. Thorough

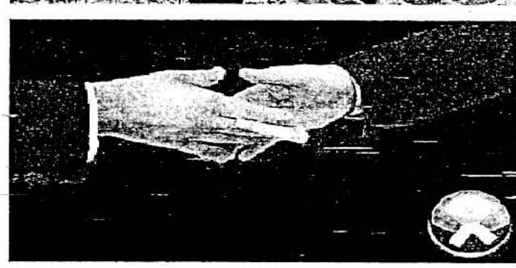
Inspection and documentation comprehensive & precise.



Inspector Ethics

2. Show Integrity

avoid corruption

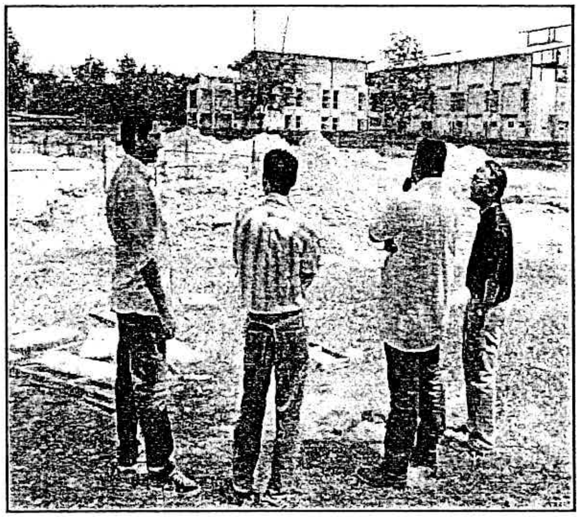


Inspector Ethics

*3. **Resolve Conflict***

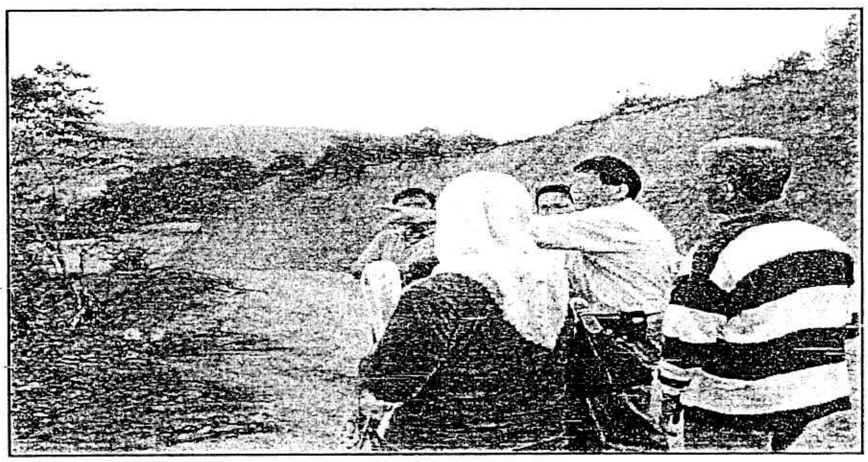
Responsible to protect public interest

Be professional in any conflict.



Inspector Ethics

*4. **Communicate*** : Inform all relevant persons on site problems.



SAFETY MEASURES DURING INSPECTION

Safety Measures during inspection

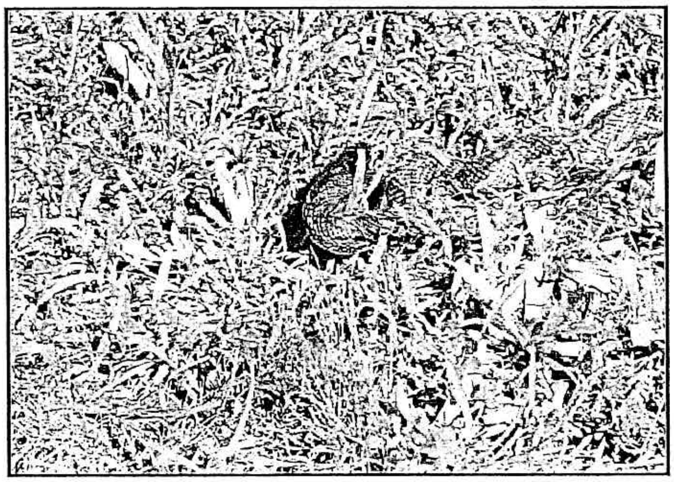
Insects

Wear long sleeves

Safety Measures during inspection

Dangerous animals

Be careful of snakes, monitor lizards etc on construction sites.



Safety Measures during inspection

Exposure to the elements

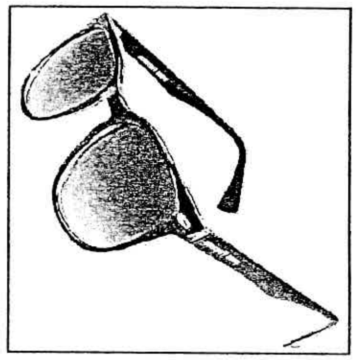
- Anticipate sudden thunderstorms and lightning.
- Stay away from sheds or open shelters.
- Keep all windows and doors closed.

Safety Measures during inspection

In view of our strong tropical sun, always:

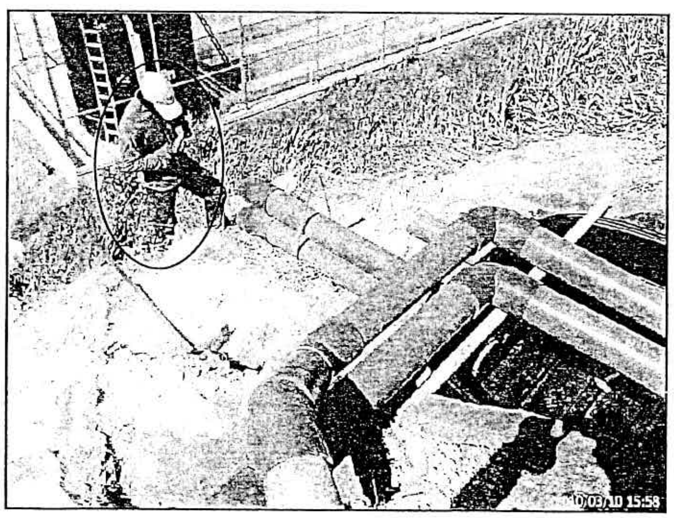
1. Drink plenty of water.

2. Use sunglasses with UV protection.

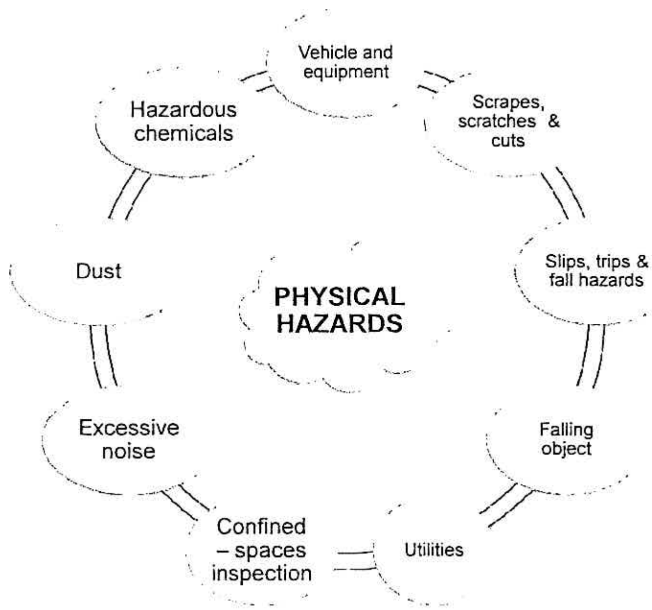


Safety Measures during inspection

3. Wear a hat and protect skin against the sun.



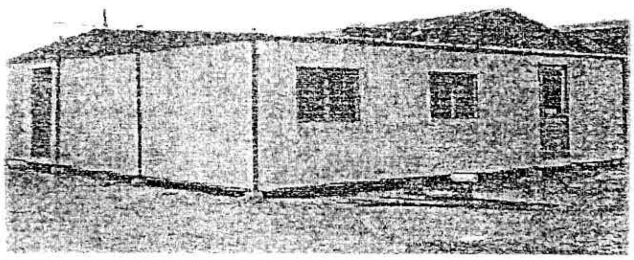
PHYSICAL HAZARDS



Physical Hazards

1. Vehicle and Equipment

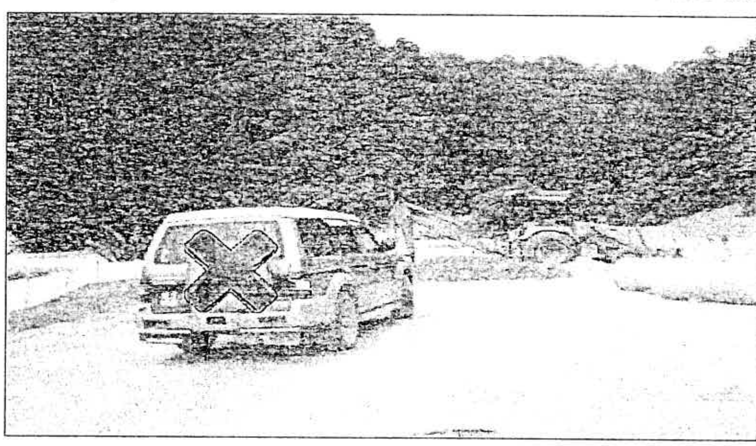
◈ Report to the site office before entering the site.



Physical Hazards

1. Vehicle and Equipment

Park away from areas where earth machines are moving.



Physical Hazards

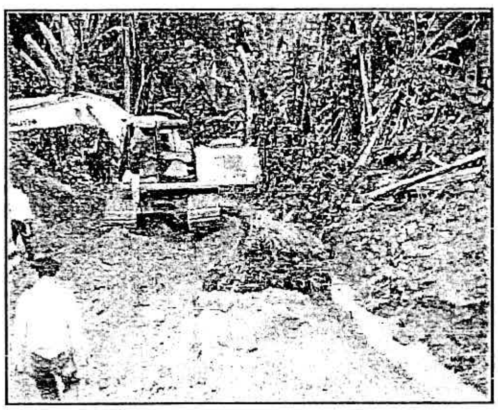
1. **Vehicle and Equipment**

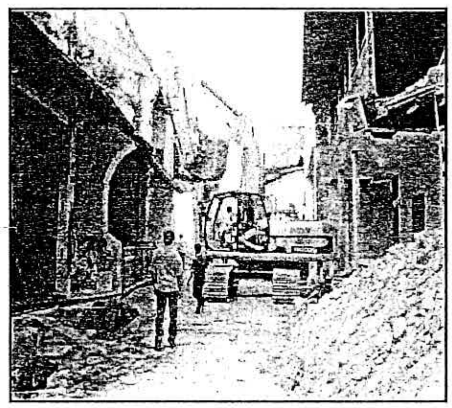
- Wear a safety vest to make yourself visible.

Physical Hazards

1. **Vehicle and Equipment**

◈ Do not go behind machines

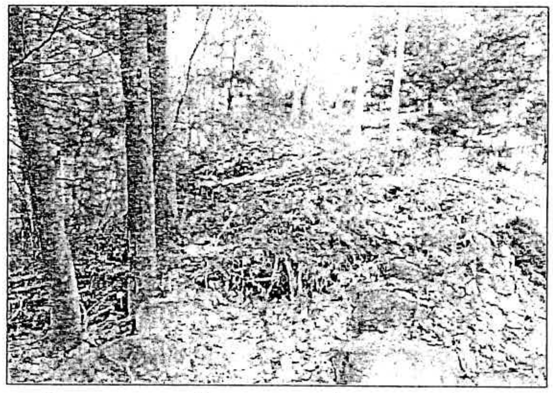




Physical Hazards

2. Scrapes, Scratches and Cuts

- Wear safety shoes



- Be aware of surroundings and avoid high risk areas such as debris and brush piles.

Physical Hazards

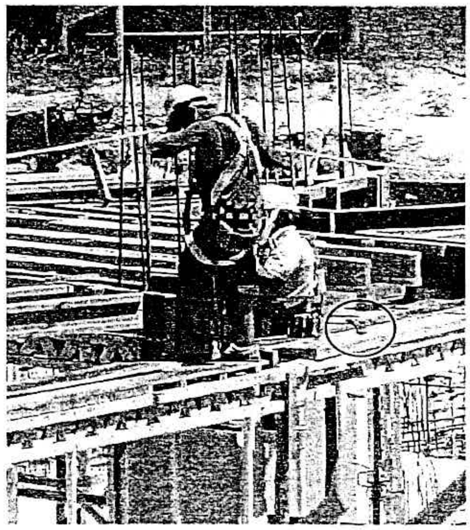
3. Slips, Trips and Fall Hazards

Be very careful of steep slopes, loose soil and open excavations

Physical Hazards

4. Falling Objects

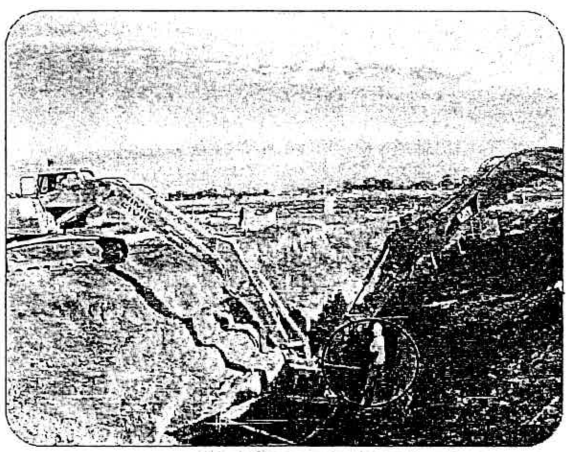
- *Be careful of falling objects from buildings under construction.*
- *Wear a hard hat and watch out for suspended equipment.*



Physical Hazards

5. Utilities

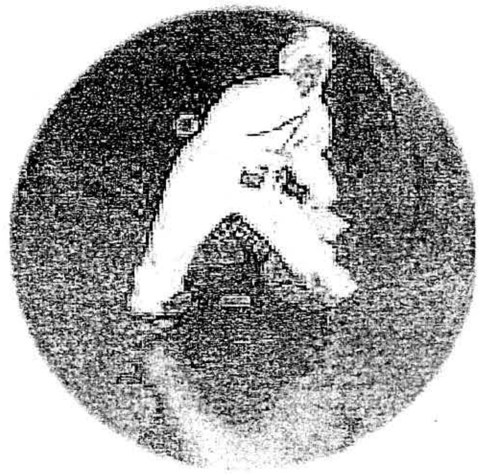
- *Watch out for exposed electrical wires.*
- *Be careful of slides when walking near trenches*



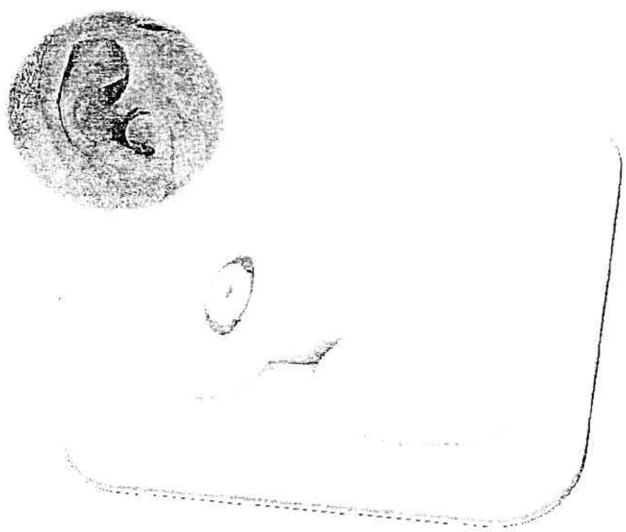
Physical Hazards

6. **Confined-Space Inspections**

◈ Never work alone



Physical Hazards



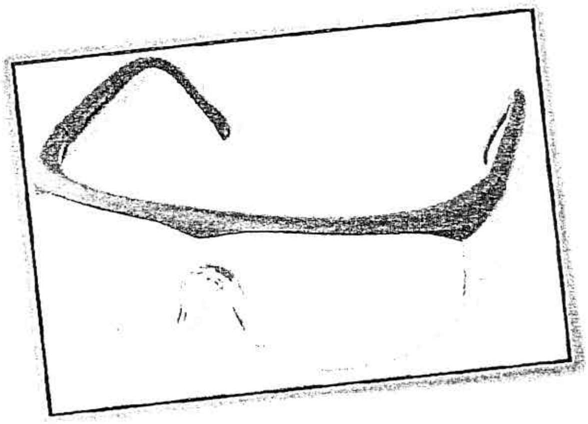
7. **Excessive Noise**

◈ Wear ear plugs

Physical Hazards

8. Dust

- Use protective eye-ware where there is excessive dust.



Physical Hazards

9. Hazardous chemicals

- Avoid exposure to hazardous chemicals like herbicides and pesticides.

VERBAL AND WRITTEN COMMUNICATION

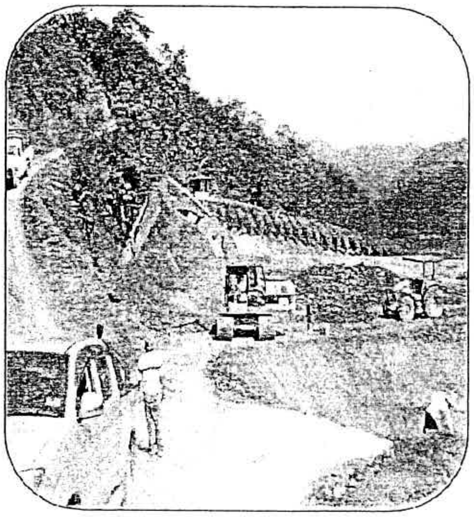
Arrival Introductions

- Your credentials and identification
- Purpose of the visit
- What they can expect at the end of the visit
- When follow-up will occur

Working with Contractors

Communicate effectively with contractors

- Be reliable and on time, if not call ahead.
- Respect other's opinions.
- Be consistent.



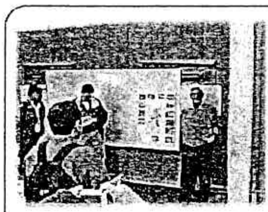
Dealing with Difficult People

- ***Be professional***

1. Be friendly but *firm.*
2. Express concern for the problem and confidence that the person can solve it.
3. Don't show anger in arguments. Keep calm

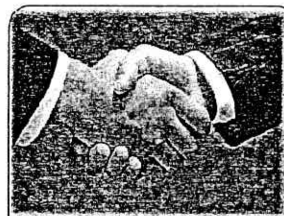
Dealing with Difficult People

◈ ***Be sensitive***



Be conscious of your body language and facial expression.

Express empathy and acknowledge their issues.



Apologize if you are wrong and correct YOUR error only.

Dealing with Difficult People

◈ ***Use questions to clarify***

1

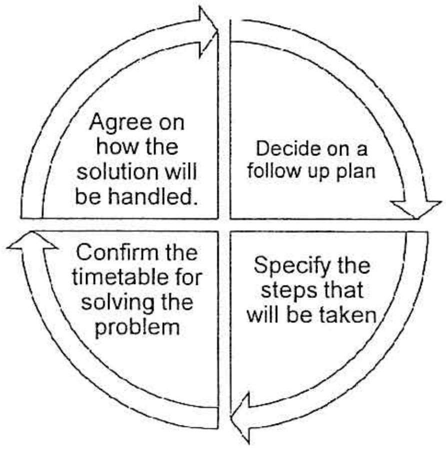
- Allow the person to explain his problem.

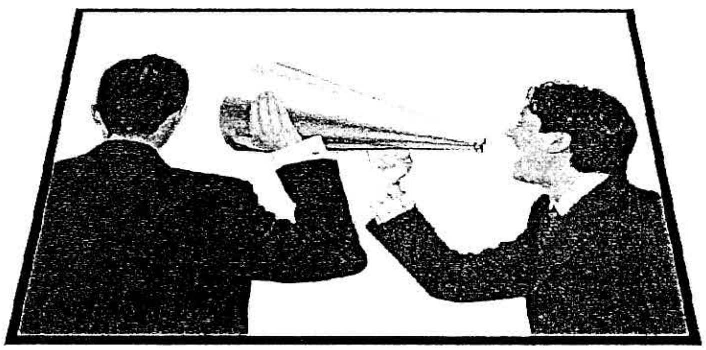
2

- Be sure that all parties understand the real problem

Dealing with Difficult People

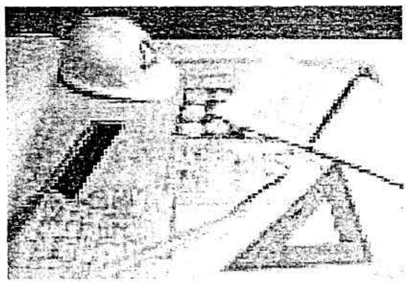
◈ ***Get joint solutions***





THANK YOU....

Module : ESCP



1

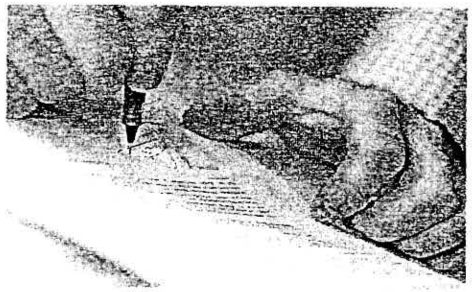
The Plan

- Site Specific
- Dynamic

2

Plan Certification

- Signed and dated by authorized parties
- Identifies the person responsible for implementation



3

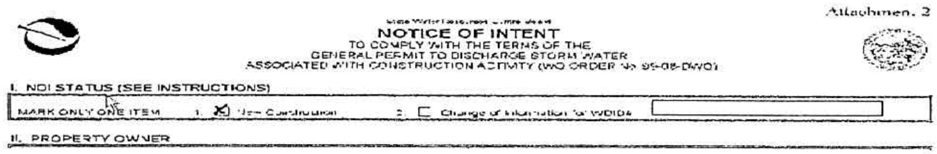
Components of the Plan

- Table of Contents
- ESC Plan - addresses land disturbance activities
- Certification

"I certify under penalty of law..."

4

Components of the Plan


Attachment 2

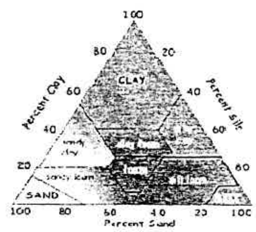
NOTICE OF INTENT
TO COMPLY WITH THE TERMS OF THE
GENERAL PERMIT TO DISCHARGE STORM WATER
ASSOCIATED WITH CONSTRUCTION ACTIVITY (WQ ORDER No. 99-08-DWQ)

I. NOI STATUS (SEE INSTRUCTIONS)

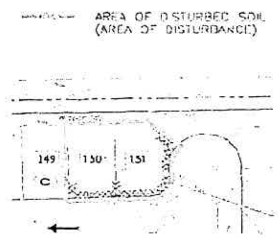
MARK ONLY ONE ITEM

II. PROPERTY OWNER

- Notice of Intent
- Soils
- Topography



Components of the Plan

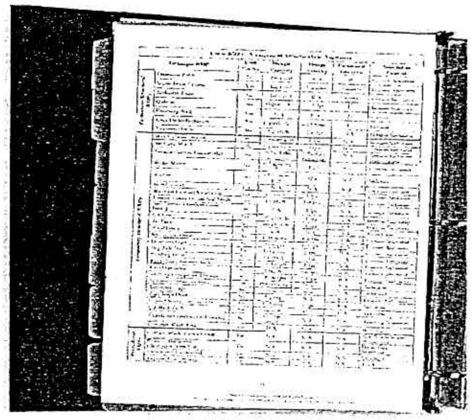


- Project Information
- Disturbed areas of the project
- Scheduling of Construction Activities

Commercial Sequence of Soil Disturbing Activities		
Activity	Start	Finish
1. Installation of Sediment Controls Around the Perimeter	Days 0-5	
2. Site Preparation-Mobilization	Days 5-10	
3. Clearing and Grading	Days 10-25	
4. Excavate and Install Utilities	Days 25-40	
5. Pour Slab	Days 40-65	
6. Construction of Structure	Days 65-141	
7. Stabilize Site/Completion	Days 140-180	
8. Remove Temporary BMPs	Days 180-182	

Components of the Plan

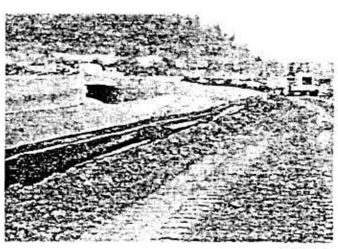
- ◈ Best Management Practices (BMPs)



7

Categories of BMPs

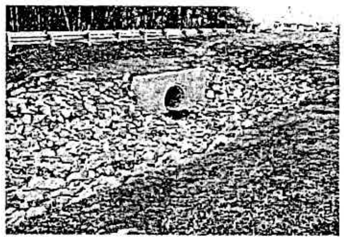
- ◈ Site Planning and Management
  - Training/scheduling
- ◈ Erosion Control BMPs
- ◈ Sediment Control BMPs

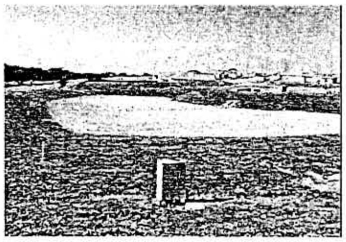


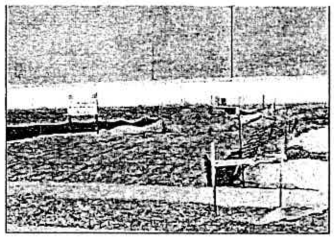
8

Categories of BMPs

- Runoff Control BMPs
- Good Housekeeping/ Materials Management BMPs
- Post Construction BMPs







9

Amendments

- Changes in area of disturbance
- Inadequate or additional BMPs
- Other identified pollutants
- Changes in drainage areas
- Post construction BMP changes

10

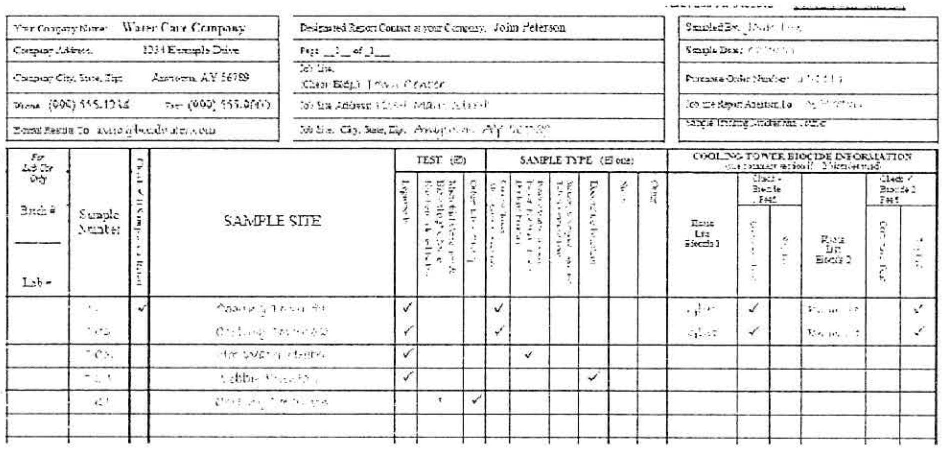
Inspections

- Inspector Qualifications or Credentials
- Inspection Report Form
- Inspection Frequency

11

Monitoring/Sampling and Analysis

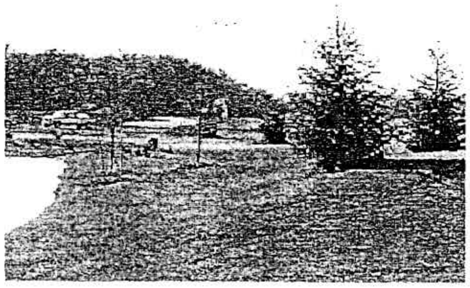
Chain of Custody


Your Company Name: Water Care Company
Company Address: 1234 Example Drive
Company City, State, Zip: Anytown, AY 56789
Phone: (000) 555-1234
Email Results To:
Designated Report Contact at your Company: John Peterson
Page 1 of 1
Job Site Address:
Job Site City, State, Zip:
Sampled By:
Sample Date:
Purchase Order Number:
TEST
SAMPLE TYPE
COOLING TOWER BIOCIDE INFORMATION
For Lab Use Only
Batch #
Lab #
Sample Number
SAMPLE SITE

12

Termination of Coverage

- Final Stabilization
- Transfer of Coverage



13

Termination of Coverage

Notice of Termination (NOT)

State of California
State Water Resources Control Board

NOTICE OF TERMINATION

OF COVERAGE UNDER THE NPDES GENERAL PERMIT NO. CAS000002
FOR DISCHARGES OF STORM WATER
ASSOCIATED WITH CONSTRUCTION ACTIVITY

Submission of this Notice of Termination constitutes notice that the owner (and his/her agent) of the site identified on this form is no longer authorized to discharge storm water associated with construction activity by NPDES General Permit No. CAS000002.

I. WDID NO.

II. OWNER

COMPANY NAME CONTACT PERSON

STREET ADDRESS TITLE

CITY STATE ZIP PHONE

14

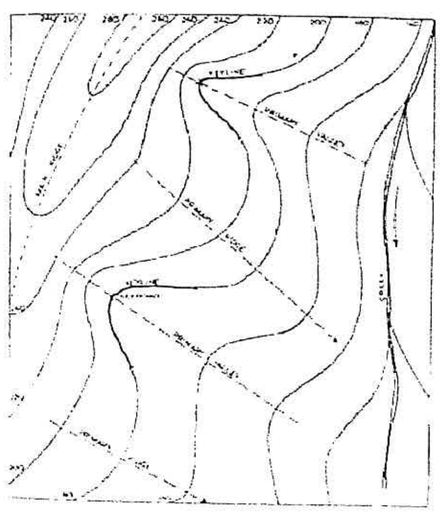
Drawing and Maps

- Existing features
- Future improvements or changes
  - How changes will be made

15

Drawing and Maps

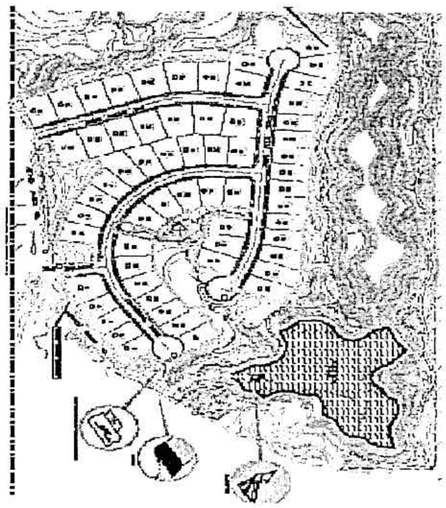
- Topography
- Final Grade topography
- Location of BMPs



16

Drawing and Maps

- Ground features
  - Terrain variations
  - Heights of natural features
  - Existing vegetative cover
  - Water features



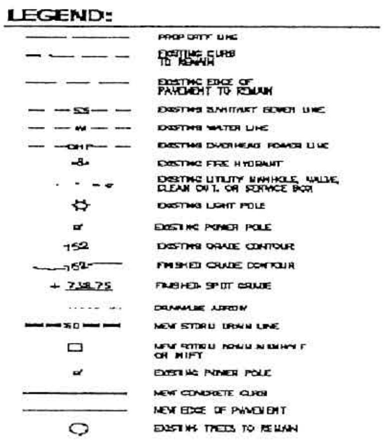
17

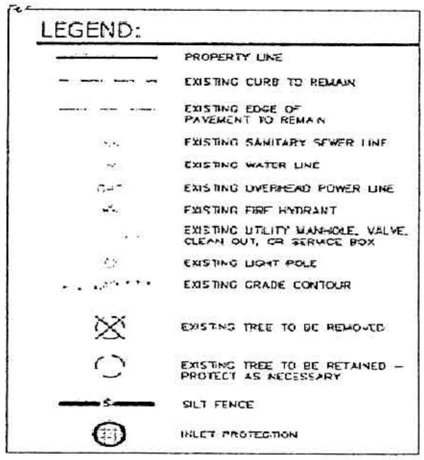
Drawing and Maps

The finest map available is worthless unless the Inspector knows how to read and interpret them.

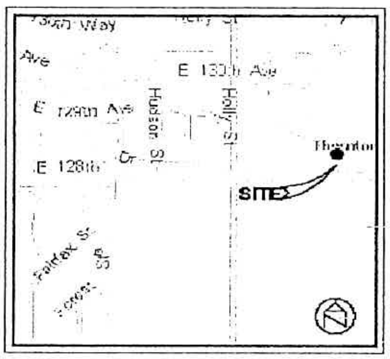
18

Map-Legend

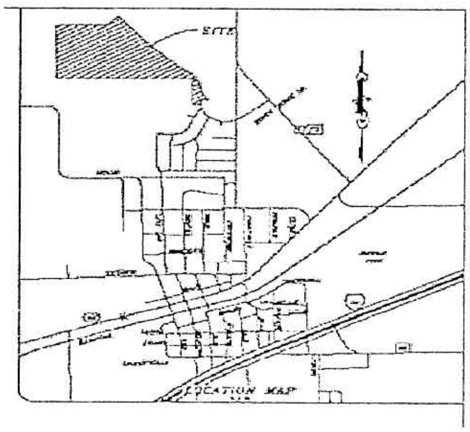




Vicinity Map



VICINITY MAP
NOT TO SCALE

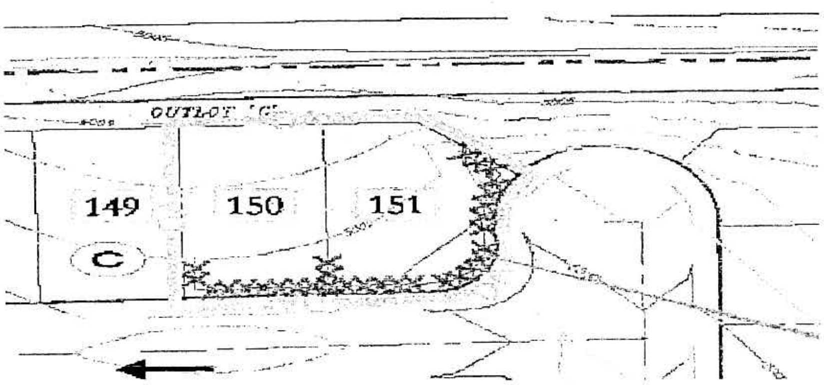


Total Site Area

21

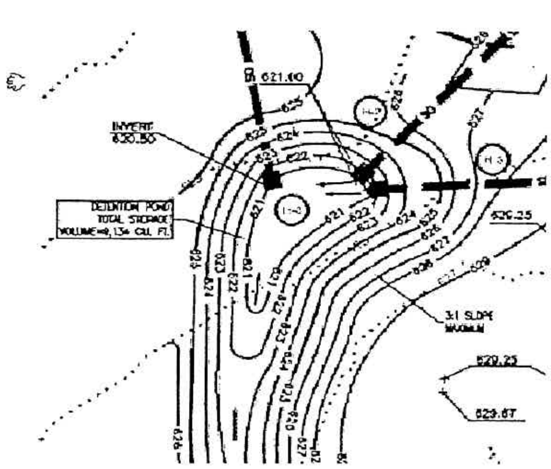
Areas of Disturbance

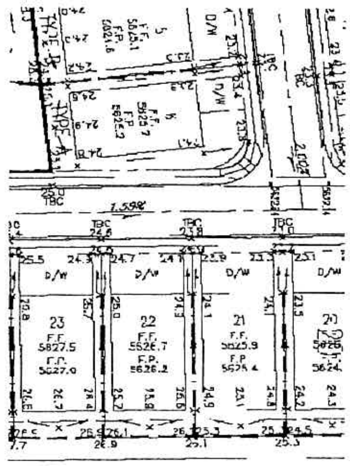
AREA OF DISTURBED SOIL
(AREA OF DISTURBANCE)



22

Elevation & Slope

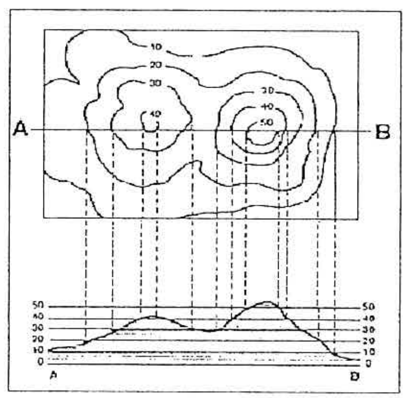




23

Type of Slope

- Slope features
- Slope measurements
- Rise over run
- Slope percentage
- Slope degrees

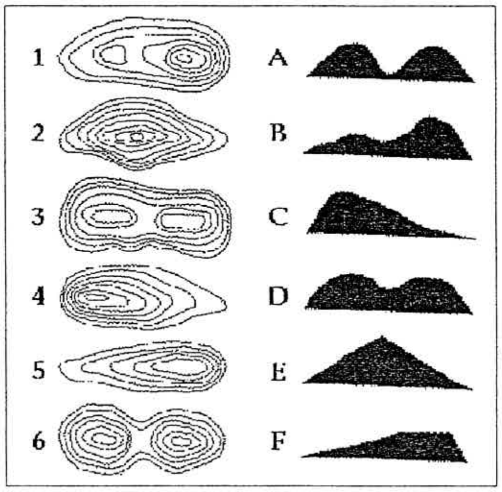


24

Type of Slope

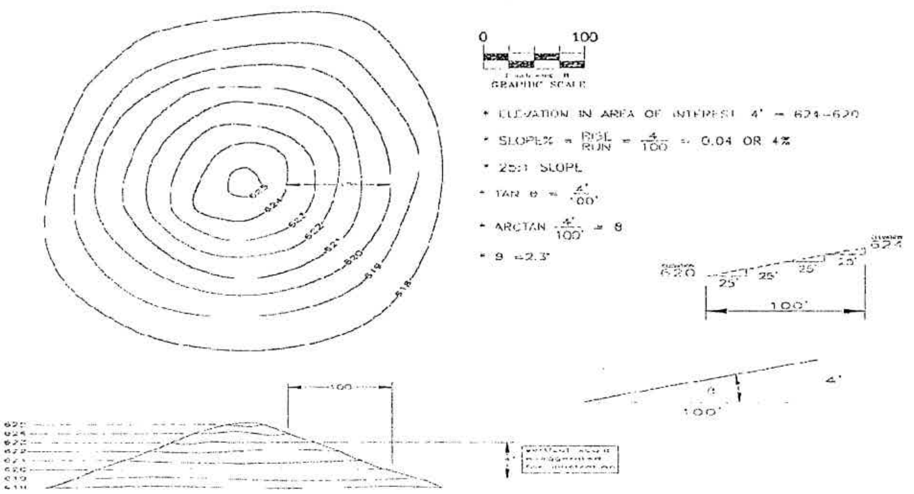
- Slope Features

Which contour corresponds to which profile?



25

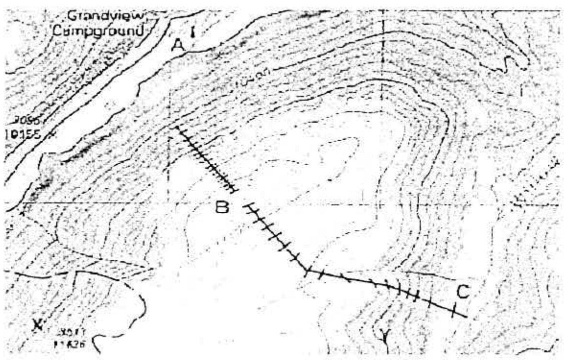
- Slope Measurements



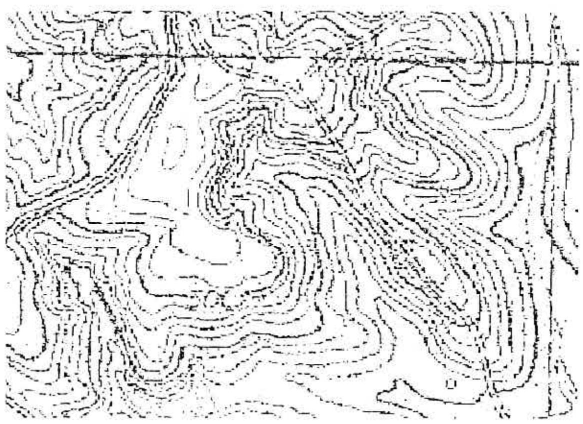
26

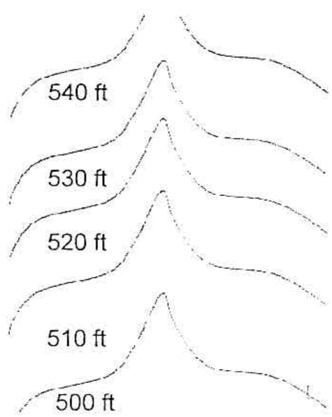
Direction of Sheet Flow

- Flow is always perpendicular to the contour lines

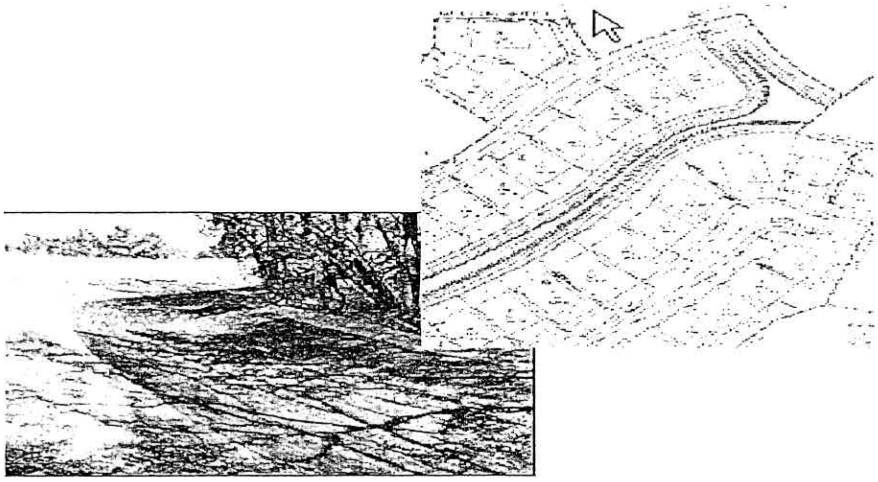


Direction of Concentrated Flow



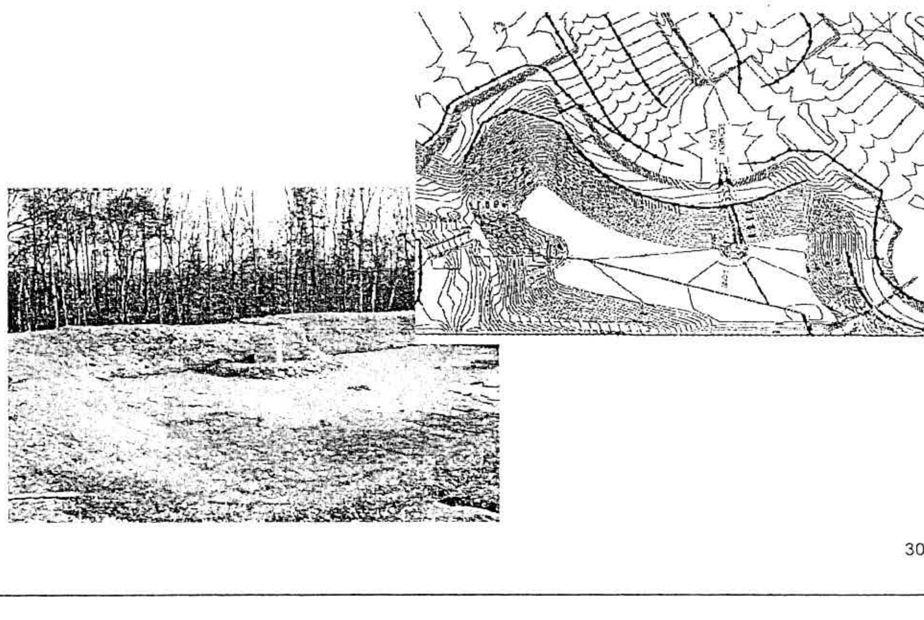


Drainage Channels



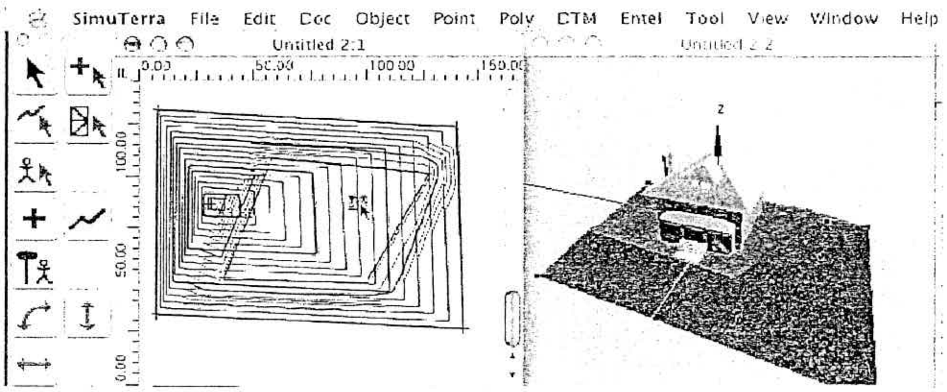
29

Detention/Retention Facilities



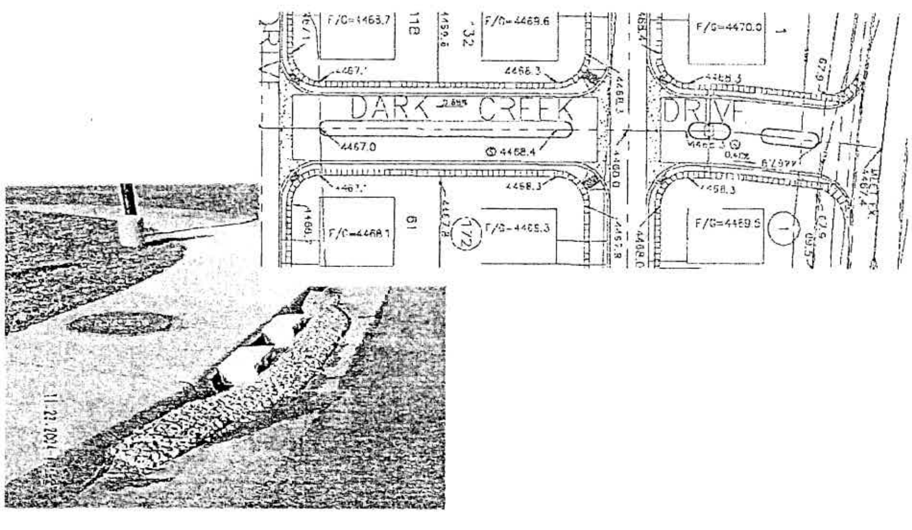
30

Building Pads and Other Foundations



31

Streets & Roads



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North Arrow

1 Inch = 50 feet
1:600
GRAPHIC SCALE

33

ESCP - SOIL LOSS ESTIMATION

MAJOR PURPOSE OF SOIL-LOSS EQUATIONS

To guide in making methodical decisions in soil conservation planning.

The equation enables the planner to predict the average rate of erosion for various combinations of management techniques on a site.

Soil loss estimation is a set of management strategies for prevention of soil being eroded from the earth's surface or becoming chemically altered by overuse, acidification, salinization or other chemical soil contamination

2

APPLICATION OF SOIL LOSS IN CIVIL CONSTRUCTION

In civil construction projects, soil loss estimation is used for the following activities :

- Assessment of the potential erosion hazard associated with the given project
- Identification of high risk construction projects during the planning and/or design phase
- The sizing of the "sediment storage volume" of *Sediment Basins*
- Assessment of the relative performance of alternative soil conservation practices, Erosion and Sediment Control procedures or construction programs

3

SOIL LOSS

The amount of eroded soil that is delivered to a point in the watershed that is remote from the origin of the detached soil particles.

4

SOIL LOSS

In a watershed, soil loss includes the erosion from slopes, channels, and mass wasting, minus the sediment that is deposited after it is eroded but before it reaches the point of interest.

5

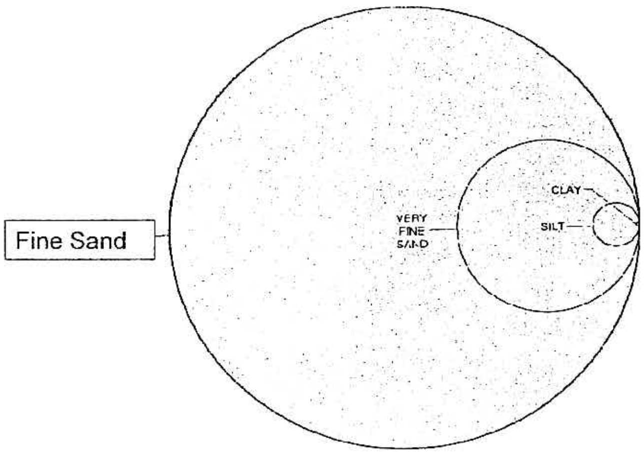
SOIL PHYSICAL PROPERTIES

Separate	Diameter (mm)	Comparison	Feel
Very coarse sand	2.00-1.00	36"	Grains easily seen, sharp, gritty
Coarse sand	1.00-0.50	18"	
Medium sand	0.50-0.25	9"	
Fine sand	0.25-0.10	4 1/2"	Gritty, each grain barely visible
Very fine sand	0.10-0.05	1 3/4"	
Silt	0.05-0.002	7/16"	Grains invisible to eye, silky to touch
Clay	<0.002	1/32"	Sticky when wet, dry pellets hard, harsh

SOIL SEPARATES

6

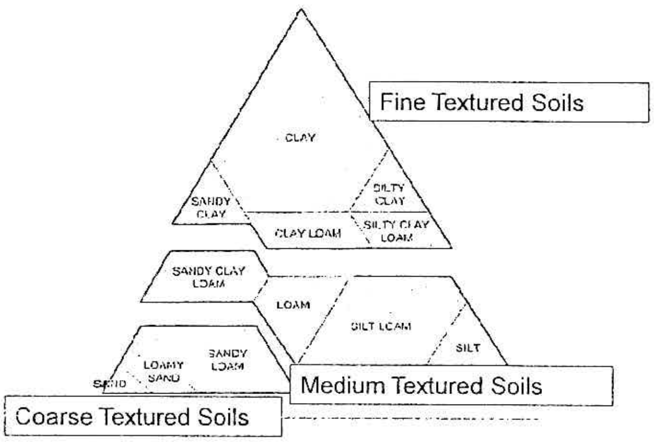
SOIL PHYSICAL PROPERTIES



RELATIVE SIZES OF SOIL SEPARATES

7

SOIL PHYSICAL PROPERTIES



SOIL TEXTURE

8

PREDICTION EQUATIONS

- 'UNIVERSAL' SOIL LOSS EQUATION (USLE)
- REVISED USLE
- MODIFIED USLE

9

UNIVERSAL SOIL LOSS EQUATION (USLE)

10

WHAT DOES *USLE* DO ?

- Compute average annual soil loss caused by sheet and rill erosion
- Applies to overland flow on slopes
- Computes sediment yield from slope
- Computes deposition on slope
- Computes soil particles

11

HOW IS *USLE* USED?

- Tool for conservation planning
  - Assess BMP effectiveness
  - Assess performance goals
  - Achieve sustainable use of soil resource
  - Prevent excessive sedimentation
  - Prevent degradation of water quality
- Not for water quality enforcement

12

WHAT KIND OF LAND ?

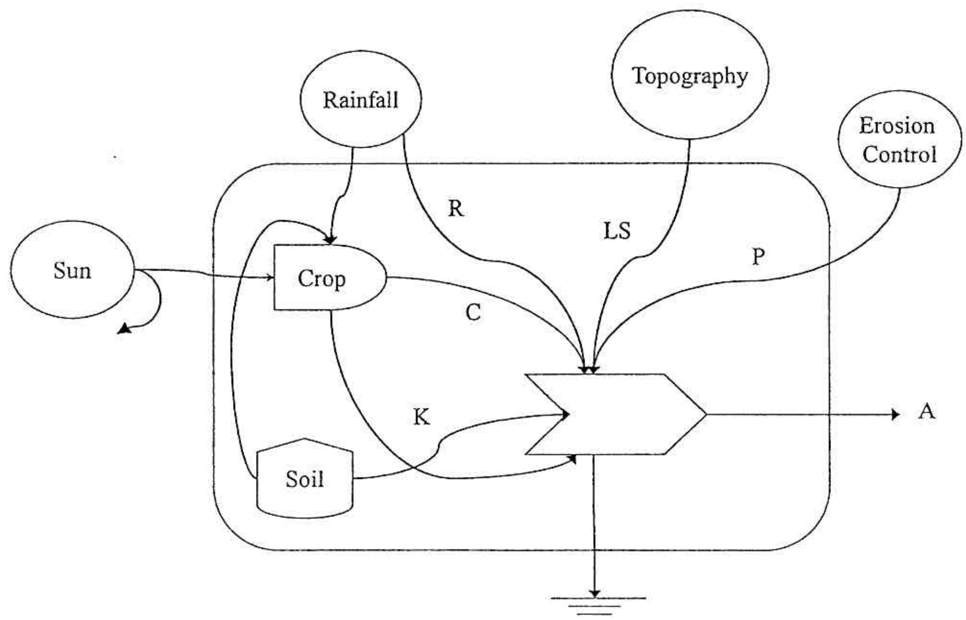
- Cropland
- Construction sites
- Disturbed forestland
- Rangelands
- Surface mined land
- Reclaimed land
- Landfills

13

WHY IS *USLE* WIDELY USED ?

- Easy to understand and use
- Minimal resources
- Input values readily available
- Independent of land use
- Vast experience (50 years)

14



Model of USLE Equation

15

WHAT FACTORS DOES *USLE* CONSIDER ?

- A = Average annual Soil Erosion Loss (t/ha/yr)
- R = Rainfall Erosivity Factor (MJ.mm/(ha.hr.yr))
- K = Soil Erodibility Factor (t.ha.hr/(ha.MJ.mm))
- L = Slope Length Factor
- S = Slope Steepness Factor
- C = Cover and Management Factor
- P = Conservation Practice Factor

A	=	RKLSCP

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RAINFALL EROSIVITY R FACTOR

- The rainfall erosivity index, *R* is calculated from Equation as shown below:
- $$R = \frac{1}{n}\sum_{j=1}^{n}\left[\sum_{k=1}^{m}(E)(I_{30})_k\right]$$
- The total storm kinetic energy for each storm, *E* is obtained by summation of the product of unit kinetic energy and the respective rainfall volume of all the increments in a rainfall event, as given below:
- $$E = \sum_{r=1}^{k} e_r V_r$$
- Where,
- *E* - total storm kinetic energy
- *K* - number of storm intervals
- *R* - index number of storm intervals
- e_r - unit kinetic energy for the r^{th} interval
- V_r - total rainfall depth for r^{th} interval

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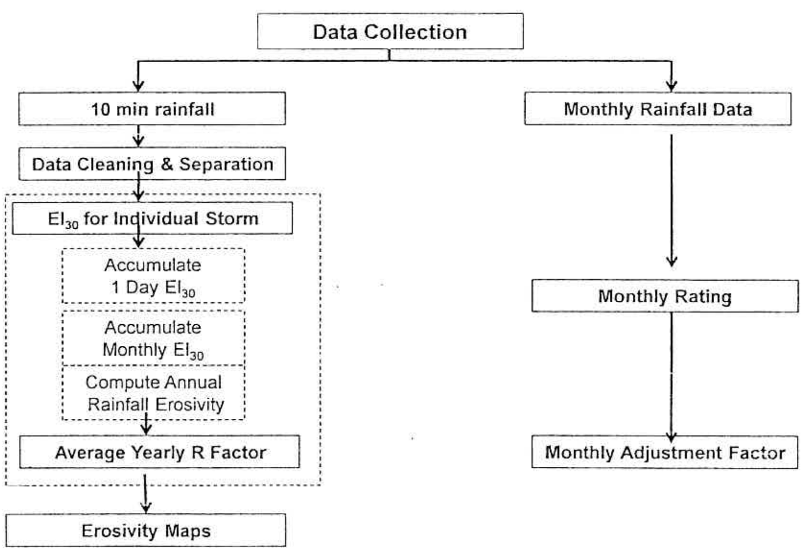
RAINFALL EROSIVITY ANALYSIS



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RAINFALL EROSIVITY R FACTOR

Creating Isoerodent Map of Ranfall Erosivity

- Isoerodent Maps for R factor are generated using Geographical Information System.
- GIS tool is used to spatially interpolate the results of R factor and to convert point form result (rain gauge) into raster form, which will cover the entire peninsula.
- The method used for this interpolation is kriging.
- Kriging is based on statistical models that include autocorrelation—that is, the statistical relationships among the measured points.

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RAINFALL EROSIVITY R FACTOR

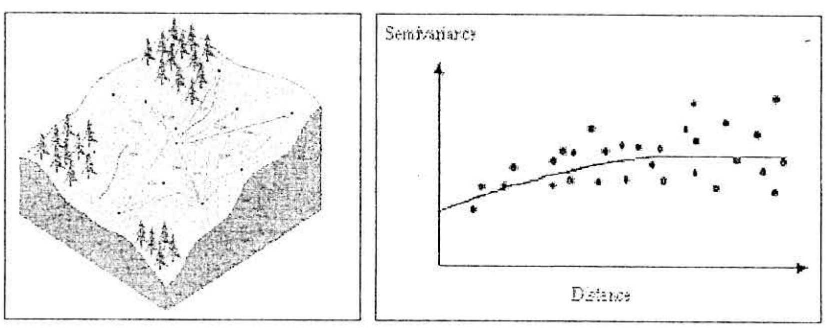

Figure : The concept of Geostatistical Kriging Method

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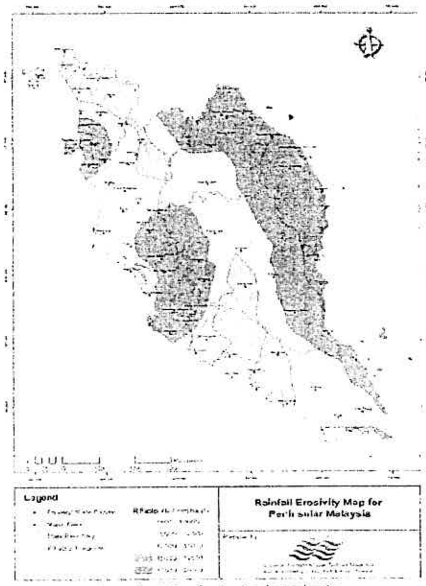
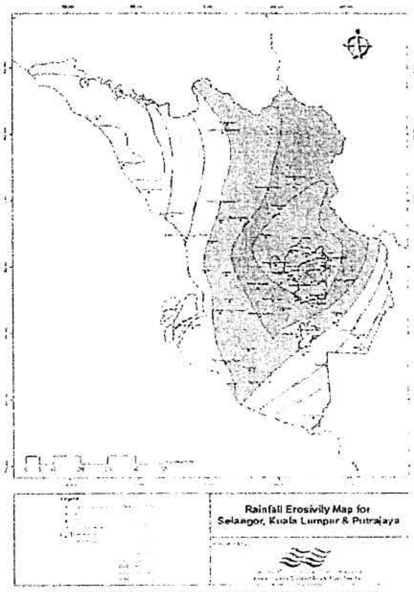
ISOERODENT MAP, R FACTOR

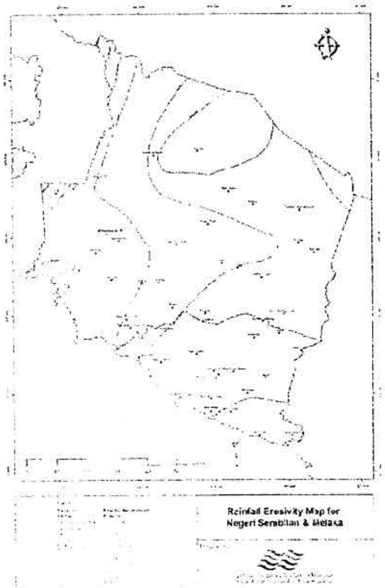


Isoerodent Map for Peninsular Malaysia

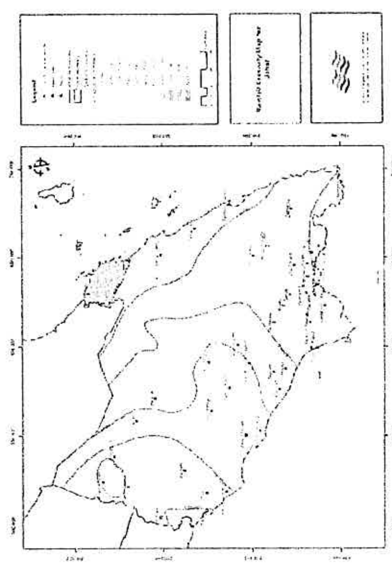


Isoerodent Map for Selangor State, Kuala Lumpur F.T., & Putrajaya F.T.

ISOERODENT MAP, R FACTOR

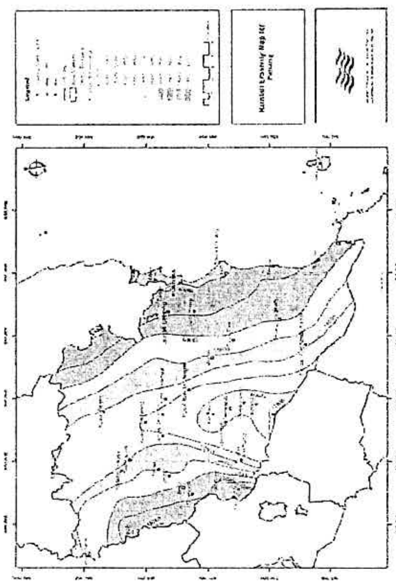


Isoerodent Map for Negeri Sembilan & Melaka States

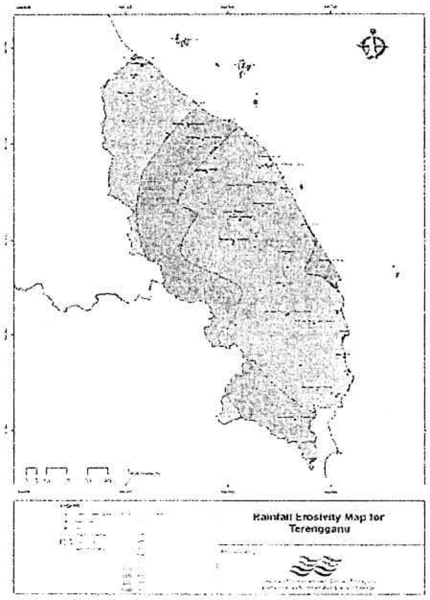


Isoerodent Map for Johor States

ISOERODENT MAP, R FACTOR



Isoerodent Map for Pahang States



Isoerodent Map for Terengganu State.

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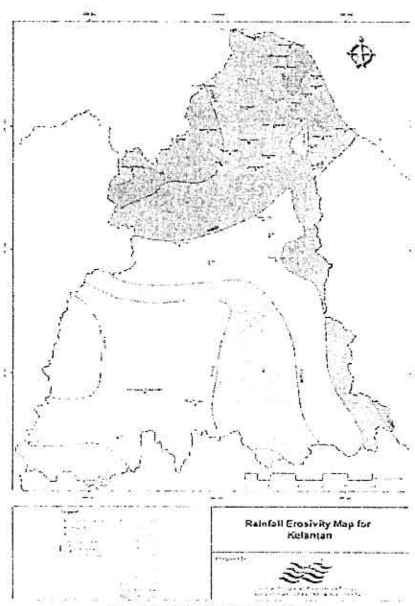
ISOERODENT MAP, R FACTOR



Isoerodent Map for Kelantan State

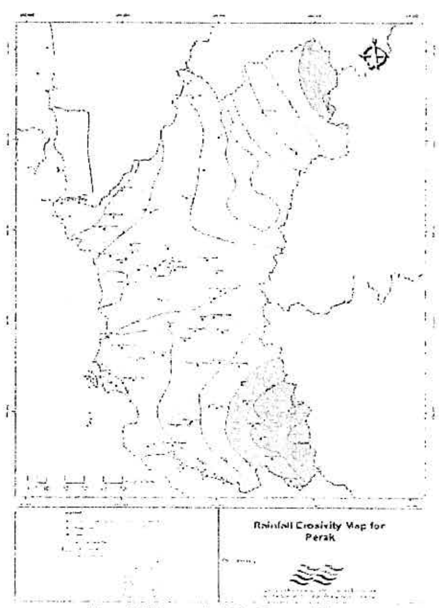


Figure 3.16: Isoerodent Map for Perak State

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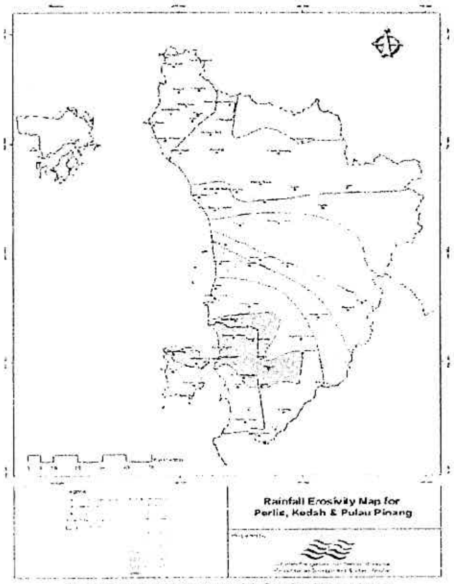
ISOERODENT MAP, R FACTOR



Isoerodent Map for Perlis, Kedah & Pulau Pinang States.

25

Soil Erodibility Factor, K

- The K factor can also be determined using Nomograph.
- The nomograph has been derived from the following equation (Tew,1999)

$$100K = 1.0M^{1.14}(10^{-4})(12-a) + 4.5(b-3) + 8.0(c-2)$$

Where;

M = (% silt + % very fine sand) x (100% clay)

a = % organic matter

b = soil structure code

c = permeability class

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Soil Erodibility Factor, K

- The soil-erodibility factor, K is the rate of soil loss per unit of rainfall erosivity factor R or EI_{30} for a specified soil.
- It is measured on a unit plot, which is a 22.1m length of uniform 9% slope continuously in clean tilled fallow.
- The K factor has unit of mass per area per erosivity unit.
- The soil-erodibility are affected are
  - i) physical features of the soil
  - ii) topographic features
  - iii) land management

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SOIL ERODIBILITY, K FACTOR

- Soil erodibility, K defines the resistance of the soil to both detachment and transport.
- It is an important index to measure soil susceptibility to water erosion, and an essential parameter needed for soil erosion prediction.
- The soil-erodibility factor (K) represents the effect of soil properties and soil profile characteristics such as soil texture, aggregate stability, shear strength, infiltration capacity, organic and chemical content on soil loss.

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SOIL ERODIBILITY, K FACTOR

Determination of Soil Properties

Soil properties including soil permeability (p), soil structure code (s) and related parameters are not available in the soil survey data provided, but necessary in the equations available for K factor.

Table :Soil Layer for Soil Series in Malaysia

Soil Layer	Soil Layer Texture	Soil Layer Depth (m)
A	Surface soil	0.00 – 0.50
B	Subsoil	0.51 – 1.00
C	Substratum	1.01 – 1.50

29

SOIL ERODIBILITY, K FACTOR

i) Determination of *M* Value

The *M* value, which represents for silt, very fine sand and clay content, in Tew Equation can be obtained from particle size distribution of the soil from test of wet or dry sieving analysis in according to BS 1377: Part 2, 1990.

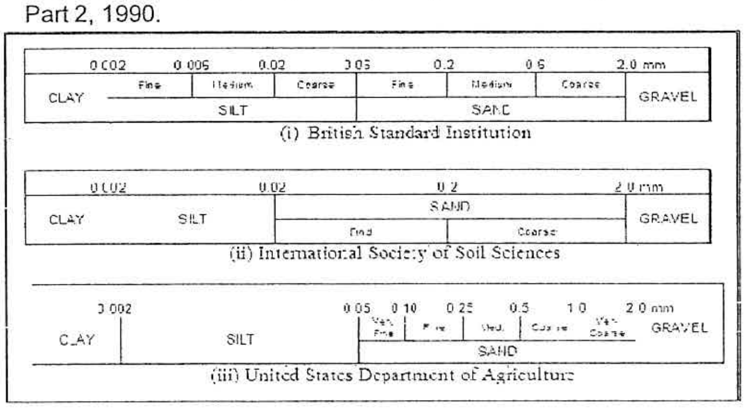

Figure : Soil Classification Standards

30

SOIL ERODIBILITY, K FACTOR

Soil Name	: Linau Series.
Classification: USDA	Typic Sulfaquent.
FAO	: Thionic Fluvisol.
Date	: 21.1.1976.
Described by	Dr. S. Paramananthan, S.W. Soo, A.K. Rao.
Location	Simpang Tiga, Kuala Kurau, Perak, Peninsular Malaysia.
Landform	Flat coastal plain.
Elevation	3 - 4 feet a.s.l.
Slope	0 – 1%
Landuse	Irrigated rice.
Parent Material	Marine alluvium.
Drainage	Somewhat very poorly drained.

Profile Description

A_1 0 – 50cm

Dark brown (7,5YR 3/2) wet; clay loam; massive non sticky, abundant fine roots, clear boundary.

AC 50 – 90cm

Brown (10YR 5/3) wet; clay; massive; slightly sticky, many pieces of decaying wood present; abrupt boundary.

BC_G 90 – 130cm

Dark greenish grey (5BG 4/1) wet; silt loam massive non sticky, many fine roots

Note : Symbol "G" after Kano (1962).

Figure : Soil Survey Data Sheet for Malaysia Soil Series (Source: DOA, Malaysia)

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SOIL ERODIBILITY, K FACTOR

iii)Determination of *s* Value – Soil Structure Code

- Three broad and fundamental s groups of soil structure are recognized as sands, loams and clays.
- In determination of the soil structure codes for soil series in Malaysia, the textural triangle as shown in Figure below which is identical to the Soil Textural Pyramid produces by USGS can be used by drawing horizontal and vertical lines corresponding to the percentage of clay and sand fraction.
- The value of soil structure code, can be determine from the intersection point of both lines

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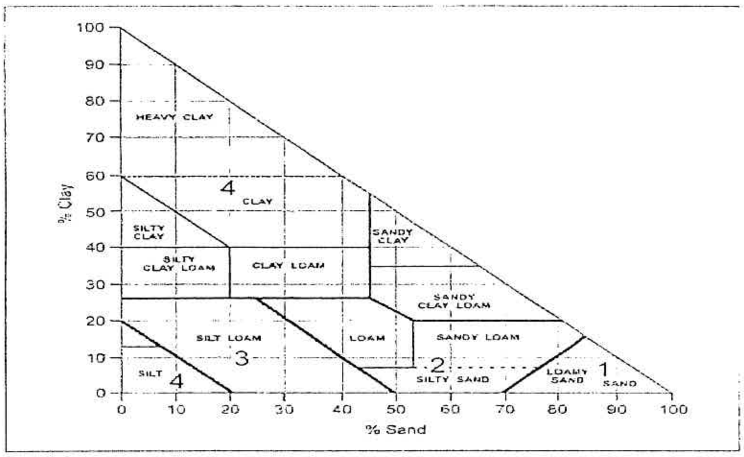
Soil Structure Code



Soil Structure Code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

SOIL ERODIBILITY, K FACTOR

iv)Determination of *p* Value – Permeability Code

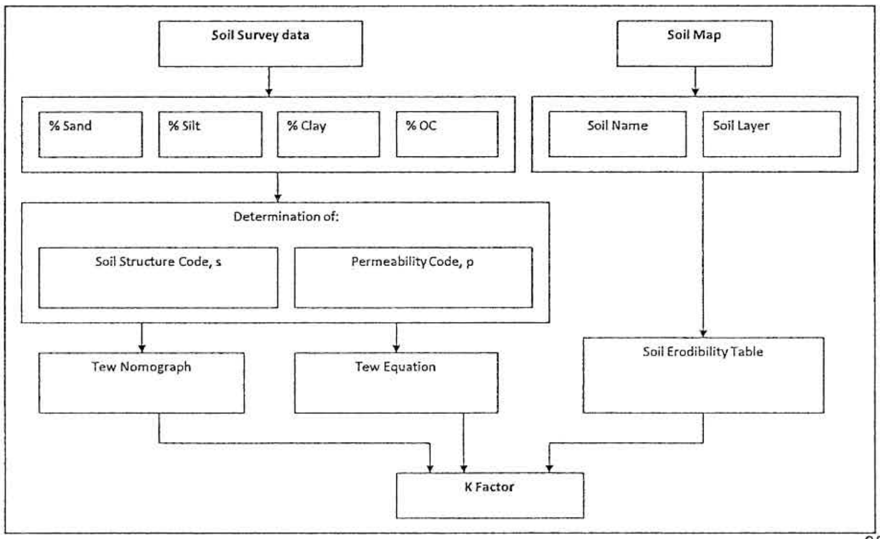
- Permeability of a soil is a measure of the properties in which a particular fluid flows through its voids. Soils permeability is differ from each type and roughly correlated with its grain size distribution or soil texture.

Table : Soil permeability code based on soil texture class

Soil Texture	Permeability Code[1]	Hydrologic Soil Group[2]
Heavy clay, Clay	6	D
Silty clay loam, clay	5	C-D
Sandy clay loam, Clay loam	4	C
Loam, Silt loam	3	B
Loamy sand, loam	2	A
Sand	1	A+

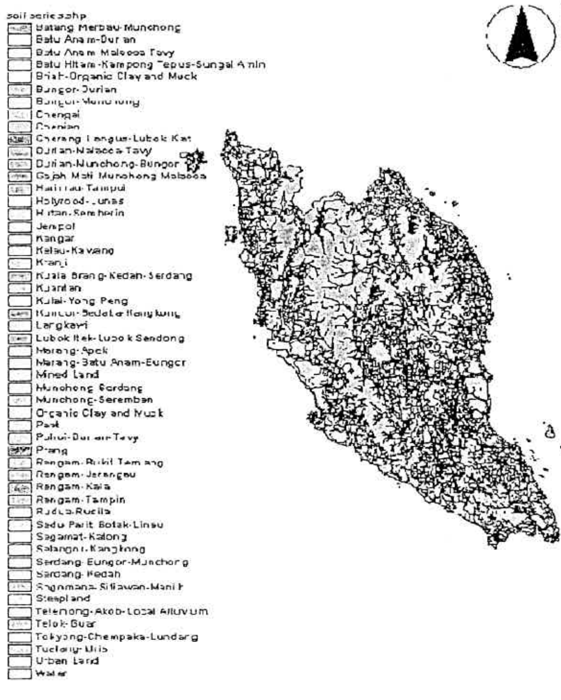
1 – National Soil Handbook (USDA, 1983)
2 – National Engineering Handbook (USDA, 1972)

SOIL ERODIBILITY, K FACTOR



35

Soil Map



Soil map for Peninsular Malaysia (Source: DOA)

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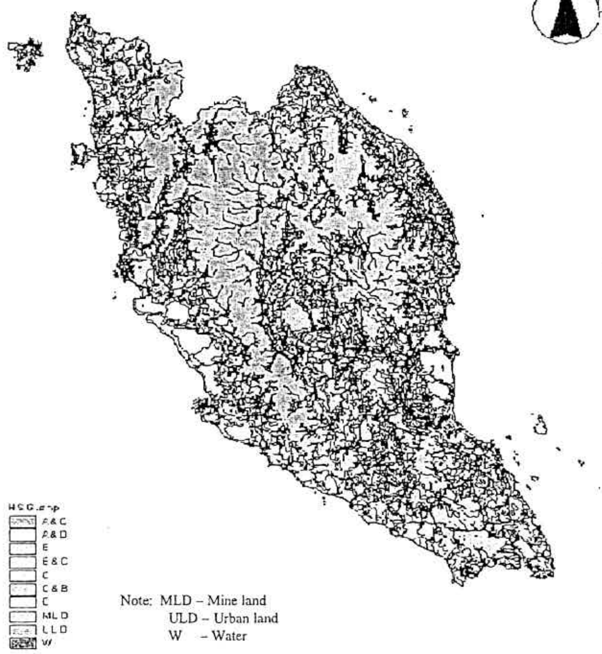
Soil Map



Hydrologic soil map for Peninsular Malaysia (Source: DOA)

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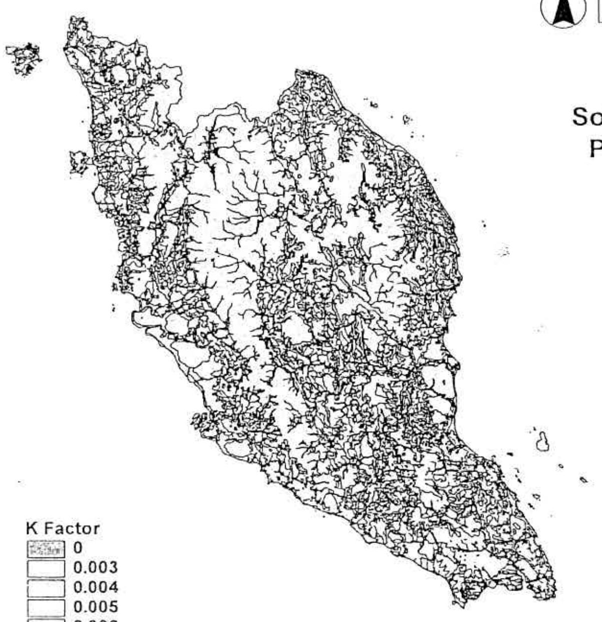
Soil Map



Soil erodibility map for Peninsular Malaysia (Source: DOA)

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Table : Soil erodibility factors (K) for Malaysia soil series

Bil.	Series	Layers	K Factor	Texture	HSG
1	Akob	A	0.053	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
2	Apek	A	0.045	clay loam	C
		B	0.055	clay loam	C
		C	0.062	clay	D
3	Batu Anam	A	0.056	clay	D
		B	0.057	clay	D
		C	0.051	clay	D
4	Batu Hitam	A	0.060	clay	D
		B	0.063	clay	D
		C	0.063	clay	D
5	Batu lapan	A	0.045	clay loam	C
		B	0.049	clay laom	C
		C	0.060	clay	D
6	Bukit Temiang	A	0.029	sandy clay loam	C
		B	0.038	sandy clay	C-D
		C	0.035	sandy clay loam	C
7	Beriah	A	0.053	clay	D
		B	0.057	clay	D
		C	0.057	clay	D
8	Bungor	A	0.036	sandy clay loam	C
		B	0.053	clay	D
		C	0.054	clay	D

Bil.	Series	Layers	K Factor	Texture	HSG
9	Clay Over Organic	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
10	Chat	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
11	Chempaka	A	0.049	clay loam	C
		B	0.049	clay loam	C
		C	0.045	clay loam	C
12	Chengai	A	0.049	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
13	Chenian	A	0.056	clay	D
		B	0.058	clay	D
		C	0.060	clay	D
14	Durian	A	0.053	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
15	Guar	A	0.052	clay	D
		B	0.052	clay	D
		C	0.053	clay	D
16	Halu	A	0.051	sandy clay loam	C
		B	0.058	sandy clay loam	C
		C	0.051	sandy clay loam	C

Bil.	Series	Layers	K Factor	Texture	HSG
33	Klau	A	0.041	sandy clay	C-D
		B	0.048	clay	D
		C	0.052	clay	D
34	Kranji	A	0.051	clay	D
		B	0.050	clay	D
		C	0.048	clay	D
35	Kundor	A	0.053	clay	D
		B	0.053	clay	D
		C	0.055	clay	D
36	Kuala Perlis	A	0.047	clay	D
		B	0.046	clay	D
		C	0.046	clay	D
37	Kuala Brang	A	0.035	sandy clay loam	C-D
		B	0.034	sandy clay loam	C-D
		C	0.029	sandy clay loam	C-D
38	Linau	A	0.029	sandy clay loam	C-D
		B	0.044	clay	D
		C	0.032	silt loam	B
39	Linau 1	A	0.030	sandy clay loam	C
		B	0.042	clay	D
		C	0.045	clay	D
40	Lubok Itek	A	0.045	clay	D
		B	0.030	clay loam	C
		C	0.028	sandy clay loam	C

Bil.	Series	Layers	K Factor	Texture	HSG
41	Lubok Kiat	A	0.060	clay	D
		B	0.063	clay	D
		C	0.063	clay	D
42	Lunas1	A	0.028	sandy loam	A
		B	0.036	sandy clay loam	C
		C	0.039	sandy clay	C-D
43	Lundang1	A	0.046	clay loam	C
		B	0.045	clay loam	C
		C	0.045	clay loam	C
44	Manik	A	0.035	sandy clay loam	C
		B	0.042	clay	D
		C	0.042	clay	D
45	Malacca	A	0.049	clay	D
		B	0.052	clay	D
		C	0.052	clay	D
46	Marang	A	0.046	clay loam	C
		B	0.044	clay loam	C
		C	0.044	clay loam	C
47	Marang1	A	0.036	sandy loam	A
		B	0.040	sandy clay loam	C
		C	0.051	clay	D
48	Munchong	A	0.039	sandy clay	C-D
		B	0.039	sandy clay	C-D
		C	0.039	sandy clay	C-D

Bil.	Series	Layers	K Factor	Texture	HSG
49	Munchong1	A	0.054	clay	D
		B	0.052	clay	D
		C	0.052	clay	D
50	Munchong2	A	0.038	sandy clay	C-D
		B	0.052	clay	D
		C	0.052	clay	D
51	Organic Clay	A	0.050	clay	D
		B	0.035	clay	D
		C	0.032	silty clay loam	C-D
52	Organic Clay1	A	0.045	clay	D
		B	0.049	clay	D
		C	0.050	clay	D
53	Rengam	A	0.038	clay	D
		B	0.046	clay	D
		C	0.053	clay	D
54	Rengam1	A	0.028	sandy clay loam	C
		B	0.032	sandy clay	C-D
		C	0.032	sandy clay	C-D
55	Rengam2	A	0.023	sandy clay loam	C
		B	0.031	sandy clay	C-D
		C	0.032	sandy clay	C-D
56	Rengam3	A	0.042	clay	D
		B	0.050	clay	D
		C	0.050	clay	D

Bil.	Series	Layers	K Factor	Texture	HSG
57	Rudua	A	0.027	silt loam	B
		B	0.017	silt loam	B
		C	0.017	silt loam	B
58	Rusila	A	0.013	silt loam	B
		B	0.015	silt loam	B
		C	0.014	silt loam	B
59	Rotan	A	0.052	clay	D
		B	0.050	clay	D
		C	0.052	clay	D
60	Sedu	A	0.040	clay loam	C
		B	0.046	clay	D
		C	0.046	clay	D
61	Selangor	A	0.055	clay	D
		B	0.060	clay	D
		C	0.043	sandy clay	C-D
62	Selangor1	A	0.051	clay	D
		B	0.053	clay	D
		C	0.053	clay	D
63	Sedaka	A	0.050	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
64	Sembrin	A	0.047	clay loam	C
		B	0.054	clay	D
		C	0.054	clay	D

41

Bil.	Series	Layers	K Factor	Texture	HSG
65	Serdang	A	0.036	sandy clay loam	C
		B	0.039	sandy clay loam	C
		C	0.042	sandy clay	C
66	Segamat	A	0.048	clay	D
		B	0.048	clay	D
		C	0.048	clay	D
67	Sitiawan	A	0.051	clay	D
		B	0.050	clay	D
		C	0.050	clay	D
68	Sogomana	A	0.050	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
69	Tavy	A	0.050	clay	D
		B	0.051	clay	D
		C	0.050	clay	D
70	Telemong	A	0.049	clay	D
		B	0.050	clay	D
		C	0.045	clay	D
71	Telok	A	0.051	clay	D
		B	0.051	clay	D
		C	0.051	clay	D
72	Telok1	A	0.045	clay	D
		B	0.049	clay	D
		C	0.054	clay	D

Bil.	Series	Layers	K Factor	Texture	HSG
73	Tok Yong	A	0.051	clay	D
		B	0.051	clay	D
		C	0.055	clay	D
74	Tualang1	A	0.052	clay	D
		B	0.054	clay	D
		C	0.055	clay	D

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Slope Length and Steepness Factor, LS

- The effects of slope length and steepness are usually combined into one single factor, namely LS factor, which can be computed by

$$LS = (\lambda/22.13)^m(0.065 + 0.046S + 0.0065S^2)$$

where

λ = slope length (m)

S = slope gradient in percent

m = 0.2 for $S<1\%$, 0.3 for $1\%<S<3\%$, 0.4 for $3\%<S<5\%$,

0.5 for $5\%<S<12\%$ and 0.6 for $S>12\%$

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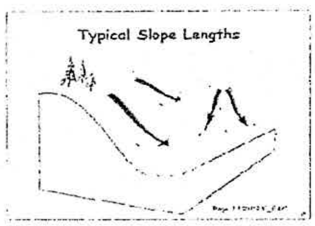

Slope-Length selection

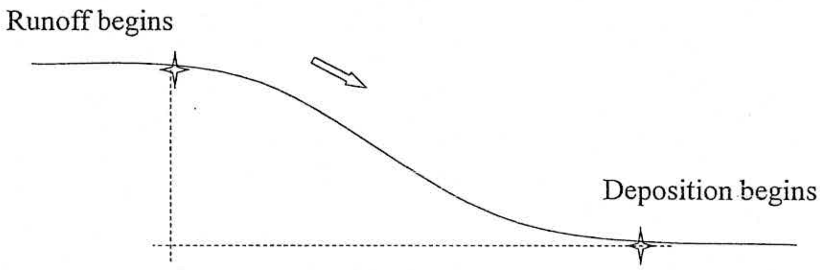

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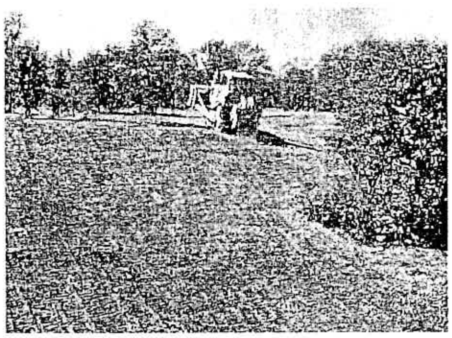
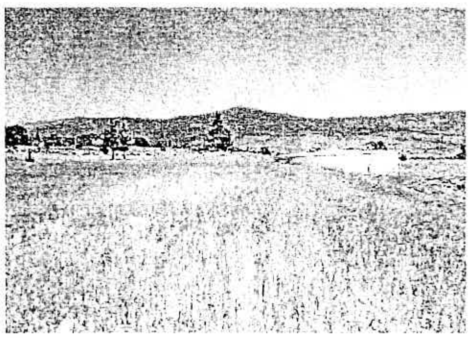
Table: LS calculated using MSMA approach

SLOPE			M	Slope Length in meters (λ)								
s(%)	S(o)	S(rad)		1.0	3.0	5.0	10.0	15.0	25.0	50.0	75.0	100.0
0.10	0.06	0.001	0.200	0.037	0.047	0.052	0.059	0.064	0.071	0.082	0.089	0.094
0.20	0.12	0.002	0.200	0.040	0.050	0.055	0.064	0.069	0.076	0.088	0.095	0.101
0.50	0.29	0.005	0.200	0.048	0.060	0.067	0.076	0.083	0.092	0.105	0.114	0.121
0.75	0.43	0.007	0.200	0.056	0.069	0.077	0.088	0.095	0.106	0.121	0.132	0.139
1.00	0.57	0.010	0.300	0.046	0.065	0.075	0.093	0.105	0.122	0.150	0.169	0.185
2.00	1.15	0.020	0.300	0.072	0.100	0.117	0.144	0.163	0.190	0.234	0.264	0.288
3.00	1.72	0.030	0.400	0.076	0.118	0.144	0.190	0.224	0.275	0.362	0.426	0.478
4.00	2.29	0.040	0.400	0.102	0.159	0.195	0.257	0.302	0.371	0.489	0.575	0.645
5.00	2.86	0.050	0.500	0.097	0.168	0.217	0.308	0.377	0.486	0.688	0.842	0.973
10.00	5.71	0.100	0.500	0.250	0.433	0.559	0.790	0.967	1.249	1.766	2.163	2.498
20.00	11.31	0.197	0.600	0.559	1.081	1.469	2.226	2.839	3.857	5.846	7.457	8.861
30.00	16.70	0.291	0.600	1.138	2.199	2.988	4.529	5.777	7.849	11.896	15.173	18.032
40.00	21.80	0.381	0.600	1.919	3.710	5.041	7.640	9.744	13.239	20.067	25.593	30.415
50.00	26.57	0.464	0.600	2.903	5.612	7.625	11.558	14.741	20.028	30.357	38.718	46.012
60.00	30.96	0.540	0.600	4.090	7.907	10.743	16.283	20.767	28.216	42.767	54.546	64.823
70.00	34.99	0.611	0.600	5.480	10.593	14.392	21.815	27.823	37.802	57.297	73.078	86.846

C & P factor





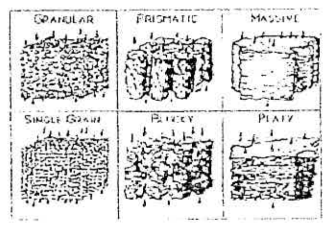
C Cover factor = The ratio of soil loss from an area with specific cover compared to bare soil conditions.

P Management practice factor = The ratio of soil loss for a given surface condition compared to a hill where plowing is perpendicular to contours.

Use C factor & P factor charts

Cover Management Factor, C

- The cover management factor is the ratio of soil loss from a field with given cropping and management practices to the loss from the fallow conditions used to evaluate the K factor.
- The factor C also depends upon a period of time within which weather effects would have varying influences.



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Conservation Practice Factor, P

- The conservation practice factor, P is the ratio of soil loss with one of these practices to the loss with straight-row farming up and down the slope.
- The factor P of USLE is a dimensionless supporting erosion control, which has a specific value for slope groups from 1.1 to 24% as shown in Table 4

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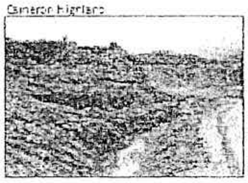
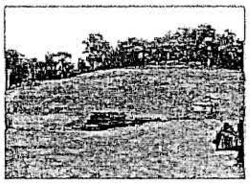
Typical C Factor Values

Table : Cover Management, C factor for BMPs at construction sites (Adapted from Layfield, 2009, Troeh et al., 1999, Mitchell and Bubenzer, 1980, ECTC, 2003, Israelsen et al. 1980, HDI, 1987; SCS, 1978; Wischmeier and Smith, 1978, Kuenstler, 2009;)

Erosion control treatment	C Factor	Figure
Bare soil / Newly clear land	1.00	Cameron Highland  
Cut and fill at construction site		 
Fill Packed, smooth	1.00	
Freshly disked	0.95	
Rough (offset disk)	0.85	
Cut Below root zone	0.80	

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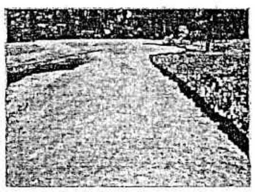
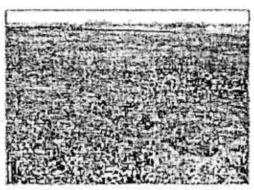
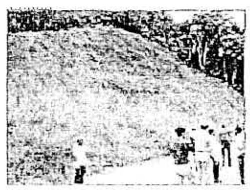
Typical C Factor Values

Mulch		 
plant fibers, stockpiled native materials/chipped		
50% cover	0.25	
75% cover	0.13	
100% cover	0.03	
Grass-seeding and sod		 
40% cover	0.10	
60% cover	0.05	
100% cover	0.02	

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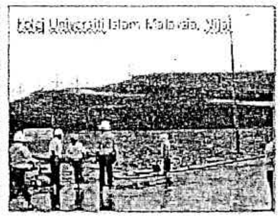
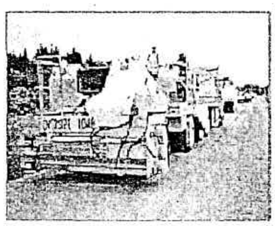
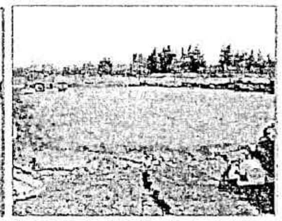
Typical C Factor Values

Turfing 40% cover 60% cover ≥90% cover	 0.10 0.05 0.02	 
Compacted gravel layer	[illegible]	 

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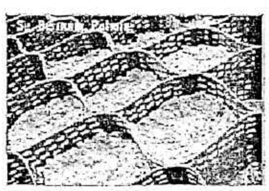
Typical C Factor Values

Table Cover Management, C factor for BMPs at construction sites (Adapted from Layfield, 2009, Tuoh et al., 1998, Mitchell and Bubenzer, 1980, ECTC, 2003, Israelsen et al. 1980; HDI, 1987; SCS, 1978, Walschmeier and Smith 1978; Kuenstler, 2009) (Continued)

Erosion control treatment	C Factor	Figure
Geo-cell	0.05	 
Rolled Erosion Control Product Erosion control blankets	 0.02	  [illegible] Damansara, Kuala Lumpur

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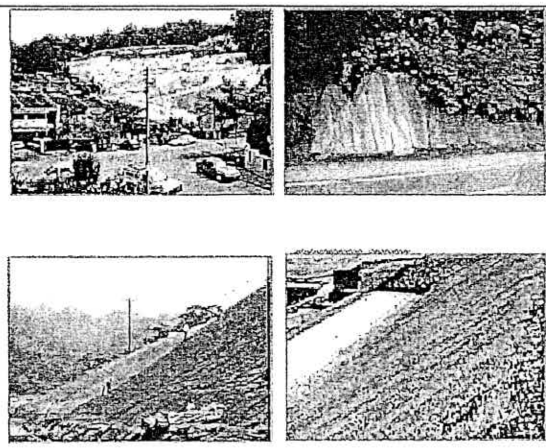
Typical C Factor Values

Plastic sheeting	0.02	
Turf reinforcement mats	0.02	

C – average runoff condition

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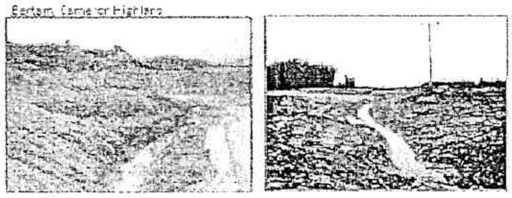
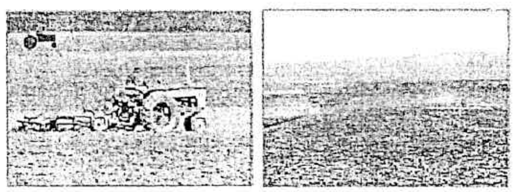
Typical P Factor Values

Table : Support Practice, P factor for BMPs at construction/ developing sites[1] (Adapted from Layfield, 2009; Troeh et al., 1998; Mitchell and Bubenzer, 1980, ECTC, 2003; Israelsen et al. 1980; HDI, 1987; SCS, 1978, Wischmeier and Smith, 1978; Kuenstler, 2009)

Erosion control treatment	P Factor	Figure
Bare soil	1.00	Bertam, Cameron Highlands 
Disked bare soil (rough or irregular surface)	0.90	

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Cropping and Management Practices factor (CP)

Land Cover	CP factor
Water body	0.000
Bareland (mining areas, newly cleared land, etc)	1.000
Horticultural	0.250
Permanent Cropland	0.150
Cropland	0.200
Rangeland	0.229
Grassland	0.015
Forest	0.010
Swamps	0.001
Residential	0.003
Impervious	0.005
Commercial	0.008
Construction	1.000

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Table 4 : Conservation Practice Factor (P) for Contouring and Terracing

Slope (%)	Conservation Practice (P) Values	
	Contouring	Terracing (Strip contour-cropping)
1.1 – 2.0	0.60	0.30
2.1 – 7.0	0.50	0.25
7.1 – 12.0	0.60	0.30
12.1 – 18.0	0.80	0.40
18.1 – 24.0	0.90	0.45

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LIMITATIONS OF THE *USLE*

- ☑ The USLE predicts the average soil loss.
- ☑ The USLE considers only sheet and rill erosion not gully erosion.
- ☑ The USLE does not calculate sediment deposition.

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STEP-BY-STEP PROCEDURE TO USE *USLE*

Step 1 : Determine the R factor

Step 2 : Determine the K value from the nomograph i.e based on the particle size distribution analysis of the soil sample.

Step 3 : Divide the area into sub-area of uniform slope gradient and length (LS).

Step 4 : Choose appropriate values C to represent the seasonal average of the effect of mulch and vegetation.

Step 5 : Use recommended values of P based on the erosion control practice being considered.

Step 6 : Evaluate the product of the five factors to obtain the soil loss per unit area.

Step 7 : Multiply the soil loss per unit area by the total basin area to obtain the total sediment volume.

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MODIFIED UNIVERSAL SOIL LOSS EQUATION (MUSLE)

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MUSLE EQUATION

$$Y = 89.6(VQ_p)^{0.56}(K.LS.C.P)$$

Where:

Y -Sediment yield per storm event (tones)
V - Runoff volume in cubic meters
Q_p - Peak discharge in m^3/s

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MUSLE EQUATION

V - Runoff volume in cubic meters

- V = Direct Runoff x Area

Q_p - Peak discharge in m^3/s

$$Q_y = \frac{C\,{}^{y}I_t A}{360}$$

Where,

Q_y - y year ARI peak flow (m^3/s).
C - Dimensionless runoff coefficient.
${}^{y}I_t$ - y year ARI rainfall intensity over t_c (mm/hr).
A - Catchment area (hectares)

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CN VALUES

Table : *CN* values factor for forested and undisturbed lands

Ground Conditions	*CN* value			
	A	B	C	D
Rangeland	59	74	82	86
Forest[2]				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Bushes				
<50% cover	54	72	81	86
50 to 75% cover	63	77	85	88
>75% cover	55	66	80	87
Grassland				
< 50% cover	68	79	86	89
50 to 75 % cover	49	69	79	84
>75% cover	39	61	74	80
Swamps/ mangrove	77	80	83	86
Water body	100	100	100	100

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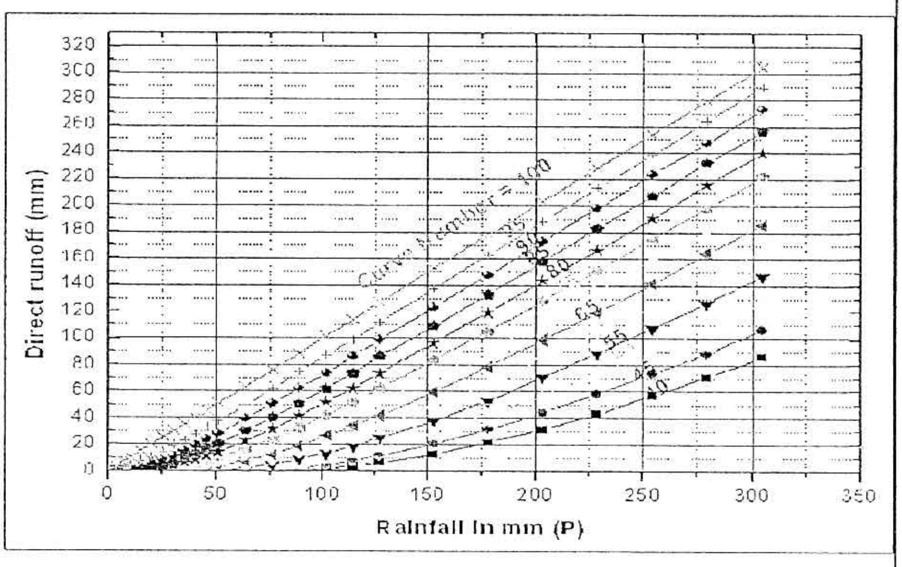
CN VALUES

Table : *CN* factor for agricultural and urbanized areas

	CN values			
	A	B	C	D
Rubber	64	74	81	85
Oil palm	50	66	80	87
	64	74	81	85
Coconut	71	80	87	90
Horticulture	62	70	78	81
Paddy	64 **Conditions** 86	75	83	**Ground**
Mining areas	68	79	86	89
Bare land/ Newly Graded land	71	86	91	94
Impervious (Pavement, Roof etc)	98	98	98	98
Established Urban Areas: (including Residential, Commercial, Educational and Industrial)				
Low density (50% green area)	57	72	81	86
Medium density (25% green area)	77	85	90	92
High density (5% green area)	89	92	94	95

1 - average runoff condition

RAINFALL-RUNOFF CHART



EXAMPLES

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Location: Blue Valley Estate Ulu Telom

Cameron Highlands

Area Plot 1	=	38500	
Area Plot 2	=	47750	
Total Catchment area		=	86250 m2
		=	8.62 ha

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1.How to determine R

- Using Isoerodent Map for Pahang State
  R = 15000 MJ.mm/ha.yr

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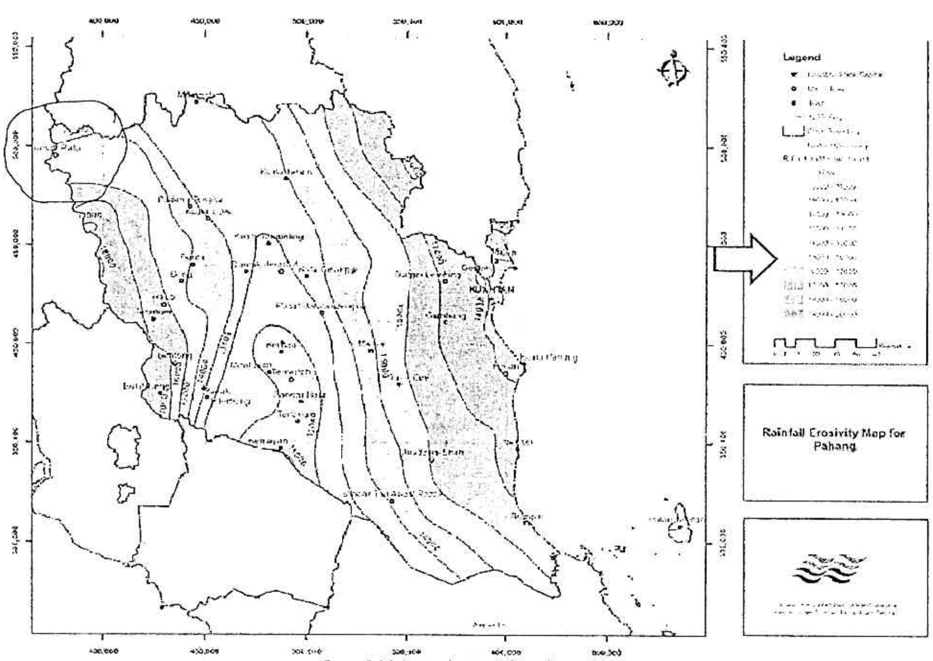

Figure 3.13: Isoerodent Map for Pahang State

1.How to determine K

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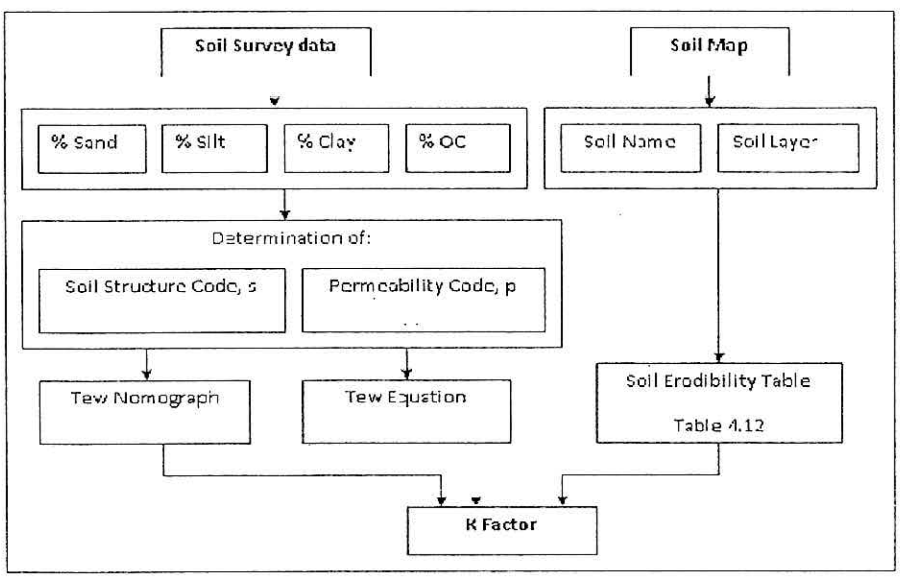

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SOIL SURVEY DATA

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1.How to determine K

BTS Engineering Sdn. Bhd.

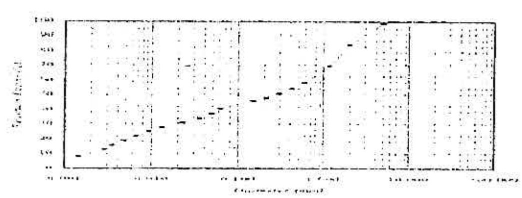
Client : [illegible]
Consultant : VT Soil Erosion Research & Consultancy
Project : Proposed High-Tech Hydroponic Farming on Lot [illegible], [illegible] Cameron Highlands, Pahang Darul Makmur
Date Tested : [illegible]
Tested By : Aziah
Borehole No : [illegible]
Sample No : A
Depth, m : 0.50m

Sieve Analysis

[illegible]

Hydrometer Analysis

[illegible]



[illegible]

1.How to determine K

Summary of Laboratory Test Result (Deng Seng, 2004)Malaysia

BTS ENGINEERING SDN BHD

SUMMARY OF LABORATORY TEST RESULTS

Client : Deng Seng Enterprise Sdn Bhd
Consultant : VT Soil Erosion Research & Consultancy
Project : Proposed High-Tech Hydroponic Farming on Lot 1587 & 1592, Part of Blue Valley Estate Mukim Hulu Telom, Daerah Cameron Highlands, Pahang Darul Makmur

HAND AUGER NO.	SAMPLE NO.	DEPTH (m) NO.	MOISTURE CONTENT %	PARTICLE SIZE DISTRIBUTION				CHEMICAL TEST ORGANIC MATTER %
				GRAVEL %	SAND %	SILT %	CLAY %	
HA 1	A	0.5	22	15.9	43.1	30.3	10.8	0.1
	B	1.0	26	35.4	27.1	27.2	10.3	
HA 2	A	0.5	20	12.3	53.1	29.7	4.8	0.1
	B	1.0	14	20.6	56.0	21.7	1.7	
HA 3	A	0.5	23	8.5	54.3	30.3	6.4	0.1
	B	1.0	26	11.1	38.8	36.9	13.2	
HA 4	A	0.5	24	14.1	50.8	27.7	7.4	0.1
	B	1.0	23	10.6	52.9	32.2	4.2	
HA 5	A	0.5	26	13.2	49.1	26.2	11.5	0.4
	B	1.0	30	19.1	38.5	22.8	19.5	
HA 6	A	0.5	38	0.2	16.0	65.8	18.0	0.1
	B	1.0	38	0.1	13.9	65.6	20.4	

Summary of Laboratory Factor Analysis Result Summary

1.How to determine K

Hand Auger No.	Depth (m)	% Silt & Very Fine Sand	% Sand (0.06 – 2.0 mm)	% Organic Matter	Soil Structure Classification	Permibility Classification	K Factor	Average K factor
HA1	0.5	41.7	43.1	0.1	2	3	0.039	0.06
	1.0	37.5	27.1	0.1	3	2	0.051	
HA2	0.5	34.5	53.1	0.1	3	3	0.09	0.09
	1.0	23.4	56.0	0.1	3	3	0.08	
HA3	0.5	36.7	54.3	0.1	3	3	0.11	0.16
	1.0	50.1	38.8	0.1	3	3	0.20	
HA4	0.5	35.1	50.8	0.1	3	3	0.09	0.10
	1.0	36.4	52.9	0.1	3	3	0.10	
HA5	0.5	37.7	49.1	0.1	3	3	0.10	0.10
	1.0	42.2	38.5	0.1	3	3	0.10	
HA6	0.5	83.8	16.0	0.1	3	4	0.44	0.45
	1.0	86.0	13.9	0.1	2	4	0.45	

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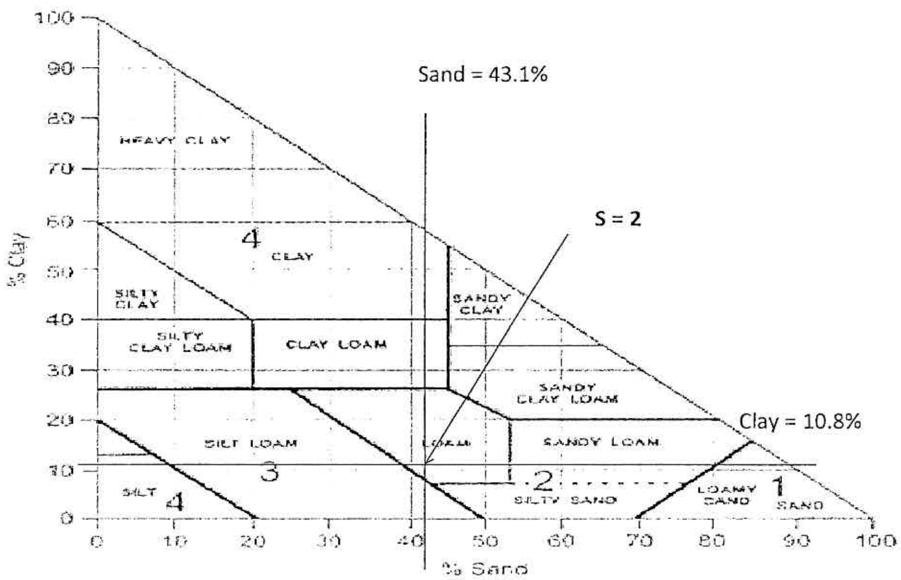
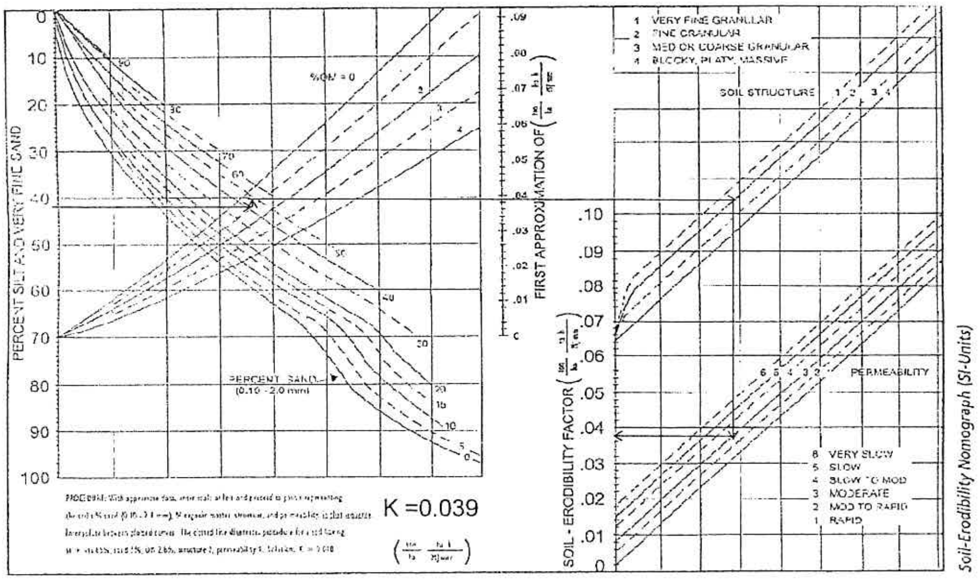


Soil Structure Code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

Soil permeability code based on soil texture class

Soil Texture	Permeability Code[1]	Hydrologic Soil Group[2]
Heavy clay, Clay	6	D
Silty clay loam, Sandy clay	5	C-D
Sandy clay loam, Clay loam	4	C
Loam, Silt loam	3	B
Loamy sand, Sandy loam	2	A
Sand	1	A+

1.How to determine K



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1.How to determine K- Using Equation

$$K = \left[1.0x10^{-4}(12 - OM)M^{1.14} + 4.5(s-3) + 8.0(p-2)\right]/100$$

Calculation of *M*

M = (% silt + % very fine sand) x (100 - % clay)
= (30.3 + 43.1) x (100 – 10.8)
= 6,547.28

OM = 0.1% from lab test result

s = 2

p = 3

$$K = [1.0x(10^{-4})6547.28^{1.14}(12-0.1)+4.5(2-3)+8.0(3-2)]/100$$

=0.302 ton.acre-hour/ hundreds of acre foot*toninch

(Convert from Imperial unit to metric unit = 0.1317)
K = 0.0397 tones/ha/MJmmha-1h-1

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SOIL MAP

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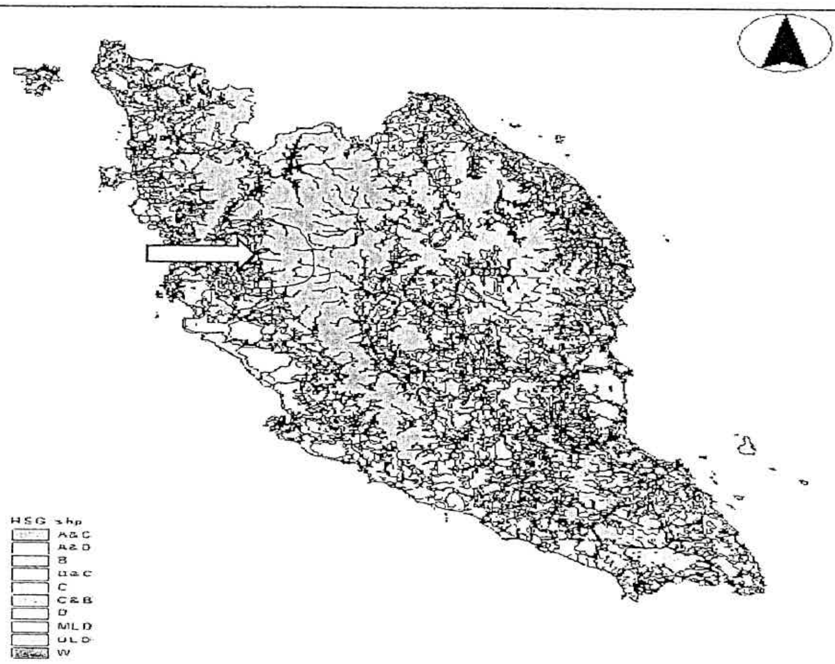

Hydrologic soil map for Peninsular Malaysia (Source: DOA)

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Soil permeability code based on soil texture class

Note: MLD – Mine land
ULD – Urban land
W – Water

Soil Texture	Hydrologic Soil Group[2]
Heavy clay, Clay	D
Silty clay loam, Sandy clay	C-D
Sandy clay loam, Clay loam	C
Loam, Silt loam	B
Loamy sand, Sandy loam	A
Sand	A+

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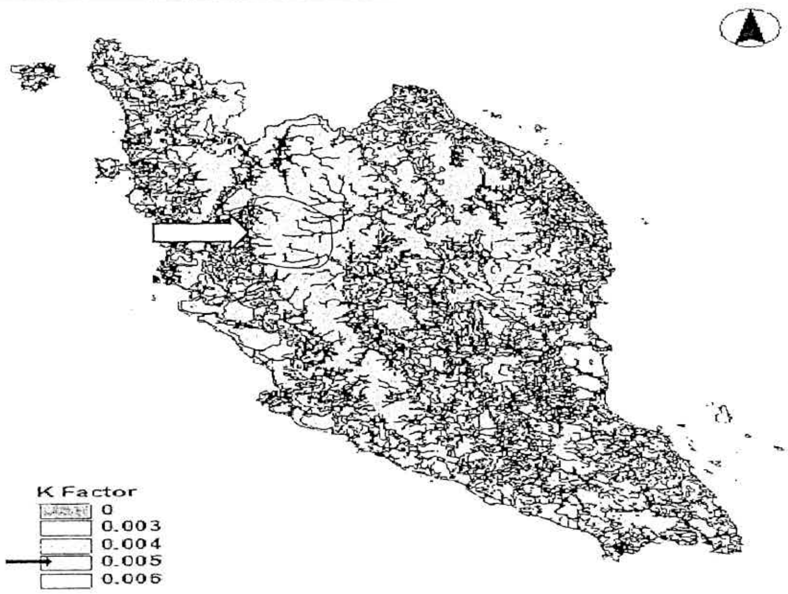

Soil erodibility map for Peninsular Malaysia (Source: DOA)

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2.Calculation of LS factor

1. Calculation of LS factor using MSMA approach

S = 10%

M = 0.5

λ = 60 m

LS = 1.9248

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LS calculated using MSMA approach

[illegible]	S(o)	S(rad)	[illegible]	1.0	3.0	5.0	10.0	15.0	25.0	50.0	75.0	[illegible]
[illegible]	0.06	0.001	0.2	0.037	0.047	0.052	0.059	0.064	0.071	0.082	0.089	[illegible]
[illegible]	0.12	0.002	0.2	0.040	0.050	0.055	0.064	0.069	0.076	0.088	0.095	[illegible]
[illegible]	0.29	0.005	0.2	0.048	0.060	0.067	0.076	0.083	0.092	0.105	0.114	[illegible]
[illegible]	0.43	0.007	0.2	0.056	0.069	0.077	0.088	0.095	0.106	0.121	0.132	[illegible]
[illegible]	0.57	0.010	0.3	0.046	0.065	0.075	0.093	0.105	0.122	0.150	0.169	[illegible]
[illegible]	1.15	0.020	0.3	0.072	0.100	0.117	0.144	0.163	0.190	0.234	0.264	[illegible]
[illegible]	1.72	0.030	0.4	0.076	0.118	0.144	0.190	0.224	0.275	0.362	0.426	[illegible]
[illegible]	2.29	0.040	0.4	0.102	0.159	0.195	0.257	0.302	0.371	0.489	0.575	[illegible]
[illegible]	2.86	0.050	0.5	0.097	0.158	0.217	0.308	0.377	0.486	0.688	0.842	[illegible]
[illegible]	5.71	0.100	0.5	0.250	0.433	0.559	0.790	0.967	1.249	1.756	2.163	[illegible]
[illegible]	11.31	0.197	0.6	0.559	1.051	1.469	2.226	2.839	3.857	5.846	7.457	[illegible]
[illegible]	16.70	0.291	0.6	1.138	2.199	2.988	4.529	5.777	7.849	11.896	15.173	[illegible]
[illegible]	21.80	0.381	0.6	1.919	3.710	5.041	7.640	9.744	13.239	20.067	25.593	[illegible]
[illegible]	26.57	0.464	0.6	2.903	5.612	7.625	11.558	14.741	20.028	30.357	38.718	[illegible]
[illegible]	30.96	0.540	0.6	4.090	7.907	10.743	16.283	20.767	28.216	42.767	54.546	[illegible]

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3.Determine the CP factor

Assuming the condition at site is bareland (newly cleared area)

CP = 1.00

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C Factor and P Factor values for Construction-site rainfall

TREATMENT	C-FACTOR	P-FACTOR
Bare Soil Packed and smooth Freshly disked or rough, irregular surface	1.00 1.00	1.00 0.90
Sediment Containment Systems (a.k.a. Sediment Trap/Basin)	1.00	0.10 - 0.90[A]
Bale or Sandbag Barriers	1.00	0.90
Rock (Diameter = 25-50 mm) Barriers at Sump Location	1.00	0.80
Silt-Fence Barrier	1.00	0.60
Asphalt/Concrete Pavement	0.01	1.00
Gravel (Diameter = 60-400mm) at 300 tonnes/ha	0.05	1.00
Established Vegetation	Figs. 4-3, 4-4	1.00
Sod Grass	0.01	1.00
Temporary Vegetation/Cover Crop	0.45[B]	1.00
Hydraulic Mulch at 4.5 tonnes/ha	0.10[C]	1.00
Soil Sealant	0.10 - 0.60[D]	1.00
Rolled Erosion Control Products	0.10 – 0.30[D]	1.00

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4. Calculation of sediment yield using MUSLE

Storm Event

The design storm event for Plot 1 & Plot 2 (3month ARI)

Plot 1 catchment area = 38500 m2

Plot 2 catchment area = 47750m2

Overland flow length = 500m

Duration of storm = 16.2 min

Intensity of design storm = 104.8 mm/hr

Runoff coefficient = 0.74

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4. Calculation of sediment yield using MUSLE

Sub-catchmt (m2)	Volume (m3)	Peakflow (m3/s)	K factor	LS factor	CP factor	Sediment Yield (tonnes)
38500	806.153	0.8294	0.06	1.9248	1.00	395.32
47750	999.8392	1.0286	0.06	1.9248	1.00	503.11

$Y = 89.6(VQ)^{0.56}(K.LS.C.P)$

$= 89.6(806.153 \times 0.8294)^{0.56}(0.06 \times 1.9248 \times 1.00)$

$= 395.32$ tonnes per storm event

Total sediment yield for Plot 1 and Plot 2 = 898.431 tonnes per storm event

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4. Calculation of sediment yield using USLE

Sub-catchment (m2)	K factor	LS factor	CP factor	Soil Loss (tonnes)
38500	0.06	1.9248	1.00	1732.32
47750	0.06	1.9248	1.00	1732.32

A = R.K.LS.CP

= 15000 x 0.06 x 1.9248 x 1.00

= 1732.32 tonnes /ha/yr

Total sediment yield for Plot 1 and Plot 2 = 3464.64 tonnes/ha/yr

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ASSIGNMENT

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Assignment 1: ESCP

The exercise given is to enable the participants to predict soil loss using USLE and the sediment yield using MUSLE equation.

1.Given soil properties. Calculate K factor using nomograph.

Catchment	Depth	% silt & very fine sand	% sand	% organic matter	Soil structure Classification	Permeability Classification	K factor	Average K
A	0.1	36.4	54.3	0.1	3	3		
	0.5	50.1	38.8	0.1	3	3		

2.

Calculate LS factor.

Given: $S = 15\%$

$\lambda = 70$ m

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5. Calculation of sediment yield using MUSLE eqn.

Use K,LS,CP from previous USLE exercise.

Given:

Catchment area A = 40,000m^2

Duration of storm = 30 min

Intensity of design storm = 93.088 mm/hr

Runoff coeff. = 0.82

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Assignment 2: ESCP

The exercise given is to enable the participants to predict soil loss using USLE and the sediment yield using MUSLE equation.

1. Given soil properties. Calculate K factor using nomograph.

Catchment	Depth	% silt & very fine sand	% sand	% organic matter	Soil structure Classification	Permeability Classification	K factor	Average K
A	0.1	36.4	54.3	0.1	3	3	**0.051**	**0.0458**
	0.5	50.1	38.8	0.1	3	3	**0.0405**	

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2. Calculate LS factor.

Given: S = 15%

therefore choose **m** = **0.6**

$\lambda = 70$ m

- $LS = (\lambda / 22.13)^{m} (0.065 + 0.046S + 0.0065S^2)$
- $= (70 / 22.13)^{0.6} (0.065 + 0.046[15]) + 0.0065(15)^2)$
- $= (1.9955)(0.065 + 0.69 + 1.4625)$
- $= (1.9955).(2.2175)$
- $= 4.425$

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Using MSMA approach

[illegible]	S(o)	S(rad)	[illegible]	1.0	3.0	5.0	10.0	15.0	25.0	50.0	75.0	[illegible]
[illegible]	0.06	0.001	0.2	0.037	0.047	0.052	0.059	0.064	0.071	0.082	0.089	[illegible]
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[illegible]	1.15	0.020	0.3	0.072	0.100	0.117	0.144	0.163	0.190	0.234	0.264	[illegible]
[illegible]	1.72	0.030	0.4	0.076	0.118	0.144	0.190	0.224	0.275	0.362	0.426	[illegible]
[illegible]	2.29	0.040	0.4	0.102	0.159	0.195	0.257	0.302	0.371	0.489	0.575	[illegible]
[illegible]	2.86	0.050	0.5	0.097	0.168	0.217	0.308	0.377	0.486	0.688	0.842	[illegible]
[illegible]	5.71	0.100	0.5	0.250	0.433	0.559	0.790	0.967	1.249	1.766	2.163	[illegible]
[illegible]	11.31	0.197	0.6	0.559	1.081	1.469	2.226	2.839	3.857	5.846	7.457	[illegible]
[illegible]	16.70	0.291	0.6	1.138	2.199	2.988	4.529	5.777	7.849	11.896	15.173	[illegible]
[illegible]	21.80	0.381	0.6	1.919	3.710	5.041	7.640	9.744	13.239	20.067	25.593	[illegible]
[illegible]	26.57	0.464	0.6	2.903	5.612	7.625	11.558	14.741	20.028	30.357	38.718	[illegible]
[illegible]	30.96	0.540	0.6	4.090	7.907	10.743	16.283	20.767	28.216	42.767	54.546	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

LS = 4.6092

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3. Calculate R factor using isoerodent map

Site: Cameron Highland, Pahang

Value between 15,000 – 16,000 MJ.mm/ha.yr

Adopt 15,500 MJ.mm/ha.yr

4. Calculate soil loss;

Given: CP = 1.00

A = RKLSCP

= 15,500x 0.0458 x 4.425 x 1.0

= 3141 tonne/ha/yr

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5. Calculation of sediment yield using MUSLE eqn.

Use K,LS,CP from previous USLE exercise.

Given:

Catchment area A = 40,000m^2 = **4 ha**

Duration of storm = 30 min

Effective rainfall (Pe) = 40 mm

Q_P = 0.85 m^3/sec

$T = \Psi_2 (V \times Q_P)^{0.56} \times K \times LS \times C \times P$; where Ψ = psi

= 89.6 for S.I units

Volume, **V** = **A x Pe** = 40000 x 0.04= **1,600 m3**

As such ,

$T = 89.6 \times (1{,}600 \times 0.85)^{0.56} \times 0.1475 \times 4.425 \times 1.0$

$= 89.6 \times 55.30 \times 0.1475 \times 4.425 \times 1.0$

= 3325 tonnes

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Density of sediment, $\rho = 2.6$ tons/m^3

ρ = Weight / Volume

Volume sediment = 3,325 / 2.6

= 1,279 m^3

Assumption: Cost for excavation and transportation of sediment at site;

1 m^3 = RM 10.00

Therefore cost for excavation + transportation

= 1,279 m^3 x RM 10.00

= **RM 12,790** per rainfall event

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