GUIDELINES ON LAND DISTURBING POLLUTION PREVENTION AND MITIGATION MEASURES (LD-P2M2)

APPENDICES

Department of Environment
Ministry of Natural Resources and Environment
Malaysia

Department of Environment, Malaysia

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APPENDIX A

ISSUES RELATING TO EROSION AND SEDIMENTATION

ISSUE 1: PLANNING

<table>
<tr><th>Details</th><th>Picture</th></tr>
<tr><td>CONSTRUCTION ROAD CONSTRUCTED ON THE EDGE OF THE RIVER BANK IS AN UNACCEPTABLE ACT UNLESS PROVEN UNAVOIDABLE
Location of construction road appears to be haphazardly proposed, and to make matter worse, the road alignment was proposed to be constructed adjacent to a river.</td><td>
</td></tr>
<tr><td>Lacking prior planning, physical marking of construction limits as well as mitigation measures, land disturbing activity took place just next to the river, resulting in muddy runoffs into the river during rainy periods.</td><td>
</td></tr>
<tr><td>Damage to the sides of the river bank in progress, which was very difficult to be rectified.</td><td>
</td></tr>
</table>

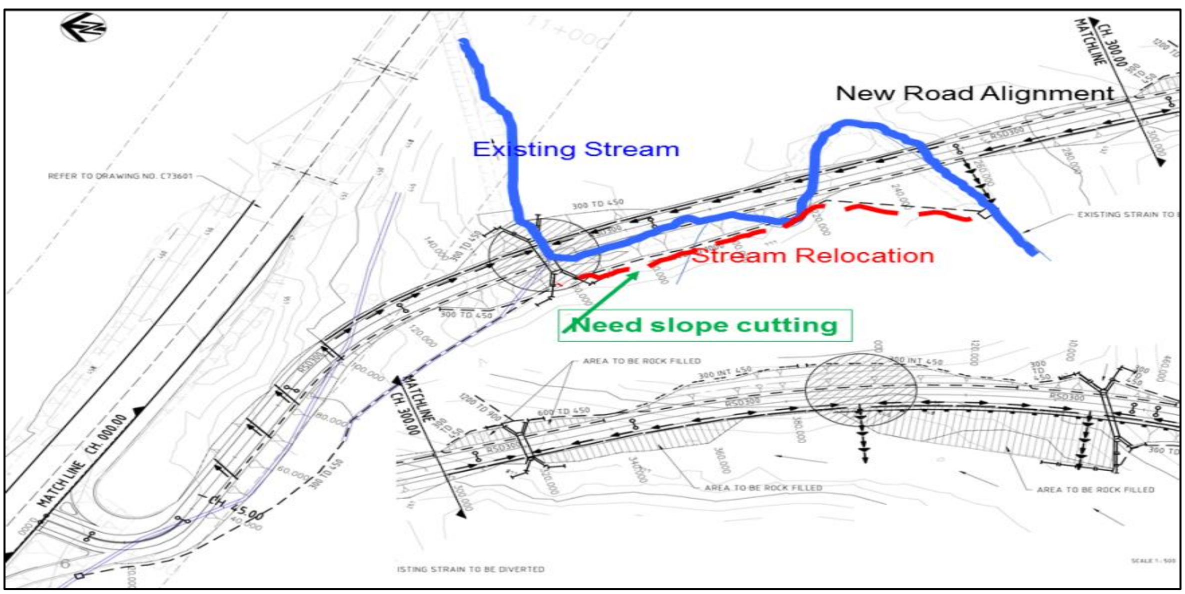
Safety and cost became a significant consideration to rectify the damage done.	
LOSS OF TREES A significant consequence of the lack of planning in this example is the unnecessary loss of trees within the project site. Based on the previously designed alignment location, a large extent of trees and land was cleared to construct this road alignment. However, after the clearing was done, a new alignment was proposed to supersede the earlier alignment, and thus resulted in a large extent of trees was cleared unnecessarily for the designed alignment.	  

Had this planning was properly executed before the commencement of the construction of the 1st alignment, the trees that were not felled would have serve as a buffer to protect a nearby river.	

ISSUE 2: WORK SEQUENCING

<table>
<tr><th>Details</th><th>Picture</th></tr>
<tr><td>SITE CLEARING

• Should have temporarily preserve the existing vegetation along this boundary or establish perimeter drain or diversion dyke
• Have to resolve surface runoff from neighbouring properties</td><td></td></tr>
<tr><td colspan="2">Stream Diversion (Relocation) To Fit In Road Alignment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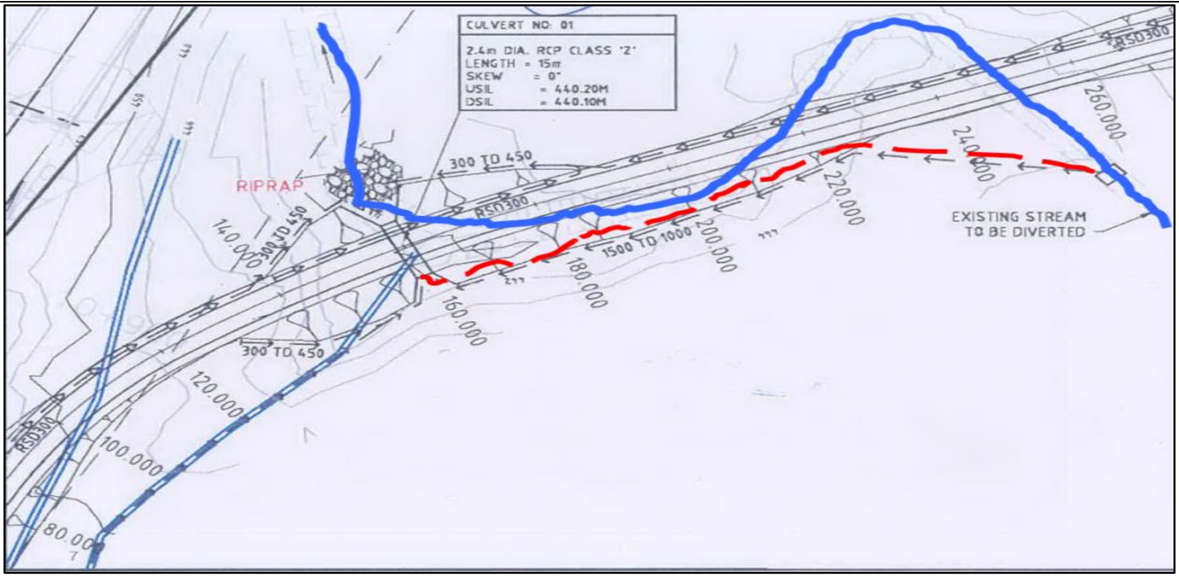
<tr><td colspan="2">



</td></tr>
<tr><td>

UNNECESSARILY SITE CLEARING, causing a large extent of disturbed land which was left unprotected.

</td><td>

</td></tr>
</table>


Site office & material staging area was cleared indiscriminately
Instruct to mitigate the area and stop land disturbance while initiate construction of stream relocation
13/03/2013 13:48


Ad-hoc installation of silt fence and without following standard and specification
11/04/2013 10:11


Instruct to stop all other activities and complete the Stream Relocation first
11/04/2013 10:15

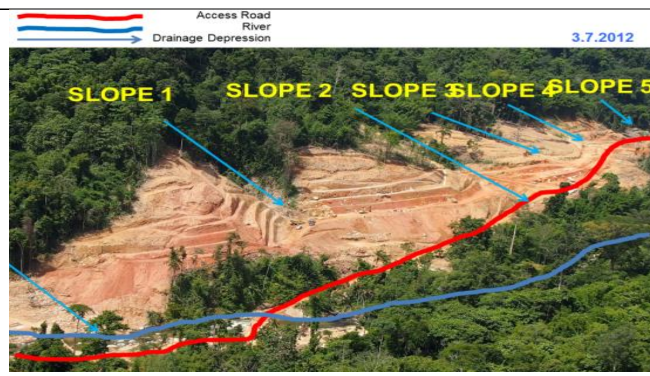

Stream relocation already commenced
16/05/2013 11:30


16/05/2013 11:38
Add more BMPs


Stream Relocation
16/05/2013 11:26


Stream Relocation
completed
11/06/2013 10:54

<table>
<tr>
<td>In-Stream Work (Sub-con almost skip construction sequence)</td>
<td>


</td>
</tr>
<tr>
<td>Critical Drainage Depression</td>
<td>


</td>
</tr>
</table>

	
RUN-ON • Stream flows through disturbance area	 

• Run-On Flowing Through The Disturbance Area	• Scope of work: • - To backfill an area that has a stream flowing through the area. • - To relocate the stream to flow through a new subsoil drainage (blanket/French drain). **POSSIBLE OPTIONS:** 1. Start by first constructing a diversion channel, and providing this diversion channel with stabilization, such as TRM or suitable channel-bed liner (to maintain clean water clean). Then re-route existing stream into diversion channel and commence backfilling activity. 2. Establish a temporary setback along the stream with an earth bank / diversion berm and/ or preserve the existing vegetation along the stream bank. Backfill first the surrounding area followed by stabilization. After that, proceed to clear and backfill stream bank area - maybe with no cost; or 3. Fully stabilize the already disturbed channel in conjunction with other suitable runoff control application along the stream bank until the construction of subsurface drainage is completed for the stream relocation. 4. Earlier should have construct **stream diversion** and **stabilize channel** with TRM or suitable channel-bed liner so as to maintain **clean water clean**. Then proceed backfilling activity. 5. Temporarily, **establish the setback** with earth bank / diversion berm and/ or preserve the existing vegetation towards the stream bank and attend to it in the later time (backfilling) when the surrounding backfilled area is stabilised; maybe with no cost; or 6. Fully **stabilised** the already disturbed channel in conjunction with other suitable runoff control application along the stream bank until the construction of subsurface drainage is completed for the stream relocation work to proceed.

ISSUE 3: CONSTRUCTION LIMIT

Details	Pictures
IMPORTANT TO PHYSICALLY MARK AND DELINEATE LIMIT OF DISTURBANCE ACTIVITIES Note the proximity of residential areas and vegetated areas which are sensitive receivers of this construction activity	
Without properly marked construction limits, damages to surrounding environment is likely to occur	
Without clear marking on site, possible consequence is inadequate room for further mitigation measures. The resulting erosion materials washed into river will incur cost and time to rectify, thus increasing project cost significantly.	
Again, the consequence of not physically marking the limit of construction will inevitably result in encroachment of works or in this case erosion into adjacent properties.	

At times, damaging public assets and amenities.	
BAD EARTHWORK PRACTICE INCURRED ADDITIONAL COST (20.1.2011) Earth tipped into the stream	
KEEP ON CHANGING PLASTIC SHEET FOR MONTHS **17.2.2011** **19.2.2011** Such additional costs could have been prevented if clear marking of construction limits was provided at the start of construction, and thus, minimising the damaging impact to the surrounding environment.	 

Issue 5: Silt Trap Across Drainage Way

Details	Picture
CONSTRUCTION OF SILT TRAP ACROSS DRAINAGE WAY OR EVEN WATERWAY MUST BE AVOIDED • Silt trap across drainage way; problem with inadequate retention time, worsens the pollution situation of the river course, difficulty in maintenance	  
• Silt trap across waterway	

• Silt trap failure. Note the overflowing of sediment laden waters over the trap walls. Shortcircuiting has occured • Under designed silt trap - Shortcircuiting has occured	 

ISSUE 5: SPECIFICATION

<table>
<tr><td>Details</td><td>Picture</td></tr>
<tr><td>CLOSE TURFING shall need to comply with product specification and supplier's instruction</td><td>
</td></tr>
<tr><td>Further provisions needed such as liner, curbs.</td><td>
</td></tr>
<tr><td>Shortcircuiting has occurred – inflow and outflow pond water quality appear to be similar.</td><td>
</td></tr>
</table>

<table>
<tr><td>Installation not done properly</td><td></td></tr>
<tr><td>EXAMPLES OF INCORRECT APPLICATION:

• Silt fence installed at the worng location – should have been at the toe of the exposed slope</td><td></td></tr>
<tr><td>• Silt fence not anchored down adequately and without proper maintenance, rendering it ineffective.</td><td></td></tr>
<tr><td>• Another ineffective installation; note sediment on the other side of the silt fence</td><td></td></tr>
<tr><td>• Silt fence installed at the worng location – should have been at the toe of the exposed slope</td><td></td></tr>
</table>

ISSUE 6: DEWATERING ACTIVITY

Details	Picture
DEWATERING ACTIVITY – Proper receiving facilities to be provided to cater for the pumped out construction wastewater • Looks like it is going to be permanent practice. Contractor is more concerned with dewatering the area for works to be carried out and ignored the consequences of his dewatering practice without proper treatment.	   

Note sediment-laden water being discharged into river without proper prior treatment	

ISSUES 8: STREAM CROSSING

Details	Picture
STREAM OR DRAINAGE CROSSING / DIVERSION	
• Irish crossing Even this excavator should have been seated parallel to the river flow to reduce flow obstruction	
	
• A proper temporary river crossing, observe the gravels, ford	
• Culvert Crossing with no inlet protection; erosion of surrounding banks will inevitably be washed off via the unprotected culverts	

• Temporary crossing (no protection)	
BRIDGE CROSSING • Unprotected temporary stream crossing • No protection around the temporary crossing LHS. Note the significant amount of exposed soil adjacent to crossing.	 
STREAM DIVERSION SHALL FOLLOWS STRICTLY UPON THE APPROVED METHOD STATEMENT • Badly managed crossing	

• Stream crossing with basically no erosion protection of the disturbed land surface • Temporary bridge crossing (not protected)	  
AN EXAMPLE OF BADLY MANAGED STREAM CROSSING / DIVERSION AND THE CONSEQUENCES	

- The consequences

- Stream crossing during re-grade, not protected

- Stream Crossing, seriously eroded unprotected channel downstream. During rainy periods, sediment-laden runoff will be carried to river downstream.

- Stream crossing (unfinished job)

ISSUES 8: MAINTENANCE ISSUES

<table>
<tr><td>Details</td><td>Picture</td></tr>
<tr><td>

ISSUES WITH LACK OF MAINTENANCE
The lack of maintenance such as infrequent desilting of sedimentation basin or silt pond will render these facilities ineffective. Inflows rich with sediment which flow into the facilities shown in Pictures (i) and (ii) are not expected to be accorded the proper sedimentation treatment, but will rather short-circuit the pond and discharge untreated almost immediately upon entering the facilities.

Sediment control measures shall be maintained periodically and as frequent as needed to ensure their effectiveness and functionality. Ideally, markers could be installed to indicate depth of silts and consequently, the need for maintenance.

Erosion control measures such as TRM (Picture iii) need to be maintained to ensure their continual effectiveness.

</td><td>

i. Silt pond full with sediment

ii. Note the excessive thickness of silt/sediment accumulated in this pond

iii. Improper installation of TRM

</td></tr>
</table>

Maintenance initiated once the problem started	 iv. Maintenance in progress
Effect of lack of maintenance; culvert clogged within a week	 v. Inadequate maintenance provided

APPENDIX B

MINIMUM STANDARD REQUIREMENTS OF POLLUTION

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

PP shall **comply the minimum standards requirements** outlined in the section 7.0 of this guidance document.

PP shall attach or insert these minimum standards requirements in the LD-P2M2 document.

PP shall adopt, apply and implement as the minimum P2M2s wherever necessary throughout the process of carrying out land disturbing activities at the development site.

- The term “standard requirements” here refer to the physical or non-physical measures to be taken to prevent, reduce and control the discharge of suspended solids and other pollutants from the development site. The standard requirements are meant to achieve a certain quality or attainment.

7.0 MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

7.1 Pollution Prevention and Mitigation Measures (P2M2s)

a. Schedule of Phasing, Staging and Sequencing
b. Scheduled Site Meeting
c. Construction Markers
d. Stabilized Construction Entrance
e. Stream/drainage way/waterway/watercourse buffers
f. Perimeter Control
g. Sediment Basin/Trap
h. Runoff Management
i. Temporary or permanent watercourse diversion
j. Temporary or permanent watercourse crossing
k. Temporary or permanent roadways
l. Temporary Stabilization
m. Stockpile Soil Management
n. Spoil Management Area (Disposal Area)
o. Dewatering practices
p. Active Treatment System (ATS)
q. Discharge
r. Corrective Actions
s. Site Inspections
t. Maintenance
u. Standards and Specifications for P2M2s

7.2 Self-Regulation

a. Establishment of Environmental Performance Monitoring Committee (EPMC) and Performance Monitoring Documentation

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

7.1: Pollution Prevention and Mitigation Measures (P2M2s)

- The Project Proponent shall ensure that:
- All relevant parties including project consultant, contractors, and Environmental Officer (EO) understand LD-P2M2 in order to facilitate compliance with the minimum standards requirements.
- All relevant pollution prevention and mitigation measures (P2M2s) especially temporary BMPs at the constructional phase are installed and maintained to mitigate the potential pollution due to land disturbing activities.

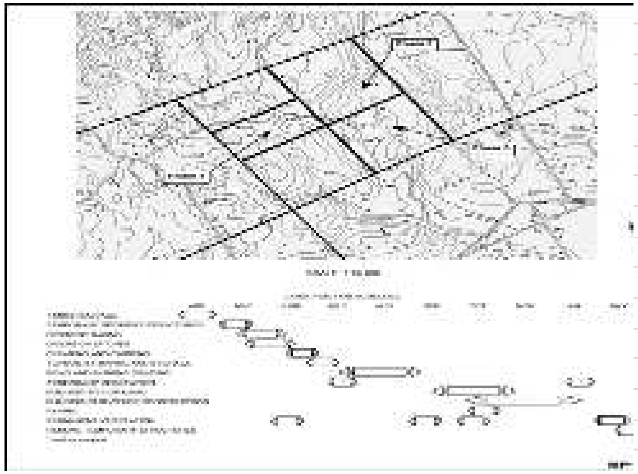
MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

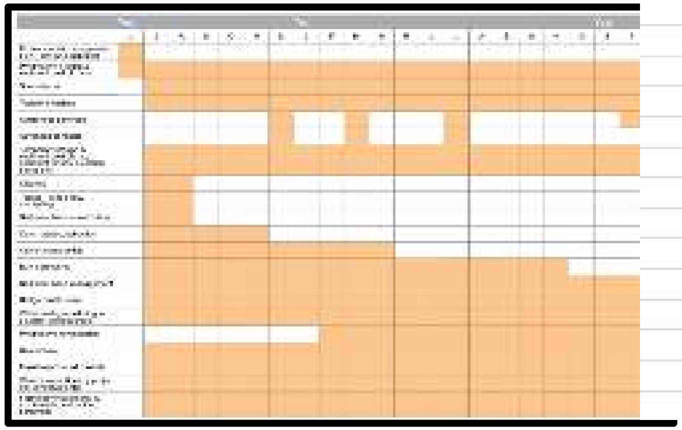
(a) Schedule of Phasing, Staging and Sequencing

A project schedule shall be prepared in advance to ensure the jobs involved in project implementation are properly scheduled in order to effectively address and manage the environmental pollution. The schedule shall include the following:

i. Project construction scheduling for all major land-disturbing activities which include work zone(s), phasing of construction within the work zone(s), staging and sequencing within the phases of construction that coincides with the installation of P2M2s.

ii. Critical Path Method (CPM) may be adopted in establishing work program that shall fit in the elements of pollution prevention and mitigation measures for each phase, stage and sequence of project development.





Task Name	Baseline Start	Baseline Finish	Baseline Duration
TMS Report 5	30 May '16	06 Jun '16	6 d
TMS Report 6	30 Aug '16	06 Sep '16	6 d
TMS Report 7	30 Nov '16	06 Dec '16	6 d
TMS Report 8	28 Feb '17	06 Mar '17	6 d
TMS Report 9	30 May '17	06 Jun '17	6 d
TMS Report 10	30 Aug '17	07 Sep '17	6 d
TMS Report 11	30 Nov '17	07 Dec '17	6 d
TMS Report 12	28 Feb '18	06 Mar '18	6 d
10.0 ENVIRONMENTAL PROTECTION WORKS	01 Apr '15	03 Mar '18	865 d
10.2 EMP	01 Apr '15	28 Feb '18	862 d
Prepare, submit & Approval of EMP	22 May '15	26 Jun '15	30 d
Env Officer (E.O)	01 Apr '15	28 Feb '18	862 d
10.3 AIR QUALITY CONTROL	01 Apr '15	28 Feb '18	862 d
Water Browser - 2 nos	01 Apr '15	28 Feb '18	862 d
Tyre Washing Facilities - 2 nos	01 Apr '15	28 Feb '18	862 d
10.4 WATER QUALITY CONTROL	16 Jul '15	18 Sep '17	643 d
Maintenance of Silt Fence	16 Jul '15	18 Sep '17	643 d
maintenance of Silt Trap	17 Aug '15	18 Sep '17	618 d
10.5 EROSION CONTROL	30 Mar '16	12 Jan '17	231 d
10.5.1 Gabion Protection	30 Mar '16	26 May '16	48 d
10.5.2 Drain Check Dam - Sand bag & Rock check Dam	30 Mar '16	26 May '16	48 d
10 kg Sand bag with Geotextile filter	30 Mar '16	26 May '16	48 d
Rock check Dam	30 Mar '16	26 May '16	48 d
10.5.3 Temporary Slope Drain	16 May '16	12 Jan '17	192 d
Temporary Slope Drain	16 May '16	18 Jul '16	48 d
Rip Rap Stone outlet & Remover	19 Jul '16	14 Sep '16	48 d
Tapered Inlet	15 Sep '16	14 Nov '16	48 d
Plastic Mat or Blanket	15 Nov '16	12 Jan '17	48 d
10.6 CONTROL OF FUEL	11 Aug '15	22 Aug '15	10 d
10.6.1 Skid Tank - Concrete base	11 Aug '15	22 Aug '15	10 d
10.6.1 Waste storage shed	11 Aug '15	19 Aug '15	7 d
10.7 ENVIRONMENTAL MONITORING	01 Apr '15	28 Feb '18	862 d
Air Quality Monitoring	01 Apr '15	28 Feb '18	862 d
Noise Quality Monitoring	01 Apr '15	28 Feb '18	862 d
Water Quality Monitoring	01 Apr '15	28 Feb '18	862 d
10.8 ENVIRONMENTAL REPORT	01 Apr '15	28 Feb '18	862 d
Env Report	01 Apr '15	28 Feb '18	862 d
10.9 ENVIRONMENTAL AUDIT	14 May '15	03 Mar '18	830 d

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(b)Scheduled Site Meeting

i. Conduct site meeting prior to start of any construction activity or land-disturbing activity to be attended by PP, project EO, project contractors and/or sub-contractors to discuss in detail all of the relevant scopes of work that have relevance to pollution prevention and mitigation measures.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(c) Construction Markers

i. Physically mark on site to show the limit of the following:-

- Land disturbing from any drainage way or waterway or watercourse within project site;
- Areas not to be worked or disturbed, and
- Buffer area or/and existing vegetation meant for temporary or permanent preservation and for protection.

ii. The construction markers are fences, signs, tapes, flags or other similar marking device.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(d) Stabilized Construction Entrance

i. All entrance/exit roads to the site shall be stabilized and paved for a suitable distance from where these access roads join the existing paved roads or public road where Stabilized Construction Entrance P2M2 and/or Tires Washing Facility shall be constructed from this point inward to the subjected construction site.

ii. Any swept soil or sediment accumulated on pavement or other impervious surfaces from within Stabilized Construction Entrance P2M2 and sediment-laden washed water from Tires Washing Facility are not allowed to be hosed downed and discharged respectively into any off-site drainage way, storm drain inlet or watercourse unless connected to a sediment basin or sediment trap.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(e) Stream/drainage way/waterway/watercourse buffers

i. Retain a 20 metres natural buffer between on-site land disturbance and any watercourse (intermittent or permanent) unless otherwise specified by the relevant authority; or

ii. Provide vegetated buffer that is less than 20 metres between on-site land disturbance and any watercourse (intermittent or permanent) in combination with additional erosion and sediment controls; or

iii. If not feasible to provide natural or vegetated buffer of any size between on-site land disturbance and any watercourse (intermittent or permanent), install suitable erosion and sediment controls in combination with all possible perimeter controls.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(f) Perimeter Control

i. Before land-disturbing activities are executed, perimeter control shall be first constructed and made operational. The perimeter control shall include but is not limited to filter or perimeter berms, silt fences, sediment traps, sediment basins, construction entrance, temporary diversion dikes or earth bunds and diversion drains that control discharges from the site.

(**Notes**: A certain amount of initial land disturbance may be required to provide access for equipment to install the perimeter controls, but site clearing and grading should be kept to a minimum until the perimeter controls are in place).

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(g) Sediment Basin/Trap

i. Before land-disturbing activities are executed, principal sediment basin/trap shall be first constructed and made operational. Any constructed sediment basin/trap shall install vertical silt marker for the purpose of measuring the depth of accumulated sediment to facilitate maintenance program.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(h) Runoff Management

i. Before land-disturbing activities are executed, key runoff control measures shall be first constructed and made operational. The runoff control measures shall include but is not limited to temporary earth drain, diversion channel and conveyance system that control flows and discharges from and within the site and to be combined with installation of interval check dams along the channel to reduce the runoff velocity.

ii. Slope drains, flexible pipe slope drains or downpipe, rock lined drainage chutes or flume, cascade drain shall be applied to convey upslope runoff down slope without affecting the slope surface.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(h) Runoff Management

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MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(h) Runoff Management....cont;

iii. In-slope or out-slope diversion runoff control P2M2s shall be applied in combination with water bars to divert runoff towards stabilized area or sediment treatment P2M2 prior to discharge.

iv. Any incomplete permanent drainage lines constructed along sloping area, shall not be left unattended without first applying rocks dissipater at the end points or at the toe end of the incomplete adjoining conveyance structure. The anticipated runoff discharge from this point should be diverted using temporary earth drain combined with check dam towards stabilized area or into sediment treatment P2M2s. It is highly recommended that pipe slope drains are used to convey runoff directly into sediment containment system.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(i) Temporary or permanent watercourse diversion

i. Temporary or permanent diversion channel of any watercourse or off-site run-on water shall be protected either by using rock lined channel bed with protected side slope using Turf Reinforcement Mat (TRM) or plastic sheeting or by installing plastic sheeting canvas along the channel with extend across the side slope in combination with constructed check dams or sump slot checks. This has to be done to minimize erosive forces flow velocity along the channel bed and channel side slope surface to prevent it from eroding.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(j) Temporary or permanent watercourse crossing

i. Construction of culvert or bridge for any watercourse crossing, the surface of the filling material (if earth is used) on the inlet and outlet end of the culvert or abutment of the both sides of the bridge shall be covered with appropriate materials such as rocks, Rolled Erosion Control Products (RECPs) and plastic sheeting or turf.

ii. The approach distance of 10 metres or any suitable distance from both sides of the watercourse crossing shall be installed with sediment fence or equivalent along the sides, together with gravels or stone pad and water bar to prevent sediment traction onto the crossing that may potentially enter the stream.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(k) Temporary or permanent roadways

i. Runoff conveyance system such as road ditch, temporary earth drain, catch drains, berm drains, toe drains, slope drains and in-slope or out-slope diversion shall be constructed and conveyed runoff to stabilized area or into sediment treatment P2M2s prior to discharge.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(I) Temporary Stabilization

i. Temporary soil stabilization shall be applied to exposed areas within fourteen (14) days after final formation level is reached on any portion of the site.

ii. Temporary soil stabilization shall be applied within seven (7) days to exposed areas that may not be at final grade but will remain unattended for longer than fourteen (14) days.

iii. Temporary stabilization means a condition where exposed soils or disturbed areas are provided a temporary vegetative and/or non-vegetative protective cover to prevent erosion and sediment loss. Temporary stabilization may include temporary seeding, geotextiles, mulches, and other techniques to reduce or eliminate erosion until further construction activities take place to re-disturb this area.

Slope Formation: 13.4.2009

Slope Formation: 14.4.2009

Slope Formation Hydroseeding: 15.4.2009

Slope Formation Stabilization Mat: 16.4.2009

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(m) Stockpile Soil Management

i. Location of the stockpiles area shall be away at a minimum distance of 20 metres from any watercourse.

ii. The stockpiled soil shall be protected from contact with runoff water (including run-on) using a temporary perimeter control such as berms, dikes, fiber rolls, silt fences, sandbag and gravel bags.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(n) Spoil Management Area (Disposal Area)

i. Location of any disposal area shall be away at a minimum distance of 20 metres from any watercourse

ii. All disposal area shall be protected from contact with runoff water (including run-on) using a temporary perimeter sediment barrier such as berms, dikes, fiber rolls, silt fences, sandbags and gravel bags.

iii. All anticipated runoff flowing from any disposal area shall be drained into a sediment trap/basin prior to discharge.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(o) Dewatering practices

i. Accumulated runoff water from excavations, trenches, foundations, vaults, or other similar points of accumulation shall be treated effectively using appropriate controls such as but are not limited to sediment basins / traps, dewatering tank treatment system, active treatment system, bag or sand filters prior to discharge.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(p) Active Treatment System (ATS)

i. Whenever recommended by the consultant, Active Treatment System (ATS) shall be implemented. The installation and operation of the ATS shall be in accordance with good engineering practices, and with design and specifications recommended by the provider of the treatment system.

(Note: Active Treatment System (ATS) refers to the treatment of runoffs using a mechanical system with the application of coagulants and flocculants to promote the settling of suspended solids out of the aqueous phase. Only coagulants and flocculants which have been approved for use by environmental agencies such as USEPA or similar authorities are allowed to be used.)

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(p) Active Treatment System (ATS)…cont;

ii. The Director General of DOE reserves the right to instruct any PP to install ATS system whenever:-

a) The project site has been found to have violated the total suspended solids discharge standard stipulated in the EIA approval conditions (COAs); or

b) Analyses of soil investigation in the project site shows that the dispersible fine-grained clays contain more than 10% of dispersible material.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(p) Active Treatment System (ATS)…cont;

For Additional Information Purpose Only:

ACTIVE TREATMENT SYSTEM is a water quality improvement system that combines latest chemical treatment and mechanical dewatering technology to effectively remove fine sediment, organics and metal contaminants in sludge masses.

Typically, anionic PAM flocculants are applied in pre-test dilutions to flocculate suspended solids whilst the filtration media traps the flocs allowing clean water to discharge. The process is accelerated with pumping and on-line dosing to reduce reaction time for flocculation and dewatering. Addition of coagulants and cationic conditioners are required when treating organic animal wastes and very fine bentonite sludges. A qualified technician with appropriate training is required to be present during the operation.

Pollutant Source : sediment pond

Active Treatment Containers/ Filtration System

Flocculant Dosing & Dewatering/ Filtration Process

Flocs trapped within containers. Clean water discharged

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(p) Active Treatment System (ATS) …cont;

For Additional Information Purpose Only:

i. ATS-mini is a Polymer Enhanced BMP.

ii. When construction areas are "tight" and space allocation for temporary sediment containment is very limited eg. as in linear construction light rail and existing highway widening projects, application of ATS-mini with "polymer flocculation – gravity filtration system" system may be appropriate and allowed under the recommendations of the environment consultant and meet the of Department of Environment approval.

iii. Contaminated sludge from sediment pond/trap is pumped via "sand pump" to temporary mixing container situated on higher platform where correct PAM is added and stirred. Mixture flows by gravity to filtration bags. Flocs are trapped within the recyclable engineered bags whilst clean water is discharged.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

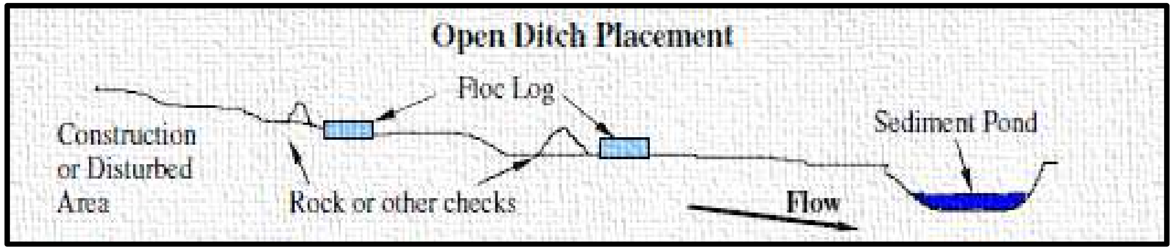
(p) Active Treatment System (ATS)…cont;

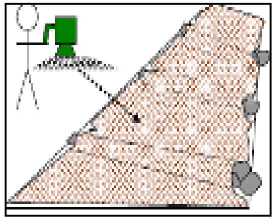
For Additional Information Purpose Only:

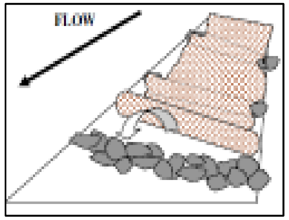
Polymer Enhanced BMP (PEBMP)

i. (PAM) used for erosion and sediment control is a water soluble anionic polyacryamide approved to enhance water quality discharges at construction sites by binding fine clay particles and reducing turbidity (NTU). PAM comes in powder, “slow release” polymer blocks and concentrate liquid for easy storage and applications. Some of the applications include powder additives to reinforce hydromulching & seeding process, PAM Blocks installed in drainage ditches as pre-treatment to flocculate and “settle-out” suspended solids in sediment traps/basins, application as emulsion-liquid medium in mechanical applications in ATS and ATS-mini to flocculate and “filter-out” suspended solids.

POLYMER ENHANCED BMP
(LDPPMM - BMP)







MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(q) Discharge

i. All discharge runoff water from any land-disturbing activities shall be made through a sediment control P2M2 such as sediment basin or trap or any other erosion and sediment controls which is regarded as the designated final discharge(s).

ii. All disturbed areas shall drain to sediment control measures at all times during land-disturbing activities and during site development until stabilized, after which, the sediment controls shall be removed. Any trapped sediment and the disturbed soil areas resulting from the removal of temporary measures shall be permanently stabilized to prevent further erosion and sedimentation.

iii. The discharge point of the treated runoff shall be released by using a dissipater or other means of outlet protection.

iv. All discharge run off water to offsite area shall only be allowed through a sediment basin or trap or other specified control measures.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(r) Corrective Actions

i. In a case where a required P2M2 was installed incorrectly, or are not effective enough to produce a discharge that complies with the discharge standards, the PP shall install a new or modified control or additional control and make it operational by no later than 7 calendar days from the time of discovery.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(r) Corrective Actions;…cont;

ii. The PP shall within 7 calendar days of discovering the occurrence of one of the triggering conditions above complete a report as described in the Performance Monitoring Document (PMD) and which shall be reported in the Performance Monitoring Report (PMR). The report details which shall also be recorded in the logbook include the following:

a) Any follow-up actions taken to review the design, installation, and maintenance of P2M2s , including the dates such actions occurred; and
b) A summary of P2M2 modifications taken or to be taken, including a schedule of activities necessary to implement changes, and the date the modifications are completed or expected to be completed; and
c) The PP shall send a report with photographic evidence as soon as practicable whenever corrective actions or measures have been taken or scheduled to be taken, using an online communication medium to the DOE.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(r) Corrective Actions;…cont;

iii. In all circumstances, the PP shall immediately take all reasonable steps to minimize or prevent the discharge of pollutants until a permanent solution is taken and an appropriate P2M2 is installed or applied and made operational, including cleaning up any contaminated surfaces so that the material will not be discharged in subsequent storm events.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(s) Site Inspections

i. Site inspections shall be conducted to check and to ascertain that all P2M2s specified in the EIA Report and this document have been properly installed and maintained as well as to determine whether any controls that are clearly not operating as intended or any P2M2s requires replacement, or additional P2M2s are required. The site inspections shall also assess if pollution is effectively being controlled and off-site discharge is being prevented in compliance with the EIA conditions of approval (COAs).

ii. All inspection activities shall be recorded in the PM logbook.

iii. At a minimum, inspections shall be conducted at the site prior to commencement of land clearing activities and after every storm event during construction and as specified in the established inspection schedule.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(s) Site Inspections

i. Site inspections shall be conducted to check and to ascertain that all P2M2s specified in the EIA Report and this document have been properly installed and maintained as well as to determine whether any controls that are clearly not operating as intended or any P2M2s requires replacement, or additional P2M2s are required. The site inspections shall also assess if pollution is effectively being controlled and off-site discharge is being prevented in compliance with the EIA conditions of approval (COAs).

ii. All inspection activities shall be recorded in the PM logbook.

iii. At a minimum, inspections shall be conducted at the site prior to commencement of land clearing activities and after every storm event during construction and as specified in the established inspection schedule.

Claim to be "CLOSE TURFING"

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(s) Site Inspections;…cont;

iv. At a minimum, the following areas shall be inspected:

a) All areas that have been cleared, graded, or excavated and that have not yet completed stabilization;

b) Construction entrances/exits ;

c) Roadways;

d) All P2M2s installed or applied at the site;

e) Material storage areas, spoil area, borrow area, or equipment storage and maintenance areas;

f) All areas where runoff water typically flows within the site, including drainage ways designed to divert, convey, and/or treat runoff water;

g) All points of discharge from the site;

h) All locations where stabilization measures have been implemented at least once every seven (7) days and within 24 hours after the end of a storm event of 12.5 mm or greater.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(s) Site Inspections;…cont;

v. Rain gauge shall be properly maintained at the site so as to determine if a storm event of 12.5 mm or greater has occurred on the site. In a circumstance that a rain gauge is faulty, the storm event information shall be obtained from a weather station that is representative of the project site.

vi. Major observations and incidents of non-compliance should be recorded in the inspection report, as well as corrective actions and maintenance and shall be recorded in the PM log book.






MINIMUM STANDARDS REQUIREMENTS OF POLLUTION
PREVENTION AND MITIGATION MEASURES

(t) Maintenance

The PP shall maintain the P2M2s in accordance with the following requirements:

i. Maintenance shall begin as soon as the first P2M2 is installed or applied and shall continue through all the succeeding activities until the permanent erosion control measures are established and functioning. Maintenance method shall be in accordance to design specification.

ii. Unless advised otherwise, maintenance shall occur within seven (7) calendar days of the inspection noted/reported. All maintenance activities shall be recorded in the PM logbook.

iii. Sediment Basin/Trap shall be kept in effective operating condition and remove accumulated sediment to maintain at least ½ of the design capacity of the sediment basin/trap at all times.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(t) Maintenance;…cont;

iv. Sediment shall be removed before it accumulates to one-half of the above-ground height of any perimeter control such as by cleaning out the silt fences when they are 1/2 full of sediment and/or by replacing them when they are torn or lifted, to retain their functionality.

v. Stabilized Construction Entrance or wash trough or Tires Washing Facility shall be maintained so as not to track-out sediment or mud onto any adjacent public roads. In any occasion where sediment has been tracked-out from the project site onto the off-site streets, the deposited sediment shall be removed the end of the same work day by sweeping, shoveling, or vacuuming the surfaces, or by using other similarly effective means of sediment removal. Hosing or sweeping tracked-out sediments into any drainage is prohibited unless it is connected to a sediment basin, sediment trap, or similarly effective control.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(u) Standards and Specifications for P2M2s

i. All P2M2s shall be designed, constructed, installed, and maintained in accordance with good engineering practices and applicable design specifications.

ii. Application of all P2M2s onsite shall be in accordance with standards and specifications indicated, specified, stated, depicted and set forth in:

a) Department of Irrigation and Drainage – DID. 2010. Guideline for Erosion and Sediment Control in Malaysia

b) Department of Irrigation and Drainage – DID. 2000. Urban Storm Water Management Manual for Malaysia

c) Erosion and Sediment Control Planning and Design Manual issued by North Carolina Department of Environment and Natural Resources*

Note: This manual can be accessed at https://enviro.doe.gov.my/

d) Best Management Practices for Construction and Maintenance Activities issued by North Carolina Department of Transportation**

Note: This manual can be accessed at https://enviro.doe.gov.my/

- [Note: For the use of the manuals mentioned in (c) and (d), credit is hereby given to the Sedimentation Control Commission for granting permission for its use in Malaysia- See the acknowledgement page of this Guidance Document]

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

7.2: Self-Regulation

- The Project Proponent shall ensure that:
- All relevant parties including project consultant, contractors, and Environmental Officer (EO) understand LD-P2M2 in order to facilitate compliance with the minimum standards requirements.
- All relevant pollution prevention and mitigation measures (P2M2s) especially temporary BMPs at the constructional phase are installed and maintained to mitigate the potential pollution due to land disturbing activities.

(v) Establishment of Environmental Performance Monitoring Committee (EPMC) and Performance Monitoring Documentation

i. The PP shall establish a project Environmental Performance Monitoring Committee (EPMC) to monitor the environmental performance and effectiveness of P2M2s, and status of regulatory compliance of the project.

ii. The EPMC shall be represented by all relevant parties involved in project implementation and chaired by a senior member representing the PP. The chairman shall be responsible for ensuring the decisions of the meeting are responsibly executed. The EPMC shall meet at a minimum, once in a quarter and the minutes of the meeting be maintained.

(v) Establishment of Environmental Performance Monitoring Committee (EPMC) and Performance Monitoring Documentation

iii. The PP through the Environment Officer (EO) shall prepare a Performance Monitoring Document (PMD) that describes in detail how EIA approval conditions (COAs) are going to be complied and how performance monitoring of the P2M2s will be conducted to ensure the optimal functionality of the P2M2s is maintained. The details in the PMD shall include, among others: performance monitoring equipment/instruments, sampling protocols and analysis, monitoring parameters, sampling frequency, preventive and corrective maintenance procedure for the P2M2s, discharge compliance, record keeping, etc.

iv. The PP through the EO shall establish and execute an environmental performance monitoring (PM) program to monitor and evaluate the effectiveness of the P2M2s, inspect, maintain, take corrective actions on the P2M2s to ensure their functionality and effectiveness throughout the entire process of the land disturbing activities.

(v) Establishment of Environmental Performance Monitoring Committee (EPMC) and Performance Monitoring Documentation

v. The PP shall set up a "mini laboratory" to facilitate the implementation of environmental performance monitoring program. This mini laboratory shall be adequately equipped with relevant resources including portable analytical testing equipment such as in-situ total suspended solids meter, turbidity meter, etc.

vi. The PP through the EO shall establish and maintain proper records using a log book (called the Performance Monitoring logbook) that contains among others, Checklist of P2M2s List Sheet, Installation Sheet, Maintenance Sheet, Site and P2M2 Inspection Sheet, Photograph Folder Sheet, Corrective Action Sheet, Performance Monitoring Sheet, etc. The PMD and PMR shall be maintained for five years upon completion of project development. For a reference, see **Appendix I** **and** **Appendix II** for the samples of the PMD conducted at two different development project sites.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES

(v) Establishment of Environmental Performance Monitoring Committee (EPMC) and Performance Monitoring Documentation

vii. The PP is required to keep a current copy of the PMD and PM log book at the site or at an easily accessible location, so that it can be made available at the time of an onsite inspection or upon request by the Department of Environment inspector. This log book shall be maintained or updated by weekly/event-based inspections.

viii. The PP through the EO shall prepare a Performance Monitoring Report (PMR) that discusses the results of the performance monitoring conducted as described in the PMD. Wherever relevant, PMR shall include data interpretation and assessment of the effectiveness of the P2M2s by making comparison of the performance monitoring parameters with their recommended ranges (or standards). Statistical techniques and graphical presentation of the performance monitoring parameters shall be used wherever appropriate. PMR shall also make some definitive conclusions on the overall performance of the P2M2s and suggest improvement measures to be taken if necessary. PMR shall be submitted to the EPMC as established by the PP for the EIA project.

MINIMUM STANDARDS REQUIREMENTS OF POLLUTION PREVENTION AND MITIGATION MEASURES: Briefly - Functions of EPMC

PMD

1. Detail of how EIA approval conditions (COAs) are going to be complied
2. Detail of how performance monitoring of the P2M2s will be conducted

PM

1. Logbook

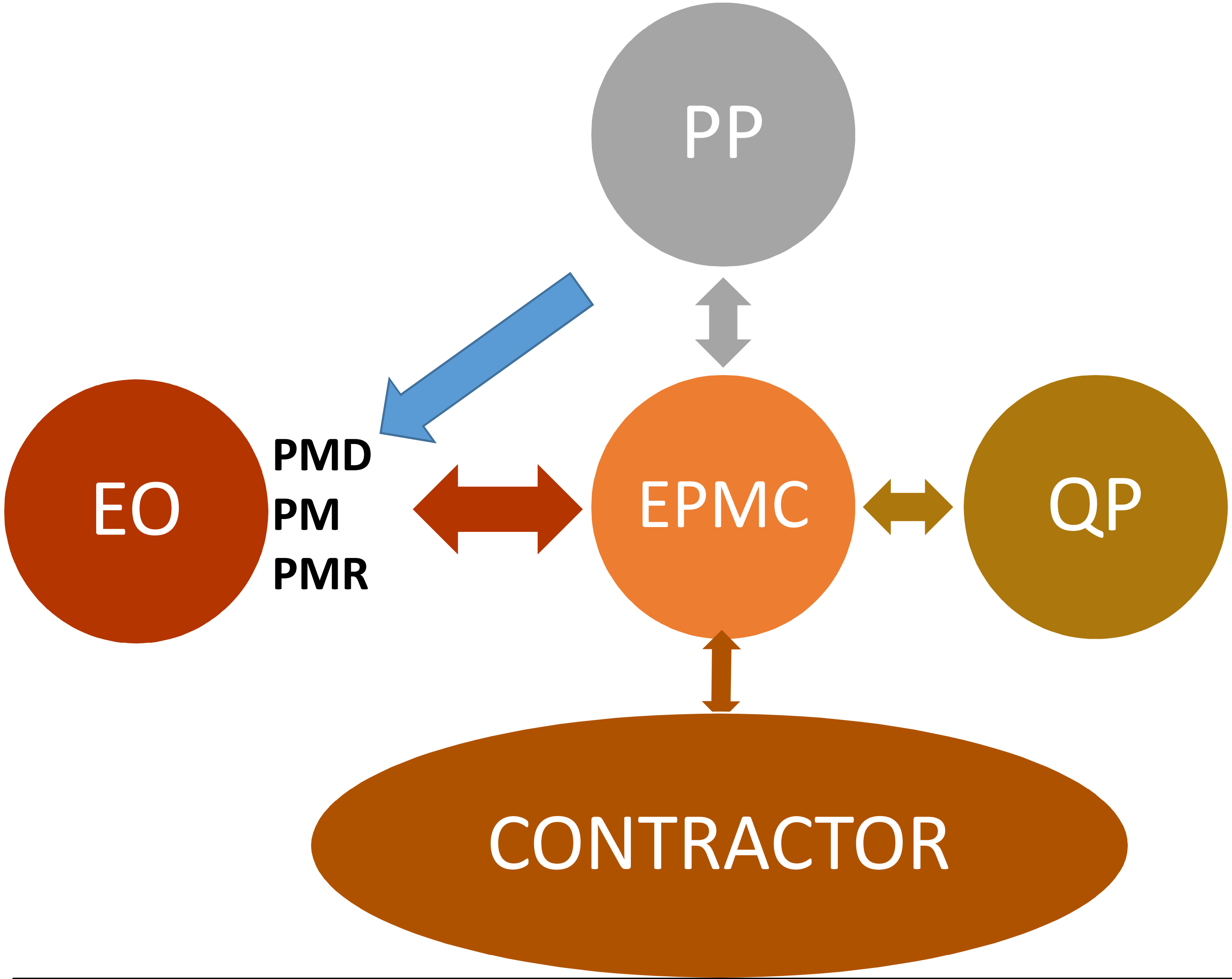
- Checklist of P2M2s List Sheet, Installation Sheet,
- Maintenance Sheet,
- Site and P2M2 Inspection Sheet,
- Photograph Folder Sheet, Corrective Action Sheet, Performance Monitoring Sheet, etc.

2. Environmental performance monitoring (PM) program

Establish and execute to monitor and evaluate the effectiveness of the P2M2s, inspect, maintain, take corrective actions on the P2M2s

PMR

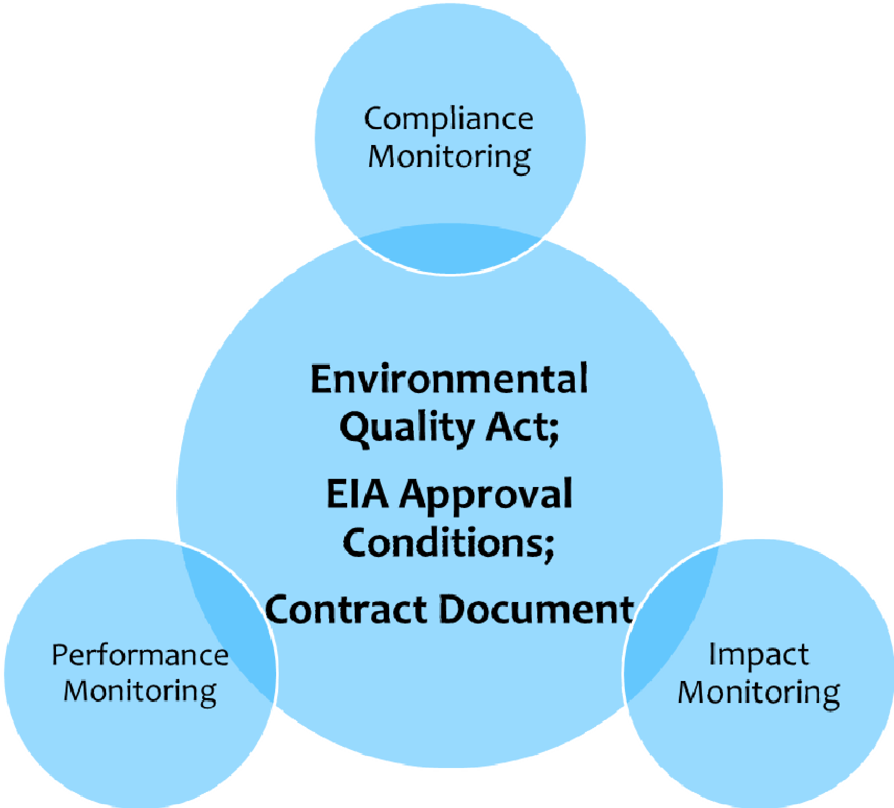
1. Discusses the results of the performance monitoring
2. Data interpretation and assessment of the effectiveness of the P2M2s.
3. Statistical techniques and graphical presentation of the performance monitoring parameters.
4. Definitive conclusions on the overall performance of the P2M2s and suggest improvement measures to be taken if necessary.
5. PMR shall be submitted to the EPMC as established by the PP.

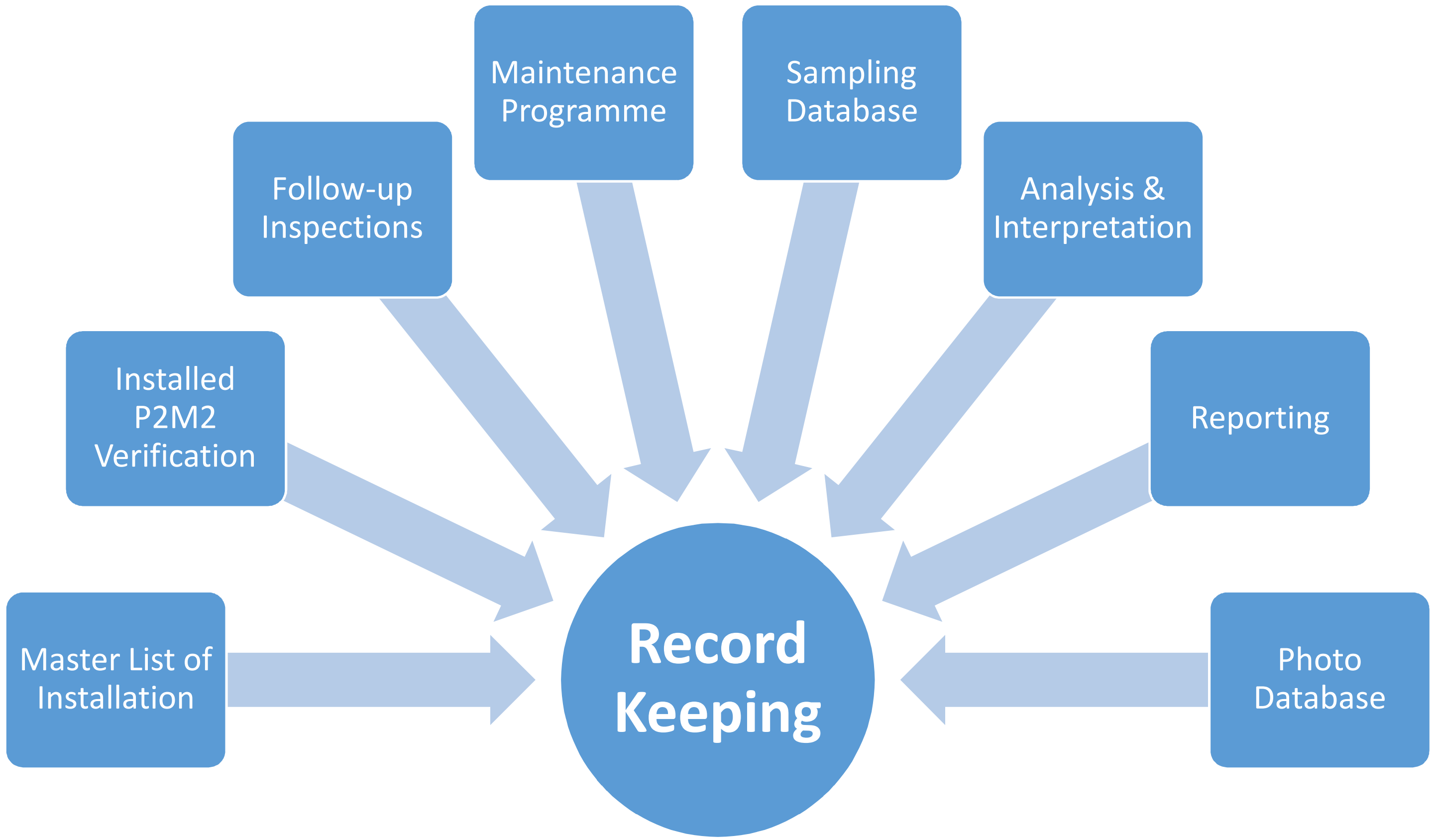


ROLES OF FOUR PARTIES RELATIONSHIP IN EPMC

INSTALL	• Contractor to adhere to LD-P2M2 on the what, where & when to install. • Contractor to ensure fit-for-purpose of installation.
INSPECT	• EO to verify correctness based on specification and LD-P2M2 Document. • EO to verify functionality throughout life of installation.
MAINTAIN	• Contractor to maintain installation per EO's maintenance program. • EO to verify if maintenance were done timely. • Contractor to ensure fit-for-purpose throughout life.

Types of Monitoring




Maintenance Programme
Sampling Database
Follow-up Inspections
Analysis & Interpretation
Installed P2M2 Verification
Reporting
Master List of Installation
Record Keeping
Photo Database

APPENDIX C

CULTURE OF OUR CONSTRUCTION INDUSTRY

Culture of our Construction Industry

Stakeholders' Perception on Erosion and Sediment

The issue of erosion and sedimentation continues to be a hot subject of discussion in the context of Malaysian projects, and the current situation remains unchanged or without improvement when undertaking major projects, this issue will continue to deteriorate, resulting in further damage to the environment and liability to the public.

Based on data collected by DOE over the past years, selected key challenges claimed by the various stakeholders on this subject matter are depicted in the following diagrams:

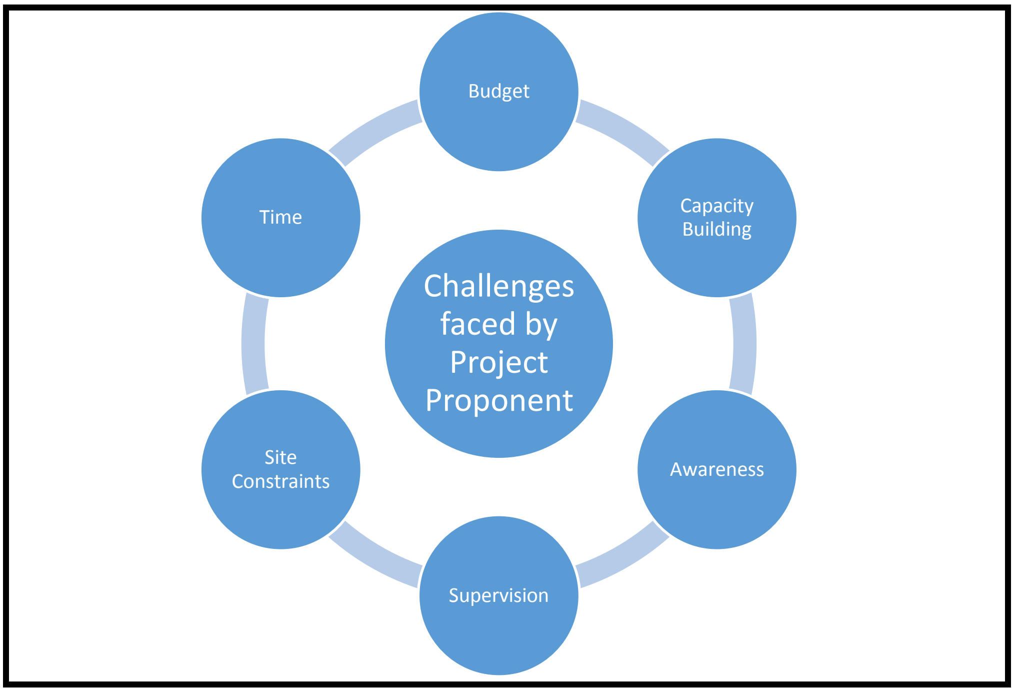


Figure 1: What Project Proponents Say

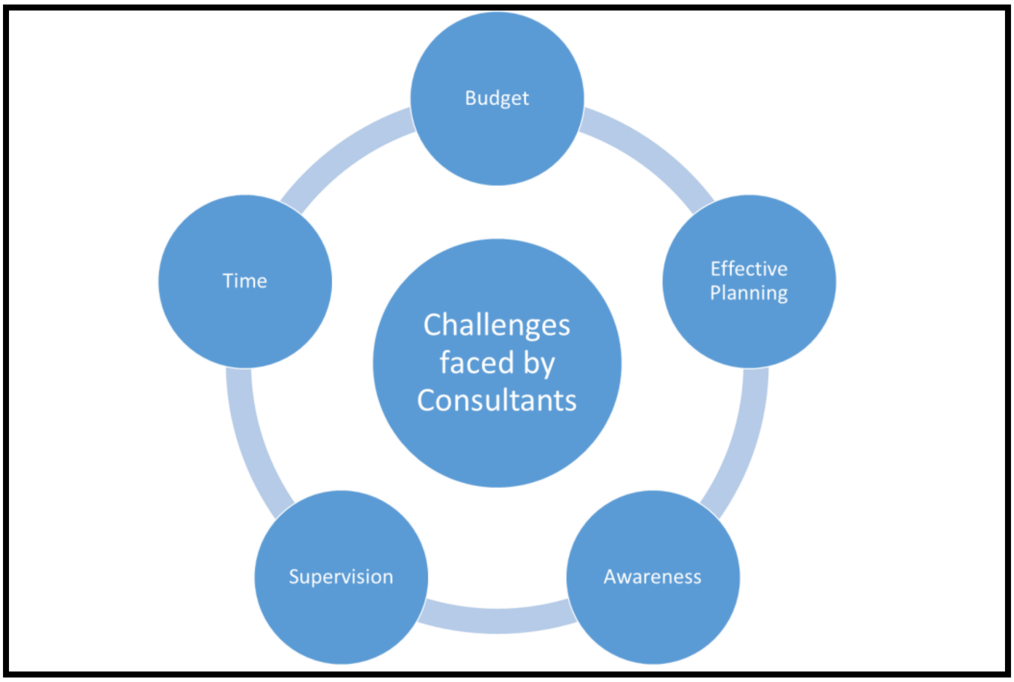


Figure 2: What Consultants Say

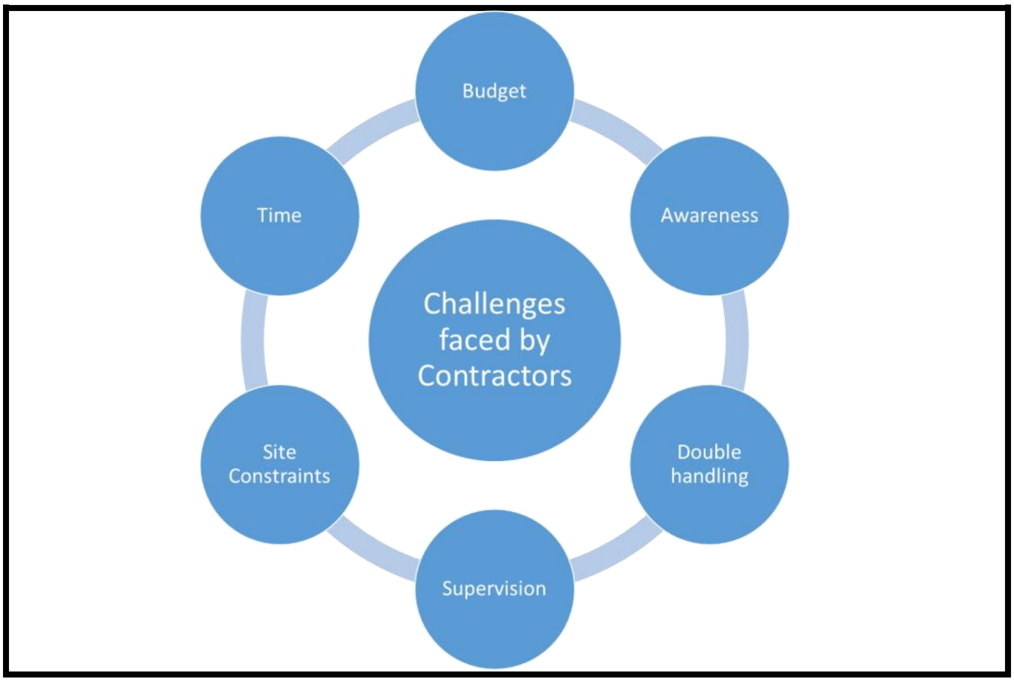


Figure 3: What Contractors Say

<u>Challenges faced by Project Proponent</u>

The key challenges perceived by Project Proponents in dealing with erosion and sediment control on their projects are graphically shown above in the first diagram. It is quite common for the project proponents to cite budget constraint as probably their biggest challenge in dealing with erosion and sediment issues on site, followed by time and site constraints as well as lacking the suitable experience site staff. For some projects, the PP may cite that since limited information is available at the early stage of the project, such as at the EIA stage (as the Contractor has not been appointed yet), it would be difficult for the cost of the mitigation measures to deal with erosion and sediment issues to be estimated and included in the tender documents. Similarly, the same reason is also applied for the constraints of time and site conditions, whereby not enough time or working space has been allowed to implement related mitigation measures to prevent or minimize erosion and sediment deposition arising from land disturbing activities in the project. A strongly related factor that may have resulted in the preceding challenges may be due to the relatively low awareness amongst the managerial or supervision team of the project proponent on the measures or practices that can be undertaken to prevent or minimize erosion and sediment deposition during site works.

Although some of the above may be valid reasons for certain projects, it should be noted, however, that the project proponents have to take into consideration the fundamental requirements of the EIA and environmental mainstreaming in regard to their projects. The following excerpts from the *"Environmental Impact Assessment Guideline in Malaysia, 2016*" are particularly relevant (*Note: these excerpts have been mentioned elsewhere in this Guidelines but repeated herein due to their importance*):

"The EIA procedure, a preventive strategy of the DOE also needs to embrace the environmental mainstreaming and self-regulation goal in order to enhance its effectiveness in mitigating the adverse impacts from development projects on the environment at every stage of the EIA procedure. Self-regulation culture in EIAs means that the Project Proponent will be charged with full responsibility and accountability for taking environmental friendly options and instituting effective pollution prevention and mitigation measures (P2M2) and self-demonstration of regulatory compliance of the EIA procedure at all stages of project implementation."

"Legal responsibility rests on the shoulders of the Project Proponent hence he shall be totally committed towards ensuring regulatory compliance of his project with the EIA procedure at all stages of project planning and implementation. The Project Proponent is the key driver for ensuring the success self-regulation approach in environmental management through the mainstreaming of environmental agenda throughout his project implementation phases. The project proponent shall ensure top-down organizational commitment to environmental regulatory compliance to all personnel, at all levels of the organization, including the registered EIA consultant, the EO, the contractors, and other parties involved in the project implementation."

"Allocating sufficient funds for all steps in the EIA process and every stage of project planning and implementation with itemized budget required for water quality monitoring, air quality and noise monitoring, for comprehensive site survey and investigation of the specific existing site conditions, for implementation of Environmental Management Plan

(EMP) including temporary pollution prevention and mitigation measures (P2M2). P2M2 shall be those which can be described as state of the art technologies, best available technologies (BATs), or industry best practices."

"The investor whose project has been planned on sound environmental principles right from the start might be safeguarded against environmental costs once the project has been implemented. EIA being a preventative-planning tool helps to avoid costly remedial actions by taking proactive measures also helps to protect the investment."

Challenges faced by Consultants

Similarly to the challenges faced by the project proponents, the Consultants may perceive the lack of adequate information at the early stage of project as a deterrent to being able to effectively plan for handling erosion and sediment issues during the planning stage of the project. The awareness level needs to be raised to understand the measures or practices that can be undertaken to prevent or minimize erosion and sediment deposition during site works, particularly at the planning stage. Despite the above, the Consultants and his site representatives such as the Environmental Officer (EO) have to take into consideration the fundamental requirements of the EIA and environmental mainstreaming in regard to their projects. The following excerpts from the *"Environmental Impact Assessment Guideline in Malaysia, 2016*" are particularly relevant:

"The registered EIA Consultant is the key person who is entrusted with the responsibilities for ensuring environmental impacts from a project are correctly identified, assessed, and mitigated."

"The Environmental Officer (EO) is the main project personnel responsible for ensuring regulatory compliance at the project implementation stage (post submission of EIA Report)."

The EO's role also include "*preparing Environmental Performance Monitoring Document (EPMD). PMD describes in detail how EIA approval conditions are going to be complied and how performance monitoring* of the various pollution prevention and mitigation measures (P2M2) will be conducted to ensure the optimal functionality of the P2M2 is maintained."*

Challenges faced by Contractors

Typically, the Contractor's scope of works would be dictated by the requirements as spelled out in the tender drawings and specifications. Provided that the requirements for erosion and sediment control are adequately detailed in the above documents (i.e., drawings and specifications), the Contractor can then allow for the appropriate resources on the required mitigation measures. Nonetheless, contractors normally plan their work activities to limit the amount double handling in the site works or long idling time for their equipment and machineries. Awareness on measures to deal with erosion and sediment issues is also a challenge for the contractor.

<u>How LD-P2M2 Addresses Challenges in Erosion and Sedimentation in Malaysia</u>

Based on the aforementioned discussions, the key potential “factors” contributing to erosion and sedimentation issues are summarized and allocated respectively to the three main key players, namely Project Proponents, Consultants and Contractors (including his Sub-Contractors).

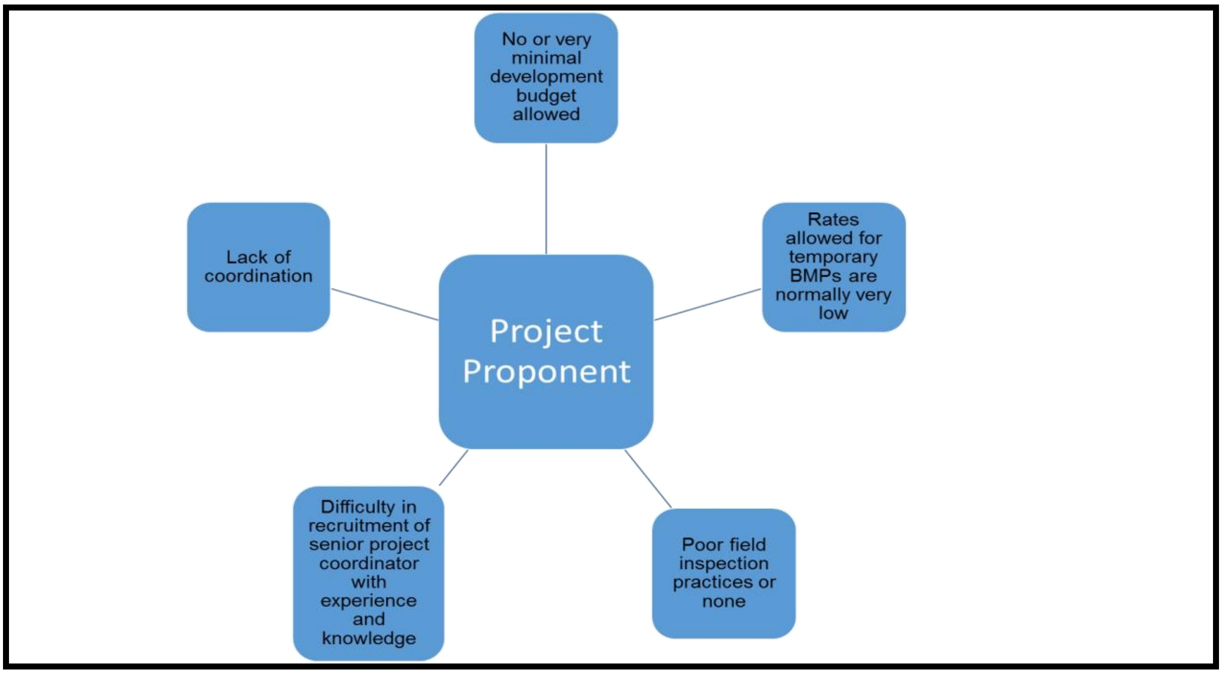


Figure 4: Project Proponents' Challenges

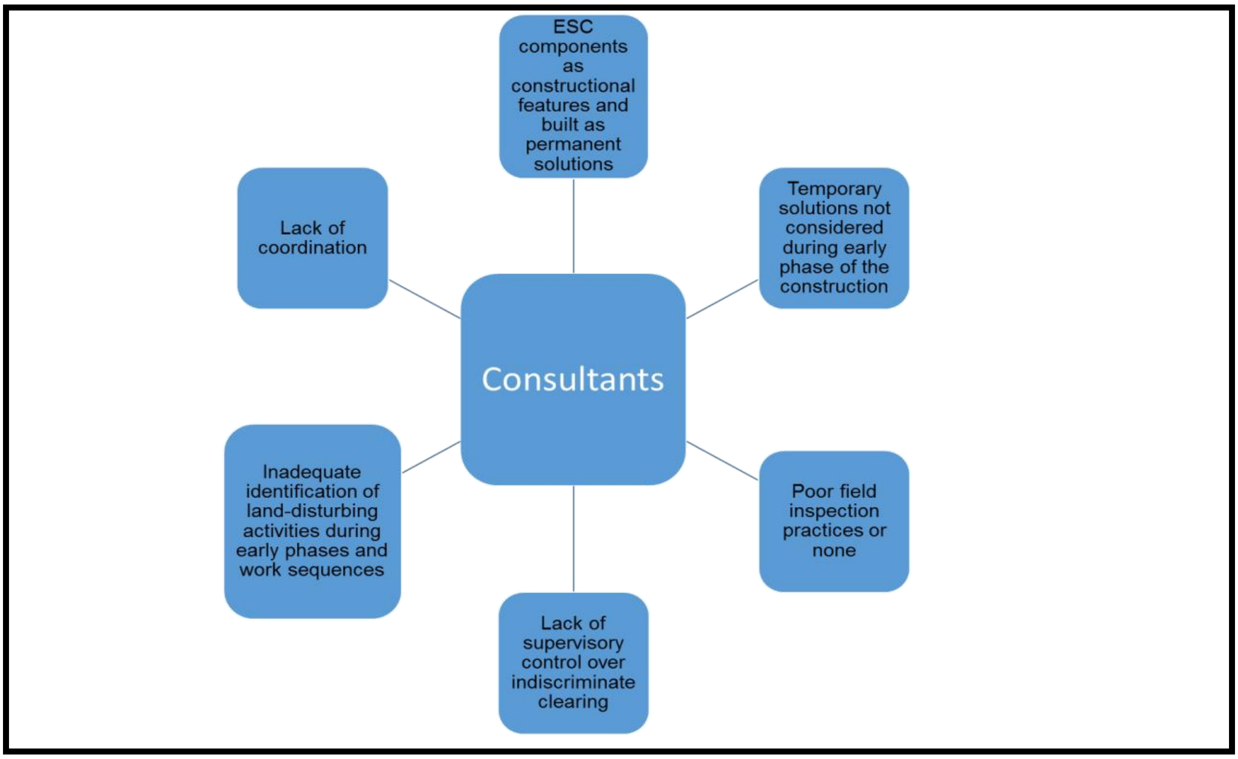


Figure 5: Consultants' Challenges

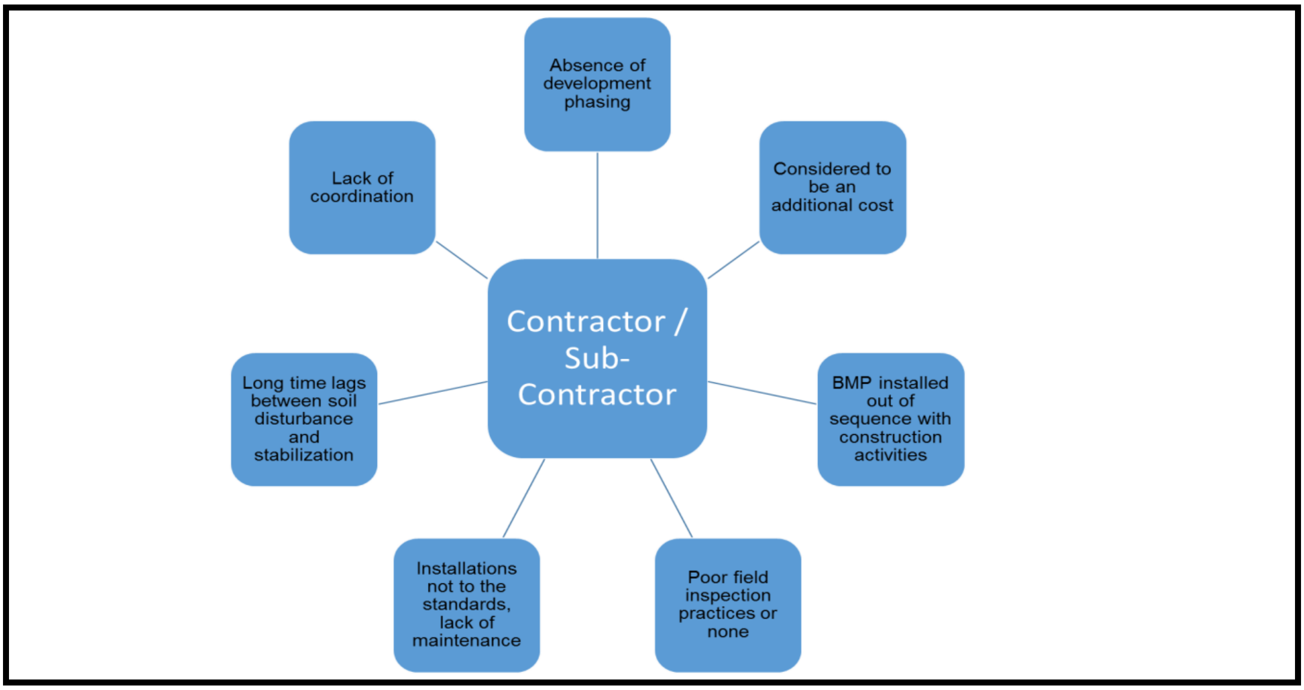


Figure 6: Contractors' Challenges

Taking into account each of the above factors, it can be seen that the adoption of LD-P2M2 can assist in the management of erosion and sedimentation issues by responding directly to these factors in the following manner:

Key Challenges	**Potential Solutions**
No or minimal development budget allowed	LD-P2M2 needs to be prepared during the EIA stage; this then enables the Project Proponent to appreciate the extent of BMPs and mitigation measures that would be anticipated during the site works. Such information then allows the Project Proponent to allocate the appropriate resources including budget into his overall project cost estimation.
Rates allowed for temporary BMPs are normally low	Early knowledge as mentioned above allows the Project Proponent and Consultants adequate time to research market prices for the BMPs and mitigation measures that would be utilised, whether these are temporary or permanent measures.
Lack of coordination & communication	LD-P2M2 Document will be a common reference document for all parties, since LD-P2M2 Document is a part of the EIA report, and hence will involve the participation of all parties.
Poor or limited field inspection practices	Training on LD-P2M2 will be rolled out in the future.
Difficulty in recruitment of staff with experience and knowledge	Training on LD-P2M2 will be rolled out in the future.
ESC components as constructional features / permanent solutions	LD-P2M2 scope starts from the preconstruction stage up through closure, thus addressing also temporary solutions.
Temporary solutions not considered during early phase of the construction	LD-P2M2 scope starts from the preconstruction stage up through closure, thus addressing also temporary solutions.
Inadequate identification of land-disturbing activities during early phases and work sequences	One of key focus of LD-P2M2 is on early identification of land disturbing activities and work sequences at the EIA stage.
Lack of supervisory control over indiscriminate clearing	LD-P2M2 document to spell out the requirements on project phasing and work sequences. Additionally, training on LD-P2M2 will be rolled out in the future.
Absence of	One of the key focus of LD-P2M2 is addressing changes in site

development phasing	conditions during development phasing.
Considered to be an additional cost	LD-P2M2 seeks to prevent potentially even larger costs associated with rehabilitation or corrective actions.
BMP installed out of sequence with construction activities	LD-P2M2 will address the changing site conditions and accordingly the appropriate BMPs.
Long-time lags between soil disturbance and stabilization	LD-P2M2 will identify those land disturbing activities that are needed to be mitigated accordingly.
Installations not to the standards, lack of maintenance	Training on LD-P2M2 will be rolled out in the future to inspectors to identify such problems

<u>Summary of Overall Gap in Today's Construction Practices</u>

Together with the above challenges, a compilation of the overall gap in dealing erosion and sedimentation in our construction sites is provided below.

Table 1: Gaps in Erosion & Sediment Control Inspection
➢ Absence of development phasing whereby only a portion of the construction site is cleared and graded at any one time; ➢ Unnecessary clearing of environmental sensitive areas, such as stream riparian buffers, steep slopes, wetlands and seeps; ➢ Lacked of coordination and communications among players; ➢ Misunderstood erosion and sediment control with Storm Water Management and Landscaping; ➢ Long-time lags between soil disturbance and soil stabilization; ➢ Installations not to the standards and specifications; ➢ Perception that erosion and sediment control is "all about putting up sediment basin"; ➢ Poor or limited field inspection practices; ➢ Lack of maintenance; and ➢ Negative attitude towards erosion and sediment control

Table 2: Common Failures of BMPs at Construction Sites
➢ Incorrect design or construction instruction; ➢ BMP not suited for the function; ➢ BMP installed incorrectly; ➢ No maintenance; ➢ Changing site conditions; ➢ BMP installed out of sequence with construction activities; ➢ Inadequate erosion and sediment control plan and unrevised; ➢ Construction activities often reveal site conditions that were not anticipated in the erosion and sediment control plan; ➢ Changes in the construction sequence or weather conditions will impact the erosion and sediment control plan; and ➢ The erosion and sediment control plan may address the initial and final phase of construction but may not address interim construction phases with adequate temporary BMPs.

Table 3: Common Pitfalls during Design & Construction Phases
➢ No or minimal development budget allowed for during the project inception stage; ➢ Erosion and sediment control components are often designed as constructional features and scheduled to be built as permanent solutions typically towards the advanced stage of the civil works, not temporary solutions during early phase of the construction which involved massive clearing of earth covering vegetation, slope cutting and profiling, and earthmoving works; ➢ Due to the lack of budget during the planning and design phase, erosion and sediment control implementation is considered to be an additional cost to the project which has not been accounted for or anticipated earlier; ➢ Erosion and sediment control is to be implemented as permanent solution and shall be completed together with other infrastructure components including stormwater runoff detention system, drainage system, landscaping and turfing etc.; ➢ There is lack of supervisory control over indiscriminate clearing of project site as there is always pressure to keeping track with the project progress. Implementation of temporary erosion and sediment control measures is considered as non-productive works; ➢ Rates allowed for temporary BMPs are normally on the low side and often considered as items with negative profit and given very low priority in construction planning; ➢ Site clearing and earthmoving are normally carried out in large area at one time, instead of staggered and phased development, as it will yield higher return on the reason of economic of scale; and ➢ Environmental pollution from sediment discharges into water courses is

considered as a temporary impact and will not have permanent impact. There is lack of concern for downstream areas which receive sediments transported from upstream construction site.

SWOT Analysis of LD-P2M2

A SWOT analysis (Strength/Weakness/Opportunities/Threat) of the LD-P2M2 is also presented below for information.

Strength	Weakness
➢ LD-P2M2 is not something new, and it seeks to enhance / strengthen the industry's effort on minimising erosion and sediment discharges; ➢ Formulated at EIA stage and carried forward to construction stage, hence engaging the participation of all relevant parties from Project Proponent up to the Contractors; ➢ Formulation at early stage of project allows resources for probable mitigation measures to be incorporated into tender document; ➢ Main focus of LD-P2M2 will be on the progressive state of the site and interim BMPs (as opposed to final phase of construction and lacking temporary solutions); ➢ Sufficient details are required from the drawings to provide meaningful data on the recommended BMPs.	➢ Perceived to substitute other erosion and sediment control plans; ➢ Detailed information on site methodologies and operations may yet to be readily available at the time of LD-P2M2 preparation; ➢ Nos. of drawings may increase due to accounting for the changing site conditions which may result in revision or upgrading of P2M2 (but may be offset by the information provided).
Opportunities	**Threat**
➢ This concept could be extended to non-EIA projects in the future; ➢ Steady increase in the Project Proponent and/or Contractors awareness on erosion and sediment control; ➢ More collaborative effort between all project parties to play their role in addressing erosion and sediment control.	➢ Lack of understanding by the Project Proponent and/or Contractors in the use of LD-P2M2 at this moment.

APPENDIX D

SAMPLE WORKSHEET TO QUANTIFY SOIL LOSS AND SEDIMENT YIELD

'MSMA 2nd Edition, 2012 / DID Malaysia

Introduction to SOIL LOSS & SEDIMENT YIELD
USLE (Erosion Rate), Rational Method (Runoff Volume), MUSLE (Sediment Yield)

MODULE #5 EROSION AND SEDIMENT CONTROL (Chapter 12)

MALAYSIAN
STORMWATER
ORGANIZATION

Leong Kwok Wing PE (Calif),
MASCE, CPESC, CPSWQ, CESSWI

EROSION & SEDIMENT CONTROL

WORK EXAMPLES

FORESTRY

You are the consultant responsible for developing an Erosion and Sediment Control Plan (ESCP) for Malaysian Food Agriculture

(MAFC)'s new tech vegetable farming of 600 acres near Ringlet town, Cameron Highlands. The ESCP calls for a dividing the area in various lots at a developed area of 10 hectares each for the "built-up" platform areas, roads vegetable collection points, storage and loading areas.

WORK EXAMPLES

Given the following information for this lot in existing condition, slope at 30% slope steepness & 100m in horizontal slope length, Soil Sample at Borehole at 0.5m is [Clay 12.83%, Silt 35.99%, Sand 51.19%, Organic Matter (OM) 0.1%], Forest with Good Cover and assume R -= 17,500 MJ.mm/ha/yr for this area, determine the following.

WORK EXAMPLES

- What is the soil type given the above data?
- What is the "K" Soil Erodibility Factor for soil at pre-bulk?
- What is the estimated rate of sheet and rill erosion after this site is cleared of all trees, shrubs and vegetation
- What is the estimated rate of sheet and rill erosion after this site is cleared of all trees, shrubs and vegetation and it is decided that for erosion control reasons, the slope is terraced by cutting horizontal slope length creating 4berms?
- What is the estimated rate of sheet and rill erosion if 100% of slope is covered by erosion control mattress?
- Check dams shall be installed along the roadside ditch. What should be the spacing be for 500mm high check dams, if the ditch has a slope of 2%?

LOSS EQUATION (USLE)

$$A = R.K.LS.C.P \qquad (12.1)$$

where,

A = Annual soil loss, in tonnes/ha/year;

R = Rainfall erosivity factor, an erosion index for the given storm period in MJ.mm/ha/h;

K = Soil erodibility factor, the erosion rate for a specific soil in continuous fallow condition on a 9% slope having a length of 22.1 m in tonnes/ha/(MJ.mm/ha/h);

LS = Topographic factor, which represents the slope length and slope steepness. It is the ratio of soil loss from a specific site to that from a unit site having the 9% slope with a slope length of 22.1 m when other parameters are held constant;

C = Cover Management factor, which represents the protective coverage of canopy and organic material in direct contact with the ground. It is measured as the ratio of soil loss from land cropped under specific conditions to the corresponding loss from tilled land under clean-tilled continuous fallow (bare soil) conditions. This is the factor that indicates the effect of erosion control facilities in an ESCP; and

P = Support practice factor, which represents the soil conservation operations or other measures that control erosion, such as contour farming, terraces, and strip cropping. It is expressed as the ratio of soil loss with a specific support practice to the corresponding loss with up and-down slope culture. This is also the factor that indicates the effect of sedimentation control facilities in an ESCP.

GIVEN SOIL TYPE FROM SITE SAMPLING PROCEDURE

Table 12.C1: Summary of Laboratory Test Result of Soil Data

Hand Auger No.	Sample Number	Depth (m)	Particle Size Distribution (%)		
			Clay	Silt	Sand
HA 1	A	0.5	12.83	35.99	51.19
	B	1.0	15.94	42.11	41.95

WORK EXAMPLES

- What is the soil type given the above data?
- Refer to Fig. 3.14, Sand @51.19% & Clay @12.83%
- Soil Type is **LOAM**

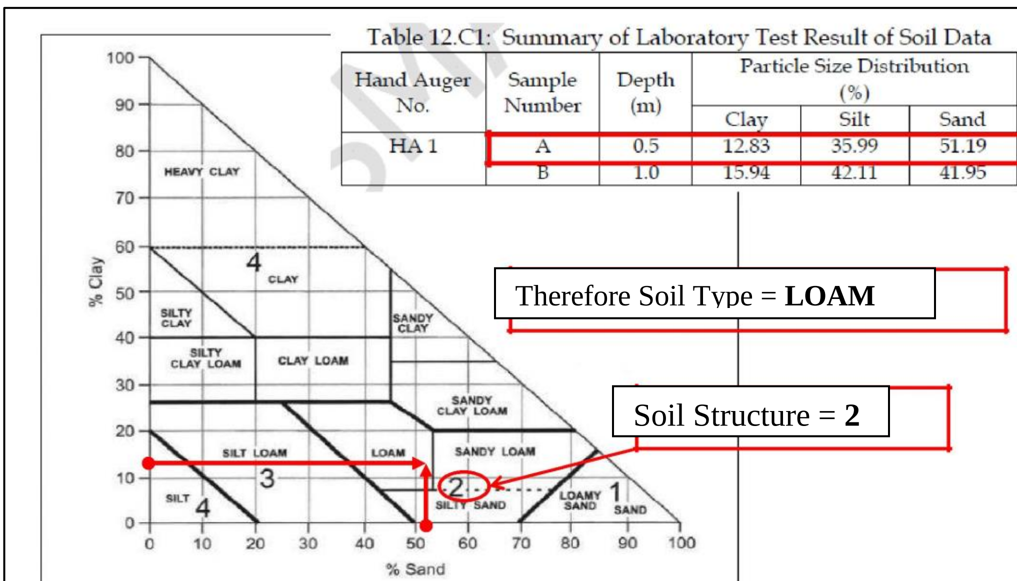


Figure 3.14: Soil Structure Code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

Table 3.2: 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+

Note: 1 – National Soil Handbook (SCS, 1983)
2 – National Engineering Handbook (SCS, 1972)

Table 3.3: Soil Layer for Soil Series in Malaysia

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

Calculations:

What is the estimated rate of sheet and rill erosion after this site is cleared of all trees, shrubs and vegetation?

A = R x K x LS x C x P *(USLE formula – MSMA2 p12-5)*

Here: R *(is given)* = 17,500 MJ.mm/ha/yr

K *(is calculated)* = 0.02

Rainfall Erositivity

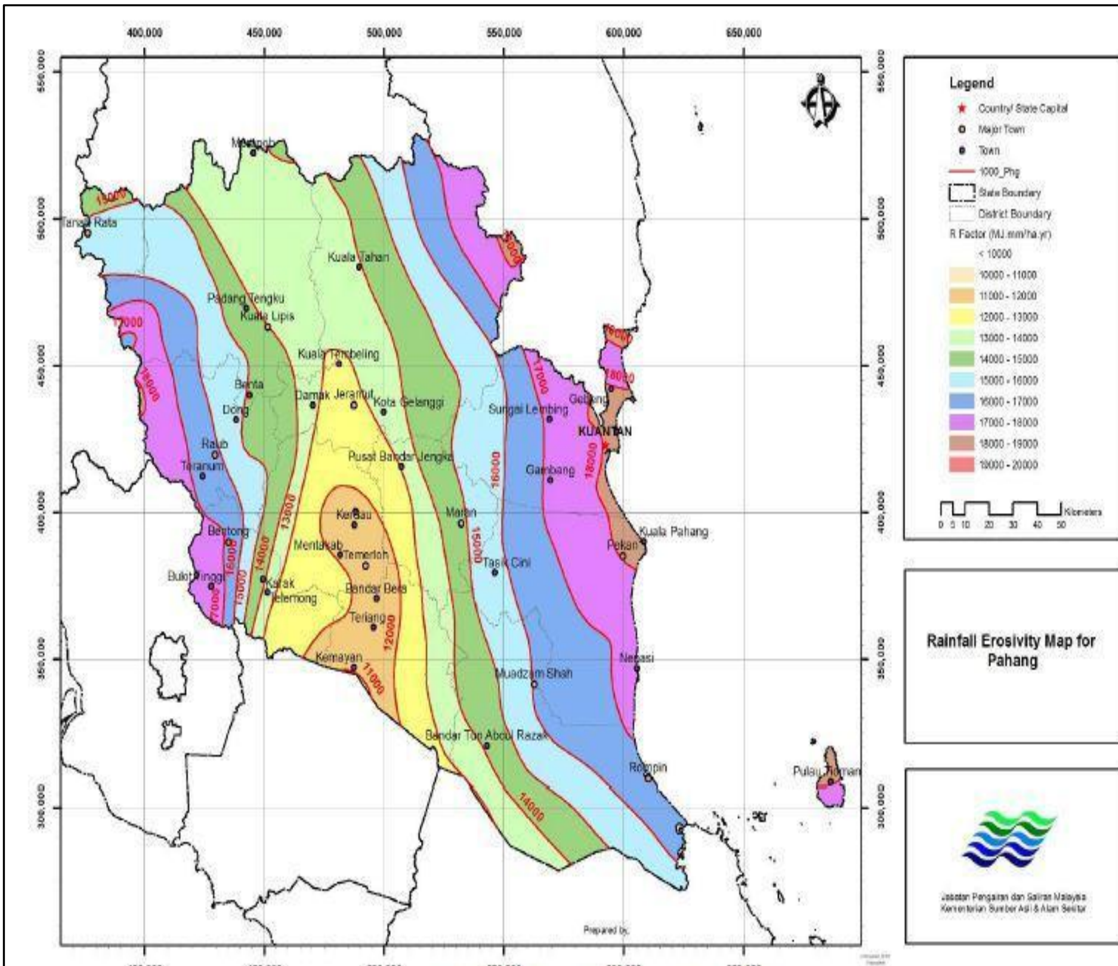


Figure 3.7: Rainfall Erosivity Map for Pahang State

SLOPE LENGTH AND STEEPNESS FACTOR

Table 3.5: Slope Length and Steepness Factor (LS)

Slope Steepness, s (%)	Slope Length, λ (m)											
	2	5	10	15	25	50	75	100	150	200	250	300
0.1	0.043	0.052	0.059	0.064	0.071	0.082	0.089	0.094	0.102	0.108	0.113	0.117
0.5	0.055	0.067	0.076	0.083	0.092	0.106	0.114	0.121	0.131	0.139	0.146	0.151
1	0.057	0.075	0.093	0.405	0.122	0.150	0.170	0.185	0.209	0.228	0.243	0.257
2	0.089	0.117	0.144	0.163	0.190	0.234	0.264	0.288	0.325	0.354	0.379	0.400
3	0.100	0.144	0.190	0.224	0.275	0.362	0.426	0.478	0.563	0.631	0.690	0.742
4	0.135	0.195	0.257	0.302	0.371	0.489	0.575	0.646	0.759	0.852	0.932	1.002
5	0.138	0.218	0.308	0.377	0.487	0.688	0.843	0.973	1.192	1.376	1.539	1.686
6	0.173	0.273	0.387	0.474	0.612	0.865	1.059	1.223	1.498	1.730	1.934	2.119
8	0.255	0.404	0.571	0.699	0.903	1.277	1.564	1.806	2.212	2.554	2.855	3.128
10	0.353	0.559	0.790	0.968	1.250	1.767	2.165	2.499	3.061	3.535	3.952	4.329
15	0.525	0.909	1.378	1.757	2.388	3.619	4.616	5.486	6.997	8.315	9.506	10.605
20	0.848	1.470	2.228	2.841	3.860	5.851	7.463	8.869	11.311	13.442	15.368	17.145
25	1.249	2.164	3.279	4.183	5.683	8.613	10.986	13.955	16.651	19.788	22.623	25.239
30	1.726	2.991	4.533	5.782	7.855	11.906	15.185	18.046	23.017	27.353	31.272	34.887
40	2.911	5.045	7.646	9.752	13.250	20.083	25.614	30.440	38.824	46.139	52.749	58.846
50	4.404	7.631	11.567	14.753	20.044	30.382	38.749	46.050	58.733	69.798	79.798	89.023
60	6.204	10.751	16.296	20.784	28.239	42.802	54.590	64.875	82.744	98.333	112.420	125.416
70	8.312	14.404	21.833	27.846	37.833	57.344	73.138	86.917	110.856	131.741	150.615	168.026
80	10.728	18.590	28.177	35.938	48.827	74.008	94.391	112.174	143.070	170.025	194.383	216.854
90	13.451	23.309	35.329	45.060	61.221	92.793	118.350	140.648	179.386	213.182	243.723	271.898
100	16.482	28.560	43.289	55.212	75.014	113.700	146.016	172.337	219.803	261.214	298.637	333.159

EROSION & SEDIMENT CONTROL

WORK EXAMPLES

What is the estimated rate of sheet and rill erosion after this site is cleared of all trees, shrubs and vegetation and it is decided that for erosion control reasons, the slope is terraced by cutting horizontal slope length creating 4-berms?

L was 100m, now divided into 4 sections horizontally to create 4 berms, hence 100m/4 = 25m,

Slope still 30%

SLOPE LENGTH & STEEPNESS FACTOR
(LS FACTOR)

Table 3.5: Slope Length and Steepness Factor (LS)

Slope Steepness, s (%)	Slope Length, λ (m)											
	2	5	10	15	25	50	75	100	150	200	250	300
0.1	0.043	0.052	0.059	0.064	0.071	0.082	0.089	0.094	0.102	0.108	0.113	0.117
0.5	0.055	0.067	0.076	0.083	0.092	0.106	0.114	0.121	0.131	0.139	0.146	0.151
1	0.057	0.075	0.093	0.405	0.122	0.150	0.170	0.185	0.209	0.228	0.243	0.257
2	0.089	0.117	0.144	0.163	0.190	0.234	0.264	0.288	0.325	0.354	0.379	0.400
3	0.100	0.144	0.190	0.224	0.275	0.362	0.426	0.478	0.563	0.631	0.690	0.742
4	0.135	0.195	0.257	0.302	0.371	0.489	0.575	0.646	0.759	0.852	0.932	1.002
5	0.138	0.218	0.308	0.377	0.487	0.688	0.843	0.973	1.192	1.376	1.539	1.686
6	0.173	0.273	0.387	0.474	0.612	0.865	1.059	1.223	1.498	1.730	1.934	2.119
8	0.255	0.404	0.571	0.699	0.903	1.277	1.564	1.806	2.212	2.554	2.855	3.128
10	0.353	0.559	0.790	0.968	1.250	1.767	2.165	2.499	3.061	3.535	3.952	4.329
15	0.525	0.909	1.378	1.757	2.388	3.619	4.616	5.486	6.997	8.315	9.506	10.605
20	0.848	1.470	2.228	2.841	3.860	5.851	7.463	8.869	11.311	13.442	15.368	17.145
25	1.249	2.164	3.279	4.183	5.6[illegible]3	8.613	10.986	13.055	16.651	19.788	22.623	25.239
30	1.726	2.991	4.533	5.782	7.855	11.906	15.185	18.046	23.017	27.353	31.272	34.887
40	2.911	5.045	7.646	9.752	13.250	20.083	25.614	30.440	38.824	46.139	52.749	58.846
50	4.404	7.631	11.567	14.753	20.044	30.382	38.749	46.050	58.733	69.798	79.798	89.023
60	6.204	10.751	16.296	20.784	28.239	42.802	54.590	64.875	82.744	98.333	112.420	125.416
70	8.312	14.404	21.833	27.846	37.833	57.344	73.138	86.917	110.856	131.741	150.615	168.026
80	10.728	18.590	28.177	35.938	48.827	74.008	94.391	112.174	143.070	170.025	194.383	216.854
90	13.451	23.309	35.329	45.060	61.221	92.793	118.350	140.648	179.386	213.182	243.723	271.898
100	16.482	28.560	43.289	55.212	75.014	113.700	146.016	172.337	219.803	261.214	298.637	333.159

RUNOFF COEFFIIENT

Table 12.4c: Cover Management, *C* Factor for BMPs at Construction Sites

Erosion Control Treatment	C Factor
Bare soil / Newly cleared land	1.00
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
Mulch	
plant fibers, stockpiled native materials/chipped	
50% cover	0.25
75% cover	0.13
100% cover	0.02
Grass-seeding and sod	
40% cover	0.10
60% cover	0.05
≥90% cover	0.02
Turfing	
40% cover	0.10
60% cover	0.05
≥90% cover	0.02
Compacted gravel layer	0.05
Geo-cell	0.05
Rolled Erosion Control Product:	
Erosion control blankets / Turf reinforcement mats	0.02
Plastic sheeting	0.02
Turf reinforcement mats	0.02

Note: The values are compiled from Layfield (2009), Troeh et al. (1999), Mitchell and Bubenzer (1980), ECTC (2006), Israelsen et al (1980), Weischmeier and Smith (1978), and Kuenstler (2009).

What is the estimated rate of sheet and rill erosion if **100% of slope is covered by erosion control mattress**?

A = R K LS C P

(new C = 0.02)

A = 17500 x **0.02** x 18.046 x 0.02 x 1.0

A = 126 tonnes/ha/yr *(compared to A = 6,316 tonnes/ha/yr*)

A (6316 – 126)/6316 = ***98.1% Reduction*** *in erosion rate by using this*
erosion control mattress (400g/m^2) BMP

EROSION & SEDIMENT CONTROL

WORK EXAMPLES

Check dams shall be installed along the roadside ditch.
What should be the spacing be for 500mm high check dams, if the ditch has a slope of 2%?

Height of check dam is
500mm Gradient of channel
is 2%

y/x = 0.5m/x =2/100

Hence x = $\frac{0.5m \times 100}{}$ = **25m intervals**

Given a Rainfall event of 50mm @ intensity of 50mm/hr, duration 60min and time of concentration tc = 20min, please determine the following:

- What is the Peak Flow Qp during this rainfall event **before grading**?
- What is the Runoff Volume **before grading**?
- Determine the Sediment Yield **before grading**?
- What is the Peak Flow Qp during this rainfall event **after grading**?
- What is the Runoff Volume **after grading**?
- Determine the Sediment Yield **after grading**?

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

Where Y - Sediment yield per storm event (tonnes)

V - Runoff volume in cubic meter

Q_p - peak discharge in m^3/s

Table 3.6: Cover Management, C factor for forested and undisturbed lands[1] (modified from: Layfield, 2009; Troeh et al., 1999; Mitchell and Bubenzer, 1980; ECTC, 2003; Ayad, 2003)

Erosion control treatment	**C Factor**
Rangeland	0.23
Forest/Tree	
25% cover	0.42
50% cover	0.39
75% cover	0.36
100% cover	0.03
Bushes/ Scrub	
25% cover	0.40
50% cover	0.35
75% cover	0.30
100% cover	0.03
Grassland (100% coverage)	0.03
Swamps/ mangrove	0.01
Water body	0.01

Note: 1 - average runoff condition

Determine the <u>Sediment Yield</u> **before grading**?

From equation 12.4, Y = 89.6(VQp) $^{0.56}$ (K.LS.C.P)

$Y = 89.6(500 \times 0.4166)^{0.56} (0.02 \times 18.046 \times 0.03 \times 1)$

$= 89.6 \times 19.88 \times (0.01083)$

= **19.3 tonnes**

What is the <u>Peak Flow Qp</u> (peak discharge) during this rainfall event **after grading**?

Use Rational Formula to determine Qp.

Qp = CIA/360

where,

C_{avg} = Average runoff coefficient;
C_i = Runoff coefficient of segment i;
A_i = Area of segment i (ha); and
m = Total number of segments.

Table 2.5: Recommended Runoff Coefficients for Various Landuses
(DID, 1980; Chow et al., 1988; QUDM, 2007 and Darwin Harbour, 2009)

Landuse	Runoff Coefficient (C)	
	For Minor System (≤10 year ARI)	For Major System (> 10 year ARI)
Residential		
Bungalow	0.65	0.70
Semi-detached Bungalow	0.70	0.75
Link and Terrace House	0.80	0.90
Flat and Apartment	0.80	0.85
Condominium	0.75	0.80
Commercial and Business Centres	0.90	0.95
Industrial	0.90	0.95
Sport Fields, Park and Agriculture	0.30	0.40
Open Spaces		
Bare Soil (No Cover)	0.50	0.60
Grass Cover	0.40	0.50
Bush Cover	0.35	0.45
Forest Cover	0.30	0.40
Roads and Highways	0.95	0.95
Water Body (Pond)		
Detention Pond (with outlet)	0.95	0.95
Retention Pond (no outlet)	0.00	0.00

Note: The runoff coefficients in this table are given as a guide for designers. The near-field runoff coefficient for any single or mixed landuse should be determined based on the imperviousness of the area.

What is the <u>Peak Flow Qp</u> (peak discharge) during this rainfall event **after grading**?

Use Rational Formula to determine Qp.

Qp = CIA/360

C = 0.5 (from Table 2.5 MSMA2)

Qp = (0.5 x 50mm/hr x 10ha)/360

Qp = 0.6944 m^3/s

What is the Runoff Volume **after grading**?

From Rational Method Hydrograph Method (Type2) Time of Concentration **Tc = 20 mins**

Qp = 0.6944m3/s

V = **0.5** x (2 x Tc) x (Qp)

= 0.5 x (2 x 20 x 60) x **0.6944**

= **833m^3**

Determine the Sediment Yield **after grading**?

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

V = 833m^3

Qp = 0.6944m^3/s

K = 0.02

LS = 18.046

Determine the <u>Sediment Yield</u> **after grading**? Y = 89.6(833 x

$0.6944)^{0.56}$ (0.02 x 18.046 x **1** x 1)

= 89.6 x 35.22 x (0.36092)

= **1,139 tonnes**

Determine the Sediment Yield after grading?

Y = $89.6(833 \times 0.6944)^{0.56}$ (**<u>0.02</u>** x 18.046 x 1 x 1)
= 89.6 x 35.22 x (0.36092)

= **1,139 tonnes**

Sediment Yield Before Grading = 19.3 tonnes

Sediment Yield After Grading = 1,139 tonnes

Sediment Yield INCREASE (1,139-19.3)/19.3 = 58.0X or = 5800% If **1 Lorry**

Load = 30tons

14 tons = 19.3/30 = ½ Lorry Load

1139 tons = 1139/30 = 38 Lorry Loads

Savings in Lorry Loads?

Savings in Excavation ?

Savings in Time ie. Delay in Construction to Clean-up?

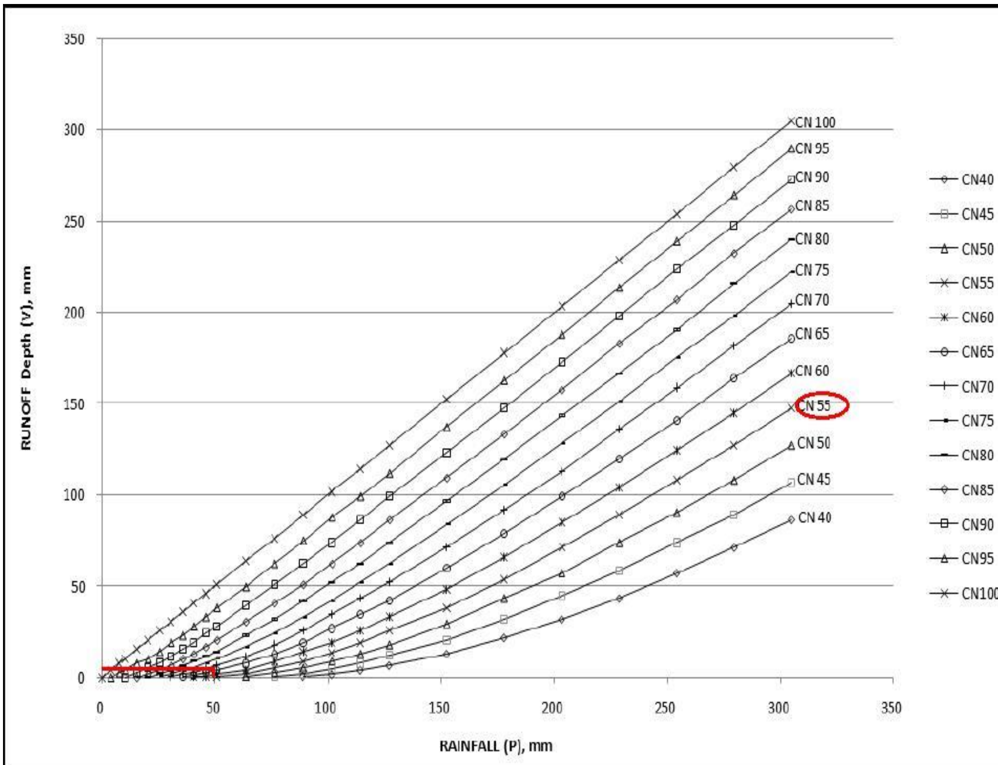


Figure 3.17: SCS Rainfall - Runoff Chart

What is the Runoff Volume before grading?

Check for CN value, given HSG=B & Soil Type = Loam See Table 3.10

Forest – Good Cover, HSG “B”, CN = 55

From Fig 3.17 CN Graph, Rainfall 50mm @ CN 55 Runoff Volume **V**

= 2.8mm x 10ha

V = 2.8/10³ x 10 (10,000) m³

Determine the Sediment Yield before grading?

$Y = 89.6(280 \times 0.4166)^{0.56}\ (0.02 \times 18.046 \times 0.03 \times 1)$

$= \quad 89.6 \times 14.37 \times (0.011)$

$=$ **14 tonnes**

Table 3.11: CN factor for agricultural and urbanized areas[1] (modified from: Shamshad et al., 2008; Leow et al., 2009; Fifield, 2004)

Ground Conditions	CN values			
	A	B	C	D
Rubber	64	74	81	85
Oil palm	50	66	80	87
Cocoa	64	74	81	85
Coconut	71	80	87	90
Horticulture	62	70	78	81
Paddy	64	75	83	86
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

Note: 1- Average runoff condition

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

Where Y - Sediment yield per storm event (tonnes)

V - Runoff volume in cubic meter

Q_p - peak discharge in m^3/s

APPENDIX E

BMPs

SITE PLANNING AND MANAGEMENT BMPs

Code	Details	Picture
B1-B2	**BIOMASS** **<u>EARTN BANK</u>** **DEFINITION** A temporary berm, dike, embankment or ridge of compacted soil, located in such a manner as to intercept, divert and channel water to a desired location. **PURPOSE** To direct runoff to a sediment trapping device or to direct run-on (clean water) around the site and away from disturbed areas, thereby reducing the potential for erosion and off site sedimentation. **APPLICATION** Earth dikes are often constructed across disturbed areas and around construction sites. The dikes shall remain in place until the disturbed areas are permanently stabilized. **<u>SILT FENCE</u>** **DEFINITION** A silt fence is a temporary sediment barrier made of woven, synthetic filtration fabric stretched across and attached to supporting wood or steel posts and entrenched. **PURPOSE** To prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing storm water runoff and causing the deposition of sediment at the structure. Silt fencing encourages sheet flow and reduces the potential for development of rills and gullies. **APPLICATION** • Whenever to intercept, divert and capture sediment from sheet flow runoff. • Below the toe of exposed and erodible slopes. • Down-slope of exposed soil areas. • Around temporary stockpiles.	 

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<td><u>BRUSH BARRIER</u>

DEFINITION
A temporary sediment barrier constructed at the perimeter of a disturbed area or on slope surface from the residue materials available from clearing and grubbing the site.

PURPOSE
By properly packed and stacked, the branches layer placed on the berm or terrace step and covering the slope as mat may function to intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

APPLICATION
• Below disturbed areas subject to sheet and rill erosion,
• Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (1:2).
• On slope surfaces having gradient no steeper than 1:2.</td>
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<tr>
<td>PTV1-PTV3</td>
<td><u>PRESERVE EXISTING TREES & VEGETATION</u>

DEFINITION
Preservation of existing vegetation relates to the identification and protection of desirable vegetation such as trees, shrubs and plants, native vegetation and natural Vegetated Filter Strip (VFS).

PURPOSE
• To minimize disturbances on construction sites,
• To stabilize soil,
• To trap suspended particles from sheet flow runoff,
• To promote infiltration of storm water.

APPLICATION
• Areas within the site where no construction activity is occurring.
• Areas where existing vegetation can be utilized for erosion and sediment control.</td>
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</table>

		
ROSR1-ROSR2	**RESOURCE ON-SITE ROCKS FOR BMPs** • Stockpiling available rocks **DEFINITION** Explore the existing site sources that can benefit the potential material for erosion control such as rocks **PURPOSE** To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement. **APPLICATION** Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.	 
STS1-STS2	**STOCKPILE TOPSOIL** • Averagely to produce 2.5 cm topsoil will take 500 years **DEFINITION** Explore the existing site sources that can benefit the potential material for erosion control such as topsoil **PURPOSE** To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement.	

APPLICATION

Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.

PRACTICE APPLICATION:

All excavated top soil shall be stockpiled trough the proper storage and use of erodible materials to reduce stormwater pollution and later used for revegetation. Geotextiles or plastic covers may be placed over stockpiles or disturbed soil areas to protect against wind and/or water erosion. Compost filter sock or sediment fence may also be used when necessary to retain stockpiledsediment.

PLANNING CONSIDERATIONS:

-Avoid stockpiling on impervious surfaces, near storm drains, and on steep slopes. Stockpile side slopes should not exceed 2:1. When installing on slopes, key into the top of the slope and along edges to prevent infiltration of surface water under the geotextile. Seams are typically taped or weighted down their entire length. Off-site borrow/fill areas should also be protected by adequate sediment and erosion control BMPs.

-Stockpile covers by tarpaulins or other sheet-like materials should also have weights placed on them to prevent the tarps from being blown off of the stockpile either in part or in whole.

-Stockpiles of soil are typically required to have erosion and sediment control devices instituted after a predetermined period of inactivity.

-If stockpiles on the site will remain inactive for a period of days, stabilization measures must be instituted as specified in the plan

-Some stockpile can be managed by implementing erosion and sediment control measures such as silt fence, fiber rolls, or other perimeter protection.

<table>
<tr>
<td>ST1-
ST2</td>
<td><u>SALVAGE TREES (TRANSLOCATION)</u>

DEFINITION
Explore the existing site sources that can benefit the potential material for erosion control such as trees

PURPOSE
To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement.

APPLICATION
Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.</td>
<td>
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</tr>
<tr>
<td>EN1-
EN5</td>
<td>ESTABLISH NURSERY

• Projects owners are encourage to establish their own nursery and grass growing
• Grass growing wherever available space at jobsite

DEFINITION
Explore the existing site sources that can benefit the potential material for erosion control such as trees and make use of existing native vegetation to establish seedbed preparation or grass growing and plant nursery.

PURPOSE
To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement.

APPLICATION
Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.

PRACTICE APPLICATION:
Explore the existing site sources that can benefit the</td>
<td>

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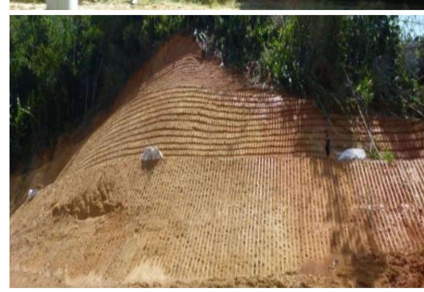
</table>

	potential material for erosion control such as plant nurseryfor erosion and sediment control which may minimized cost and time in the material procurement. **PLANNING CONSIDERATIONS:** Nursery location should be closed to land disturbing area to minimize the cost of transportation.	

EROSION CONTROL BMPs

Code	Details	Picture
T1 & T2	**<u>LAND GRADING - TERRACING</u>** **Practice Application:** Terracing are techniques for creating unevenness on bare soil by creating furrows across slopes, creating stair-steps, or by tracking the soil surface. Terracing reduces erosion potential by decreasing runoff velocities, trapping sediment, and increasing infiltration of water into the soil. **Planning Considerations:** Planting pattern and terracing needs are usually determined by the degree of slope present. Slope assessments should be made before any terracing and lining work is considered.	 
SR1- SR8	**<u>SOIL ROUGHENING</u>** **DEFINITION** The use of mechanized equipment to roughening the soil on a bare slope with grooves or terraces that run perpendicular to the direction of the slope. **PURPOSE** To loosen compacted soil on a slope that has been cleared and graded, cut, or filled as well as creates small grooves or terraces which reduce runoff velocity, trap seed, fertilizer and sediment, and provide more favorable conditions for vegetation establishment. **APPLICATION** • On slopes steeper than 1:3, • On excavated soil stockpiles • In areas with highly erodible soils. • Appropriate for soils that are frequently moved or disturbed.	   Before

		 After
HM1- HM10	**MULCHING & HYDROMULCHING** **DEFINITION** The application of plant residues or other suitable materials to the soil surface as ground cover. When applying mulch materials with water and glue, the application is referred to as hydromulch. **PURPOSE** • To prevent erosion by protecting the soil surface from raindrop impacts and reducing the velocity of overland flow. • To foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat. **APPLICATION** • Any bare and/or disturbed area subject to next intended construction activities to proceed in more than 30 days • Any seeded area to promote growth.	 Straw mulching  Woods excelsior  Hydromulch & fiber roll  Oil Palm Biomass Used for Mulching

Mulch promote sediment settling and trapping

Potential to wash away due to less coverage


An unattended area been mulched promotes native shrub to grow healthily

HS1- HS4	<u>**HYDROSEED**</u> **DEFINITION** Hydroseeding or may also be called hydromulching (if no seed is applied) is a mechanical method with forced water of applying seed, fertilizer, and mulch to land in one step in order to re-vegetate. **PURPOSE** To temporarily protect exposed soils from erosion. **APPLICATION** • On any cleared soil surface where vegetative cover is needed which includes diversions berms and embankment, dams, temporary sediment basins, temporary road banks, and topsoil stockpiles. • Where areas need temporary stabilization before final stabilization is installed. • On disturbed areas that will be re-disturbed after a period of extended inactivity.	 Very rare the SB embankment been seeded.  Temporarily hydro-seeded slope bench  Hydroseeded stepped slope and vertiver planting
T1-T6	**TURFING** **DEFINITION** The establishment of temporary vegetative cover with fast growing species for seasonal protection on disturbed or denuded areas. **PURPOSE** • To reduce storm water runoff velocity and maintain sheet flow	

- To protect the soil surface from erosion
- To promote infiltration of runoff into the soil

APPLICATION

Any completed graded area such as bare area, slope surfaces and areas meant to be vegetated permanently.

BONDED FIBRE MATRIX

DEFINITION

The application of plant residues or other suitable materials to the soil surface as ground cover.

PURPOSE

- To prevent erosion by protecting the soil surface from raindrop impacts and reducing the velocity of overland flow.
- To foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat.

15.7.2009

APPLICATION

- Any bare and/or disturbed area subject to next intended construction activities to proceed in more than 30 days
- Any seeded area to promote growth.

22.7.2009

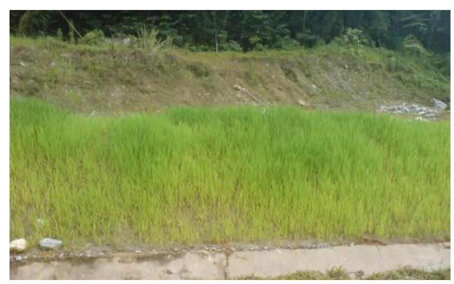
<table>
<tr><td></td><td></td><td>
25.8.2009

5.10.2009

13.3.2012</td></tr>
<tr><td>TCGM1
-
TCGM4</td><td><u>TEMPORARY COVER GEOXTILE MAT</u>

PRACTICE APPLICATION:
Temporary cover geotextile mat are used to temporary stabilized soil, reduce erosion from rainfall impact, hold soil in place, and absorb and hold moisture near the soil surface. Matting will be used alone or with mulch during establishment of protective cover on critical slope.

PLANNING CONSIDERATIONS:
i. Size of the area</td><td></td></tr>
</table>

	ii. Duration of use iii. Adequate anchoring and installation	
PC1-PC7	**<u>TEMPORARY PLASTIC SHEET COVER</u>** **DEFINITION** Plastic cover material commonly made of polyethylene which is used in conjunction with weights, stakes or rebar temporarily placed on slopes or stockpiles. **PURPOSE** To be used for temporary soil stabilization. To prevent infiltration of surface waters onto unstable slope. **APPLICATION** Any incomplete slope that is going to be attended to at a later time.	 
S1-S4	**<u>SEEDING</u>** **Practice Application:** Seeding is about establishment of annual (temporary) or perennial (permanent) vegetative cover. Seeding will establish roots and shoots to prevent erosion. **Planning Considerations:** Seed areas that are at final grade as soon as possible Allow seed time to establish and grow Adequate seedbed preparation Good seed/ground contact	 

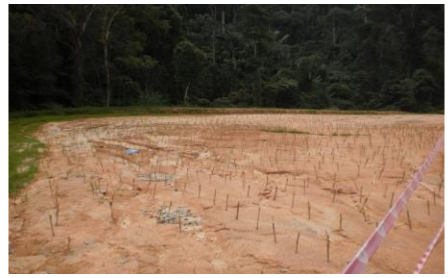
<table>
<tr>
<td>R1-R3</td>
<td>RE-VEGETATION

DEFINITION
Preservation of existing vegetation relates to the identification and protection of native vegetation.

PURPOSE
• To minimize disturbances on construction sites,
• To stabilize soil,
• To trap suspended particles from sheet flow runoff,
• To promote infiltration of storm water.

APPLICATION
• Areas within the site where no construction activity is occurring.
• Areas where existing vegetation can be utilized for erosion and sediment control.

Practice Application:
The establishment of temporary vegetative cover with fast growing species for seasonal protection on disturbed or denuded areas.

Planning Considerations:
Should be considering the type of species of vegetative cover to be planted at exposed area.</td>
<td>

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</tr>
<tr>
<td>HSM1-HSM5</td>
<td>HYDROSEED+EROSION CONTROL MAT (ECM)

DEFINITION
Hydroseeding or may also be called hydromulching (if no seed is applied) is a mechanical method with forced water of applying seed, fertilizer, and mulch to land in one step in order to re-vegetate.

PURPOSE
To temporarily protect exposed soils from erosion.</td>
<td></td>
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</table>

	APPLICATION • On any cleared soil surface where vegetative cover is needed which includes diversions berms and embankment, dams, temporary sediment basins, temporary road banks, and topsoil stockpiles. • Where areas need temporary stabilization before final stabilization is installed. • On disturbed areas that will be re-disturbed after a period of extended inactivity. •	
RECP1-RECP16	**<u>Rolled erosion control product</u>** **DEFINITION** A protective blanket or soil stabilization mat used to assist in establishment of temporary or permanent vegetation on steep slopes, channels, or stream banks. **PURPOSE** To protect soil and hold seed and mulch in place on slopes and in channels so that vegetation can become well established. **APPLICATION** • On steep slopes where erosion hazards are high. • Where conventional seeding is likely to be too slow in providing adequate protective cover. • Concentrated flow areas. • All slopes steeper than 1:2, with a height of three metres or greater, and cuts and fills within stream buffers, should be stabilized with the appropriate erosion control matting or blanket. **NOTES** • Turf reinforcement mats can be used to permanently reinforce grass in drainage ways during high flows. It consists a permanent, non-degradable, three-	 

	dimensional plastic structure that is filled with soil prior to planting • Nets are made of high tensile material woven into an open net which overlays mulch materials. • Blankets are made of interlocking fibers, typically held together by biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. **PRACTICE APPLICATION:** Rolled erosion control products is design as a erosion control blanket, that act as soil stabilization devices to protect disturbed areas from wind and water erosion. These products made from natural materials such as straw, wood excelsior or coconut husk. **PLANNING CONSIDERATIONS:** Material selected will be dependent upon site conditions i.e size of area to be covered, slope, soil condition. Soil must be properly prepared (by grading and ensuring the possibility of direct contact between soil and RECP) before RECPs are installed. Install per manufactures recommended	
D1-D16	**<u>TRM ON DISCHARGE CHANNEL</u>** **TEMPORARY OR PERMANENT WATERCOURSE DIVERSION** Temporary or permanent diversion channel of any watercourse or off-site run-on water shall be protected either by using rock lined channel bed with protected side slope using Turf Reinforcement Mat (TRM) or plastic sheeting or by installing plastic sheeting canvas along the channel with extend across the side slope in combination with	

	constructed check dams or sump slot checks. This has to be done to minimize erosive forces flow velocity along the channel bed and channel side slope surface to prevent it from eroding.	

1.4.4 SEDIMENT CONTROL BMPs

Code	Details	Picture
WT1- WT7	**<u>WASH TROUGH AND STABILIZED ENTRANCE/EXIT</u>** **DEFINITION** A stabilized pad located at points where vehicles enter and leave a construction site. This control may take the form of tracking pads, boards, rumble strips, washes or through pool of water. **PURPOSE** To reduce or eliminate the amount of sediment transported onto public roadways by motor vehicles or runoff. **APPLICATION** • All points of construction ingress and egress. • Wherever traffic will be leaving a construction site and moving directly onto a public road or other paved area. **Practice Application:** i. The basic of wash trough is to prevent sediment being track onto the public road and dust in the form of Total Suspended Particulate (TSP) which would be dispersed by wind during dry weather to the nearest receptors including settlement area. ii. The wash trough was install at main entrance to project site to ensure that the tires of any vehicles are free from earth dirt and sediment before entering the main road **Planning Considerations:** i. Removed materials and collected sediment must be disposed off in a suitable manner that will not cause erosion or pollution hazard to river water quality.	 Wash trough - left right position?  Washing facility with grating/rumble surface  Washing facility equipped with recycle pump  Tire Wash, Grating, Trough, Recycle Water and Spilled Control

	ii. The overflows and storm water from the wash trough should be directed to a sediment trap.	 Stabilized entrance/exit-crusher run
RS1-RS3	**<u>CONSTRUCTION ROAD STABILIZATION</u>** **DEFINITION** A stabilized construction roadway is a temporary access connecting existing public roads to a remote construction area. **PURPOSE** • To provide a fixed stable route for the heavy construction traffic • To reduce erosion and subsequent re-grading of permanent roadbeds between the time of initial grading and final stabilization. • To stabilize soils on which a travel way is constructed of which may severely eroded and rutted created by vehicular tracking. **APPLICATION** • Applicable whenever travel ways are needed around poor soils area in a construction site of which the exposed soil is continually disturbed which eliminating the possibility of stabilization with vegetation. • Any anticipated extended period of exposure of roadways to surface runoff around the construction site.	 
BB1-BB4	**<u>BRUSH BARRIER</u>** **DEFINITION** A temporary sediment barrier constructed at the perimeter of a disturbed area or on slope surface	

<table>
<tr>
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<td>from the residue materials available from clearing and grubbing the site.

PURPOSE
By properly packed and stacked, the branches layer placed on the berm or terrace step and covering the slope as mat may function to intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

APPLICATION
Below disturbed areas subject to sheet and rill erosion,
Where the size of the drainage area is no greater than one-fourth of an acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (1:2).
On slope surfaces having gradient no steeper than 1:2.</td>
<td>

Brush Barrier serves as sediment barrier. Consider to cover with filter fabric


Brush Barrier may serve as sediment barrier – good for sheet flow similar to silt fence.</td>
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<tr>
<td>SF1-SF8</td>
<td><u>SILT FENCE</u>

DEFINITION
A silt fence is a temporary sediment barrier made of woven, synthetic filtration fabric stretched across and attached to supporting wood or steel posts and entrenched.

PURPOSE
To prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing storm water runoff and causing the deposition of sediment at the structure. Silt fencing encourages sheet flow and reduces the potential for development of rills and gullies.</td>
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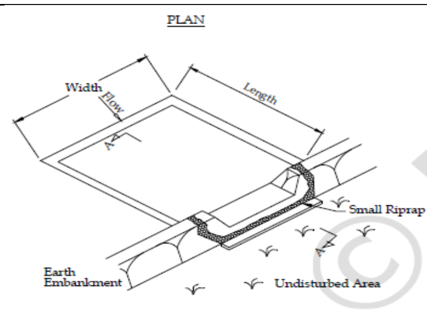
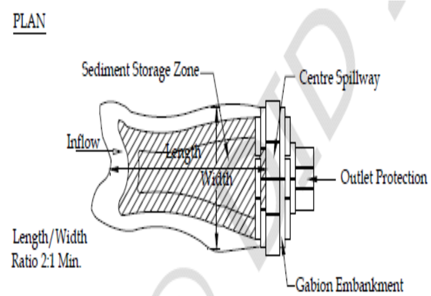
</table>

	APPLICATION • Whenever to intercept, divert and capture sediment from sheet flow runoff. • Below the toe of exposed and erodible slopes. • Down-slope of exposed soil areas. • Around temporary stockpiles. • Along streams and channels.	
SBT1-SBT12	**<u>SEDIMENT BASIN / TRAP</u>** **DEFINITION** A sediment trap is a temporary basin with a controlled release structure, formed by excavating or constructing an earthen embankment across a waterway or low drainage area. **PURPOSE** To detain sediment-laden runoff from small disturbed areas long enough to allow most of the sediment to settle out, thus protecting drainageways, properties, and rights of way from sedimentation. **APPLICATION** All points of discharges from any disturbed area at construction sites. **NOTES** Sediment traps can be constructed either by excavation or embankment. Each sediment trap is named according to the type of outlet that it has. The outlets shall be designed, constructed, and maintained so that sediment does not leave the trap and erosion of the outlet does not occur. There are four types of outlets for sediment traps namely : 1. **An Earth Outlet Sediment Trap** The trap has a discharge point over or cut into natural ground. 2. **A Pipe Outlet Sediment Trap** The outlet for the trap is though a perforated riser and a pipe through the embankment. The outlet pipe	  

	and riser shall be made of corrugated metal. 3. **A Stone Outlet Sediment Trap** The outlet for the sediment trap shall consist of a crushed stone section of the embankment located at the low point in the basin. The outlet shall be constructed of crushed stone. 4. **A Storm Inlet Sediment Trap** The trap has a discharge point through an opening in a storm drain inlet structure. This opening can either be the inlet opening or a temporary opening made by omitting bricks or blocks in the inlet.	 
ST1-ST7	**SEDIMENT TRAP (JPS)** **PRACTICE APPLICATION:** A sediment trap is a small temporary ponding area, usually with a gravel outlet, formed by excavation and/or construction of an earth embankment. Its purpose is to collect and store sediment from sites cleared and/or graded during construction. It is intended for use on small catchment areas with no unusual drainage features, where construction will be completed in a reasonably short period of time. **PLANNING CONSIDERATIONS:** i. When installing trap, ensure they are located where crews can easily maintain them ii. Access for maintenance iii. Outlet should be built to accommodate anticipated outflows iv. Design and construction shall comply with state, provincial and local safety laws, ordinances, rules and regulations.	 

<table>
<tr>
<td>FR/W1-
FR/W7</td>
<td>
<u>FIBER ROLLS / WATTLES</u>

DEFINITION
A fiber roll consists of straw, flax, coconut husk or other similar materials that are rolled and bound into a tight tubular roll and placed around the worksite perimeter and is referred to as wattles when placed on the face of slopes at regular intervals.

PURPOSE

To intercept runoff.
To reduce runoff flow velocity.
To release the runoff as sheet flow.
To provide some removal of sediment from the runoff.

APPLICATION

May be used along the top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
Install on disturbed areas that require immediate erosion protection.
Can be used along the perimeter of a project.
Unlined ditches as a check dam
Around temporary stockpiles

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Wattles-slope breaker


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<tr>
<td>ATS1-
ATS11</td>
<td>
<u>ATS – DE-SILTING LAKE, POLYMER, GEOTUBE & PUMP SYSTEM, CONTAINMENT / POND</u>

Active treatment system may be a good choice in treating SS but maybe the last option due to expensive cost

LIMITED SPACE CHALLENGES:

Sediment ponds has limited capacity
Treatment facilities lack space, emergency discharge

2) POLLUTANT CHALLENGES:

Suspended Organic solids
Suspended solids that stays colloidal for long

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</table>

	time • fine clays, silts, bentonites w/high ionic charge 3) VOLUME CHALLENGES w/LIMITED TIME High flow volume w/insufficient settling time **Practice Application:** i. Active treatment system is a water treatment process of which the sediment-laden runoff collected in pond into a container (geo-tube-bag). The purpose of ATS is to bind and stabilize soil particles and to treat water prior to discharge into receiving watercourses. ii. Any bare areas that need to be immediately stabilized ii. Using the ATS for treatment of sediment laden runoff especially fine clay soil type which is sediment basin are not effective enough to reduce the turbidity and suspended solid in the water. **Planning Considerations:** i. Any bare areas that need to be immediately stabilized	  
FL1-FL3	<u>**APPLICATION OF FLOC LOG**</u> **DEFINITION** PAM is a water-soluble anionic polyacrylamide product is manufactured in various forms such as emulsion, liquid, powder and block used as soil stabilization and as a water treatment additive. Active treatment system refers to the water treatment process of which, the sediment-laden runoff collected in pond are pump into a container (geo-tube bag). In the process of pumping the turbid waters, online injection of site-specific polymers/PAM are introduce to the turbid waters in such a manner to facilitate mixing and reaction between the polymer and the suspended particles. Upon reaching into the geo-tube bag, the turbid	 

TC1-TC2	waters will start to coagulate and subsequently flocculate or agglomerate stage proceeds in the pipe line and bag. A pulsing pump used to pressure the geo-tube bag leading to permeation of clear water through the geo-tube bag container wall or also known as dewatering bag leaving the sediment behind. **PURPOSE** • To bind and stabilize soil particles. • To treat turbid water prior to discharge into receiving watercourse. **APPLICATION** • Any bare areas that need to be immediately stabilized. • Along the runoff conveyances that lead to sediment trapping device. • Recommended for use when treatment of sediment-laden runoff especially dealing with fine clay soil type using sediment basin BMPs are not effective enough to reduce the turbidity and suspended solids in the water prior to be discharge into the watercourse. **<u>TURBIDITY CURTAIN</u>** **DEFINITION** A flexible floating permeable fabric or geotextile materials namely turbidity curtains/ silt curtain/barriers installed in watercourses and is placed parallel or perpendicular to the direction of flow .This curtain does not extend to the bottom and weighted or anchored down to achieve closure while supported at the top through a flotation system.. **PURPOSE** • To provide sediment containment or sedimentation protection for a watercourse. • To prevent the migration of silt from a work	 

	site in a water environment into the larger body of water. • To reduce or eliminate debris and turbidity and minimize sediment transport from a disturbed area adjacent to or within a body of water **APPLICATION** Where construction activities occurs within a water body or along its shoreline or directly adjacent to a waterway or water body and is of short duration. The activities includes but is not limited to bridge construction, rip rap placement, utility work, stream bank restoration and dredging. Turbidity or silt curtains are used in calm water surfaces and in most situations, turbidity curtains should not be installed across channel flows or flowing watercourses.	

GENERAL CONSTRUCTION CONTROL BMPs

<table>
<tr><th>Code</th><th>Details</th><th>Picture</th></tr>
<tr><td>SC1-SC2</td><td><u>STREET CLEANING</u>

DEFINITION
Practices to collect and remove tracked sediments that have escaped the perimeter of the construction site.

PURPOSE
To prevent the sediment from entering a storm drain or watercourse as well as to prevent dust blowing and movement on construction sites and roads.

APPLICATION
Anywhere sediment is tracked from the project site onto public or private paved roads, typically at points of ingress and egress.</td><td></td></tr>
<tr><td>WB1-WB2</td><td><u>WATER BROWSER</u>

PRACTICE APPLICATION:
Water browser is designed to reduce or eliminate airborne dust created by construction activities, on stabilized roads, to prevent tracking of sediment onto unpaved roadways and on material storage areas.

PLANNING CONSIDERATIONS:
i. Over watering water may cause erosion.
ii. In compacted areas, dust control water may wash sediment or other pollutants into the drain system.</td><td>

Water browser</td></tr>
</table>

SC1-SC4

<u>SECONDARY CONTAINMENT SYSTEM</u>

DEFINITION

A second containment wall or embankment constructed with concrete or pre-fabricated metal that fencing around any petroleum base products with the containment capacity of 110 % the capacity of the said vessel or tank.

PURPOSE

To failsafe the primary containment (vessel or tank wall) that leaks or spills from flowing out further into drainage way or watercourses before recovering action to be taken.

APPLICATION

Applies to petroleum-based storage vessels, including fuel, and hydraulic fluid and certain tanks sited at jobsite.

PRACTICE APPLICATION:

Is permanent or temporary that act as a backup for primary containment vessels of petroleum products, including fuel and hydraulic fluid or any other liquid stored on a site, especially on industrial sites.

PLANNING CONSIDERATIONS:

i. A liner may be required for secondary containment in your area, check local regulations for specifics

ii. Secondary containment facilities should be regularly drained and disposed of properly so that their capacity at any point in time is equal to 110% of the primary storage container

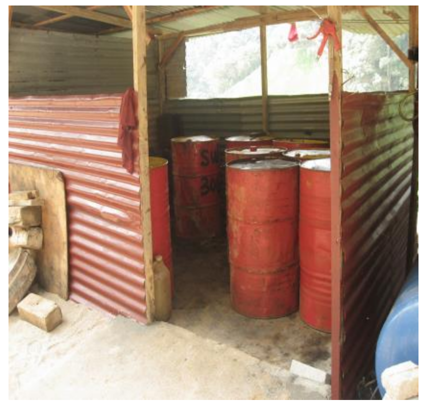
ii. Should located away from and if possible, downstream, of all critical and sensitive area and traffic.

v. Placing these storage vessels under a roof of some sort will greatly reduce the amount of water that can collect there

Secondary container with oil interceptor

Skid tank: Wrong location and no secondary containment

Secondary containment system – wrong application

	<u>SCHEDULED WASTE STORAGE</u> **DEFINITION** A designated area for storage of hazardous waste**.** **PURPOSE** To minimize or eliminate the discharge of pollutants from construction site generating hazardous waste to the storm drain system or to watercourses. To conform and comply the requirements stipulated in Environmental Quality Regulation (Scheduled Waste) 1989. **APPLICATION** Implemented in all projects that generates scheduled wastes.	 Prefabricated Skid Tank 
S1-S4	**<u>SANITATION</u>** i. **Practice Application:** Temporary or portable toilet at all construction site to prevent sanitary and septic waste material directly to the storm drain system or to watercourses without any treated first to standard requirement and compliance. ii. **Planning Considerations:** i. Temporary or portable toilet shall be located away from drainage facilities, all critical and sensitive area, watercourses and from traffic circulation. ii. Sanitary facilities should be anchored in	

	high wind areas to prevent them from blowing over. iii. To avoid overflow conditions, the regular waste collection schedule should be arranged. iv. Location of temporary or portable toilet should be easy for regular maintenance.	
CW1-CW4	**<u>CONCRETE WASHOUT</u>** **DEFINITION** A designated area for concrete washout area**.** **PURPOSE** To minimize or eliminate the discharge of concrete waste materials that normally contains high pH (alkaline base slurry) to the storm drain system or to watercourses. **APPLICATION** On construction projects where concrete is used as a construction material where the most common, the ready-mix concrete mixer truck and other concrete-coated equipment are washed on site.	 

RUNOFF CONTROL BMPs

<table>
<tr><th>Code</th><th>Details</th><th>Picture</th></tr>
<tr><td>RR1-
RR11</td><td><u>RIPRAP (RC) OR LINED SECTION</u>

DEFINITION
Riprap is a layer of large stones laid onto slopes and channel beds.

PURPOSE
To protect soil from erosion in areas of concentrated runoff.

APPLICATION
Use riprap to stabilize cut-and-fill slopes with 1:2 slope; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and streambanks and grades.</td><td></td></tr>
<tr><td>OP1-OP2</td><td><u>CULVERT OUTLET PROTECTION (RC/SC)</u>

DEFINITION
A temporary stream crossing is a structure placed across a waterway, which allows vehicles to cross the waterway during construction without entering the water, eliminating erosion and downstream sedimentation caused by the vehicles.

PURPOSE
• To provide safe, environmentally sound access across a waterway for construction equipment.

• To prevent construction equipment from damaging the waterway, blocking fish migration, and tracking sediment and other pollutants into the waterway.</td><td></td></tr>
</table>

	APPLICATION Where heavy construction must be moved from one side of a stream channel to the other and equipment and construction vehicles will cross the stream repeatedly during construction.	
CD1-CD8	**<u>CHECK DAM (RC)</u>** **DEFINITION** A check dam is a small temporary device constructed of rock, sandbags, or fiber rolls, placed across a natural or man-made channel or drainage ditch. **PURPOSE** • To reduce the velocity of concentrated stormwater flows, • To trap small amounts of sediment generated in the conveyances • To reduce scour and channel erosion. • To encourage sediment dropout. **APPLICATION** Any stormwater conveyances having concentrated flow.	 Arrangement of check dam   Observe clean water behind check dam
D1-D21	**<u>DIVERSION</u>** **PRACTICE APPLICATION:** Diversion is temporary or permanent structural BMPs that are utilized to intercept and divert run on/off site water and off site runoff to a stabilized outlet or treatment structure. Diversion can be vegetated, covered with rock and rolled or erosion control product	

	PLANNING CONSIDERATIONS: i. The diversion should be sufficient in size and shape to deliver runoff to the intended location ii. Vegetated channels should be used whenever possible iii. Velocity of water in the channel should be monitored and provide temporary stabilization until vegetation is established. iv. Adequate outfall protection should be installed to provide adequate energy dissipation and to reduce erosion at the outfall of diversion	 
DS1-DS8	**<u>DISSIPATOR</u>** **PRACTICE APPLICATION:** Energy dissipators are any device designed to protect downstream areas from erosion by reducing the velocity of flow to acceptable limits. Permanent or temporary energy dissipators prevent erosion, turbulence, and turbidity where stormwater pipes or ditches discharge to unprotected areas, such as channel banks, slopes, or upslope outfall locations **PLANNING CONSIDERATIONS:** 1. Minimizing the number and magnitude of concentrated flows during initial clearing and grading, to the extent possible 2. Installing permanent drainage features (e.g., stabilized ditches, channels, energy dissipators, vegetated channel buffers, etc.) as early as possible, especially since installing, stabilizing, and maintaining temporary drainage infrastructure is expensive and time-consuming.	 

IL1-IL10	**<u>INLET PROTECTION</u>** **PRACTICE APPLICATION:** A temporary device installed in or around a storm drain inlet, drop inlet, or curb inlet. This practice is intended to minimize sediment from entering storm drainage systems in areas where the contributing drainage area is temporarily disturbed. Inlet protection devices are for drainage areas of one acre or less. Runoff from areas larger than one acre shall be routed through a properly designed sediment trapping or settling practice upstream of the inlet. **PLANNING CONSIDERATIONS:** i. Inlet protection is only one element in an erosion control plan. Other practices, including temporary stabilization and area clean up, should also be utilized upstream of the inlet. ii. Inlets should be temporarily closed or sealed to prevent entrance of runoff and sediment when site conditions allow. ii. The use of fabric intended for a finer soil type on a construction site with coarser soil may increase the required maintenance frequency due to faster clogging. v. The effectiveness of inlet protection devices in unpaved areas can be enhanced by additional excavation to increase the storage capacity around the inlet	  
PSD1-PSD5	**<u>PIPE SLOPE DRAIN</u>** **PRACTICE APPLICATION** Pipe slope drain is design as temporary structural that use piping material to convey flow down a slope without causing erosion damage to the slope. These pipe drains may install above or below ground. **PLANNING CONSIDERATIONS:** i. Outlet protection sufficient to handle the anticipated flow of the drain structure must	

	be installed ii. Place pipe slope drains where they will not encounter traffic. iii. Required proper installation per the plan. iv. Typically increase velocity at the outlet.	
COD1-COD2	**<u>TEMPORARY CUT-OFF DRAIN</u>** **Practice Application:** A cut-off drain can be used to intercept fast flowing water on sloping paths without introducing a wide open gap, like a cross drain or a raised step, like a water bar, in the path surface. Most cut-off drains have a u-shaped cross-section and grating over the top. **Planning Considerations:** i. The grating provides a continuous surface across the drain, and should be strong enough to withstand the load of any traffic that is expected to use the path.	
F1-F4	**<u>FLUME/CHUTE</u>** **Practice Application:** Chutes and flumes are channels that are designed to conduct runoff down a slope face and discharge the water to a stable outlet area without causing erosion. Chutes and flumes may be constructed of rock, concrete or asphalt liners, or half-round pipe. Chutes and flumes can convey runoff from diversion dikes, infiltration trenches, slope steps, benches, or other runoff control facilities. Chutes and flumes discharge into a stabilized watercourse, sediment trap, or stabilized area. **Planning Considerations:** i. Rock chutes should be considered at all locations where an elevation drop may create	 

	flow velocities that exceed the ability of the existing ground surface (bare or vegetated) to prevent erosion.	
WB1- WB7	**<u>ROLLING DIP/ BROAD-BASED DIP/ WATER BAR</u>** **Practice Application:** Combination of ditch and berm installed perpendicular or skew to road or trail center line to facilitate drainage of surface water; sometimes non driveable and used to close a road. These treatments are designed to provide drainage relief for road sections or water in the inside ditch to the downhill side of roads especially when the existing culvert is expected to be overwhelmed. Rolling dips are easily constructed with road grader or dozer. Rolling dips or water bars need to be deep enough to contain the expected flow and location carefully assessed to prevent damages to other portions of the road. Water bars can be made out of rocks or logs. Armouring of fill slope at the outlet is often needed to prevent gullying. **Planning Considerations:** i. The slope of water bar is important for slowing and diverting water from road. ii. Fewer slopes can cause the water bar to fill up with sediment and fail. More slopes can cause the water bar itself to erode and add to sediment problems.	 

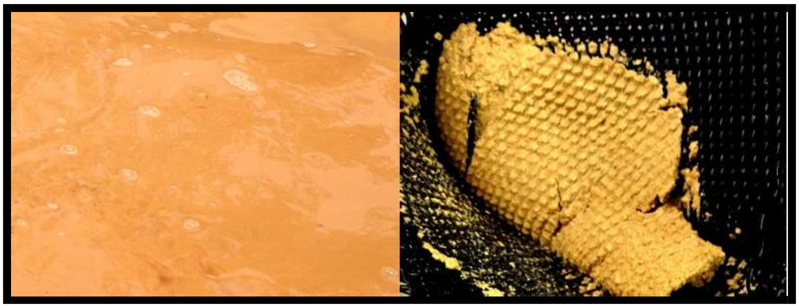
	<u>LEVEL SPREADER</u> **Practice Application:** Level Spreaders are measures that reduce the erosive energy of concentrated flows by distributing runoff as sheet flow to stabilized vegetative surfaces. Level Spreaders, of which there are many types, may also promote infiltration and improved water quality. **Planning Considerations:** i. Specific site conditions, such as topography, vegetative cover, soil, and geologic conditions must be considered prior to design; level spreaders are not applicable in areas with easily erodible soils and/or little vegetation ii. Level spreaders should safely diffuse at least the 10-year storm peak rate; bypassed flows should be stabilized in a sufficient manner. ii. It is always easier to keep flow distributed than to redistribute it after it is concentrated; multiple outfalls/level spreaders are preferable to a single outfall/level spreader.	
SR1-SR8	**<u>SOIL RETENTION</u>** **Practice Application:** Soil retention measures are structures or practices that are used to hold soil in place or to keep it contained within a site boundary. They may include grading or reshaping the ground to lessen steep slopes or shoring excavated areas with wood, concrete, or steel structures. Some soil- retaining measures are used for erosion control, while others are used for protection of workers during construction projects such as excavations. **Planning Considerations:** i. All soil retention should confirm to local building codes and ordinances	 

DEMONSTRATION OF SELECTED BMPs INSTALLED IN EIMAS SITES

LAND DISTURBING POLLUTION PREVENTION AND MITIGATION MEASURES

MANUAL

SLOPE EROSION CONTROL BMPs, SEDIMENT CONTROL PE-BMPs (PAM-BLOCK & ATS LIQUID)



INSTITUT ALAM SEKITAR MALAYSIA
(E*i*MAS)

Table of Content

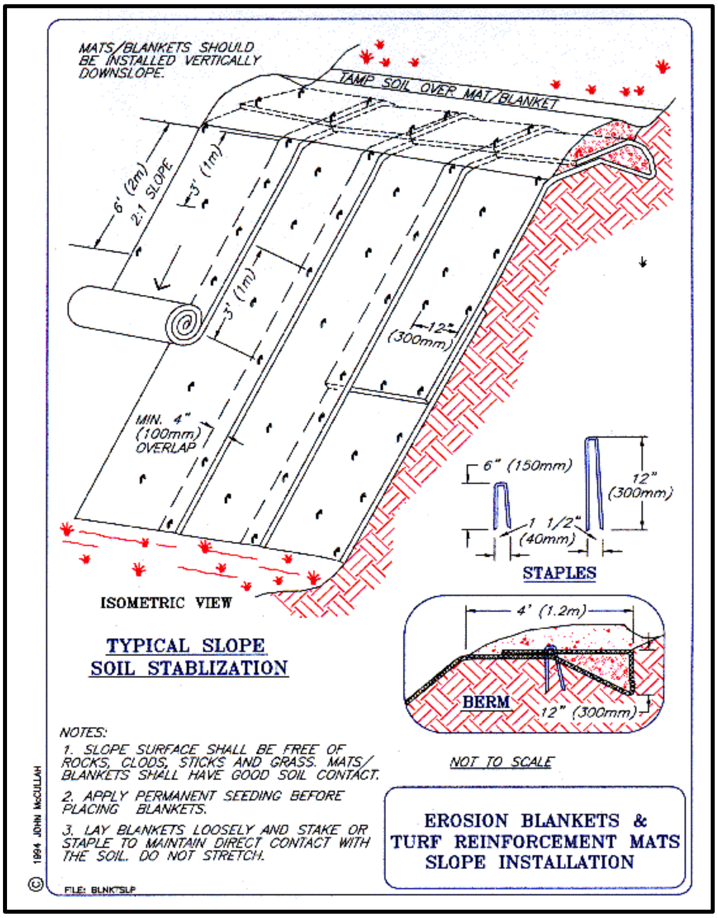
TYPICAL HILL SLOPE CONSTRUCTION SITE

ERODED HILL-SLOPES WITH NO LDPPMM BMPs

UNPROTECTED SOIL STOCKPILE CONTAMINATES ADJACENT PUBLIC PARK PONDS

SEDIMENT FLOW FROM UNPROTECTED SOIL SURFACE, KILLS POND AQUATIC LIFE

EROSION CONTROL MATTRESSES APPLIED @ LINEAR CONSTRUCTION SLOPES TO REDUCE EROSION & REVEGETATE



SLOPE EROSION CONTROL BMPs

ROLL EROSION CONTROL PRODUCTS (RECP) FUNCTIONS & BENEFITS :

- All Roll Erosion Control Products (RECPs) are manufactured with organic mulch materials and functions to protect land disturbed and "opened" soil surface from erosion.
- Manufactured typically from organic fibres (coconut coir, palm oil fibre, jute, wood chips, straw..) and "sandwiched" in-between polypropylene(HDPE, nylon…) nettings (UV or non-UVstabilized), stitched together to form a mattress/blanket.
- 3-Dimensional structure protects soil surface and seedlings by reducing rain impact during rainstorms and eroding forces onto bare soil surface by absorbing the rain impact energy.
- 3-Dimensional structure also helps reinforce vegetation root system, the organic mulch retains both moisture and nutrient, moderate temperature and shelter seedlings for good growth.
- Turf Reinforced Mattresses (TRMs..) provides high vegetation roots reinforcement together with above benefits. Made of a polymer base 3-Dimensional corrugated netting. High Strength addition provides load transfer ability and tensile force capacity in geotechnical applications.

EiMAS – LDPPMM

SLOPE EROSION CONTROL & REVEGETATION BMPs

SLOPE EROSION CONTROL BMPs

APPLICATION OF ROLL EROSION CONTROL PRODUCTS (RECP)

EiMAS – LDPPMM

SLOPE EROSION CONTROL & REVEGETATION BMPs

SLOPE SURFACE PREPARATION

1. Clear & Grub surface of all debris and vegetative matter.
2. Care: all "open-surface" to be temporarily covered after daily work, to avoid exposure to rainfall event.
3. Measure the slope angle of inclination. Typically should be less than 2(H):1(V) or 30º. Here it was at 40º….ok.

ANCHOR TRENCH

4. At top of berm, anchor earth trench is dug by hand as there is limited access and length is small.
5. Anchor earth trench 100+mm(deep) x 300mm+(wide) is approx.500+mm from edge of slope.

INSTALLATION OF RECP

5. Secure ECM/TRM mattresses ends at bottom of trench with wooden stakes and backfill with soil and compact to grade.
6. ECM/TRM mattresses are gently rolled down slope.
7. ECM/TRM mattresses are secured by wooden stakes at 1m centres.
8. Maintain side-overlap at 100mm and end-overlap at 200mm, upslope end on top of lower end, to enable water to "flow-over" connection.
9. Allow ECM/TRM to "fill-into" depressions and cavities. Maintain good mattress-soil contact by walking down slope gently. Do not over-stretch ECM/TRM.
10. Install Roll Mattress Logs (RML-150) at 1+m intervals down slope at pre-dug depression/trench of 50mm (D).
11. RML-150 logs shall be secured by wooden stakes/J-Rebars 12mm(Ø) x1300mm(L) and "criss-cross strap-down" with coated tie-wire/UV stabilized multi-purpose rope.
12. Hand seeding: mix grass seeds & NPK fertilizer in pail.
13. Disperse by hand or hand broadcaster…
14. Avoid "shadowing", seed different angle.
15. Avoid walking on slope till grass establish
16. Check ECM/TRM after storm and repair.
17. Check for bald areas(birds) and re-seed.

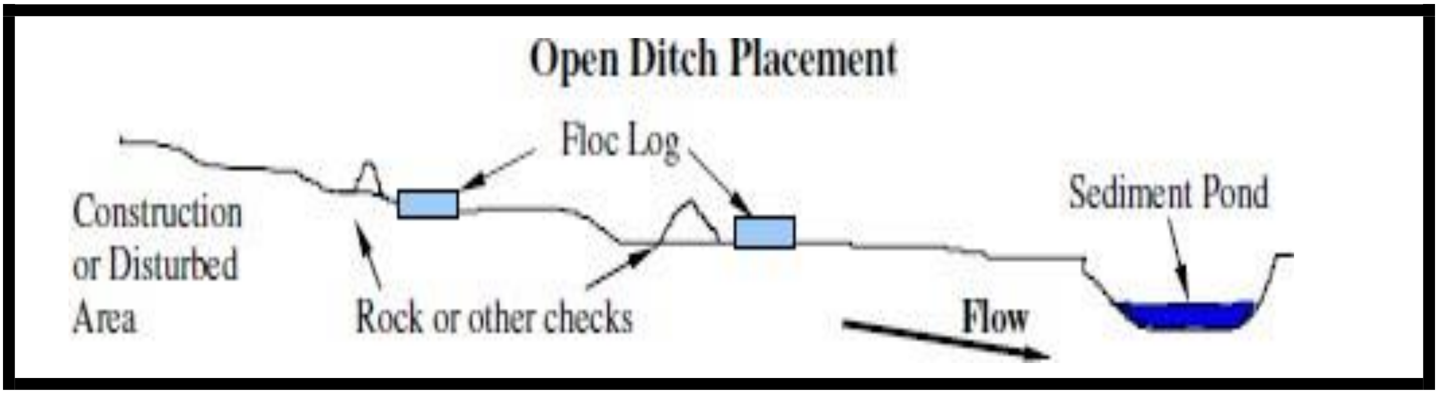
TYPICAL RESIDENTIAL DEVELOPMENT CONSTRUCTION SITE

SILT TRAPS INSTALLED TO HANDLE 100AC EXPOSURE……

MISS-PLACED INLETS & OUTLETS……ERODED EARTH DITCH

EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs (PAM-BLOCK)

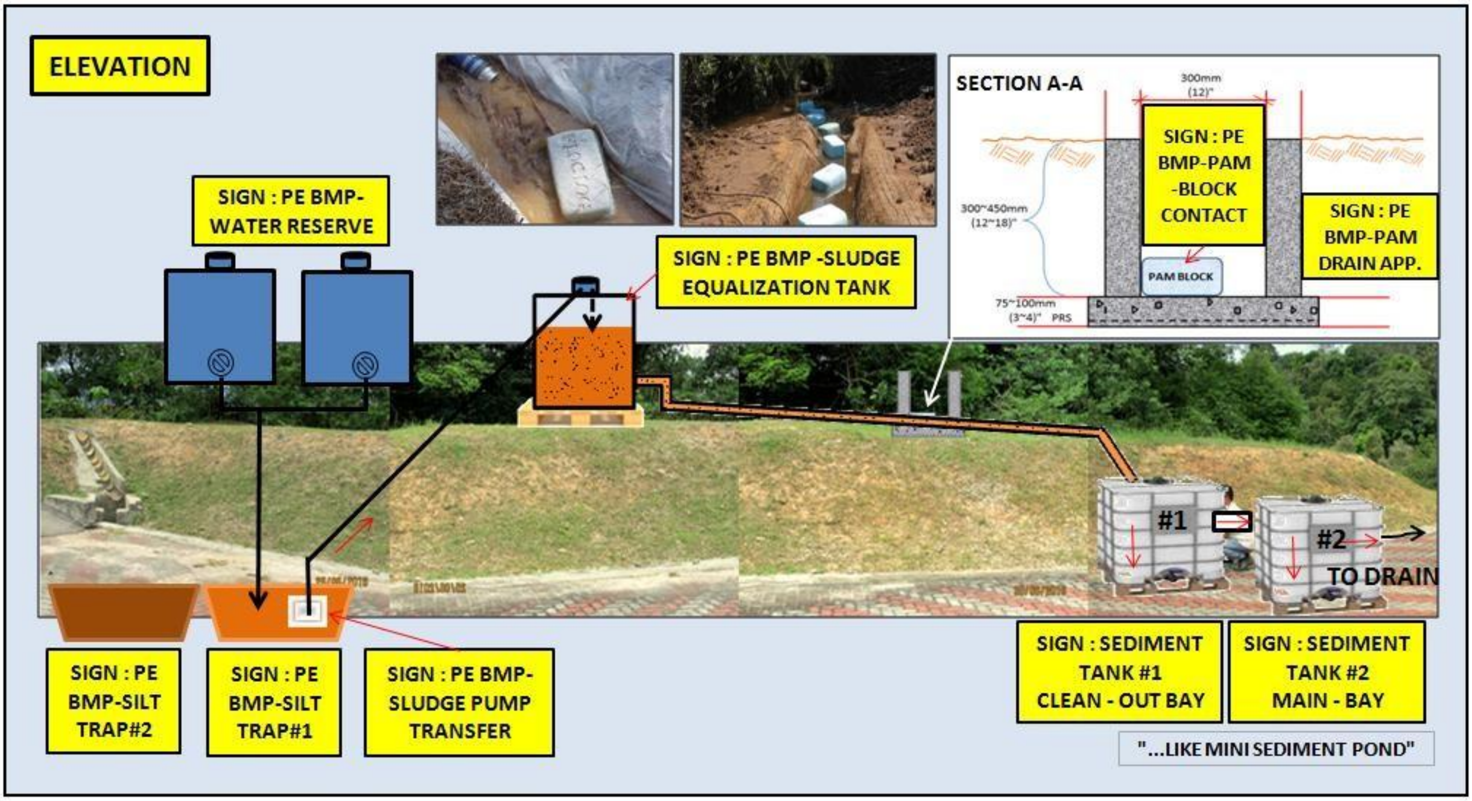
PAM-BLOCK APPLIED @ CONSTRUCTION SITES



WATER QUALITY IMPROVEMENT @ CONSTRUCTION NEAR STREAM/RIVER CHANNELS

WATER QUALITY IMPROVEMENT @ CONSTRUCTION SITE DRAINAGE DITCHES

POLYMER ENHANCED BMP (PE-BMP) PAM-BLOCK SEDIMENT REMOVAL & CLEAN WATER DISCHARGE



POLYMER ENHANCED BMP (PE-BMP)

APPLICATION OF PAM-BLOCK

PRELIMINARY ANALYSIS

1. Sample collection from construction site silt trap.
2. Perform quick PAM-BLOCK test for effectiveness of anionic PAM types.
3. Visual check floc size and uniformity.
4. Test for pH of sediment/sludge = pH 3-4.

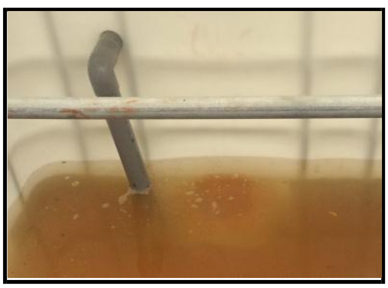
EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs (PAM-BLOCK)

PAM-BLOCK APPLICATION


5. Mix Sludge for uniformity.
5. Pump sludge to equalization tank.


7. Sludge mixture discharge into drainage channel-ditch that is lined with PAM-BLOCKS (8).


8. Sediment pollutant immediate contact, when passing over PAM BLOCKS.
9. Flocculation reaction immediately upon PAM contact and flocs “settle-out” of sludge flow.

10. Flocs fall to bottom of tank (fore-bay) and clean water “overflow” out of system into drainage system.

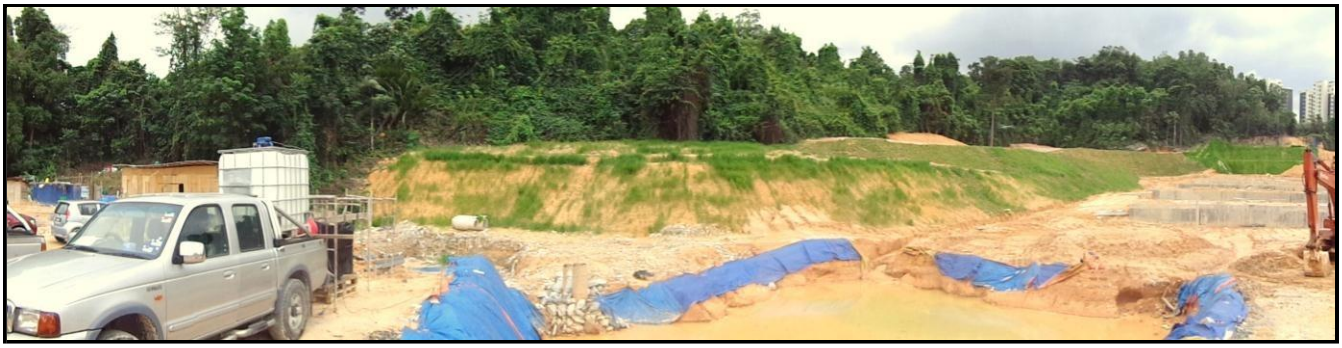

TYPICAL LINEAR CONSTRUCTION SITE

SEDIMENT PUMPED FROM PILE-FOOTING INTO SILT TRAP AFTER STORM EVENT

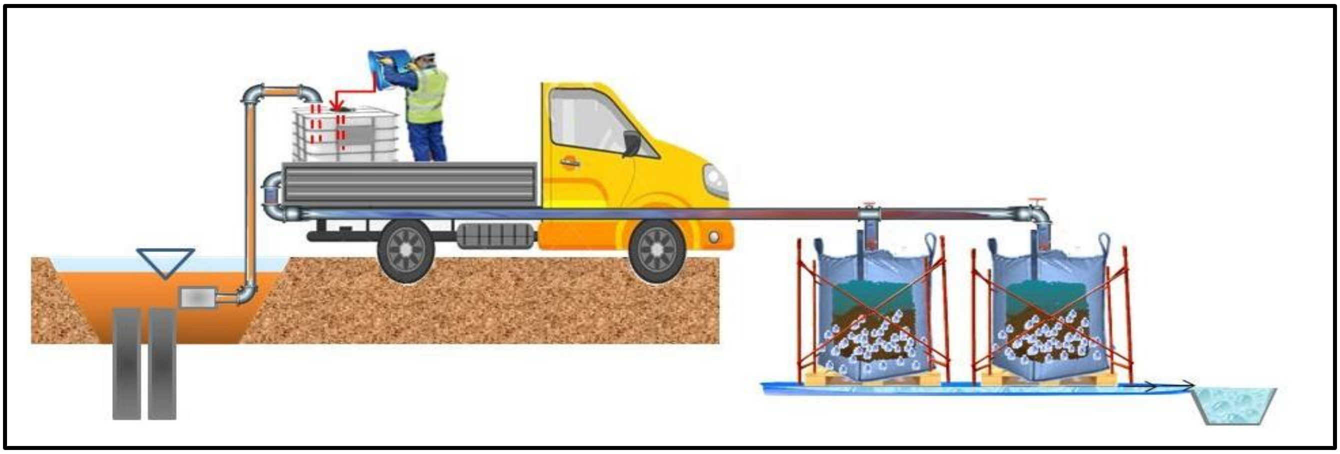
LIMITED SPACE FOR SEDIMENT TRAP & POND

SEDIMENT OVER-FLOWING SILT TRAP DURING-AFTER STORM EVENT

ATS-MINI APPLIED @ CONSTRUCTION SITE CHERAS



ATS-MINI : MOBILE WATER TREATMENT



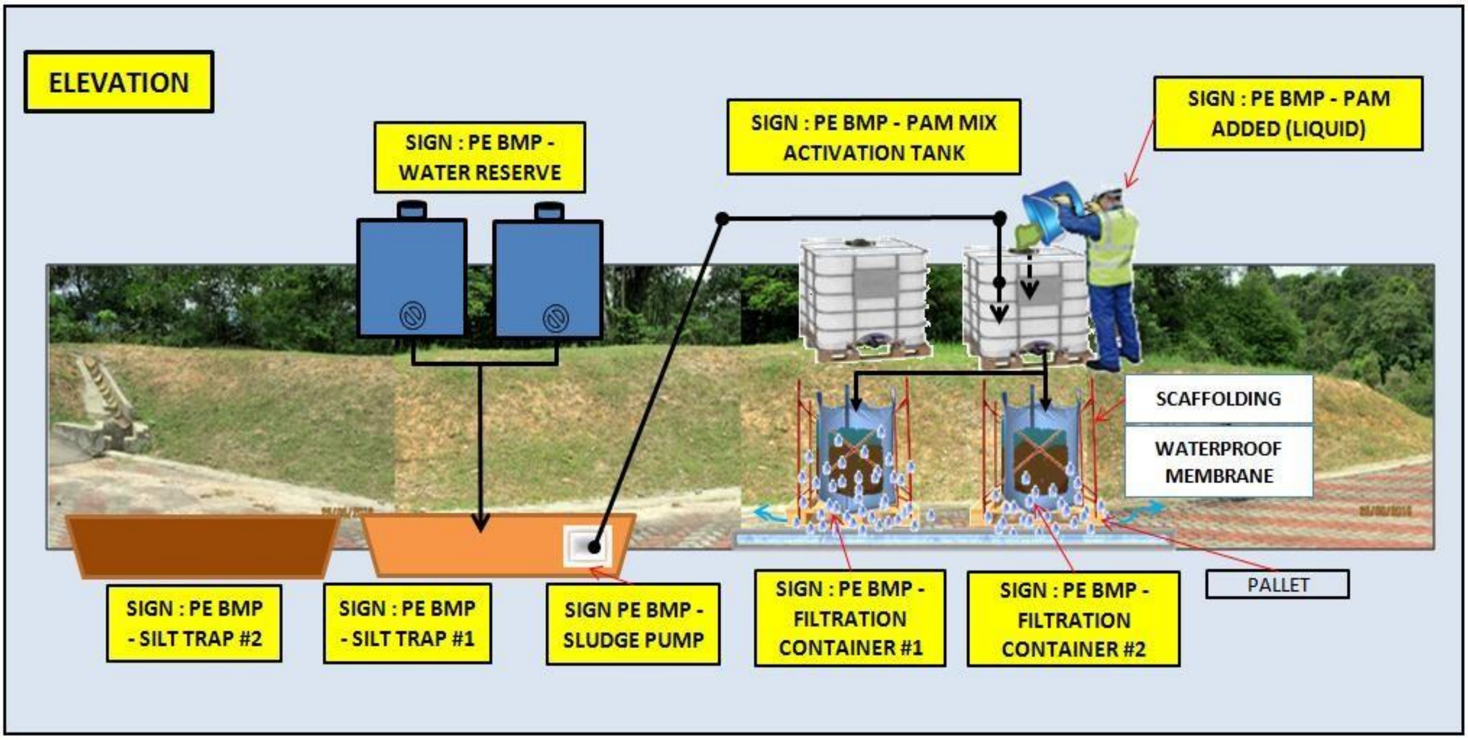
ATS-MINI: SEDIMENT REMOVAL & CLEAN WATER DISCHARGE



LIQUID PAM TREATMENT AFTER JAR TEST DETERMINES TYPE & DOASGE




EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs (ATS-LIQUID)



POLYMER ENHANCED BMP (PE-BMP)

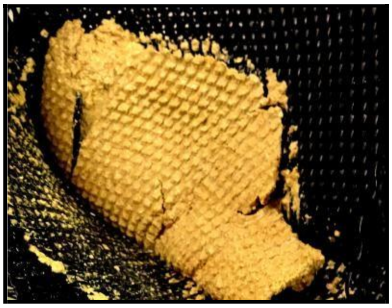
APPLICATION OF ATS-LIQUID

PRELIMINARY ANALYSIS

1. Sediment from construction site silt trap.
2. Mix Sludge for uniformity.
3. Test for pH. Sediment @ pH 3-4

4. Conduct “Jar Test” Flocculation.
5. Determine most appropriate anionic PAM.
6. Determine PAM dosage & concentration.

EiMAS – LDPPMM SEDIMENT CONTROL POLYMER ENHANCED BMPs (ATS-LIQUID)



7. Conduct “Filtration” process.
8. Determine “best floc cake” and adjust.
9. Determine “best water clarity” and adjust.

ATS-LIQUID APPLICATION

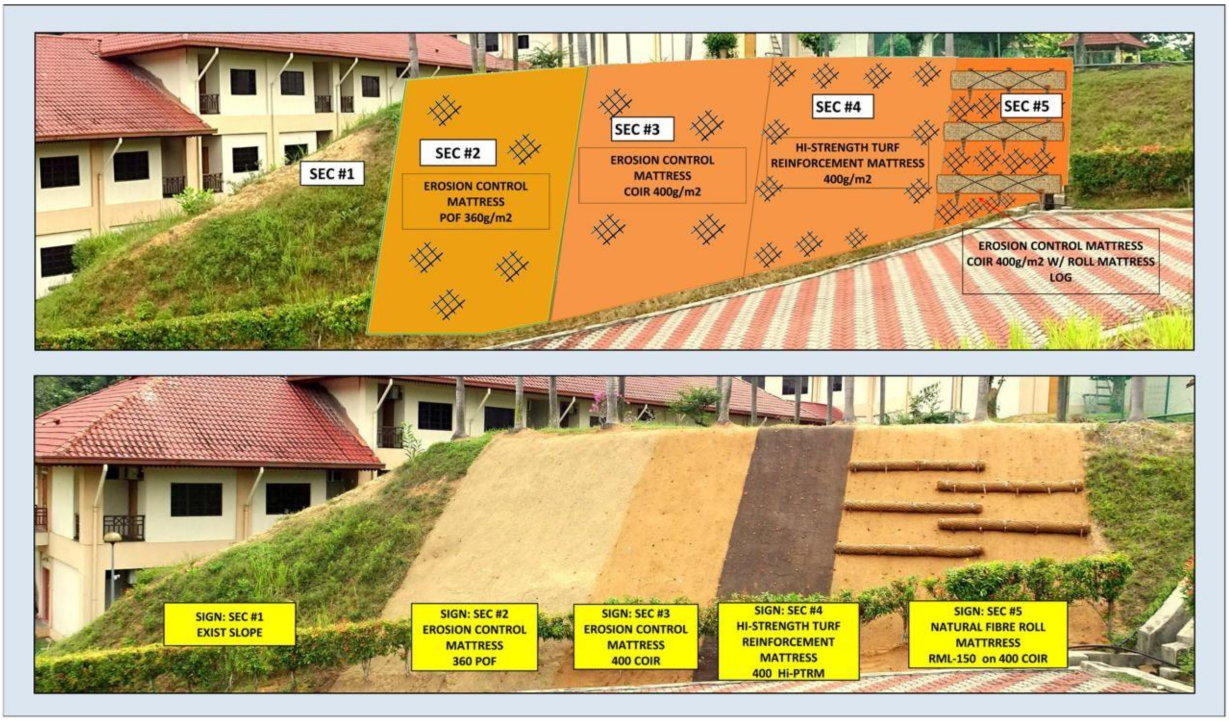
10. Pump sludge from “silt trap” into activation tank.

11. Add PAM Liquid into activation tank to proportions measured in “jar test”.
12. Stir mixture (mechanical).

13. Mixture is “gravity” pipe into filtration bag set-up.
14. Stir mixture (mechanical).

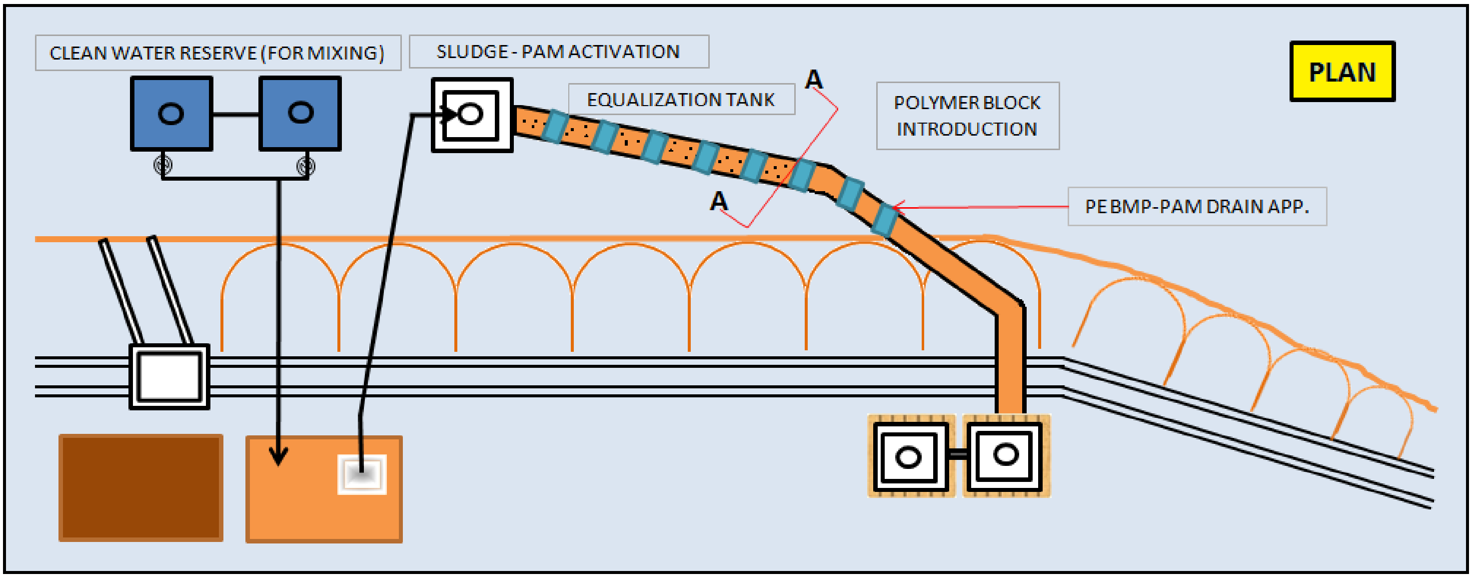
15. Floc solid is trapped in filtration bag.
16. Clean water discharged into environment, drainage system.

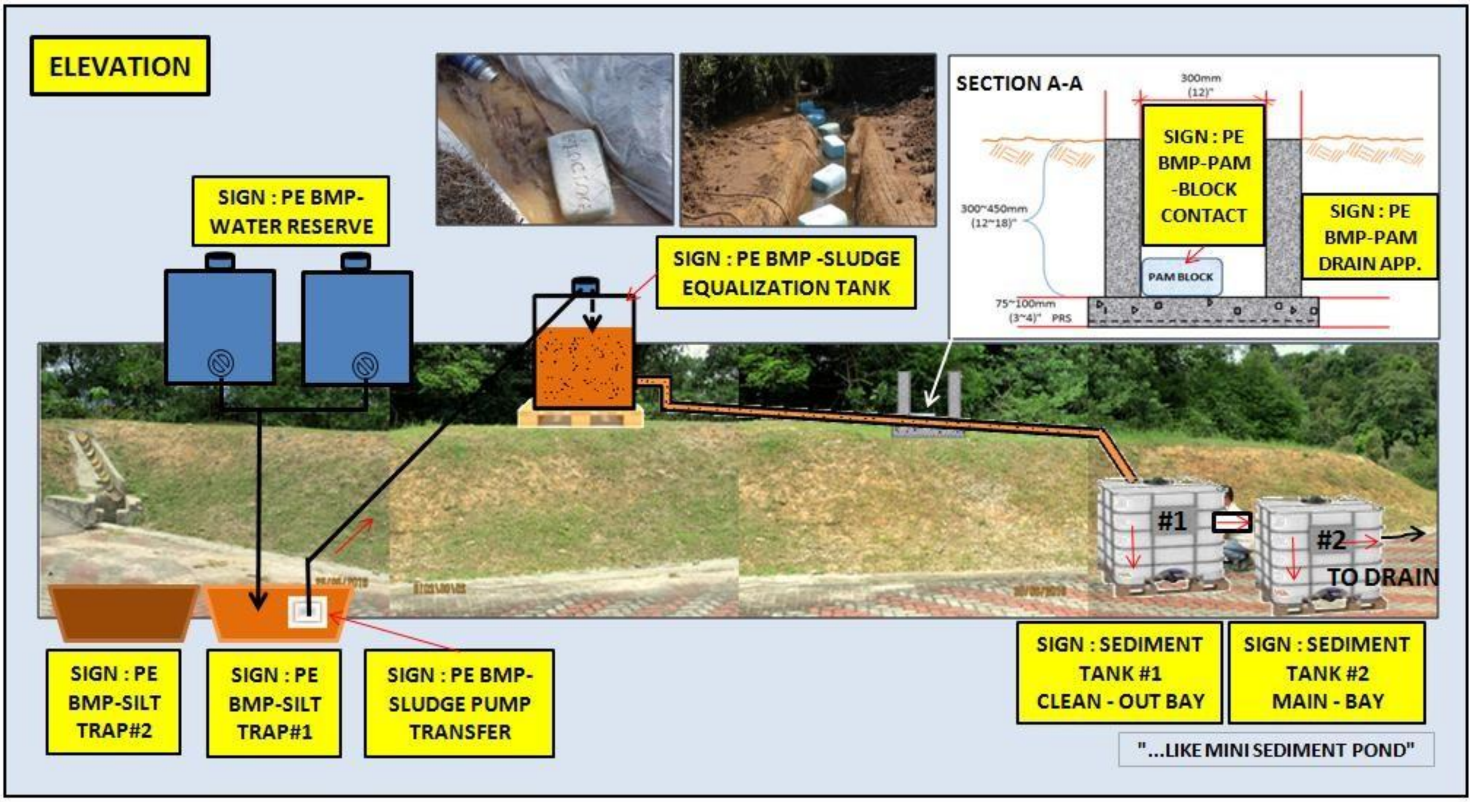
EiMAS – LDPPMM SLOPE EROSION CONTROL BMPs



	SUMMARY LIST OF SIGNS :
SEC #1	**EROSION CONTROL MATTRESS** Existing Slope Condition
SEC #2	**EROSION CONTROL MATTRESS : 360 POF** SPEC : Palm Oil FibreMattress @ 360g/m2 Density & Hand Grass Seeding
SEC #3	**EROSION CONTROL MATTRESS : 400 COIR** SPEC : Coconut Coir Mattress @ 400g/m2 Density & Hand Grass Seeding
SEC #4	**HI-STRENGTH TURF REINFORCEMENT MATTRESS : 400 Hi-PTRM** SPEC : Coconut Coir Mattress @ 400g/m2 Density Hi-Reinforcement @ 38kN/m & Hand Grass SeedingSEC #2
SEC #5	**NATURAL FIBRE ROLL MATTRESS LOG : RML-150 on COIR** SPEC : Roll Coir Mattress @ >450g/m2 Density Coconut Coir Mattress @ 400 g/m2 & Hand Grass Seeding

EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs (PAM-BLOCK)



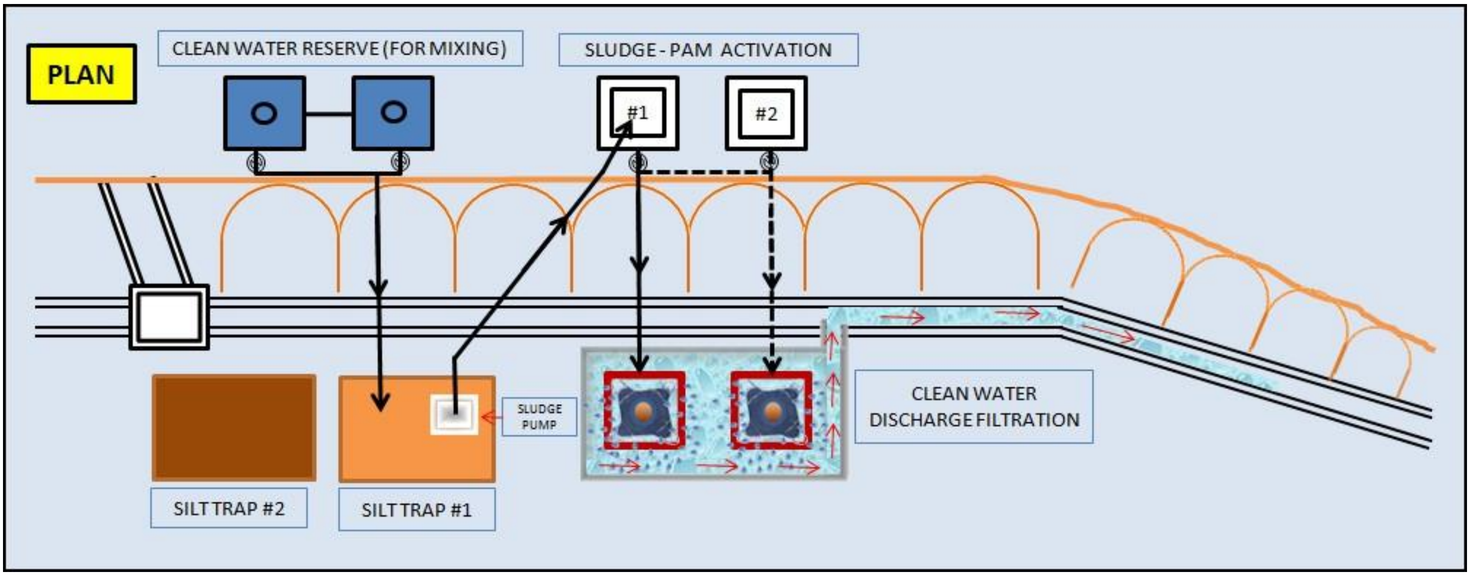


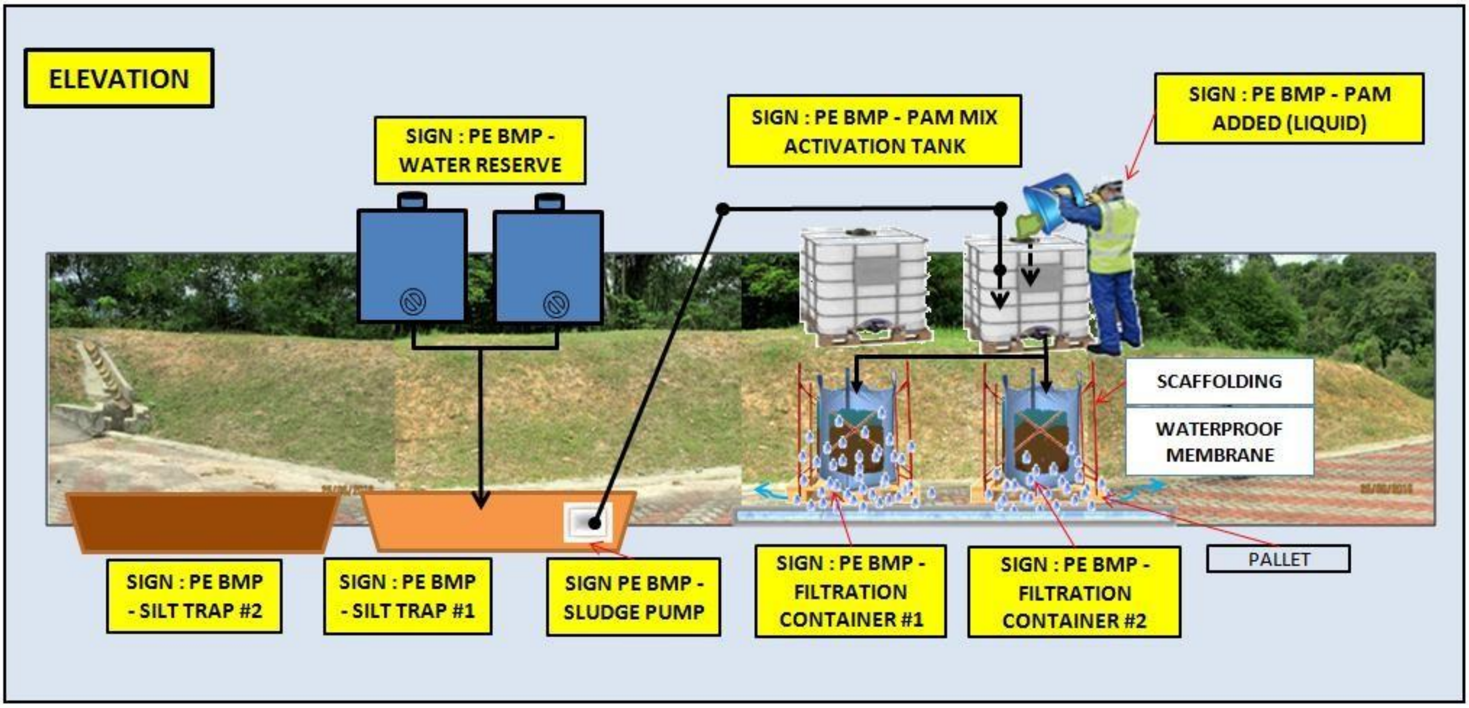
	SUMMARY LIST OF SIGNS :
PE BMP-WATER	**WATER RESERVE** SPEC :Clean Water Reserve – 2 x 1000 Litres (approx)
PE BMP-SILT TRAP #1	**SILT TRAP #1** SPEC:Silt Trap #1 –Sediment from typical Construction Site

EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs (PAM-BLOCK)

PE BMP- SILT TRAP #2	**SILT TRAP #2** SPEC :Silt Trap #2 – Sediment from Mineral Mining Site: Bauxite/Iron Ore..
PE BMP- SLUDGE PUMP	**SLUDGE TRANSFER** SPEC :Sludge Pump – Pump Sludge for Treatment
PE BMP-SLUDGE EQUALIZATION TANK	**SLUDGE EQUALIZATION TANK** SPEC :Polyacrymide Mixing-Activation Tank : Discharge of Sediment of Construction Site/Minerals Bauxite/Iron Ore Capacity : 1 x 1000 Litres. Actual Site has to be designed by ESCP/ LDPPMM specialist.
PE BMP- PAM-BLOCK INSTALLATION	**PAM – BLOCK CONTACT** SPEC :Pre-Test to determine : 1) pH, 2) PAM-BLOCK Type needed for treatment &3) Install (8-10)PAM-Blocks in series at(1-2)m intervals in construction site drainage ditch “leading” to sediment pond/basin/silt-trap (about 12-15 units).
PE BMP- PAM-DRAIN APP.	**PAM – DRAINAGE APPLICATION** SPEC :Drainage App : 1)PAM Blocks secured to bottom of drain ditch, 2)Sediment from Construction Site/Minerals tailings/sludges (Bauxite/Iron Ore..) flow over (by gravity or pumped) and treated by activation from PAM-blocks.
PE BMP- SEDIMENT TANK#1	**SEDIMENT CLEAN-OUT/FOREBAY** SPEC :Sediment Basin/Tank #1 – “Settle-out” flocculated Sediment/ Pollutants from Construction Sites, Mineral Tailings from Tire Washouts and Sediment Traps of Bauxite/Iron Mines. EiMAS Training : 1 x 1000 Litres, Actual Sediment Basin Size depends on LDPPMM designer.
PE BMP- SEDIMENT TANK#2	**SEDIMENT MAIN-BAY** SPEC :Sediment Basin/Tank #2 – “Settle-out” flocculated fine Sediments/Pollutants fromForebay/Cleanout Bay. Clean Water discharge. EiMAS Training : 1 x 1000 Litres, Actual Sediment Basin Size depends on LDPPMM designer.

EiMAS – LDPPMM SEDIMENT CONTROL
POLYMER ENHANCED BMPs ATS-LIQUID





	SUMMARY LIST OF SIGNS :
PE BMP- WATER	**WATER RESERVE** SPEC : Clean Water Reserve – 2 x 1000 Litres (approx)
PE BMP- SILT TRAP #1	**SILT TRAP #1** SPEC : Silt Trap #1 – Sediment from typical Construction Site
PE BMP-	**SILT TRAP #2**

SILT TRAP #2	SPEC : Silt Trap #2 – Sediment from Minerals Mining Site Bauxite/Iron Ore…
PE BMP- SLUDGE PUMP	**SLUDGE TRANSFER** SPEC : Sludge Pump – Pump Sludge for Treatment
PE BMP- PAM (LIQUID) ADDITION	**PAM ADDED (Liquid)** SPEC : Pre-Test to determine : 1) pH, 2) PAM Type & 3) Dosage
PE BMP- PAM MIX- ACTIVATION	**PAM MIX-ACTIVATION TANK** SPEC : Polyacrymide Mixing-Activation Tank : Treatment of Sediment of Construction Site/Minerals Bauxite/Iron Ore Capacity : 1 x 1000 Litres (approx.)
PE BMP- FILTRATION SYSTEM #1	**FILTRATION SYSTEM #1** SPEC : Filtration Container #1 – Sediment from Construction Site Floc-Cake (residue separated)
PE BMP- FILTRATION SYSTEM #2	**FILTRATION SYSTEM #2** SPEC : Filtration Container #2 –Sediment Mineral Bauxite/Iron Ore Floc-Cake (residue separated)

APPENDIX F

GUIDING ON MANAGING EROSION AND SEDIMENT CONTROL

GUIDING ON HOW TO MANAGE EROSION AND SEDIMENT CONTROL IN LAND DEVELOPMENT PROJECT

Details
Generally, apply all of the principles and elements of erosion and sediment control. • Integrate project design with site constraints. • Preserve and stabilize drainage ways. • Minimize the extent and duration of disturbance. • Control storm water flows onto, through, and from the site in stable drainage structures. • Install perimeter controls. • Stabilize disturbed areas promptly in a timely manner. • Protect steep slopes. • Use sediment controls to prevent off-site damage. • Protect inlets, storm drain outfalls, and culverts. • Provide access and general construction controls. • Inspect and maintain control measures. • Employ experienced and competent personnel. • Factors influencing erosion: R.K.LS.C.P – Rainfall erosivity factor – Soil erodibility factor – Topographic factor – Cover factor BMPs(existing & proposed) – Management practice factor BMPs **KEYWORD** • Protect, Preserve • Cover • Stabilize • Minimize, Intercept, Divert, Reduce, Decrease • Dissipate • Contain • Treatment • Inspect • Maintain

1 Husband 5 Wives: 1H5W- What, Why, Where, When, Who & How	
Place:	Where is it done? Why is it done there? Where else might it be done? Where should it be done?
Sequence:	When is it done? Why is it done then? When might it be done? When should it be done?
Person:	Who does it? Why does that person do it? Who else might do it? Who should do it?
Means:	How is it done? Why is it done that way? How else might it be done? How should it be done?

Phase construction to limit duration of soil exposure.
Minimize the extent and duration of disturbance.

- Phase the large area:
  - Area
  - Fund
  - Time
  - Contractor
- Stage the area

Time grading operations to minimize soil disturbance.

- Schedule of land clearing and grading
- Weather
- Logistic
  - Fund
  - Machinery
  - Manpower
  - Procurement

Environmental Construction Reference

- Conditions of approval
- Land Disturbing Pollution Prevention And Mitigation Measures (LD-P2M2)

Certify contractors on ESC plan implementation

Employ experienced and competent personnel.

- Certified Professional in Erosion and Sediment Control (CPESC); EnviroCert USA
- Certified in Erosion, Sediment, Storm Water Inspector (CESSWI); EnviroCert USA
- Certified Inspector of Sediment and Erosion Control; CISEC, Inc .

Land Disturbing Pollution Prevention And Mitigation Measures Plan

- Land Disturbing Pollution Prevention And Mitigation Measures plan isn't absolute but rather a 'live' document that needs to be updated frequently as needed, because the actual conditions at the construction site always differ from conditions envisioned when designing that plan in an office

Conceptual LD-P2M2 versus Construction LD-P2M2

- The approved LD-P2M2 at the EIA stage can be considered as a "conceptual" LD-P2M2, due to a lack of project site information and site development or construction methods as such the construction sequencing information and design details for temporary works or the final project design drawings may lead to insufficient references during LD-P2M2 preparation and designing procedure.
- Unfortunately in many cases, such drawings are generally not available until late in Detail Design, so the LD-P2M2 may need to be based on preliminary plans. The LD-P2M2 may be refined as this information becomes available.

Approved Plan (Adjust LD-P2M2 at construction site to adapt to field conditions)

- What Next:
- Contractor must integrate the Final site Development Plan, Earthwork Plan, Road and Drainage Plan with the LD-P2M2 Plan.
- Meaning:

  Make sure it is

  - Applicable and can be implemented
  - Need modification or total revise
  - Produce new LD-P2M2 Plan design based on the earlier approved plan.
- Following an approved plan and installing the control measures may not be enough for a site to be in compliance.
- The contractor must ensure that additional measures are installed to correct problems and may have to correct/mitigate any adverse environmental impacts that occur.

The Land-disturbing Pollution Prevention and Mitigation Measures Plan may also need to be updated to reflect changes in site conditions and BMPs.

An effective quality-control program consists of the following:

- Clear communication channel described in writing between the designer and the contractor;
- A preconstruction conference with enforcement authorities, the project owner/developer, the designer, the contractor, and others involved to review the approved plan and discuss any questions or potential problems;
- Periodic and regular supervision and inspection of implementation of the approved erosion and sediment control plan by competent personnel;
- Proper maintenance and repair of erosion and sediment control measures.

Hold the pre-construction meeting.

Verify, inventory and mark:

- Drainage depression
- Streams
- Run-on
- Discharge points
- Access construction road
- Steep slopes to be cut

Be transparent and detail out all of the relevant scope of work corresponding to erosion and sediment control / measures. Contractor to identify and understand site problem areas such as:

1. Slopes - critical area especially steep and due to soil properties factor;
2. Streams and waterways – sensitive area, must resolve run-on first;
3. Surface drainage ways, roadways - Most roadways will act as drainage paths directing up-slope storm water runoff down the road;
4. Large, flat surface areas - Large areas – may be necessary to subdivide these areas into manageable drainage areas to prevent the formation of rill erosion; and
5. Adjacent properties

Know The Problem Areas And Attend To Appropriately

1. slopes;
2. streams and waterways;
3. surface drainage ways;
4. large, flat surface areas;
5. borrow areas; and
6. adjacent properties.
    - Critical Area: (Wherever soils detachment likely to occur.)
    - Sensitive Area: (Wherever pollutants can make way out across boundary)
    - Existing site conditions and study thoroughly the LD-P2M2 plan.
    - Adjacent areas
    - Off-site areas

- Erosion and sediment control measures – Keep the list

Some Finding

Erosion is likely to occur at any concentration of flow;
however, it occurs most severely in high flow concentrations.
Erosion most commonly occurs:

- As a general rule there will be a potential hazard if slope lengths exceed the following:
- 0-7% (low erosion hazard but hazard considered to be critical if slope exceeds 100 metres); 7-15% (moderate erosion hazard but hazard considered to be critical if slope exceeds 50 metres); >15% (high erosion hazard but hazard considered to be critical if slope exceeds 25 metres).
- Vegetative stabilization, diversion measures, slope drains and slope stabilization measures may counteract problems created by modifying slopes.
- on slopes of more than300 m (and less depending on the percent slope and soil type);
- on the outer banks of curved channels;
- at a culvert outlet or inlet;
- where the longitudinal slope of the ditch exceeds 2.5%;
- where there is sheet flow over a foreslope or backslope.

Knowledge Information

- When applying topsoil to slopes steeper than 1:2 additional BMPs are required, such as stepped slopes, rolled erosion control product, or turf reinforcing mat.

Contractor must bear in mind that:

- BMPs are most effective when used in combination with each other, and customized to meet the specific needs (drainage, materials, activities, etc.) of a given operation.

Make the Most of LD-P2M2 Plan at Construction Sites

Implement the LD-P2M2 Plan accordingly as you go.

- Manage:
- Co-ordinations & Communications
- Uphold Code of Practice in Earthwork
- Start with Prevention
- Work approach: Limit and delay work
- Water: Keep clean water clean
- Disturbance: Stabilize as soon as possible
- Devise in mind and implement:
  - Site Planning & Management BMPs
  - Erosion Control BMPs
  - Runoff Control BMPs
  - Sediment Control BMPs
  - General Construction BMPs

Compliance

- Objective is to prevent accelerated erosion and offsite (receiving water) sedimentation, as well as associated pollution caused by erosion and sedimentation.
- Effective measures in controlling erosion and preventing sedimentation must be used at a construction site to be in compliance.

Causes of Noncompliance

- Little or no effort to comply
- Design errors in the erosion control system or the site conditions have changed
- Faulty or inadequate installation or maintenance
- Severe weather has occurred

Install, Inspect & Maintain (2I's 1M)

Self-monitoring
Self-auditing
Self-regulating

Construction Drawing Reference

- Site development
- Survey plan
- Earthwork plan
- Road & drainage plan
- LD-P2M2 plan
- Scope of work
- Method statement

Method statement shall be established before start of work.

Demonstrate a model/typical sequence of work for cut slope, fill slope, embankment, stream crossing, stream diversion that staging the application of, as such runoff BMPs such as temporary earth drain.

The purpose of a work method statement

- Primary tool for the integration and implementation of the environmental requirements to control works in the field.

Construction methods

- Refers to the construction means, methods, techniques, sequences and procedures and their co-ordination for which the Contractor is responsible
- Be cognizant of earthworks will be undertaken adjacent to nearby residential areas, therefore perimeter controls or buffer zones are critical

For example, in the top photo on the right, a new highway is proposed to be constructed with the alignment cutting across the existing 8-slope hillside.

As seen in the bottom photo, this hillside is adjacent to an established residential area.

As such, in the preparation of his construction methods, the Contractor needs to critically evaluate his work components, staging and sequencing, and to complement them with the appropriate environmental method statements.

Critical Drainage Depression (Must be thorough and Stage)

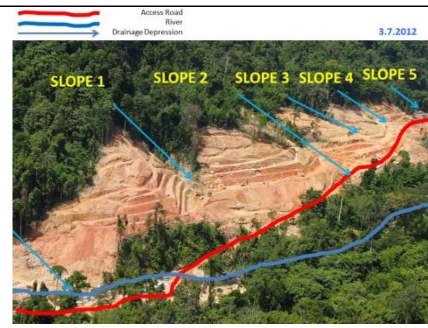
Develops a work schedule for every project / scope of work that includes staging of construction or land disturbing activities in conjunction with the implementation BMPs.
Some may refer to Critical Path Method.

In the example photos on the right, all the slope works were undertaken at one go, where no staging was planned into the works right from the start. This resulted in a large extent and duration of exposed land surfaces.

For this example, it took the Contractor about 2 years to finish the slope works as shown in the bottom two photos.

Wrong and not thorough during planning stage, improper earthwork practices and skipped construction work sequences subsequently resulting in environmental loss, extra cost and time as well as irreversible state.

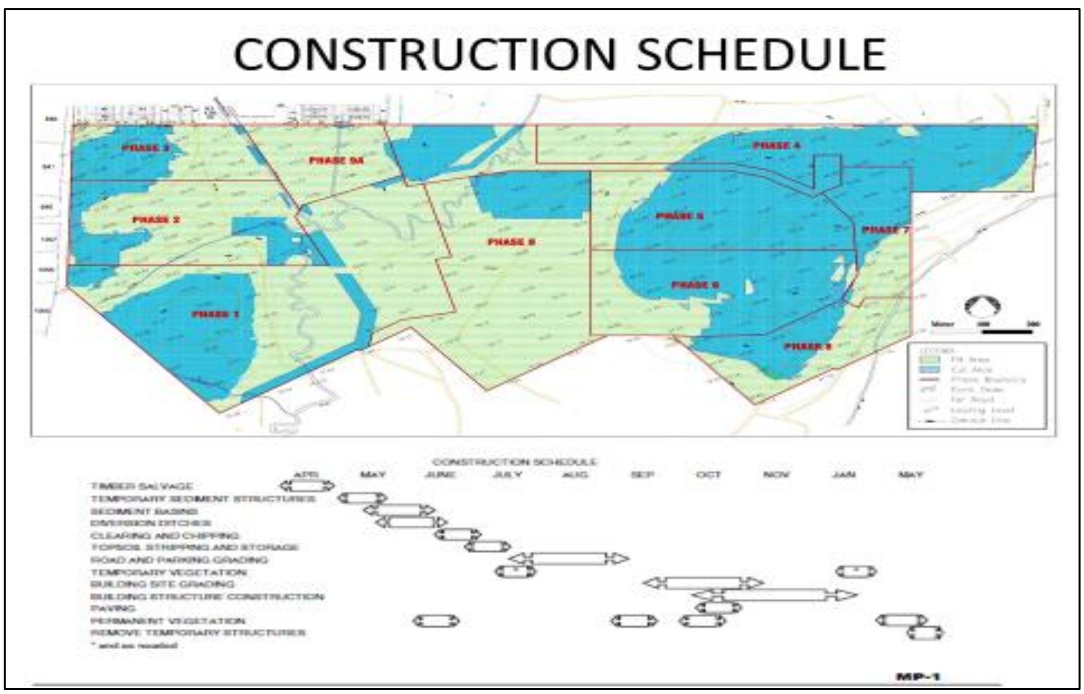
To avoid or prevent the above issue from occuring, a work programme similar to a Criticial Path Method (CPM) as shown below shall be prepared to identify the stages of work to be undertaken



Site Preparation

	Task Name	Duration	Start	Finish
1	**START**	0 days	Wed 10/09/08	Wed 10/09/08
2	**OVERALL PLANTATION PROGRAMME**	**662 days**	**Wed 10/09/08**	**Wed 16/03/11**
3	**Environmental Management Plan (EMP)**	**77 days**	**Wed 10/09/08**	**Wed 24/12/08**
4	Appointment of Environmental Consultant	7 days	Wed 10/09/08	Thu 18/09/08
5	Preparation of EMP	30 days	Fri 19/09/08	Thu 30/10/08
6	Submission of EMP	10 days	Fri 31/10/08	Thu 13/11/08
7	Presentation & approval	30 days	Fri 14/11/08	Wed 24/12/08
8	**Plantation Works**	**577 days**	**Thu 25/12/08**	**Fri 04/03/11**
20	**Development of Mitigating Measures**	**585 days**	**Thu 25/12/08**	**Wed 16/03/11**
21	Appointment of Environmental Consultant	25 days	Thu 25/12/08	Wed 28/01/09
22	Appointment of Environmental Officer	25 days	Thu 25/12/08	Wed 28/01/09
23	Setup sediment basin/silt trap	120 days	Thu 29/01/09	Mon 13/07/09
24	Setup interceptor drain	120 days	Thu 29/01/09	Mon 13/07/09
25	Setup earth bund	120 days	Thu 29/01/09	Mon 13/07/09
26	Setup permanent culvertway	300 days	Thu 29/01/09	Wed 17/03/10
27	Setup designated dumping site	60 days	Thu 29/01/09	Tue 21/04/09
28	Installation of signage	90 days	Thu 29/01/09	Tue 02/06/09
29	Construct elephant trenches/electical fencing	150 days	Thu 29/01/09	Mon 24/08/09
30	Maintenance of mitigating measures	560 days	Thu 29/01/09	Wed 16/03/11
31	**Environmental Monitoring Exercise**	**312 days**	**Thu 29/01/09**	**Fri 02/04/10**
32	EME No. 1 (Quarterly)	22 days	Thu 29/01/09	Fri 27/02/09
33	EME No. 2 (Monthly)	22 days	Mon 02/03/09	Mon 30/03/09

CONSTRUCTION SCHEDULE



Some issues pertaining to planning, construction work sequence and earthwork practices

Physically mark limit of disturbance

- Identify and mark vegetation and habitat areas to be retained or avoided at site establishment as exclusion zones.
- Exclusion zones are to be clearly set out and marked prior to commencing construction activities.

Flag or fence clearing limits

Delineation Fence (Tree Protection) such as shown on the right shall be provided to clearly mark on site the limits of clearing and to preserve or protect trees adjacent to the land clearing works.

Physical delineation shall be initiated early in this sensitive area prior to commencement of earthwork to minimize the damage to adjacent trees and vegetation.

Preservation

Identify limit of works as well as preservation of existing vegetation to serve as buffer zone, such as shown in the photo on the right

SITE PLANNING AND MANAGEMENT

- BIOMASS
- PRESERVE EXISTING TREES & VEGETATION
- RESOURCE ON-SITE ROCKS FOR BMPs
- STOCKPILE TOPSOIL
- SALVAGE TREES (TRANSLOCATION)
- ESTABLISH NURSERY

BIOMASS

Brush Barrier serves as sediment barrier. Consider to cover with filter fabric

BIOMASS

Brush Barrier may serve as sediment barrier – good for sheet flow similar to silt fence.

SILT FENCE, BRUSH BARRIER AND EARTH BANK

Serve as temporary erosion control measures, but must ensure proper and secured installation

BRANCHES MAY FUNCTION AS BRUSH LAYER, but must ensure proper and secured installation

PRESERVE EXISTING TREES & VEGETATION

Preservation of existing vegetation relates to the identification and protection of native vegetation.

PURPOSE

- To minimize disturbances on construction sites,
- To stabilize soil,
- To trap suspended particles from sheet flow runoff,
- To promote infiltration of storm water.

APPLICATION

- Areas within the site where no construction activity is occurring.
- Areas where existing vegetation can be utilized for erosion and sediment control (as circled in the two right photos)

RESOURCE ON-SITE ROCKS FOR BMPs

Stockpiling available rocks

Recycle concrete

Wood chips

Explore the existing site sources that can benefit the potential material for erosion control such as rocks

PURPOSE

To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement.

APPLICATION

Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.

SALVAGE TREES (TRANSLOCATION)

Explore the existing site sources that can benefit the potential material for erosion control such as trees

To make use of the existing site sources materials for erosion and sediment control which may minimize cost and time in the materials procurement.

Applicable on most of construction sites and is extremely recommended for anticipated prolonged land disturbing activities such as those occurring in highway and hydroelectric projects.

ESTABLISH NURSERY

Grow grasses or sods or native plants / vegetation locally wherever applicable for use whenever needed is suggested for project duration more than 3 years completion

Projects owners are encourage to establish their own nursery and grass growing

<table>
<tr><td>Grass growing wherever space available at jobsite</td><td></td></tr>
<tr><td>Site Clearing
Preserve existing vegetation and do clearing only when actually required or at the right time.
Should have temporarily preserved the existing vegetation along this boundary (first photo).

After the unnecessarily removal of the vegetation above, new crop planting was required to capture the runoff from adjacent areas. Such a practice not only illustrates the lack of consideration during the planning but also increases cost of the project.</td><td>
</td></tr>
<tr><td>Uphold Code of Practice in Earthwork

Although the BSI British Standards BS 6031 2009: Code of practice for earthworks is almost always included in the contract Specifications for most civil engineering project that would involve extensive or significant land disturbing activities, the physical practices encountered on project sites at times do not comply with the guidelines, recommendations and even requirements as stipulated under the code.</td><td></td></tr>
</table>

	
LAND GRADING – TERRACING LAND GRADING PRACTICE: Terracing will reduce the value P management practice	 
Install construction entrance(s) Washing facility with grating/rumble surface	

WASH TROUGH/ENTRANCE

- Construct wash trough or washing facility at least 50 metres from ingress.
- Construct stonepad within that 50 metres from ingress.

INSTALL PERIMETER PROTECTION (SEDIMENT FENCE, MULCH BERM, COIR LOGS, ETC.)


SILT FENCE-SPECIAL SEDIMENT FENCE-SEDIMENT
BASIN-COMPOST
19/04/2012

Keep Clean Water Clean

Run-on (on-site/offsite)

EMPHASIZE EROSION CONTROL MEASURES TO STABILIZE DISTURBED AREAS

HYDRO-MULCHING / MULCHING TO COVER THE SOIL SURFACE

HYDROMULCH & FIBER ROLL

Oil Palm Biomass Used for Mulching

Mulch slows down the flow- Earth drain missing to intercept and convey runoff

Mulch promote sediment settling and trapping

9 months later

ACCESS /CONSTRUCTION /HAUL ROADS

- Apply construction road stabilization BMPs for all of active or heavy usage roadways.
- This applies also to
  - Material Staging Areas
  - Site Office area
  - Base or workers camp

Provide stabilized construction roads for all internal traffic

Active access road should be stabilized immediately

Evidence of sediment traction on public road

Entrance / Access Road was stabilized after 3 weeks being instructed

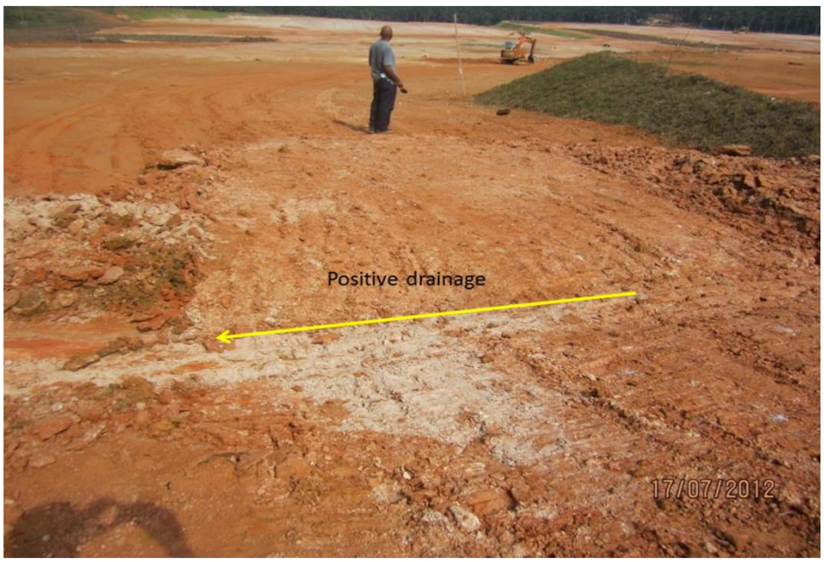
Gravelling BMPs of rutted access road

Naturally established earth drain (In-slope or Out-slope)

ESTABLISHMENT OF BROAD-BASED DIP

(RUNOFF CONTROL) ALONG THE UNSEALED ACCESS ROAD

Construct cut off drain, rolling dip or water bar (hump) or broad-base dip across the alignment



WATER BAR • Always construct water bar or rolling dip to divert and break runoff flow across any access/roadway. • Reduce the accumulated runoff volume and velocity. • Choose the interception direction. • Install 30^{o} angled water bar across the road (runoff control). • Convey runoff to sediment trapping control.	

	
CUT-OFF DRAIN ACTS AS RUNOFF DIVERTER **Practice Application:** A cut-off drain can be used to intercept fast flowing water on sloping paths without introducing a wide open gap, like a cross drain or a raised step, like a water bar, in the path surface. Most cut-off drains have a u-shaped cross-section and grating over the top. **Planning Considerations:** i. The grating provides a continuous surface across the drain, and should be strong enough to withstand the load of any traffic that is expected to use the path.	 

DISCONNECTION DRAINAGE:

Incomplete RSD on Construction Access Road due to no budget allocation

Application of rock liner

19-5-2014

15-6-2014

19-5-2014

Highway Drainage Crossing without any control

Culvert crossing constructed

Construct Water bar combined with culvert crossing

PRESERVE AND STABILIZE DRAINAGE WAYS.
Control storm water flows onto, through, and from the site in stable drainage structures.

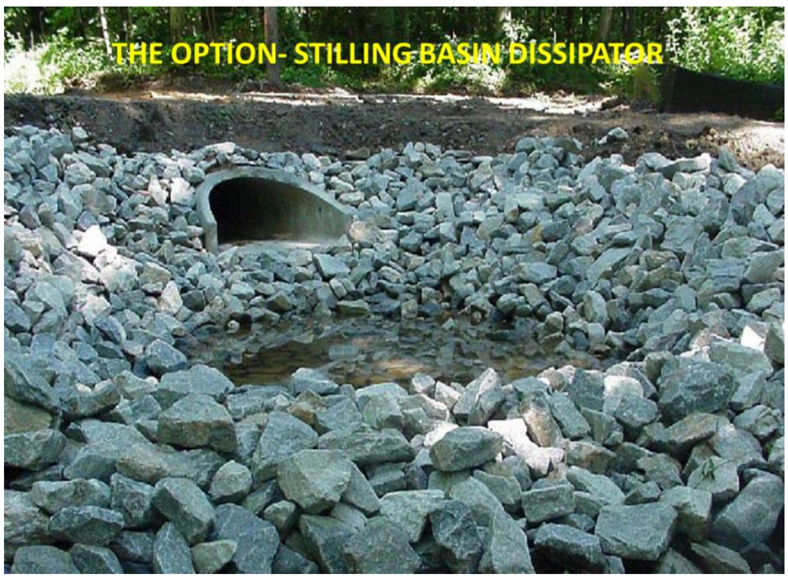
RUN-ON
Channel side-slope shall be protected and construct Dissipater as required

STABILIZE THE WATERWAY

NEED OUTLET PROTECTION

EROSIVE FLOW

The contractor has to attend for remediation work periodically at this location



PROTECTED TEMPORARY STREAM CROSSING CHANNEL
(Culvert discharge)

DEFINITION

A temporary stream crossing is a structure placed across a waterway, which allows vehicles to cross the waterway during construction without entering the water, eliminating erosion and downstream sedimentation caused by the vehicles.

PURPOSE

- To provide safe, environmentally sound access across a waterway for construction equipment.
- To prevent construction equipment from damaging the waterway, blocking fish migration, and tracking sediment and other pollutants into the waterway.

APPLICATION

Where heavy construction must be moved from one side of a stream channel to the other and equipment and construction vehicles will cross the stream repeatedly during construction.

OUTLET PROTECTION


Outlet Protection: DISSIPATER
- Improper installation
17/07/2012


Just need to provide dissipater
26/06/2014 11:26


8.7.2014

No inlet / outlet protection

ESTABLISH DITCHLINE (DIVERSION CHANNEL) WHENEVER APPLICABLE

Earth Bank-Pipe Slope Drain-Protected Ditchline

If plan well this median would serve as ditch line for runoff control in earlier stage

EXAMPLE OF ESTABLISHMENT OF ROAD DITCH OR DITCH CHANNEL

Practice Application:

Combination of ditch and berm installed perpendicular or skew to road or trail center line to facilitate drainage of surface water; sometimes non driveable and used to close a road. These treatments are designed to provide drainage relief for road sections or water in the inside ditch to the downhill side of roads especially when the existing culvert is expected to be overwhelmed. Rolling dips are easily constructed with road grader or dozer. Rolling dips or water bars need to be deep enough to contain the expected flow and location carefully assessed to prevent damages to other portions of the road. Water bars can be made out of rocks or logs. Armouring of fill slope at the outlet is often needed to prevent gullying.

Planning Considerations:

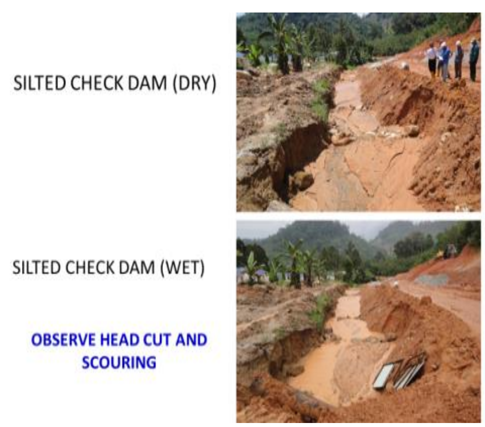
i. The slope of water bar is important for slowing and diverting water from road.

ii. Fewer slopes can cause the water bar to fill up with sediment and fail. More slopes can cause the water bar itself to erode and add to sediment problems.

Establish road ditch / channel for runoff conveyances

Unprotected Channel

Install Check Dam



Silted Check Dam

INSTRUCT TO RE-PROTECT THE CHANNEL STABILIZATION MAT (EC) & CHECK DAM (RC)	
ARRANGEMENT OF CHECK DAM Observe clean water behind check dam	  

RIPRAP (RC) OR LINED SECTION	
CULVERT OUTLET PROTECTION (RC/SC)	
STABILIZATION MAT (EC) & CHECK DAM (RC) AND PARTLY SERVE SEDIMENT TRAPPING TOWARDS THE END OF CHANNEL	
COVERED EARTH BANK / DIKE (RC)	

RIPRAP & OUTLET PROTECTION (RC)

DEFINITION

Riprap is a layer of large stones laid onto slopes and channel beds.

PURPOSE

To protect soil from erosion in areas of concentrated runoff.

APPLICATION

Use riprap to stabilize cut-and-fill slopes with 1:2 slope; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and streambanks and grades.

THE OVERALL PROFILE





CONSTRUCT SURFACE WATER CONTROLS (INTERCEPTOR DIKES, PIPE SLOPE DRAINS, ETC.) SIMULTANEOUSLY WITH CLEARING AND GRADING FOR PROJECT DEVELOPMENT

- Use flexible pipe slope drain to convey upslope runoff down slope
- Consider to use these pipes (subsurface) for Pipe Slope Drain

- Pipe slope drain

- Runoff control: pipe slope drain

- Runoff control: pipe slope drain with protected outlet

- Rock chute

<table>
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- Cascade drain on a very steep slope (Option other than cascade drain)

- Use of motor grader during road platform formation to establish berm, embankment or earth bank along road alignment immediately as work progress

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EMBANKMENT, EARTH BANK, BERM

- Earth bank and earth drain (nice but preferably concave)

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</table>

- Earth drain, earth bank and vegetated

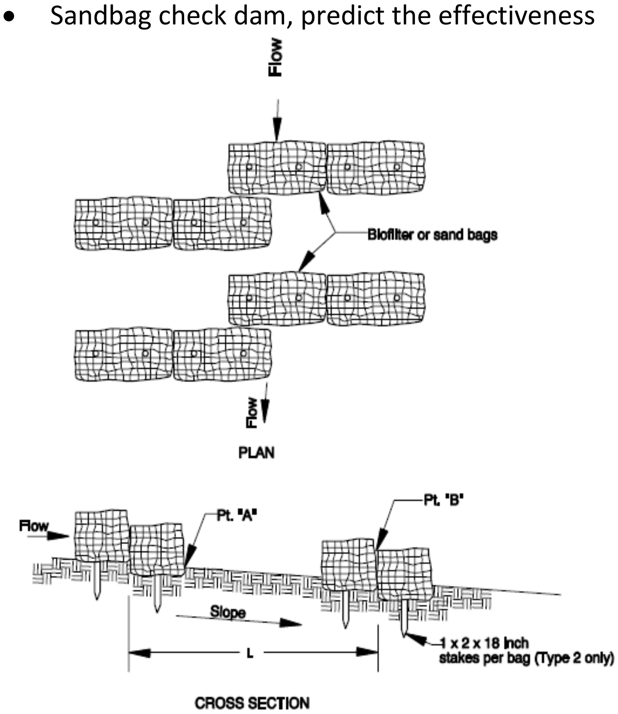
- Earth drain and earth bank diversion with canvas liner conveyance

- Check dam→swale

- Rock liner

- Install interval check dam along all earth drain or diversion channel as well as concrete drainage that partly completed or completed but does not connect directly to main drainage system.

- Sandbag check dam, predict the effectiveness



- Check dam

DEFINITION
A check dam is a small temporary device constructed of rock, sandbags, or fiber rolls, placed across a natural or man-made channel or drainage ditch.

PURPOSE
- To reduce the velocity of concentrated stormwater flows,
- To trap small amounts of sediment generated in the conveyances
- To reduce scour and channel erosion.
- To encourage sediment dropout.

APPLICATION
Any stormwater conveyances having concentrated flow.

CONSTRUCT SEDIMENT PONDS AND TRAPS IN ACCORDANCE WITH STANDARD AND SPECIFICATION

- A properly constructed sediment basin

• Vegetated Slope-SB-Rip Rap Outlet Protection-Berm • Sediment basin with forebay	   

PROTECT STEEP SLOPES

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HYDROMULCH-HYDROSEED

- Bonded fibre matrix

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- Flexterra
  15.7.2009

22.7.2009

- Flexterra
  25.8.2009

5.10.2009

13.3.2012

ROLLED EROSION CONTROL PRODUCTS

DEFINITION

A protective blanket or soil stabilization mat used to assist in establishment of temporary or permanent vegetation on steep slopes, channels, or stream banks.

PURPOSE

To protect soil and hold seed and mulch in place on slopes and in channels so that vegetation can become well established.

APPLICATION

- On steep slopes where erosion hazards are high.
- Where conventional seeding is likely to be too slow in providing adequate protective cover.
- Concentrated flow areas.
- All slopes steeper than 1:2, with a height of three metres or greater, and cuts and fills within stream buffers, should be stabilized with the appropriate erosion control matting or blanket.

NOTES

- Turf reinforcement mats can be used to permanently reinforce grass in drainage ways during high flows. It consists a permanent, non-degradable, three-dimensional plastic structure that is filled with soil prior to planting
- Nets are made of high tensile material woven into an open net which overlays mulch materials.
- Blankets are made of interlocking fibers, typically held together by biodegradable or photodegradable netting (for example, excelsior or straw blankets).

They generally have lower tensile strength than nets, but cover the ground more completely.

PRACTICE APPLICATION:

Rolled erosion control products is design as a erosion control blanket, that act as soil stabilization devices to protect disturbed areas from wind and water erosion. These products made from natural materials such as straw, wood excelsior or coconut husk.

PLANNING CONSIDERATIONS:

Material selected will be dependent upon site conditions i.e size of area to be covered, slope, soil condition.

Soil must be properly prepared (by grading and ensuring the possibility of direct contact between soil and RECP) before RECPs are installed.

Install per manufactures recommended

TURF REINFORCE MAT (TRM)

- Channel and Side Slope Liner

Temporary or permanent diversion channel of any watercourse or off-site run-on water shall be protected either by using rock lined channel bed with protected side slope using Turf Reinforcement Mat (TRM) or plastic sheeting or by installing plastic sheeting canvas along the channel with extend across the side slope in combination with constructed check dams or sump slot checks. This has to be done to minimize erosive forces flow velocity along the channel bed and channel side slope surface to prevent it from eroding.

INSTALLATION OF WATTLE (FIBER ROLL)
ACT AS A SLOPE BREAKER

DEFINITION
A fiber roll consists of straw, flax, coconut husk or other similar materials that are rolled and bound into a tight tubular roll and placed around the worksite perimeter and is referred to as wattles when placed on the face of slopes at regular intervals.

PURPOSE

- To intercept runoff.
- To reduce runoff flow velocity.
- To release the runoff as sheet flow.
- To provide some removal of sediment from the

runoff.

APPLICATION

- May be used along the top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
- Install on disturbed areas that require immediate erosion protection.
- Can be used along the perimeter of a project.
- Unlined ditches as a check dam

Around temporary stockpiles

STABILIZE DRAINAGE WAY OR DIVERSION CHANNEL

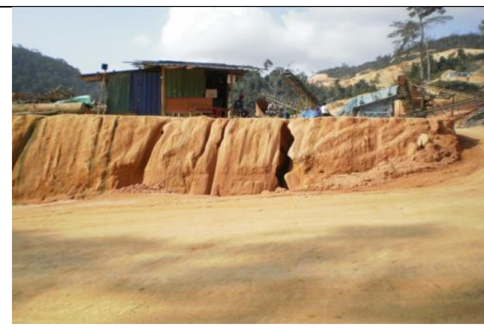
Turf Reinforcement Mat

STABILIZATION MAT (EC) & CHECK DAM (RC)

Protect drainage/stream crossing abutment

ADDRESS THE ISSUE IMMEDIATELY

- Make repair as early as possible areas that develops gully to avoid a more critical situation.



BORROW AREA (OFFSITE/ONSITE)

- Stabilize disturbed areas promptly in a timely manner.
  Protect active disposal or borrow areas and stabilize immediately after unattended for more than 14 days.

• If not attended for more than 14 days, immediately stabilize (19.7.2011)	 
• Logistic issue surface 13.9.2012 22.10.2012	 

5.11.2012	
21.11.2012	
26.11.2012	

STABILIZE DISTURBED AREAS PROMPTLY IN A TIMELY MANNER

- Slope stabilization sequence plot 1 slope 1

Slope Formation:
13.4.2009

Slope Formation
Hydroseeding:
15.4.2009

Slope Formation:
14.4.2009

Slope Formation
Stabilization Mat:
16.4.2009

- Slope stabilization sequence plot 1 slope 2

SLOPE FORMATION:
9.5.2009

SLOPE FORMATION:
9.5.2009

- Slope stabilization sequence plot 1 slope 3

SLOPE FORMATION:
28.4.2009

SLOPE
STABILIZATION:
11.5.2009

COMPACTION:
28.4.2009

GRASS
ESTABLISHMENT:
3.6.2009

- Slope stabilization sequence plot 6

PLOT 6: 13.4.2009

PLOT 6: 14.4.2009

PLOT 6: 14.4.2009

PLOT 6: PERIMETER EARTH (should construct before installations of blanket) DRAIN 14.4.2009

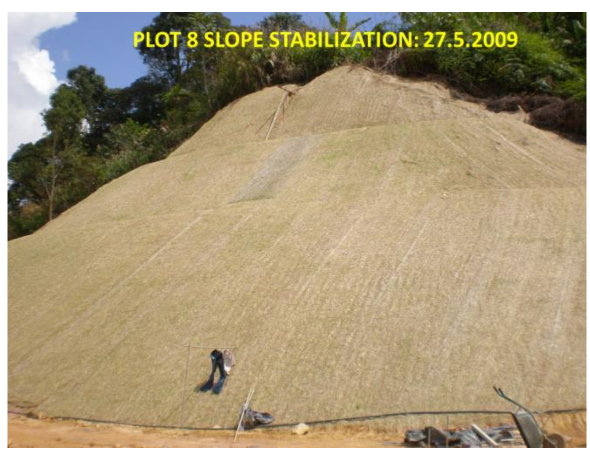
PLOT 6: PERIMETER EARTH DRAIN 16.4.2009

PLOT 6: SLOPE STABILIZATION 30.4.2009

- Slope stabilization sequence plot 8

PLOT 8 SLOPE STABILIZATION: 29.4.2009

PLOT 8 SLOPE STABILIZATION: 2.5.2009



PLOT 8 SLOPE STABILIZATION: 27.5.2009

- Slope stabilization sequence plot 11

PLOT 11 SLOPE STABILIZATION: 13.3.2009

PLOT 11 SLOPE STABILIZATION: 13.5.2009

PLOT 11 SLOPE STABILIZATION: 11.5.2009

PLOT 11 SLOPE STABILIZATION: 14.5.2009

PLOT 11 SLOPE STABILIZATION:26.5.2009

PLOT 11 SLOPE STABILIZATION: 1.6.2009

PROTECT AND STABILIZE DISPOSAL AREA

- Disposal site
- Erosion and sediment control at disposal area (especially offsite) must develop a separate LD-P2M2 Plan.

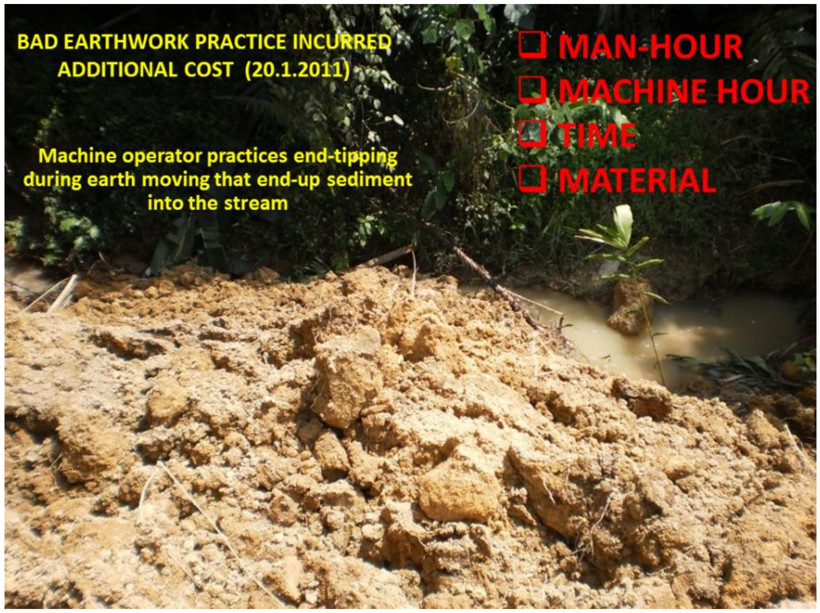
- Unsuitable materials disposal site shall be protected and stabilized

- Disposal of removal materials from sediment basin must be contained or protect from re-transport to waterway/drainage way.

- De-silts material of Sediment Basin was contained to allow decantation.

- Dried soil will be used for mounding

TRAIN MACHINE OPERATORS



Keep on changing plastic sheet for months

17.2.2011

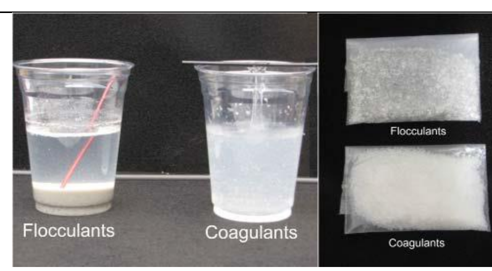
12.4.2011

19.2.2011

26.4.2011

USE ATS FOR SITE SPACE CONSTRAINT OR DIFFICULT AREAS

- Flocculants and Coagulants (Fl-Co) are formulated to assist in the solids/liquid separation of suspended particles in solution (definition)
-
- Active treatment system may be a good choice in treating SS but maybe the last option due to **expensive cost**



THE USE OF ATS (ACTIVE TREATMENT SYSTEM)

CRITERIA TO BE ADDRESSED :

1) Fine clay soil that contain more than 10 % dispersible material
2) LIMITED SPACE CHALLENGES:
    - Sediment ponds has limited capacity
    - Treatment facilities lack space, emergency discharge
3) POLLUTANT CHALLENGES:
    - Suspended Organic solids
    - Suspended solids that stays colloidal for long time
    - fine clays, silts, bentonites w/high ionic charge
4) VOLUME CHALLENGES w/LIMITED TIME
    – High flow volume w/insufficient settling time

- Active Treatment System (ATS) refers to the treatment of runoffs using a mechanical system with the application of coagulants and flocculants to promote the settling of suspended solids out of the aqueous phase.

- Only coagulants and flocculants which have been approved for use by environmental agencies such as USEPA or similar authorities are allowed to be used

• ATS de-silting lake	   

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<tr><td>APPLICATION OF FLOC LOG</td><td>
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ESTABLISH PERFORMANCE EVALUATION MONITORING

Slope ID: 1

17-8-06

6-11-06

Slope ID: 2

17-8-06

6-11-06

Slope ID: 3

17-8-06

6-11-06

Slope ID: 4

23-3-08

3-7-08

Slope ID: 5

8-4-08

3-7-08

Slope ID: 6

4-4-08

3-7-08

Slope ID: 7

7-1-09 | 30-4-09

Slope ID: 9

20-12-2005 | 14-8-2006

INSPECT CONTROL MEASURES.

- Conduct inspections on regular schedule and during severe weather
- Inspect evidence of concentrated flow
- Regular inspection must be conducted. Addressing issues early will avoid the worst case to advance.
- Delaying corrective action for a single problem will end-up into more problems and making more difficult to handle where chain reaction effects will make the situations out of control.
- Evidence of concentrated flow. This highway alignment scheduled to be paved in the next 2 months

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- NEEDS bmps TO CONTROL THE EROSIVE FLOW AND COMBINE WITH DOWNSTREAM MEASURES

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KNOWLEDGE INFORMATION

- The shape of the channel indicates the type of material being eroded:
- V-shaped channel=Sand
- ⊔ -shaped channel=Clay
- U-shaped channel=Silt

- Evidence of sediment entering the waterway

- Recreation area located about 1 km downstream of this river!

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INSPECT CRITICAL AREAS

- Not a rainy day, everything seems in order
- Conduct inspection during raining time whenever accessible.
- Locate the source of the muddy runoff
- Issues upslope should be addressed accordingly
- Earth drain,
- Earth Bank with opening at this lowest point,
- Rocks with mix aggregates at discharge point for

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filtering, • Temporary sump combined with pipe slope drain as conveyance structure, • Rock chute • Existing vegetation or/and provide Silt trap down slope maybe preferred BMPs depending on the site condition at below area	   

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PROVIDE GENERAL CONSTRUCTION CONTROLS

Street cleaning
Water browser
Secondary container and seeded slope
Secondary container and oil interceptor
Skid tank: Wrong location and no secondary containment
Prefabricated Skid Tank
Scheduled waste storage
Sanitation
Concrete Washout

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APPENDIX G

DATA FOR SAMPLE LD-P2M2 DOCUMENT

PART 1

DESIGN CONSIDERATION

1. DESIGN CONSIDERATION

- The submission is prepared in accordance with the "Urban Storm Water Management Manual for Malaysia (Manual Saliran Mesra Alam Malaysia Edition II) published by Jabatan Pengairan dan Saliran, 2012.
- From the summary of lab test result (refer SI report) which shows that more than 67 % of the soil condition at Kenyir Hotel Project site is larger

Table 12.16: Sediment Basin Types and Design Considerations

Category	Soil Description	Hydrological Soil Group	Basin Type	Design Considerations
I	Coarse-grained sand, sandy loam: less than 33% <0.02 mm	A	Dry	Settling velocity, sediment storage
II	Fine-grained loam, clay: more than 33% < 0.02 mm	B	Wet	Storm impoundment, sediment storage
III	Dispersible fine-grained clays: more than 10% of dispersible material	C, D	Wet	Storm impoundment, sediment storage, assisted flocculation

than 0.02mm. Therefore, referring to MSMAM 2 guidelines Table 12.16 (as attached), Dry Basin shall be used.

Category	Soil Description	Soil Group	Basin Type	Design Considerations
I	Coarse-grained sand, sandy loam: less than 33% <0.02mm	A	Dry	Settling velocity, Sediment storage

- The water will be discharge to the proposed temporary earth drain and flow to the sediment basin before discharge the lake reduce level is 139.0m.
- From the results of calculations shown that three number of sediment basin at main area and dumping ground are required, and the size of basin as per below:

Table 1.2 : Sediment Basin size at main area

Type	Size for Top Basin	Size of Base Basin
Sediment Basin 1	33m x 16m x 2m	26.9m x 9.4m
Sediment Basin 2	33m x 16m x 2m	26.9m x 9.4m
Sediment Basin 3	20m x 8.5m x 2.4m	12.5m x 1m

Table 1.3 : Sediment Basin size at Dumping Ground Area

Type	Size for Top Basin	Size of Base Basin
Sediment Basin 4	38m x 16m x 2m	31.5 m x 9.52 m
Sediment Basin 5	28m x 14m x 2.4m	21.6m x 7.6m
Sediment Basin 6	28m x 14m x 2.4m	21.6m x 7.6m

- For the erosion and sedimentation protection, silt fence, earth dam and double layer of silt curtain are provided as shown at layout plan of earthworks at next page.

2. ESTIMATION OF POTENTIAL SOIL EROSION

The main purpose of the soil equation is to predict soil loss from the soil erosion process and to provide a guide in conservation planning. The equation enables the planner to predict the average rate of soil of the various alternatives combinations of landscape management and conservation practices on any particular area.

By using the system develop by Drainage and Irrigation of Malaysia, the Universal Soil Loss Equation (USLE) for estimating the average annual soil loss is

$$\boxed{A = R.K.LS.C.P}$$

(Equation Urban Stromwater Management Manual for Malaysia 2 (12.1) Page 12-5)

Where ;

A = the soil loss (metric ton/ha/yr)

R = the rainfall erositivity

K = the soil erodibility factor

LS = the slope-length X slope-steepness

C = the soil cover management factor

P = the soil conservation practice factor

Table 1.4 show the soil erosion classification and **Table 1.5** shows estimation of soil loss during existing condition at the project site. The value of existing soil loss of the project site is 56.11 ton/ha/yr. While the total sediment yield generated during existing condition at the project site is estimated about 1.847 mt/event. The calculation is attached in **Calculation of Sediment Yield and Soil Loss.**

Table 1.4 Soil Erosion Classification

Soil Loss (Ton/ha/year)	Remark
<10	Low
10 - 50	Moderate
50 - 100	Moderate High
100 - 150	High
>150	Very High

Source: Erosion Risk Map (Peninsular Malaysia) – Department of Agriculture

Table 1.5: The Soil Loss during Existing Condition

PARAMETER	PROJECT SITE
R	19500.0
K	0.0583
LS	1.6464
C	0.0300
P	1.0000
A (ton/ha/yr)	**56.11**

Source: Consultant's Estimation

Table 1.6 Soil Erosion Risk During Construction Phase (Worst Case Scenario)

PARAMETER	Erosion Amount
R	19500.0
K	0.0583
LS	0.240
C	1.0000
P	1.0000
A (ton/ha/yr)	**273.05**

Source: Consultant's Estimation

The estimated soil loss for the worst condition is shown in **Table 1.6**. The cleared site will generate up to 273.05 metric tons/ha/yr of sediments especially during the wet season. Nonetheless the amount of erosion can be reduced with a good conservation practices. **Table 1.7** shows the estimated amount of soil loss if good soil conservation measures are put in place.

Table 1.7 Soil Erosion Risk (with Conservation Practices)

PARAMETER	Erosion Amount
R	19500.0
K	0.0583
LS	0.2400
C	0.2000
P	0.5000
A (ton/ha/yr)	**27.30**

Source: Consultant's Estimation

Table 1.8: Soil Erosion Risk during Operations Phase

PARAMETER	Erosion Amount
R	19500.0
K	0.0583
LS	0.2400
C	0.0500
P	1.0000
A (ton/ha/yr)	**13.65**

Source: Consultant's Estimation

Based on the data above, it shows worst case scenario is during land clearing and earthwork activities. To reduce the potential of erosion and sediment, proper mitigation measure should be planned during planning stage and may be require to implemented and put in place before land clearing and earthwork activities. The Erosion Risk for this project is 27.30 (with conservation practices) .Classifies as ***moderate*** categories.

PART 2

CALCULATION SOIL LOSS

CALCULATION SHEET	Sheet: 1
Title : CALCULATION POTENTIAL OF SOIL LOSS	

Calculation of K- Value based on the USLE

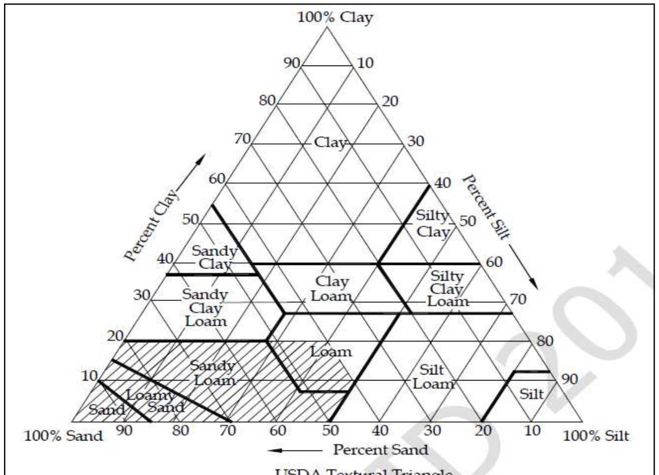
K- Value Formula = **[1.0 x M^1.14 x 10^-4 x (12 - % organic matter) + 4.5 (soil structures class - 3) + 8 (permeability - 2)]*** ***Equation 12-3 , Page 12-8 (MASMA 2)***
note need to be devided with 7.59 to convert to SI unit
M = [(% silt + % fine sand) x (100 - % clay)]

LS = (0.065 + 0.045S + 0.0065S^2) x ((λ/22.13)^m)

Component	ZONE 1
% Silt	23.56
% fine Sand	53.03
% clay	23.41
M	5866.0281
% Organic Matter	0
Soil Structure	4
Permeability	4
K- Value	0.0583
LS	1.646

Appendix 3: Nomograph for determining the topograhic factor, LS (Warrington et al. (1980))
Based on MSLE :

ZONE 1	λ= Length of Slc	105	m
	S= Slope in %	1.9	
	Exponent m	0.3	



USDA Textural Triangle
Shaded area is applicable for design of infiltration BMPs

Soil Structure Code and Permeability Class for Various Soil Textures

Soil Texture	Permeability Code	Soil Structure Code
Heavy Clay	6	4
Clay	6	4
Silty Clay Loam	5	4
Sandy Clay	5	4
Sandy Clay Loam	4	4
Clay Loam	4	4
Loam	3	2
Silty Loam	3	3
Loamy Sand	2	1
Sandy Loam	2	2
Sand	1	1

Reference: MASMA 2nd Edition, Table 12.2, page 12-8 and USDA Textural Triangle (Figure 8.4, page 8-4)

Exponent m
(MASMA pg 15-8 (equation 15-13))

0.2	for S < 1
0.3	for 1 < S < 3
0.4	for 3 < S < 5
0.5	for 5 < S < 12
0.6	for S >12%

CALCULATION SHEET	Sheet : 2
Title : CALCULATION POTENTIAL OF SOIL LOSS EXISTING CONDITION	

Calculation of Soil Erosion during Operation

A = R.K.L.S.C.P *Equation MASMA 2(12.1) Page 12-5*

PARAMETER	ZONE 1
R	19500.0
K	0.0583
LS	1.646
C	0.030
P	1.0000
A (ton/ha/yr)	**56.10**

Where:

R Rainfall erosivity factor
K Soil erodibility factor
LS Combined slope factor
P Conservation Factor
C Cover Management Factor
A The soil loss

Cover Management Factor, C during operation
Erosion Control Treatment and its C Factor
Commercial area with 5% green (0.05),

therefore C = 0.05

Consevation Factor, P during operation
Support/Sediment Control Practice and its P Factor
No management practice, P=1.0

CALCULATION SHEET	Sheet : 3
Title : CALCULATION POTENTIAL OF SOIL LOSS WITH CONSERVATION MEASURES	

Calculation of Soil Erosion with Conservation

A = R.K.L.S.C.P **Equation MASMA 2(12.1) Page 12-5**

PARAMETER	DUMPING GROUND
R	19500.0
K	0.0583
LS	0.240
C	0.2000
P	0.5000
A (ton/ha/yr)	**27.27**

Where:

R	Rainfall erosivity factor
K	Soil erodibility factor
LS	Combined slope factor
P	Conservation Factor
C	Cover Management Factor
A	The soil loss

Cover Management Factor, C during construction with conservation
Erosion Control Treatment and its C Factor
Cut (0.8), and Mulching 50% (0.25) therefore C=0.2

Consevation Factor, P during construction with conservation
Support/Sediment Control Practice and its P Factor

Sediment Trap (0.5)
therefore P = 0.5

CALCULATION SHEET	Sheet : 4
Title : CALCULATION POTENTIAL OF SOIL LOSS DURING OPERATION	

Calculation of Soil Erosion during Operation

A = R.K.L.S.C.P *Equation MASMA 2(12.1) Page 12-5*

PARAMETER	ZONE 1
R	19500.0
K	0.0583
LS	0.240
C	0.050
P	1.0000
A (ton/ha/yr)	**13.63**

Where:

R	Rainfall erosivity factor
K	Soil erodibility factor
LS	Combined slope factor
P	Conservation Factor
C	Cover Management Factor
A	The soil loss

Cover Management Factor, C during operation
Erosion Control Treatment and its C Factor
Commercial area with 5% green (0.05),

therefore C = 0.05

Consevation Factor, P during operation
Support/Sediment Control Practice and its P Factor
No management practice, P=1.0

CALCULATION SHEET	Sheet : 2	
Title : CALCULATION POTENTIAL OF SOIL LOSS DURING WORST CASE CONDITION		

Calculation of Soil erosion for worst Scenario

A = R.K.L.S.C.P ***Equation MASMA 2(12.1) Page 12-5***

PARAMETER	ZONE 1
R	19500.0
K	0.0583
LS	0.240
C	1.000
P	1.0000
A (ton/ha/yr)	**273.05**

Where:

R	Rainfall erosivity factor
K	Soil erodibility factor
LS	Combined slope factor
P	Conservation Factor
C	Cover Management Factor
A	The soil loss

Cover Management Factor, C for wosrst case condition is 1.00 (bare land)

Consevation Factor, P for wosrst case condition is 1.00 (bare land)

PART 3

CALCULATION SEDIMENT YIELD

	Calculation Sheet **-SEDIMENT YIELD ESTIMATION** **- Existing Condition**	**Job No. 1**	**Sheet No.** 1 **Rev.**
		Member/Location :	
		Drg. Ref. :	
Job Title	**SEDIMENT YIELD**	**Made by** wmr	**Date** **Remark**

SEDIMENT YIELD ESTIMATION

The Modified Universal Soil Loss Equation (MUSLE) is used to determine the sediment yield for C1

The design of all sediment control BMP's required the quantity of the sediment to be trapped.

The design rainfall as per requirement of MASMA is set to be 50 mm to the catchment under consideration — Table 1.3, CH 1

1) Determination of Runoff Parameters

a) Design Storm

	Design Storm	=	50	mm
	Catchment Area, A	=	864.00	ha
Table 2.1	Time of Concentration,tc	=	26	minutes

$t_c = \dfrac{107\, n\, L^{0.333}}{S^{0.2}}$ L = 200 m; S = 10

n = 0.06 (From Table 2.2 MSMA 2 for Existing (Forest Cover)

t_o = 23.6 minutes Adopt tc = 26 minutes

Duration of storm,D	=	60	minutes (Assume 1 hrs)
Intensity of design storm, I	=	50	mm/h

Eqn. 2.3 b) Calculate Peak Discharge, Qp using Rational Method 10

Table 2.5 Run Off Coefficient, C = 0.3 (Forest Cover)

$Q_p = \dfrac{C.\ I.\ A}{360} = 36.00\ m^3/s$

Sec 2.3.2 c) Calculate Runoff Volume, V using Rational Method Hydrograph Method (Type 1)

D>tc : Type 1

V= 0.5 x (2 x D) x (Qp)   V = 0.5 x (2 xD) x (Qp) = 129600 m^3

D<tc : Type 2   Where, tc is in seconds

V= 0.5 x (2 x tc) x (Qp)

	Calculation Sheet **-SEDIMENT YIELD ESTIMATION**	**Job No. 1** 0	**Sheet No.** 2 **Rev.**
		Member/Location :	
		Drg. Ref. :	
Job Title		**Made by** wmr	**Date** 01/00/00 **Remark**

2) Calculation of Sediment Yield

Eqn. 12.4 $Y = 89.6(VQ_p)^{0.56}$ (K.LS.C.P)

where,

Y	=	Sediment yield per storm event (tonnes)
V	=	Runofff Volume in m^3
Q_p	=	Peak Discharge in m^3/s
K	=	Soil erodibility factor
LS	=	Slope Length and Slope Steepness Factor — USLE Factor
C	=	Cover Management Factor
P	=	Support Practice Factor

Soil Erodibility Factor

Eqn. 12.3   K = [10^-4 x (12 - % OM)*M^1.14 + 4.5 (S - 3) + 8(P - 2)]/100,

where,

M	=	[(% silt + % fine sand) x (100 - % clay)]	=	NIL
% Silt			=	NIL
% Sand			=	NIL
% Clay			=	NIL
OM	=	% of organic matter;	=	NIL
S	=	Soil structure code	=	NIL
P	=	permeability class	=	NIL

NOTE   However, since no soil test was carried out, value of K is refer to the soil series as describe in the EIA report

Soil Series = Kuala Brang Series; k value as per Table 3.4 Guidelines for Erosion And Sediment Control, DID

K = 0.035

Slope Length and Sloipe Steepness Factor, LS

λ	=	200	m	, Horizontal Slope Length
s	=	10.0	%	, Slope Steepness
LS	=	3.535		

Cover management and Support Practice

C	=	0.1260
P	=	1.00

As Such, Total Sediment Yield to Load the Sediment Basin per Storm Event

Y = 7581.0 Tonnes

	Calculation Sheet -SEDIMENT YIELD ESTIMATION - With Conservation Practie	Job No. 1	Sheet No. 3	Rev.
		Member/Location :		
		Drg. Ref. :		
Job Title :	SEDIMENT YIELD	Made by wmr	Date	Remark

SEDIMENT YIELD ESTIMATION

The Modified Universal Soil Loss Equation (MUSLE) is used to determine the sediment yield for C1

The design of all sediment control BMP's required the quantity of the sediment to be trapped.

The design rainfall as per requirement of MASMA is set to be 50 mm to the catchment under consideration — Table 1.3, CH 1

1) Determination of Runoff Parameters

a) Design Storm

	Design Storm	=	50	mm		
	Catchment Area, A	=	864.00	ha		
Table 2.1	Time of Concentration,tc	=	16	minutes		

$$t_c = \frac{107\ n\ L^{0.333}}{S^{0.2}}$$

L = 200 m

S = 10.0

n = 0.035 (From Table 2.2 MSMA 2 for Construction (Poorly Grass)

t_o = 13.8 minutes Adopt tc = 16 minutes

Duration of storm,D	=	60	minutes	(Assume 1 hrs)
Intensity of design storm, I	=	50	mm/h	

Eqn. 2.3 b) Calculate Peak Discharge, Qp using Rational Method

Table 2.5 Run Off Coefficient, C = 0.35 (Bushes Cover)

$$Q_p = \frac{C.\ I.\ A}{360} = 42.00\ m^3/s$$

Sec 2.3.2 c) Calculate Runoff Volume, V using Rational Method Hydrograph Method (Type 1)

D>tc : Type 1

V= 0.5 x (2 x D) x (Qp) V = 0.5 x (2 x D) x (Qp) = 151200 m^3

D<tc : Type 2 Where, D is in seconds

V= 0.5 x (2 x tc) x (Qp)

	Calculation Sheet -SEDIMENT YIELD ESTIMATION	Job No. 1	Sheet No. 4	Rev.
		0		
		Member/Location :		
		Drg. Ref. :		
Job Title :		Made by wmr	Date 01/00/00	Remark

2) Calculation of Sediment Yield

Eqn. 12.4 $Y = 89.6(VQ_p)^{0.56}$ (K.LS.C.P)

where,

Y	=	Sediment yield per storm event (tonnes)
V	=	Runofff Volume in m^3
Q_p	=	Peak Discharge in m^3/s
K	=	Soil erodibility factor
LS	=	Slope Length and Slope Steepness Factor — USLE Factor
C	=	Cover Management Factor
P	=	Support Practice Factor

Soil Erodibility Factor

Eqn. 12.3 K = [10^-4 x (12 - % OM)*M^1.14 + 4.5 (S - 3) + 8(P - 2)]/100,

where,

M	=	[(% silt + % fine sand) x (100 - % clay)]	=	NIL
% Silt			=	NIL
% Sand			=	NIL
% Clay			=	NIL
OM	=	% of organic matter;	=	NIL
S	=	Soil structure code	=	NIL
P	=	permeability class	=	NIL

NOTE However, since no soil test was carried out, value of K is refer to the soil series as describe in the EIA report

Soil Series = Kuala Brang Series; k value as per Table 3.4 Guidelines for Erosion And Sediment Control, DID

K = 0.035000

Slope Length and Sloipe Steepness Factor, LS

λ	=	200	m	, Horizontal Slope Length
s	=	10.0	%	, Slope Steepness
LS	=	3.535		

Cover management and Support Practice

C	=	0.02
P	=	0.400

As Such, Total Sediment Yield to Load the Sediment Basin per Storm Event

Y = 572.037 Tonnes

	Calculation Sheet -SEDIMENT YIELD ESTIMATION - Operation Phase	Job No. 1	Sheet No. 5	Rev.
		Member/Location :		
		Drg. Ref. :		
Job Title :	SEDIMENT YIELD	Made by wmr	Date	Remark

SEDIMENT YIELD ESTIMATION

The Modified Universal Soil Loss Equation (MUSLE) is used to determine the sediment yield for C1

The design of all sediment control BMP's required the quantity of the sediment to be trapped.

The design rainfall as per requirement of MASMA is set to be 50 mm to the catchment under consideration — Table 1.3, CH 1

1) Determination of Runoff Parameters

a) Design Storm

Reference	Parameter		Value	Unit
	Design Storm	=	50	mm
	Catchment Area, A	=	864.00	ha
Table 2.1	Time of Concentration,tc	=	20	minutes

$$t_c = \frac{107\ n\ L^{0.333}}{S^{0.2}}$$

L = 200 m

S = 10.0

n = 0.045 (From Table 2.2 MSMA 2 for Op (Average Grass)

t_o = 17.7 minutes Adopt tc = 20 minutes

Duration of storm,D = 60 minutes (Assume 1 hrs)

Intensity of design storm, I = 50 mm/h

Eqn. 2.3 — b) Calculate Peak Discharge, Qp using Rational Method

Table 2.5 — Run Off Coefficient, C = 0.3 (Argiculture)

$$Q_p = \frac{C.\ I.\ A}{360} = 36.00\ m^3/s$$

Sec 2.3.2 — c) Calculate Runoff Volume, V using Rational Method Hydrograph Method (Type 1)

D>tc : Type 1

V= 0.5 x (2 x D) x (Qp) V = 0.5 x (2 x D) x (Qp) = 129600 m^3

D<tc : Type 2 Where, D is in seconds

V= 0.5 x (2 x tc) x (Qp)

	Calculation Sheet -SEDIMENT YIELD ESTIMATION	Job No. 1	Sheet No. 6	Rev.
		0		
		Member/Location :		
		Drg. Ref. :		
Job Title :		Made by wmr	Date 01/00/00	Remark

2) Calculation of Sediment Yield

Eqn. 12.4 — $Y = 89.6(VQ_p)^{0.56}$ (K.LS.C.P)

where,

Y	=	Sediment yield per storm event (tonnes)
V	=	Runofff Volume in m^3
Q_p	=	Peak Discharge in m^3/s
K	=	Soil erodibility factor
LS	=	Slope Length and Slope Steepness Factor — USLE Factor
C	=	Cover Management Factor
P	=	Support Practice Factor

Soil Erodibility Factor

Eqn. 12.3 — K = [10^-4 x (12 - % OM)*M^1.14 + 4.5 (S - 3) + 8(P - 2)]/100,

where,

M	=	[(% silt + % fine sand) x (100 - % clay)]	=	NIL
% Silt			=	NIL
% Sand			=	NIL
% Clay			=	NIL
OM	=	% of organic matter;	=	NIL
S	=	Soil structure code	=	NIL
P	=	permeability class	=	NIL

NOTE — However, since no soil test was carried out, value of K is refer to the soil series as describe in the EIA report

Soil Series = Kuala Brang Series; k value as per Table 3.4 Guidelines for Erosion And Sediment Control, DID

K = 0.0350

Slope Length and Sloipe Steepness Factor, LS

λ	=	200	m	, Horizontal Slope Length
s	=	10.0	%	, Slope Steepness
LS	=	3.535		

Cover management and Support Practice

C = 0.01000

P = 0.060

As Such, Total Sediment Yield to Load the Sediment Basin per Storm Event

Y = 36.100 Tonnes

	Calculation Sheet **-SEDIMENT YIELD ESTIMATION** **- Worst Case Scenario**	**Job No.** 1 **Sheet No.** 7 **Rev.** **Member/Location :** **Drg. Ref. :**
Job Title :	**SEDIMENT YIELD**	**Made by** wmr **Date** **Remark**

SEDIMENT YIELD ESTIMATION

The Modified Universal Soil Loss Equation (MUSLE) is used to determine the sediment yield for C1

The design of all sediment control BMP's required the quantity of the sediment to be trapped.

The design rainfall as per requirement of MASMA is set to be 50 mm to the catchment under consideration — Table 1.3, CH 1

1) Determination of Runoff Parameters

a) Design Storm

Reference	Parameter		Value	Unit	
	Design Storm	=	50	mm	
	Catchment Area, A	=	864.00	ha	
Table 2.1	Time of Concentration,tc	=	13	minutes	

$$t_c = \frac{107\, n\, L^{0.333}}{S^{0.2}}$$

L = 200 m

S = 10.0

n = 0.0275 (From Table 2.2 for Worst (Bare Soil)

t_o = 10.8 minutes Adopt tc = 13 minutes

Duration of storm,D = 60 minutes (Assume 1 hrs)

Intensity of design storm, I = 50 mm/h

Eqn. 2.3 — b) Calculate Peak Discharge, Qp using Rational Method

Table 2.5 — Run Off Coefficient, C = 0.5 (Bare soil (No Cover))

$$Q_p = \frac{C.\ I\ .\ A}{360} = 60.00\ m^3/s$$

Sec 2.3.2 — c) Calculate Runoff Volume, V using Rational Method Hydrograph Method (Type 1)

D>tc : Type 1

V= 0.5 x (2 x D) x (Qp) V = 0.5 x (2 xD) x (Qp) = 216000 m^3

D<tc : Type 2 Where, tc is in seconds

V= 0.5 x (2 x tc) x (Qp)

	Calculation Sheet **-SEDIMENT YIELD ESTIMATION**	**Job No.** 1 **Sheet No.** 8 **Rev.** 0 **Member/Location :** **Drg. Ref. :**
Job Title :		**Made by** wmr **Date** 01/00/00 **Remark**

2) Calculation of Sediment Yield

Eqn. 12.4 — $Y = 89.6(VQ_p)^{0.56}$ (K.LS.C.P)

where,

Y	=	Sediment yield per storm event (tonnes)
V	=	Runofff Volume in m^3
Q_p	=	Peak Discharge in m^3/s
K	=	Soil erodibility factor
LS	=	Slope Length and Slope Steepness Factor — USLE Factor
C	=	Cover Management Factor
P	=	Support Practice Factor

Soil Erodibility Factor

Eqn. 12.3 — K = [10^-4 x (12 - % OM)*M^1.14 + 4.5 (S - 3) + 8(P - 2)]/100,

where,

M	=	[(% silt + % fine sand) x (100 - % clay)]	=	NIL
% Silt			=	NIL
% Sand			=	NIL
% Clay			=	NIL
OM	=	% of organic matter;	=	NIL
S	=	Soil structure code	=	NIL
P	=	permeability class	=	NIL

NOTE — However, since no soil test was carried out, value of K is refer to the soil series as describe in the EIA report

Soil Series = Kuala Brang Series; k value as per Table 3.4 Guidelines for Erosion And Sediment Control, DID

K = 0.0350

Slope Length and Sloipe Steepness Factor, LS

λ	=	200	m	, Horizontal Slope Length
s	=	10.0	%	, Slope Steepness
LS	=	3.535		

Cover management and Support Practice

C = 1

P = 1

As Such, Total Sediment Yield to Load the Sediment Basin per Storm Event

Y = 106616.5 Tonnes

APPENDIX H

INSPECTION CHECKLISTS

Note:

Specifically, 3 inspection checklist shall be made referenced to:-

i. Project Specification Checklist
ii. BMPs Inspection Form
iii. Minimum Standard Requirements of Pollution- refer to **Appendix B**

PROJECT SPECIFICATION CHECKLIST

SAMPLE CONSTRUCTION SITE INSPECTION CHECKLIST

INSPECTION TYPE:

☐ Initial Inspection ☐ Re-Inspection ☐ Final ☐ Special ____________________

(Note type of special inspection – e.g., complaint response, corrective action, etc.):

PROJECT NAME: ____

LOCATION: ____

WEATHER: _____________________________________ DATE: ___________________________

RAINFALL IN LAST 24 HOURS: ____________________

RECEIVING WATER /DISCHARGE LOCATION:

____

INSPECTED BY: _____________________________ _____________________________________

(print name) *(title)*

____

(signature)

Check "Yes," "No" or "N/A" if not applicable. If any answer is "no," describe needed correction(s) in the space provided below each question or on an attached sheet. For self-inspections, the Contractor should indicate the location of needed correction(s), along with the date corrections are made, on the working Site Map, posted on-site.

NO	INSPECTION ELEMENT	DESCRIPTION	YES	NO	N/A	COMMENT
PRE-INSPECTION						
1.	Site management	Approved documents (EIA, COA, LD-P2M2 Document, ESCP, etc.) available on site?				
		Any revision or update of the approved documents (EIA, COA, LD-P2M2 Document, ESCP, etc)?				
		Contractor's Project Management Plan or Environmental Management Plan based on approved documents (EIA, COA, LD-P2M2 Document, ESCP, etc)?				
		Working drawings up-to-date and adequately depict erosion and sediment control measures to be implemented at the site?				
		Work programme up-to-date?				
		Work programme tally with status of site work?				
		Project construction scheduling for all major land disturbing activities which include:				
		a. work zone(s),				
		b. phasing of construction within the work zone(s),				

		c. staging and sequencing within the phases of construction that coincides with the installation of P2M2s.				
DURING INSPECTION						
1.	Site Ingress/ Engress	Are the wheel wash facility (wash trough) installed correctly?				
		Are the BMP's to minimize vehicle tracking onto road installed correctly?				
		Are construction site entrances and exits properly protected (i.e., using stabilized entrance, tire wash, street sweeping, etc.) to control off-site tracking of sediment and construction related pollutants?				
		Are the following being implemented:				
		a. Graveled, paved, or constructed entrances, exits, and parking areas in-place?				
		b. Unpaved roads on-site are graveled or have other effective measures in-place?				
		c. No dripping from trucks containing saturated soils and/or use of water-tight trucks?				
		d. Controls to prevent discharge of wash water from concrete trucks to surface waters?				
		e. Correct installation and use of all erosion and sediment control measures.				
		f. Procedures in place for prompt maintenance and repair of erosion and sediment control measures?				

2.	Sensitive areas	Width of buffer zones complies with EIA conditions?				
		Soil erosion problem from slope have been managed properly such as:				
		a. Provide Tiered terrace/ bench.				
		b. Stabilization for surfaces exposed for more than 14 days after completion of formation level.				
		c. Stabilization / temporary closure for slope cutting works which have not achieved its formation level and which have been suspended / abandoned for more than 21 days.				
		d. Slope compacted.				
		e. Slope fully or properly covered.				
		f. Surface roughening provided to cut slope.				
		g. Berm drains provided at foot				
		h. Upslope drain provided.				
		i. Set-back area adjacent to slope side.				
		Are the natural areas preserved?				
3.	Surface runoff drainage way	Has drainage system been installed and managed properly such as:				
		a. Drainage system connected properly.				
		b. Drainage system connected properly to sediment trap / sediment pond.				
		c. Control outside surface runoff from entering into project site.				
		d. Evidence of runoff discharging from site passing through sediment pond.				

		Are all storm drain inlets properly protected and well maintained?				
		Does waterway crossing have the appropriate BMP applications?				
4.	Site perimeter	Boundary control such as perimeter drain, drain earth, embankment diversion available on site?				
		Terminal discharge of sediment pond installed properly such as:				
		a. Proper inlet / outlet protection.				
		b. Proper access to sediment pond for sampling and maintenance.				
		c. Discharge via sediment pond outlet.				
		d. Riser / weir function properly.				
		e. Sediment depth markers available.				
		f. Platform for inspection and maintenance are available.				
		g. Desilting maintenance.				
		h. Embankment provided.				
		i. Size, location and number of ponds in accordance with design / plan.				
		j. Excavated sediment stockpiled at proper place.				
		Construction markers such as fences, signs, tapes, flags provided at:				
		a. Land disturbing from any drainage way or waterway or watercourse within project site				
		b. Areas not to be worked or disturbed				
		c. Buffer area or/and existing vegetation meant for temporary or permanent				

		preservation and for protection				
5.	Material storage yard	Are the skid tanks provided with bunds?				
		Are all material handling and storage areas clean and free of spills, leaks, or other deleterious materials?				
		Are all equipment storage and maintenance areas clean and free of spills, leaks, or any other deleterious materials?				
		Are all stockpiles located in designated areas and properly protected (inactive - covered or perimeter controls; active - properly located away from storm drains)?				
		Are construction materials and equipment properly stored in dedicated areas away from storm drain discharge locations with secondary containment where appropriate?				
6.	Phasing of construction schedule	Are BMPs installed as shown on the approved plans?				
		Is the contractor implementing adequate procedures to meet local erosion and sediment and stormwater management requirements?				
		Is the Site Map (including applicable drawing details) up to date and does it adequately depict erosion and sediment control measures being implemented at the site?				
7.	Managing scheduled waste (used	Is the site generally free of litter and debris and do construction wastes appear				

	oil, paint, oil filters)	to be properly managed?				
		Are hazardous materials and wastes properly stored, including being covered and stored within berms to provide secondary containment?				
		Are the chemical hazards such as pesticides, herbicides and scheduled waste kept safely?				
8.	Cement mixing area (concrete mixer / ready mix)	Are the concrete wastes left exposed without containment?				
9.	Site Planning and Management	Is the BMP's maintenance adequate?				
		Are previous noncompliance issues addressed within seven days of their occurrence?				
		Are other potential sources of pollution being controlled?				
		Are the following being implemented as applicable:				
		a. Clean-up of any significant amounts of sediment within 24 hours of leaving the site?				
		b. No intentional washing of sediment into storm sewers or drainage ways?				
		c. Removal of sediment trapped by silt fences when sediment reaches 1/3 of fence height?				
		d. Cleaning of catch basin filters when capacity is reduced by fifty percent?				
		e. Cleaning of sediment basins when capacity is reduced by fifty percent?				
		f. Install erosion and sediment controls before land disturbance except				

		where controls are in the direct path of work?				
		g. Application of fertilizers per manufacturer’s guidelines to minimize nutrients in runoff?				
		h. Site stabilization (vegetation, heavy mulch, temporary seeding or other method that does not required germination) when construction activities cease 30 days or more?				
		i. Proper storage, application, and disposal of toxic or hazardous materials?				
		j. Management of abandoned hazardous wastes, used oils, contaminated soils, etc. discovered during construction?				
10.	Runoff Control	Is runoff control installed properly?				
		a. Earth Bank/ Perimeter Dike				
		b. Diversion				
		c. Lined Waterway (Rock Materials)				
		d. Catch Drain				
		e. Cascading Drain				
		f. Riprap				
		g. Check Dam (CD)				
		h. Temporary Interceptor Dyke				
		i. Swale				
		j. Temporary and Permanent Pipe Slope Drain				
		k. Rock Outlet Protection				
		l. Sand Bag Barrier				
		m. Storm Drain Inlet Protection				
		Is there evidence of unallowable non-storm water discharges at the site?				
11.	Erosion Control	Have all disturbed soil areas not being actively worked				

		been temporarily stabilized to protect against erosion?				
		Are all other erosion prevention measures in-place and functioning in accordance with the LD-P2M2 plan?				
		Is erosion being controlled onsite?				
		Are the following being implemented as required?				
		a. Minimizing areas of exposed soil and scheduling of grading activities to reduce erosion?				
		b. Vegetative control practices (preservation of existing vegetation and vegetative erosion prevention practices)?				
		c. Additional erosion prevention practices (mulching, erosion control blankets, soil tackifiers)?				
		d. Sediment control practices (silt fences, earth dikes, brush barriers, drainage swales, check dams, subsurface drains, pipe slope drains, rock outlet protection, and sediment basins?				
		e. Stockpile protection?				
		f. Non-storm water controls (Spill prevention and response procedures, employee training, proper disposal procedures, maintenance of vehicles and equipment, covered material and waste storage areas)?				
12.	Sediment Control	Are all perimeter sediment controls in-place where required, properly installed and well maintained?				

		Are all sediment traps, barriers, and basins constructed in accordance with the LD-P2M2 plan, well maintained and functioning properly?				
		Is sediment being contained onsite?				
		Off-site sedimentation is being prevented?				
		Are controls implemented for allowable non-storm water discharges to minimize sediment transport?				
13.	General construction control	Is the general construction control provided:				
		a. Construction Fence				
		b. Limits of Construction				
		c. Concrete Washout Area				
		d. Vehicle and Equipment Fueling and maintenance				
		e. Solid Waste Management Area				
		f. Spoil Management Area				
		g. Stabilized Staging Area				
		h. Schedule Waste Management Area				
		i. Material Storage Control and Stockpile Management				
		j. Sanitary Waste Management				
		k. Spill Prevention and Secondary Containment				
		l. Dust Control & Street Cleaning				
		Are dust control measures being appropriately implemented?				
POST INSPECTION						
1.	BMPs maintenance record	Is the site being inspected/ monitored by qualified personnel identified in the LD-P2M2 document and in accordance with the required				

		frequency?				
		Are written site inspection records being kept in accordance with EIA requirements and available on-site?				
		Are the copies of the inspection report sent to all required locations/persons?				
		Is there any verification of corrective action?				
		BMP’s maintenance log book been kept?				
		Maintenance record updated?				
		Internal inspections being recorded and available for review?				
2.	Form * Check whether the form has been sent to DOE prior to site inspection	Is the inspection form submitted to DOE?				
3.	* BMPs *Sample photos, coding, common mistakes and dedicated specification for BMPs	Are the photos, coding, common mistakes and dedicated specification for BMP’s provided?				
SAFETY						
1.		Is the necessary personal protection equipment provided on site?				
2.		Are there enough PPE for inspectors?				
3.		Is the site safe from flash flood/thunderstorm/lightning and landslide?				
4.		Is there any safe place to take cover in site				

		construction when flash flood/ thunderstorm/ lightning and landslide happen?				
5.		Has the proper workshop on safety provided?				
ETHICS						
1.		Is the inspection and documentation comprehensive and precise?				
2.		Is the Contractor showing integrity?				
3.		Is the Contractor being professional and responsible in handling any conflict?				
4.		Are all relevant persons on site informed on site problems?				

BMPs INSPECTION FORM

BMPs INSPECTION FORM

Bil	Inspection Element	Component	Common Potential Non-Compliances	Remarks
1.	Site Ingress / Egress	• Wheel wash facility Plan (wash trough) • Wheel washing facility (Water jet) • Rubble grate / mild steel grating • Crusher run (coarse aggregate) Note: Installation of one or more of the above BMPs is acceptable.	• Wheel wash facility (wash trough) not installed. • No sediment pond. • Wheel wash facility (wash trough) installed on the wrong side of egress. • Installed but not in use. • Facility not maintained (no desilting). • No sediment pond. • Facility not maintained (no desilting) • Materials used not meeting the BMPs specifications. • No ingress/egress stabilization resulting in sediment being discharged outside of site ROW (right of way)	
2.	Sensitive areas Note : 1. With potential for high risk exposure to erosion	• River / watercourse buffer zones	• Width of buffer zone did not comply with EIA conditions. • No clear delineation on site. • Encroachment into buffer zone.	

BMPs INSPECTION FORM

Bil	Inspection Element	Component	Common Potential Non-Compliances	Remarks
	2. Potentially impacted by erosion	• Waterway crossing • Slope	• No appropriate BMP applications for Waterway crossing. • Tiered terrace/bench not provided. • No stabilization for surfaces exposed for more than 14 days after completion of formation level. • No stabilization / temporary closure for slope cutting works which have not achieved its formation level and which have been suspended / abandoned for more than 21 days. • Slope not compacted. • Slope not fully or properly covered. • No surface roughening provided to cut slope or wrong methods were used, e.g., parallel to contour. • No berm drains provided at foot of slopes. • No upslope drain provided. • No set-back area adjacent to slope side.	
	2. Potentially impacted by erosion (cont)	• Hill top • Green areas	• Encroachment into hilltop area. • Direct tipping of overburden over slope edges. • No earth bank / silt fence after upslope drain. • No diversion dike or slope drain pipe at the hill top. • No delineation / demarcation on site. • Not managed in accordance with ESCP. • Encroachment into green areas.	
3.	Surface runoff drainage way	• Concentrated flow in drainage way	• No drainage system. • Drainage system not properly connected. • Drainage system is not connected properly to sediment trap / sediment pond.	

BMPs INSPECTION FORM

Bil	Inspection Element	Component	Common Potential Non-Compliances	Remarks
			• No drainage system to control outside surface runoff from entering into project site. • Evidence of runoff discharging from site without passing through sediment pond.	
4.	Site perimeter	• Site marking • Boundary control • Terminal discharge sediment pond	• No demarcation of site boundary. • No BMP applications as follows: a. Surface runoff controls such as perimeter drain, drain earth, embankment, diversion b. Sediment controls such as silt fence, fiber roll / coir logs, sediment bag. • No or improper Inlet / Outlet Protection. • No proper or unsafe access to sediment pond for sampling and maintenance. • Discharge not via sediment pond outlet. • Riser / weir not functioning. • Sediment depth markers not available.	
		• Terminal discharge sediment pond (cont)	• No platform for inspection and maintenance. • Desilting maintenance not undertaken. • No embankment provided. • Size, location and number of ponds not in accordance with ESC design / plan. • Excavated sediment stockpiled at edge of pond.	
5.	Borrow areas	• Excavation and slope cutting areas	• No surface stabilization. • No runoff drainage system. • Exposed earthworks not provided with temporary cover. • Location different or not specified in ESC plan. • No perimeter control.	

BMPs INSPECTION FORM

Bil	Inspection Element	Component	Common Potential Non-Compliances	Remarks
6.	Overburden / Unsuitable material disposal sites	• Location of site	• Site inappropriately located adjacent to watercourse. • Not sited in accordance with plan. • Occurrence of open burning. • Overburden not stabilized / compacted. • No perimeter control.	
7.	Material storage yard	• Location of site	• Site not stabilized with aggregate. • Skid tanks not provided with bunds. • No collection sump and oil separator for oil spills. • Storage yard location not according to LDP2M2 plan. • Stockpile (soil, sand, aggregate and cement) not covered. • Evidence of oil spills, chemicals / fertilizers. • No equipment to control spills.	
8.	Phasing of construction schedule	• Site Mobilization • Site clearance • Major earthworks (excavation, cut, embankment) activities	• Mobilization of heavy equipment, materials and labour into site without prior notification to DOE. • Site clearance proceeded without prior application of BMPs (perimeter control, sediment trap, surface runoff controls, site delineation, defining green areas and buffer). • Large scale land opening at one go without staging and sequencing. • Earthworks undertaken during rainy season. • BMPs not consistent with the work sequence.	
9.	BMPs maintenance record	• BMPs maintenance log book	• Log book not kept. • Maintenance record not updated or incomplete.	

BMPs INSPECTION FORM

Bil	Inspection Element	Component	Common Potential Non-Compliances	Remarks
10.	Managing scheduled waste (used oil, paint, oil filters)	• Dedicated storage yard • Inventory • Labeling	• Storage area unsafe, with leakage. • Inventory not updated. • No labeling.	
11.	Cement mixing area (concrete mixer / ready mix)	• Concrete wastes • Effluent	• Concrete wastes left exposed without containment. • Effluent not neutralized (with acid).	
12.	Form * Check whether the form has been sent to DOE prior to site inspection	• Inspection Form via online: i. BMP Inspection Reporting Form ii. BMP Corrective Action Form	• Forms not submitted. • Incorrect information reported. • Incomplete form submitted. • Forms not submitted. • Incorrect information reported. • Incomplete form submitted.	
13	* BMPs * Sample photos, coding, common mistakes and dedicated specification for BMPs as in Table 1: List of BMPs and code	• Photos, coding, common mistakes and dedicated specification		

BMPs INSPECTION FORM

Table 1: BMPs List and Code

BMP Code	Component	Common Potential Non-Compliances	Remarks
SPM	**SITE PLANNING AND MANAGEMENT**		
SPM-1	Construction Scheduling - Phasing and work sequence	i. Mobilization of heavy equipment, materials and labour into site without prior notification to DOE. ii. Site clearance proceeded without prior application of BMPs (perimeter control, sediment trap, surface runoff controls, site delineation, defining green areas and buffer). iii. Large scale land opening at one go without staging and sequencing. iv. Earthworks undertaken during rainy season. v. BMPs not consistent with the work sequence.	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
SPM-2	Preserve natural areas and buffer zones.	i. No delineation / demarcation on site. ii. Failure to maintain existing green areas. iii. Encroachment into green areas / buffer zones.	
SPM-3	Control of existing resource sources i. Topsoil ii. Rock iii. Biomass (brushes and mulch) iv. Nursery with native species v. Retention of existing vegetation (buffer strips)	i. Not using resources available on site for erosion and sediment control.	
RC	**RUNOFF CONTROL**		
RC - 1	*Earth Bank/ Perimeter Dike*	i. No earth bunds provided. ii. Bunds not compacted nor covered to reduce erosion. iii. Bunds inappropriately built too close to slope / watercourses. iv. Bunds not maintained.	

BMPs INSPECTION FORM

BMP Code	Component	Common Potential Non-Compliances	Remarks
RC - 2	*Diversion*	i. Diversion drainage not provided. ii. Diversion drainage not connected to sediment pond. iii. Diversion drainage not provided with erosion control.	
RC - 3	*Lined Waterway (Rock Materials)*	i. Liner not provided. ii. Aggregate density is not appropriate and insufficient. iii. Liner not in accordance to specification.	
RC - 4	*Catch Drain*	i. Not provided. ii. Not maintained.	
RC - 5	*Cascading Drain*	i. Not provided. ii. No regular tiers provided.	
RC - 6	Riprap	i. Stone Size inappropriate. ii. Density inadequate. iii. Liner not provided.	
RC - 7	Check Dam (CD)	i. Not provided. ii. Distance inaccurate. iii. CD not in accordance to specification. iv. Built at an inaccurate location. v. Not maintained.	
RC - 8	*Temporary Interceptor Dyke*	i. Not provided. **ii.** Flow not discharged to sediment control facility.	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
RC - 9	*Swale*	i. Not maintained. ii. Not using suitable bed protection materials (Rock/mat/grass)	

BMPs INSPECTION FORM

RC -10	*Temporary And Permanent Pipe Slope Drain*	i. Not provided. ii. Sump not provided. iii. Connection unorderly. iv. No outlet protection.	
RC -11	*Rock Outlet Protection*	i. Not provided. ii. Rock material not in accordance to specification.	
RC -12	*Sand Bag Barrier*	i. Not provided. ii. Location incorrect.	
RC -13	*Storm Drain Inlet Protection*	i. No controls, such as stone / sand bag / rock bag / coir logs.	
EC	**EROSION CONTROL**		
EC -1	*Mulching/Hydro-mulching*	i. Not being used in the working areas when work stopped or when it rains. ii. Use of straw / hay / shear wood. iii. Not used in agricultural areas where open farming methods are deployed. iv. Binder not provided. v. Cellulose mixture too watery. vi. Not maintained.	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
EC -2	*Revegetation*	i. Covered area only less than 75% of planted area. ii. Using plants that are not suitable. iii. Turfing methods incorrect. Not watered regularly. iv. Dead / broken plants not replaced. v. Topsoil not used prior to planting.	
EC -3	*Hydroseeding*	i. Not provided. ii. Not fertilized. iii. Mulching / matting not applied to hydroseed that is slow growing.	

BMPs INSPECTION FORM

EC -4	*Rip-Rap Slope and channel protection*	i. Not provided. ii. Rock size not suitable. iii. Not maintained. iv. Liner not provided.	
EC -5	*Plastic Cover*	i. Not using plastic sheet that meets specification. ii. Usage became permanent. iii. Coverage not complete. iv. Not weighed down.	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
EC -6	*Erosion Control Blanket / Mat*	i. Not provided. ii. Installation not complete. iii. No overlap in end connectivity blanket.	
EC -7	*Surface Roughening*	i. Not provided. ii. Applied improperly.	
SC	**SEDIMENT CONTROL**		
SC -1	*Sediment Trap/ Basin*	i. Inlet / Outlet Protection not provided or inappropriate. ii. No proper or unsafe access to sediment pond for sampling and maintenance. iii. Discharge not via sediment pond outlet. iv. Riser / weir not functioning. v. Sediment depth markers not available. vi. No platform for inspection and maintenance. vii. Desilting maintenance not undertaken. viii. No embankment provided. ix. Size, location and number of ponds not in accordance with LDP2M2 design / plan. x. Excavated sediment stockpiled at edge of pond.	

BMPs INSPECTION FORM

BMP Code	Component	Common Potential Non-Compliances	Remarks
SC -2	*Construction Entrance Stabilization*	i. Not provided. ii. Not according to specifications. iii. Not maintained.	
SC -3	*Construction Road Stabilization (Gravelling)*	i. Not applied at areas with soft soil. ii. Not compacted.	
SC -4	*Fiber Rolls, Coir log*	i. Not installed surrounding the working area. ii. Not anchored to the ground properly (rebar/stacking)	
	Wattling	i. Not used at slopes with horizontal slope length > 5m and slope angle > 45o. ii. Not anchored to the ground properly (rebar/stacking)	
SC -5	Silt Fence	i. Not provided. ii. Wrongly applied (as filter, mounted on slope and in channel). iii. Not according to the contour. iv. No trenches provided at foot of silt fence. v. Installation not in accordance with the correct methods or supplier manual. vi. Not maintained	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
SC -6	*Turbidity Curtain/ Silt Curtain*	i. Not provided. ii. Not installed according to specifications. iii. Not maintained. iv. No anchor or weight provided.	
SC -7	*Brush Barrier / Matting*	i. Not provided.	

BMPs INSPECTION FORM

SC -8	*Active Treatment System (ATS)* *Pump, Chemical Dosing / Polymer, Flocculation & Geo-Tube*	i. Not provided. ii. Not functioning. iii. Not maintained.	
SC -9	*Temporaray Acces waterway: Bridge and culvert*	i. Bridge or culvert pipe not used. ii. No stabilization on both sides of the crossing edges. iii. Perimeter barrier not installed on both edges.	
GCC	**GENERAL CONSTRUCTION CONTROL**		
GCC -1	*Construction Fence*	i. Not provided. ii. Incorrectly installed.	
GCC-2	*Limits of Construction*	i. Not marked. ii. No demarcation of boundaries of the site.	
GCC -3	*Concrete Washout Area*	i. Concrete wastes left exposed without containment. ii. Effluent not neutralized (with acid).	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
GCC -4	*Vehicle and Equipment Fueling and maintenance*	i. Skid tanks not provided with bunds. ii. No collection sump and oil separator for oil spills. iii. Storage yard location not according to LDP2M2 plan. iv. Evidence of oil spills, chemicals / fertilizers. v. No equipment to control spills.	
GCC -5	*Solid Waste Management Area*	i. Site inappropriately located adjacent to watercourse. ii. Location not according to plan. iii. Evidence of open burning. iv. Waste bins not provided.	

BMPs INSPECTION FORM

GCC -6	*Spoil Management Area*	i. Site inappropriately located adjacent to watercourse. ii. Not sited in accordance with plan. iii. Occurrence of open burning. iv. Overburden not stabilized / compacted. v. No perimeter control.	
GCC -7	*Stabilized Staging Area*	i. Stabilization not done.	
BMP Code	**Component**	**Common Potential Non-Compliances**	**Remarks**
GCC -8	*Schedule Waste Management Area*	i. Storage area unsafe, with leakage. ii. Inventory not updated. iii. No labeling.	
GCC -9	*Material Storage Control and Stockpile Management*	i. Site not stabilized with aggregate. ii. Skid tanks not provided with bunds. iii. No collection sump and oil separator for oil spills. iv. Storage yard location not according to LDP2M2 plan. v. Evidence of oil spills, chemicals / fertilizers. vi. No equipment to control spills.	
GCC -10	*Sanitary Waste Management*	i. Toilet facilities not provided. ii. Toilets facilities not insufficient. iii. No treatment system. iv. Sullage not treated.	
GCC -11	*Spill Prevention And Secondary Containment*	i. Evidence of oil spills, chemicals / fertilizers. ii. No equipment to control spills.	
GCC -12	*Dust Control & Street Cleaning*	i. No amenities.	

APPENDIX I

SAMPLE OF STRATEGIC PLAN FOR EROSION AND SEDIMENT REDUCTION AND REMEDIATION MEASURES AT AN ACTIVE CONSTRUCTION SITE

Activity Base Strategic Plan :

Pollution Reduction & Remediation Measures For PROJECT ABC DEVELOPMENT With Referenced To LD-P2M2

(Source: Leong Kwok Wing PE(Calif)

Project Goal: Design Erosion & Sediment Reduction and Remediation Measures
Project Site Condition: 100ac (exposed) Site Rainfall-Runoff: Approx. 40,000+m3 per 50mm rainfall event

Present situation for consideration :
Site Remediation for Existing Post Bulk – Closure
Site Remediation for Existing Post Bulk – Grading
Site Soil Condition: Erosive with high clay content - suspended solids

Activity Base Strategic Plan : Pollution Reduction & Remediation Measures

PROJECT OBJECTIVES :

- Identify and Address Critical Areas immediately
- Determine sediment quantity generated in 50mm rainfall
- Determine adequacy or deficiency of existing erosion, runoff and sediment control measures…
- Propose mitigation measures with BMPs to address site deficiencies
- Formulate Activity Base Strategic Plan

SAMPLE PROJECT DEVELOPMENT LAYOUT PLAN

Activity Base Strategic Plan:

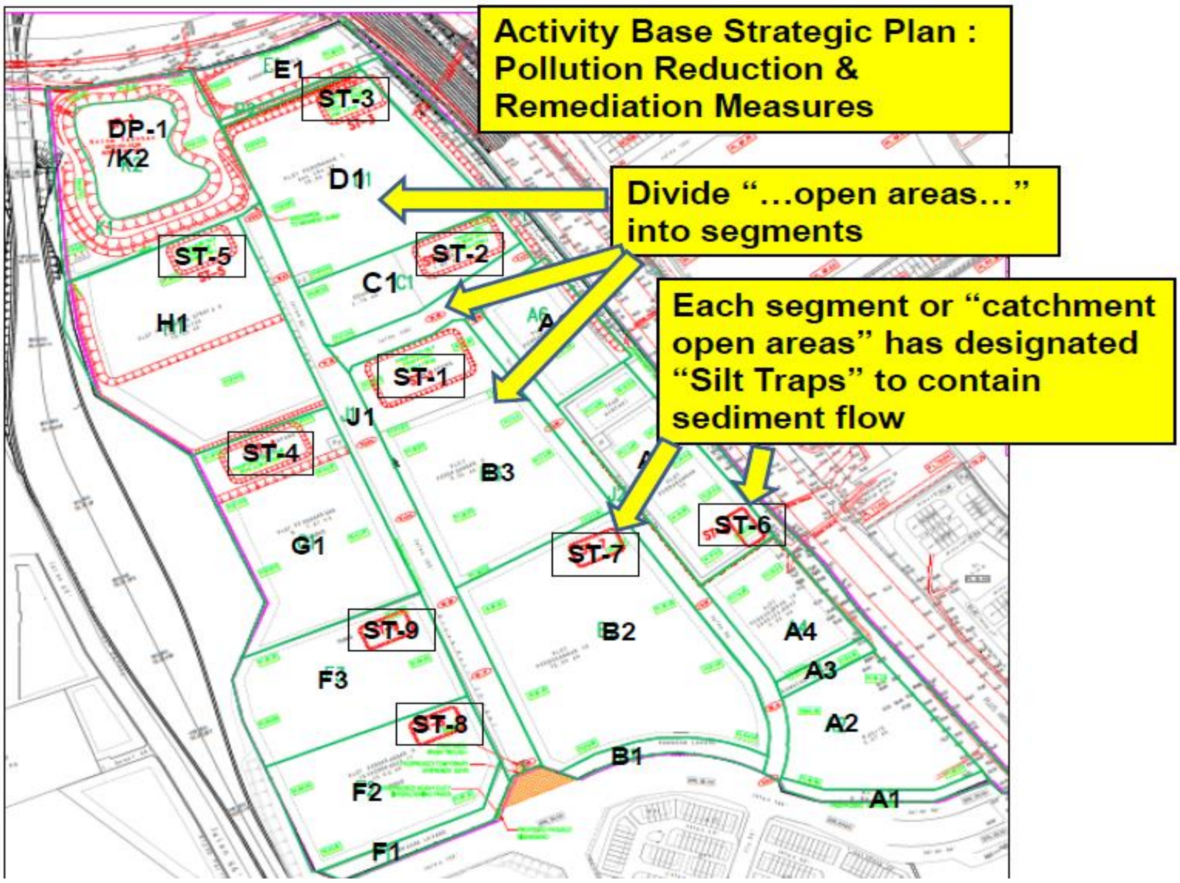
Formulate **Critical List**:

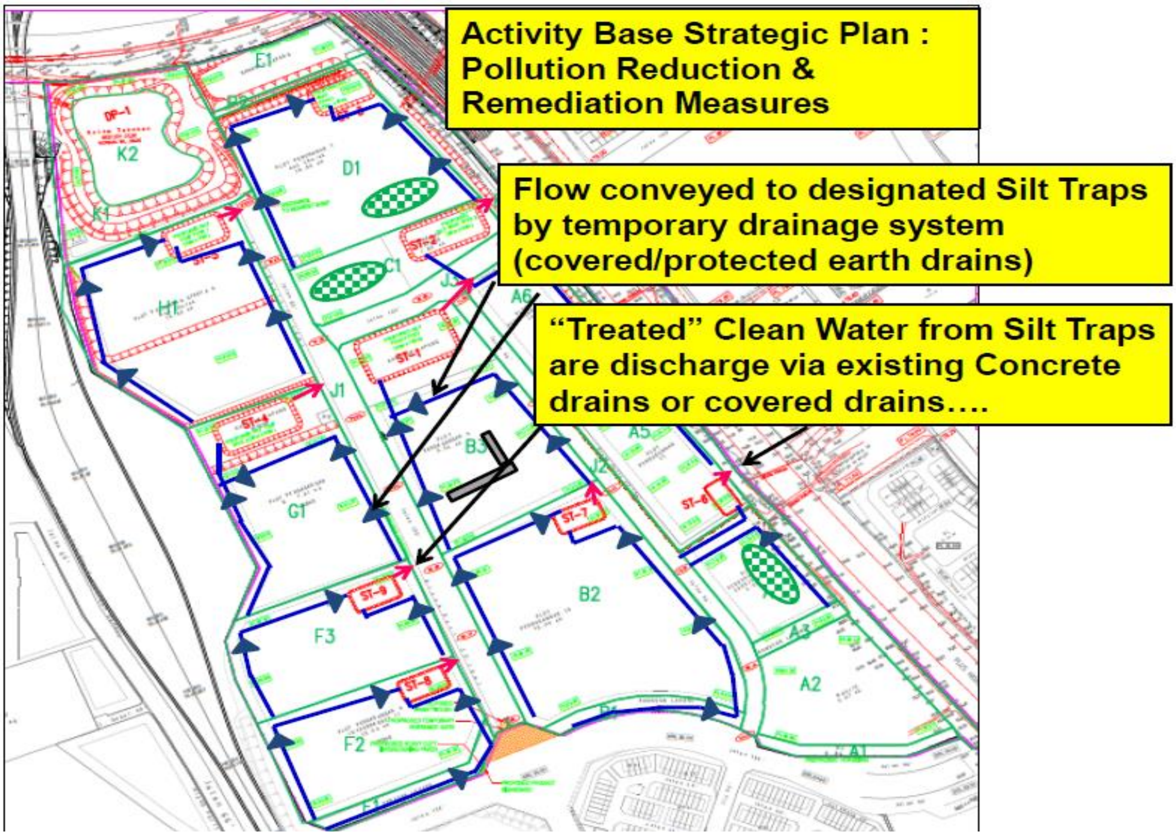
- Imminent Impact to Sensitive Receptors:
  - Example - public safety, highways, properties, rivers & streams, main drains, environment
- Prioritise:
  - Critical Area#1(Detention Pond Capacity),
  - Critical Area#2(Detention Pond Edges),
  - Critical Area#3 (Main Drain): Balance Areas of project site divide to Segments & Manage w/Silt Traps

- Divide “open-areas” into segments

- Determine each segment:

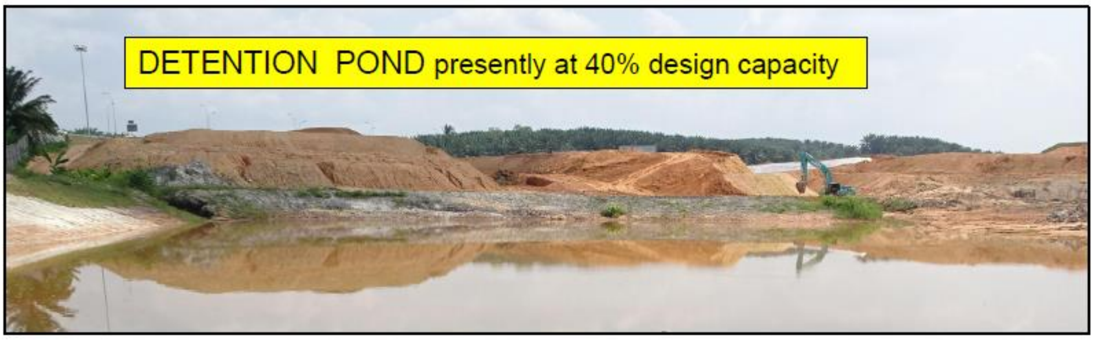
  i. areas (m2)
  ii. slope (angleº,%),
  iii. erosion rate (tonnes/ha/yr)
  iv. sediment yield (tonnes, m3)


Activity Base Strategic Plan : Pollution Reduction & Remediation Measures
Divide "…open areas…" into segments
Each segment or "catchment open areas" has designated "Silt Traps" to contain sediment flow
DP-1 /K2
E1
ST-3
D1
ST-5
ST-2
C1
H1
ST-1
J1
ST-4
B3
ST-6
ST-7
G1
ST-9
B2
A4
F3
A3
ST-8
A2
B1
F2
A1
F1


Activity Base Strategic Plan : Pollution Reduction & Remediation Measures
Flow conveyed to designated Silt Traps by temporary drainage system (covered/protected earth drains)
"Treated" Clean Water from Silt Traps are discharge via existing Concrete drains or covered drains….
E1
K2
D1
C1
H1
J1
B3
G1
B2
F3
A2
F2
A1

Activity Base Strategic Plan :
Pollution Reduction & Remediation Measures

CRITICAL AREA #1 (Northern western segment)



DETENTION POND (DP)

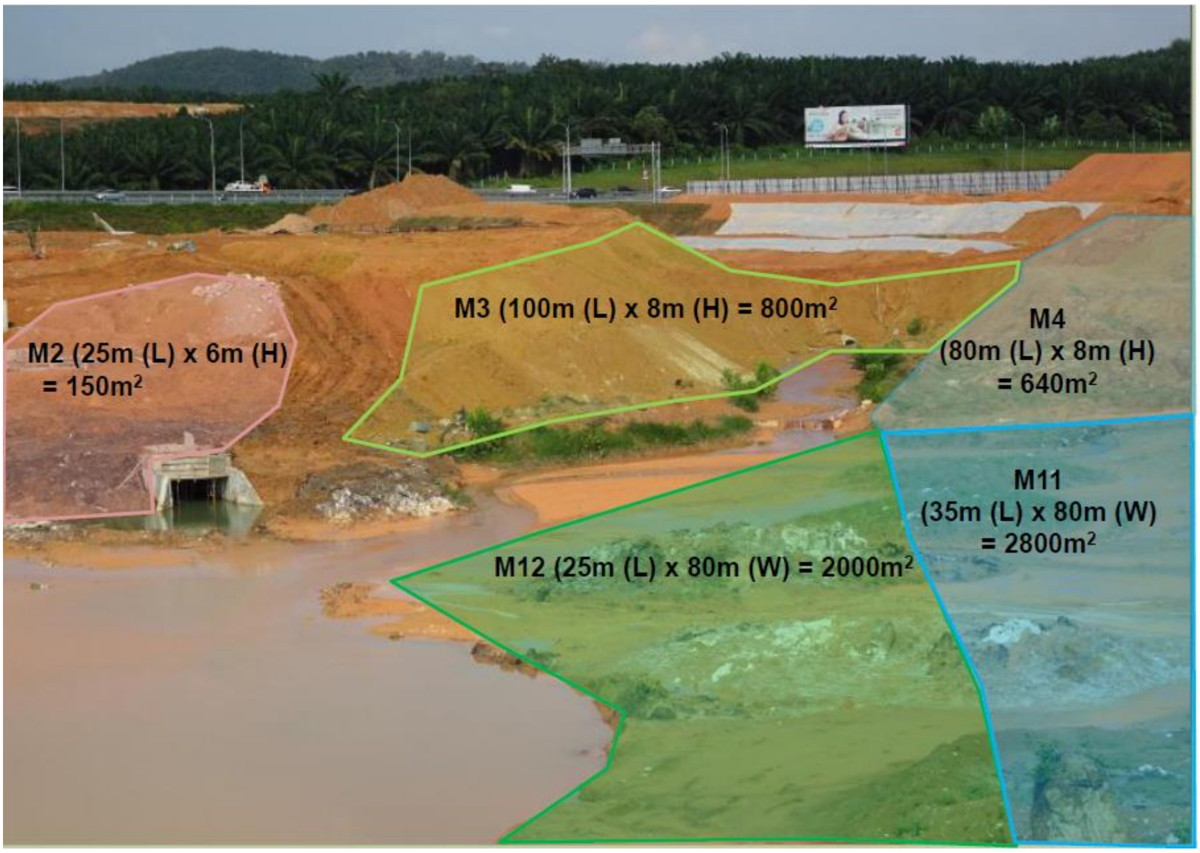
•Increase Storage Capacity (dredge)

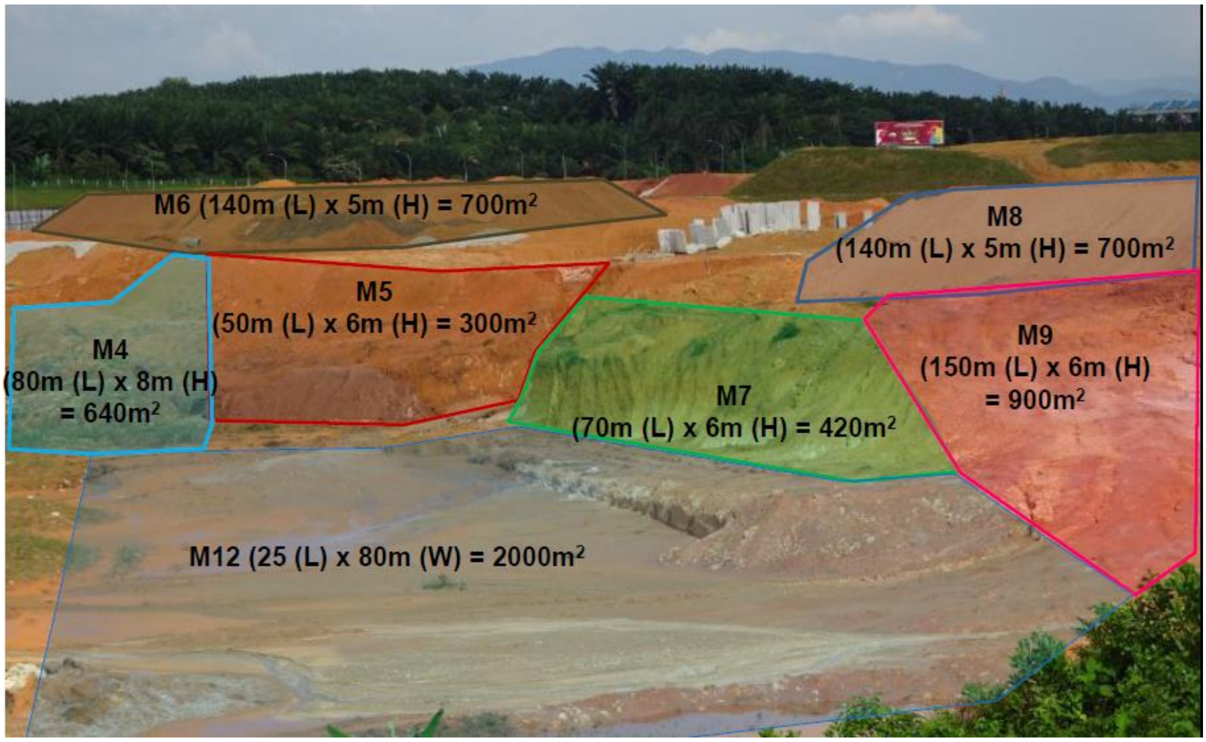
•Restore to Initial Design Capacity(excavate)

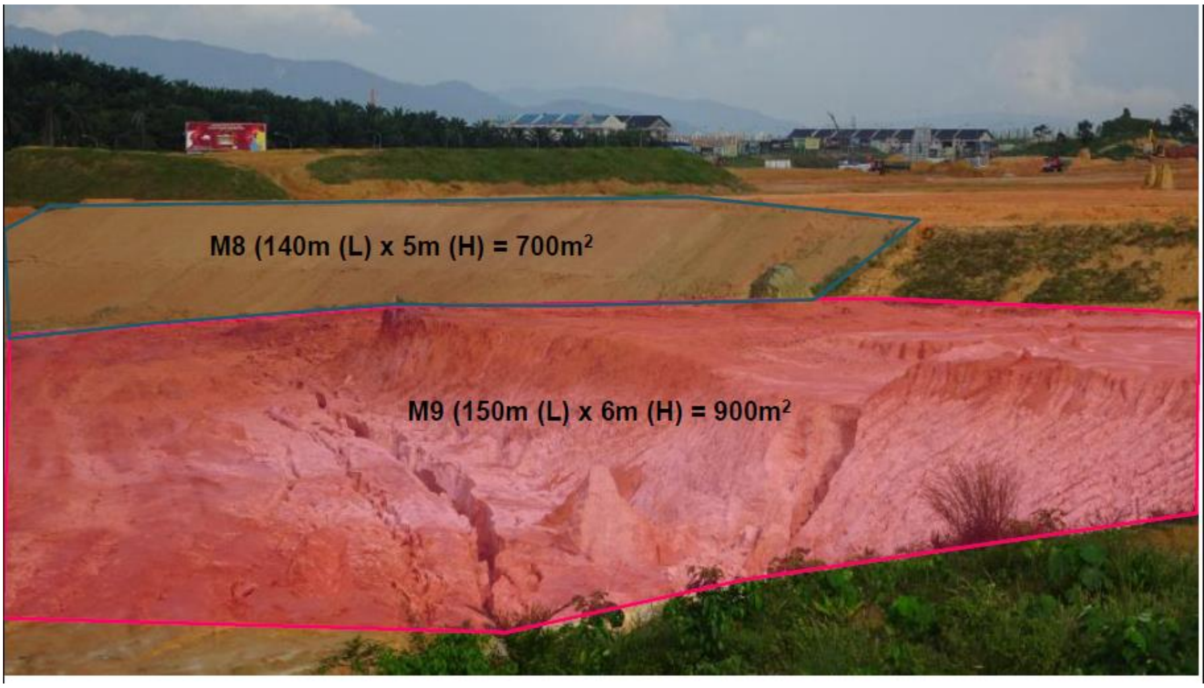
•Protect Detention Pond Edges soonest

VIEW: Looking from bridge towards the north-western edge of the site


M1 (60m (L) x 8m (H) = 480m²
M2 (25m (L) x 6m (H) = 150m²

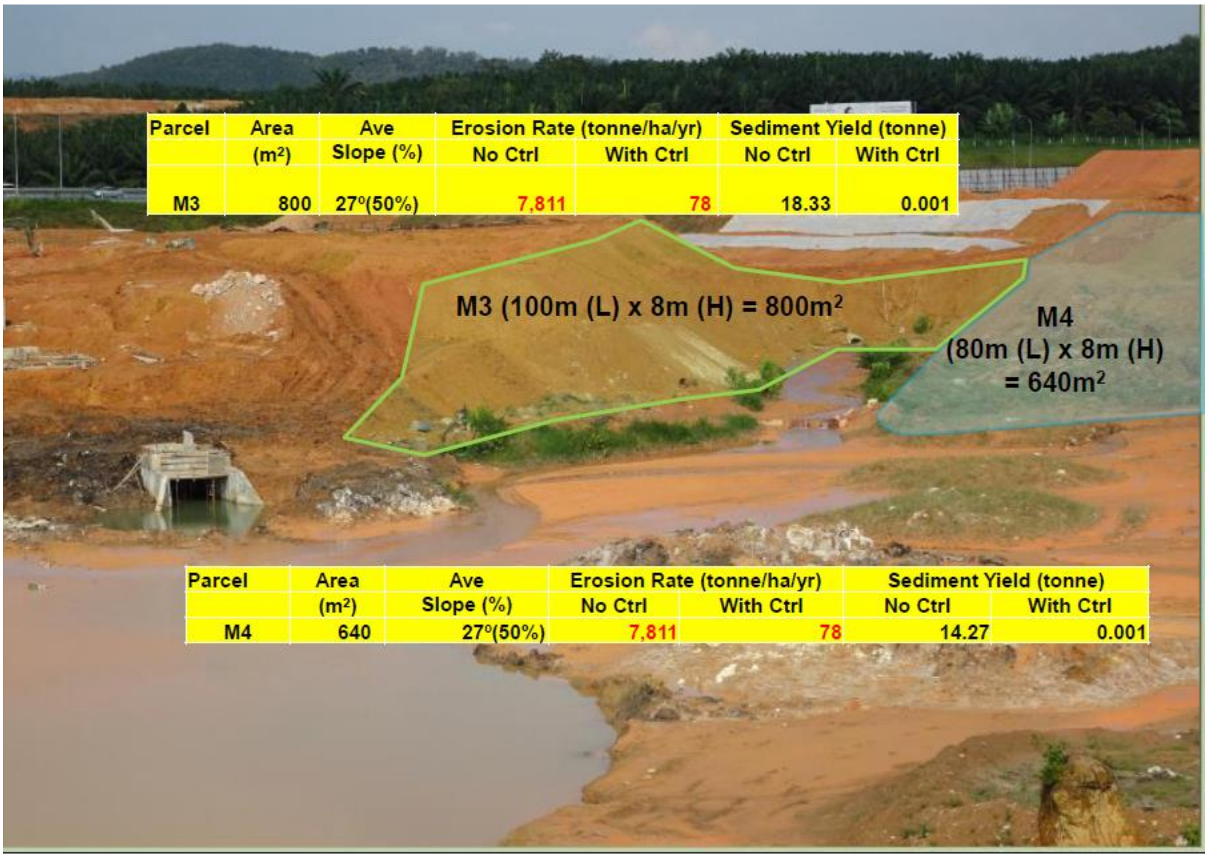

M2 (25m (L) x 6m (H)
= 150m²
M3 (100m (L) x 8m (H) = 800m²
M4
(80m (L) x 8m (H)
= 640m²
M11
(35m (L) x 80m (W)
= 2800m²
M12 (25m (L) x 80m (W) = 2000m²

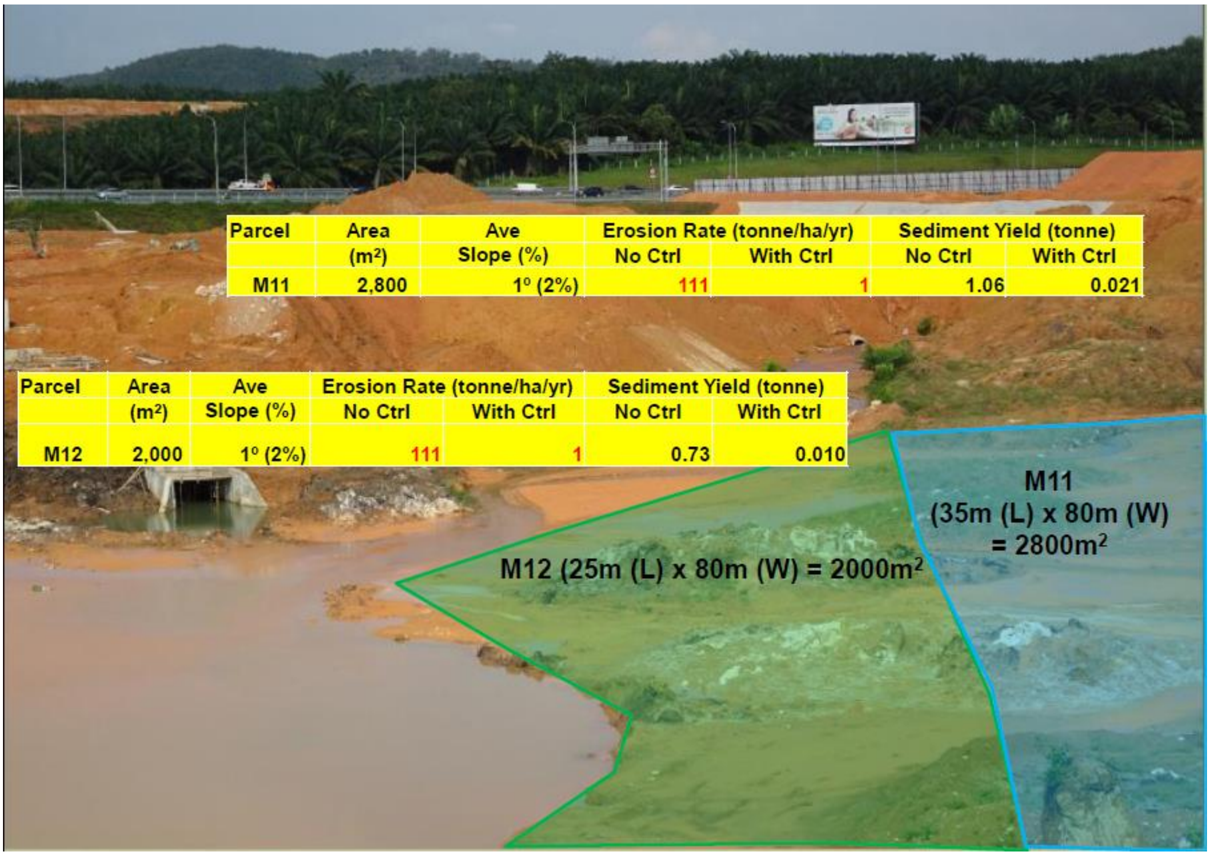

M6 (140m (L) x 5m (H) = 700m2
M8
(140m (L) x 5m (H) = 700m2
M5
(50m (L) x 6m (H) = 300m2
M4
(80m (L) x 8m (H)
= 640m2
M9
(150m (L) x 6m (H)
= 900m2
M7
(70m (L) x 6m (H) = 420m2
M12 (25 (L) x 80m (W) = 2000m2


M8 (140m (L) x 5m (H) = 700m2
M9 (150m (L) x 6m (H) = 900m2

Parcel	Area (m^2)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
M1	480	27° (50%)	7.811	78	10.34	0.0005

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
M2	150	18º(33%)	3,114	31	1.12	0.00004


Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M3 | 800 | 27º(50%) | 7,811 | 78 | 18.33 | 0.001
M3 (100m (L) x 8m (H) = 800m2
M4
(80m (L) x 8m (H)
= 640m2
Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M4 | 640 | 27º(50%) | 7,811 | 78 | 14.27 | 0.001


Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M11 | 2,800 | 1º (2%) | 111 | 1 | 1.06 | 0.021
Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M12 | 2,000 | 1º (2%) | 111 | 1 | 0.73 | 0.010
M11
(35m (L) x 80m (W)
= 2800m2
M12 (25m (L) x 80m (W) = 2000m2

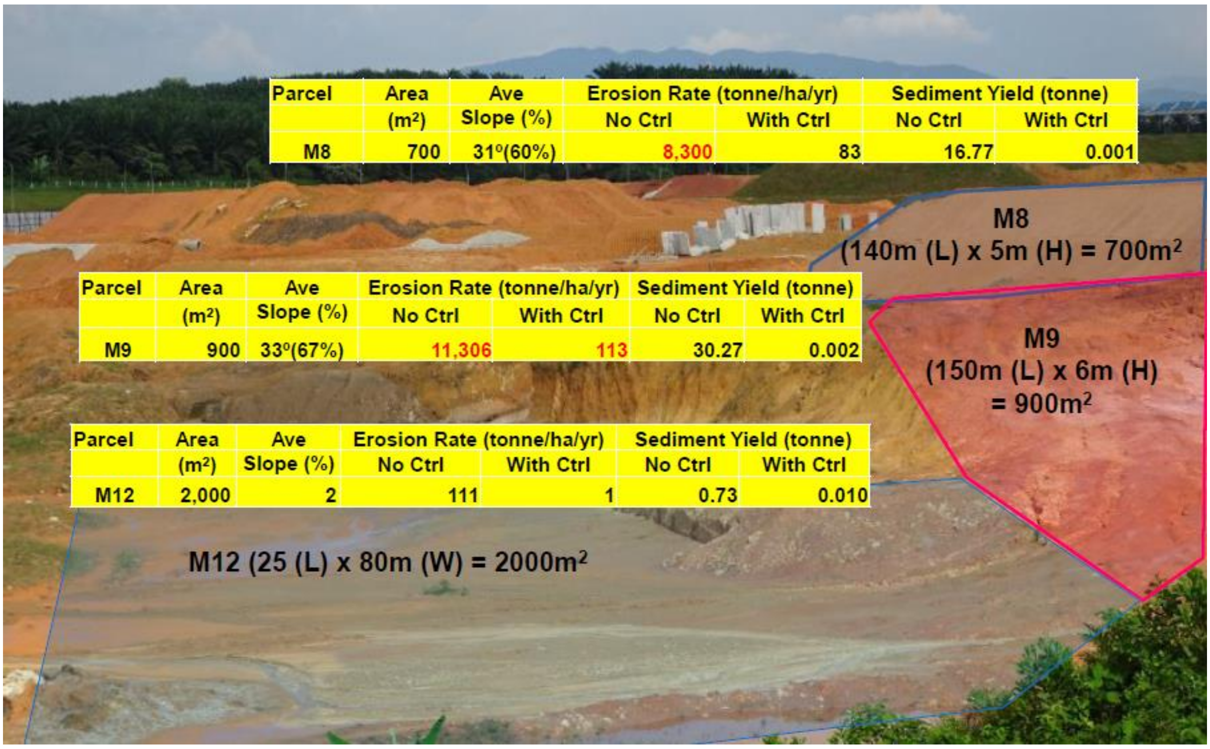
Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M6	700	31°(60%)	8,300	83	16.77	0.001

M6 (140m (L) x 5m (H) = 700m²

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M7	420	23°(42%)	4,684	47	5.34	0.0004

(50m (
M7
(70m (L) x 6m (H) = 420m²

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M5	300	18°(33%)	3,114	31	2.44	0.0002



Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M8	700	31°(60%)	8,300	83	16.77	0.001

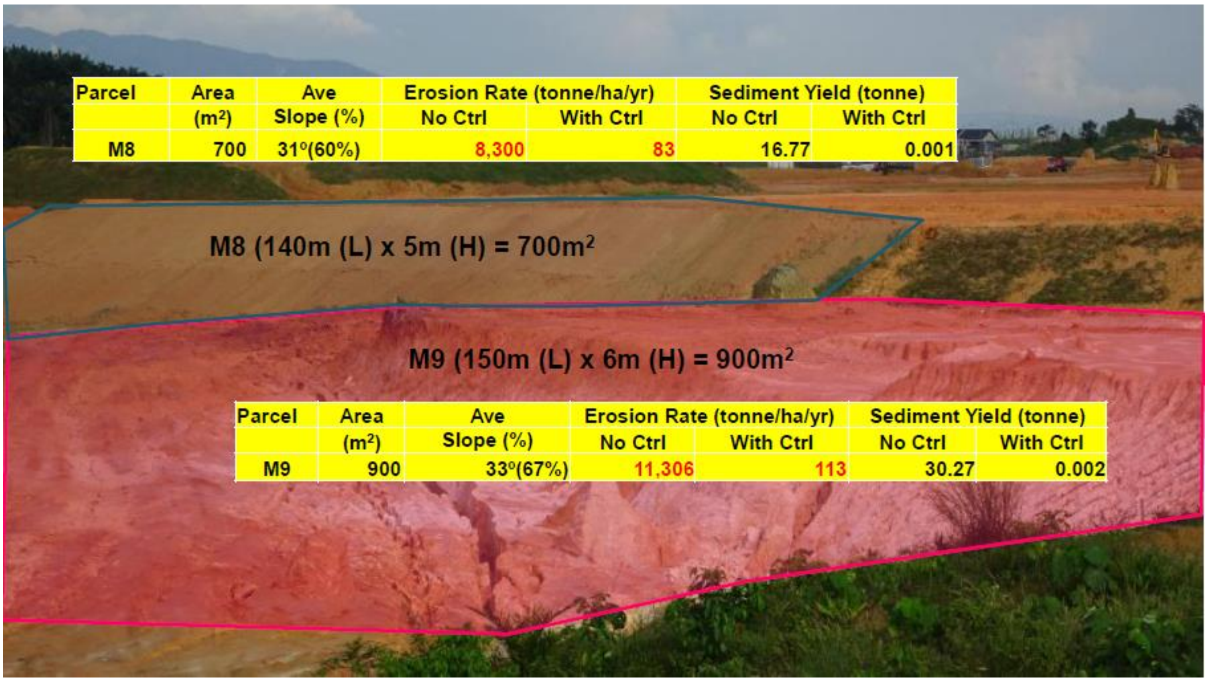
M8
(140m (L) x 5m (H) = 700m²

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M9	900	33°(67%)	11,306	113	30.27	0.002

M9
(150m (L) x 6m (H)
= 900m²

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
M12	2,000	2	111	1	0.73	0.010

M12 (25 (L) x 80m (W) = 2000m²


Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M8 | 700 | 31o(60%) | 8,300 | 83 | 16.77 | 0.001
M8 (140m (L) x 5m (H) = 700m2
M9 (150m (L) x 6m (H) = 900m2
Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M9 | 900 | 33o(67%) | 11,306 | 113 | 30.27 | 0.002

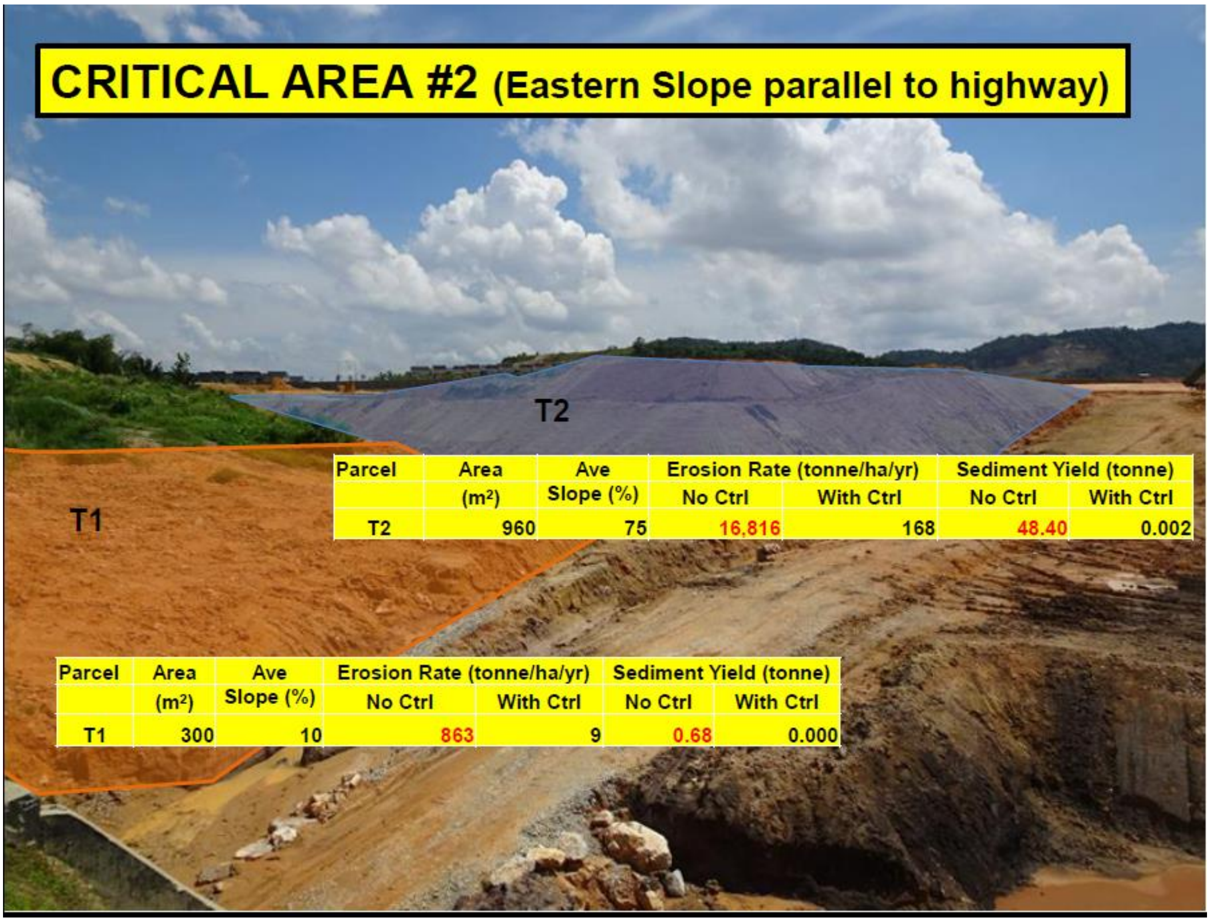

Parcel | Area (m2) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
M9 | 900 | 33o(67%) | 11,306 | 113 | 30.27 | 0.002
M9 (150m (L) x 6m (H) = 900m2

CRITICAL AREA #1 (Northern western segment)

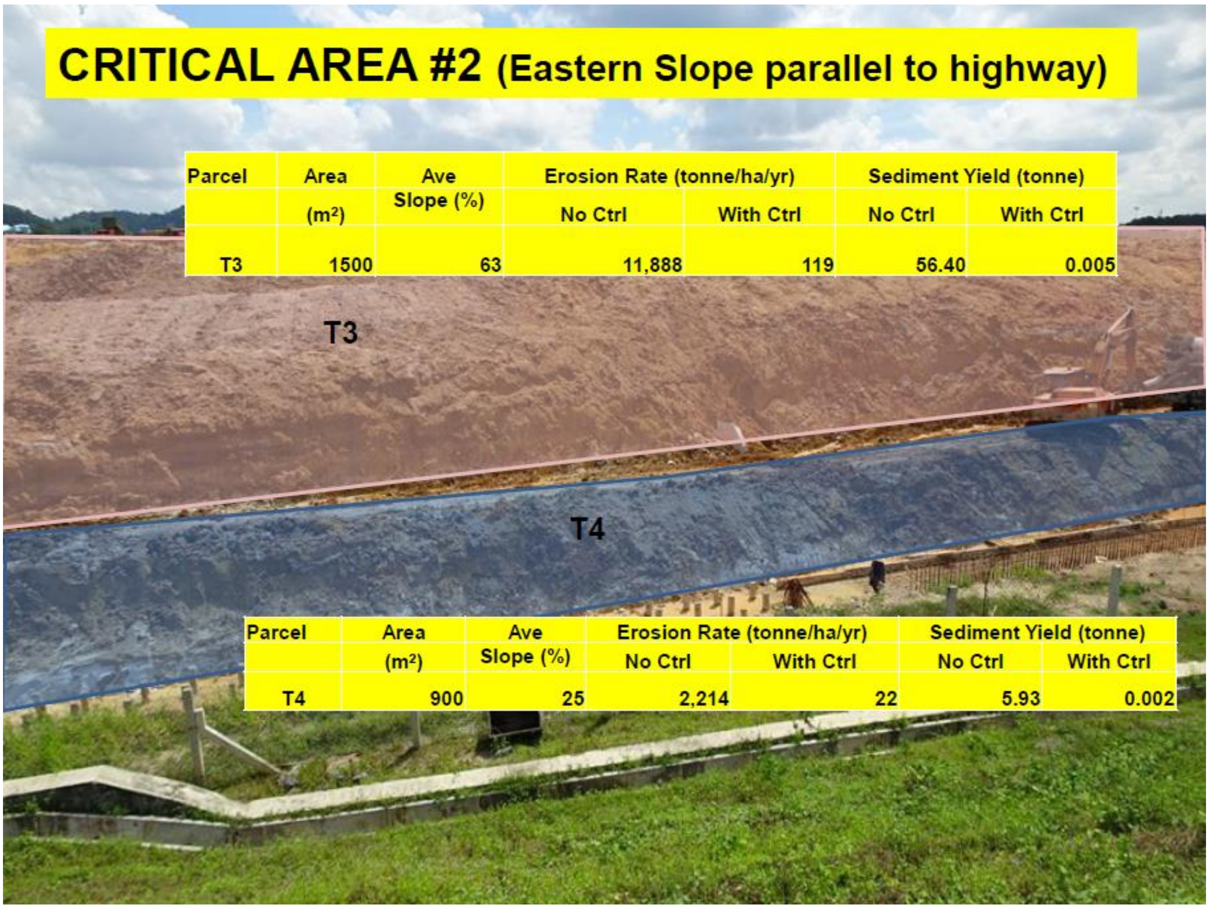
Erosion Rate at Slopes of Detention Pond 1						
Parcel	Area (m^2)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
M1	480	50	7,810.8	78	10.34	0.000
M2	150	33	3,114.4	31	1.12	0.000
M3	800	50	7,810.8	78	18.33	0.001
M4	640	50	7,810.8	78	14.27	0.001
M5	300	33	3,114.4	31	2.44	0.000
M6	700	60	8,300.0	83	16.77	0.001
M7	420	42	4,684.1	47	5.34	0.000
M8	700	60	8,300.0	83	16.77	0.001
M9	900	67	11,305.8	113	30.27	0.002
M10	540	33	3,114.4	31	4.71	0.001
M11	2,800	2	111.4	1	1.06	0.021
M12	2,000	2	111.4	1	0.73	0.010
Total	10,430 m2		65,589 t/ha/yr (29,813 m3/ha/yr)	655 t/ha/yr (298 m3/ha/yr)	122 t (56 m3)	0.039 t (0.2 m3)

CRITICAL AREA #2 (Eastern Slope parallel to highway)

MAIN DRAIN


CRITICAL AREA #2 (Eastern Slope parallel to highway)
T2
T1
Parcel | Area (m²) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
T2 | 960 | 75 | 16,816 | 168 | 48.40 | 0.002
Parcel | Area (m²) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
T1 | 300 | 10 | 863 | 9 | 0.68 | 0.000

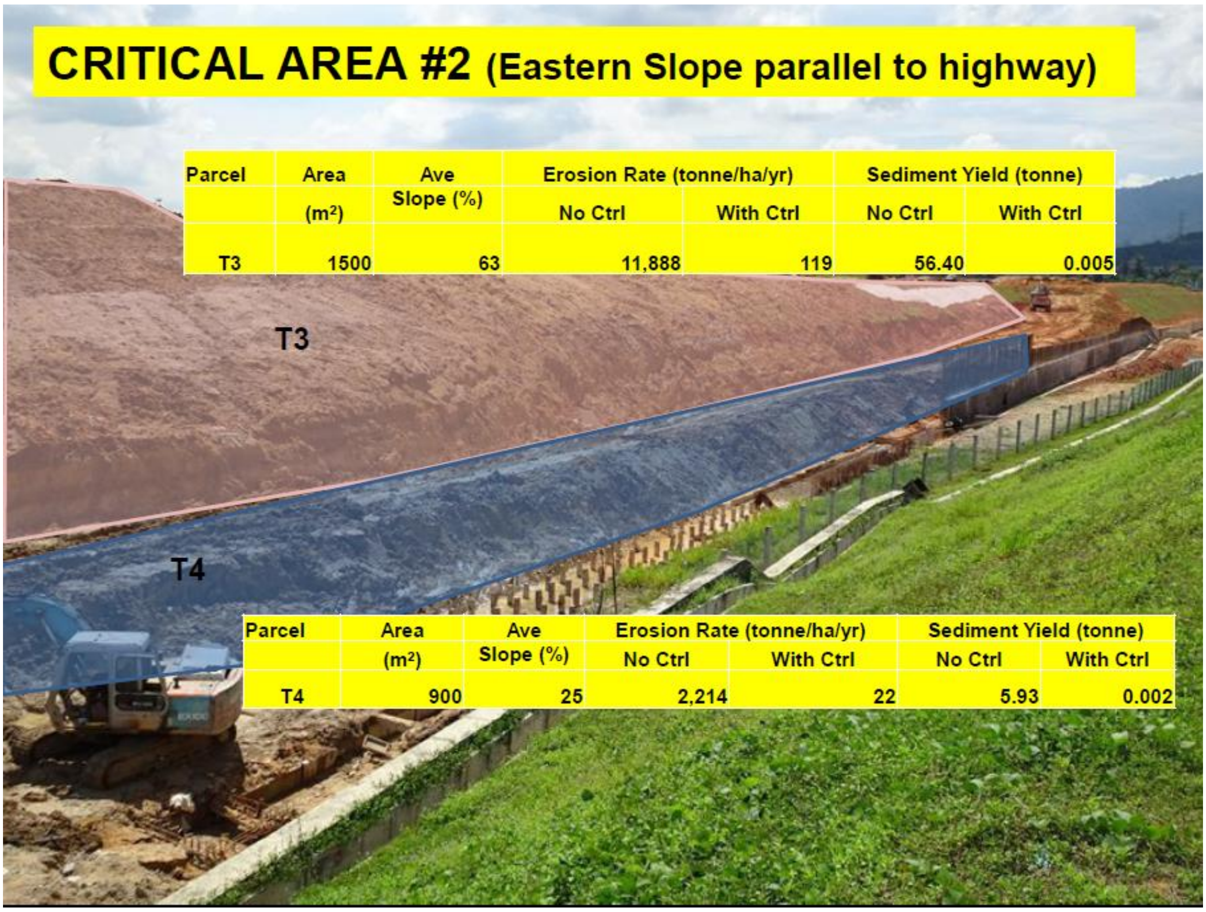

CRITICAL AREA #2 (Eastern Slope parallel to highway)
Parcel | Area (m²) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
T3 | 1500 | 63 | 11,888 | 119 | 56.40 | 0.005
T3
T4
Parcel | Area (m²) | Ave Slope (%) | Erosion Rate (tonne/ha/yr) No Ctrl | With Ctrl | Sediment Yield (tonne) No Ctrl | With Ctrl
T4 | 900 | 25 | 2,214 | 22 | 5.93 | 0.002


CRITICAL AREA #2 (Eastern Slope parallel to highway)

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
T3	1500	63	11,888	119	56.40	0.005

T3
T4

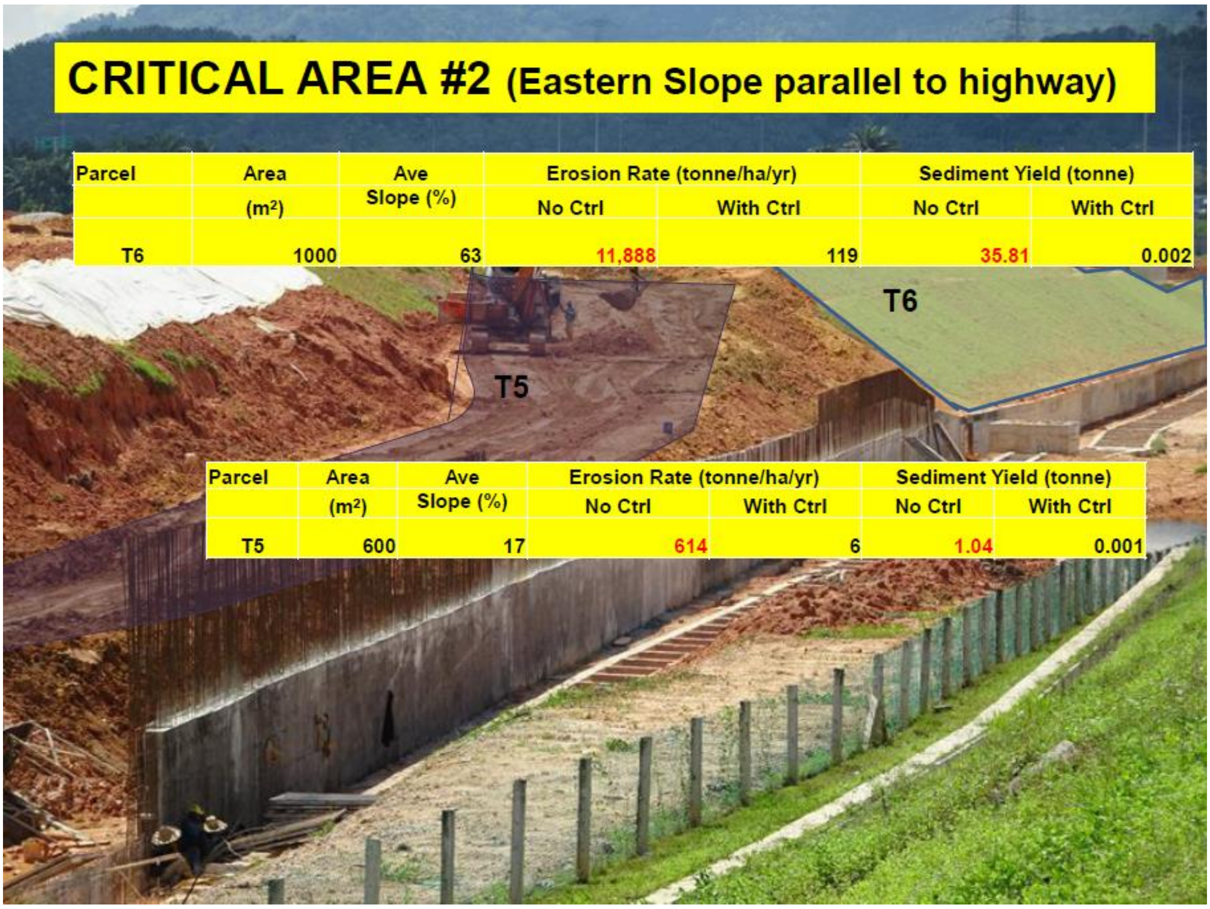
Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
T4	900	25	2,214	22	5.93	0.002


CRITICAL AREA #2 (Eastern Slope parallel to highway)

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
T3	1500	63	11,888	119	56.40	0.005

T3
T4

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr)		Sediment Yield (tonne)	
			No Ctrl	With Ctrl	No Ctrl	With Ctrl
T4	900	25	2,214	22	5.93	0.002



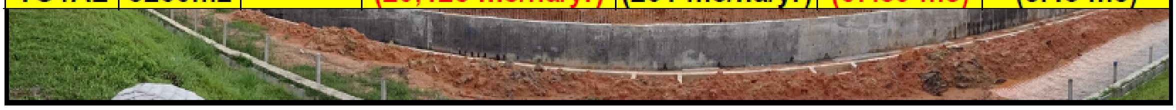
CRITICAL AREA #2 (Eastern Slope parallel to highway)

Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
T6	1000	63	11,888	119	35.81	0.002

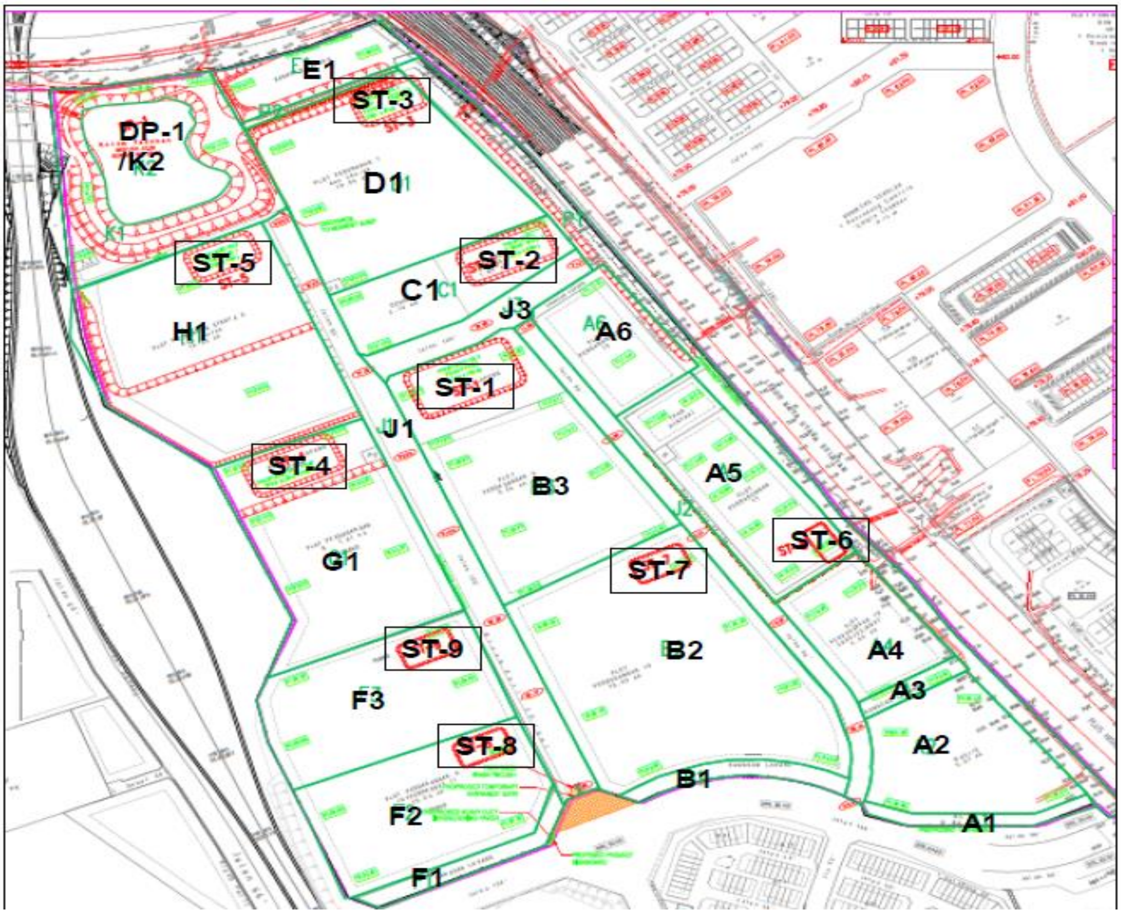
Parcel	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
T5	600	17	614	6	1.04	0.001

CRITICAL AREA #2 (Eastern Slope parallel to highway)

Parcel No	Area (m²)	Ave Slope (%)	Erosion Rate (tonne/ha/yr) No Ctrl	Erosion Rate (tonne/ha/yr) With Ctrl	Sediment Yield (tonne) No Ctrl	Sediment Yield (tonne) With Ctrl
T1	300.00	10	863.0	9	0.68	0.000
T2	960.00	75	16,816.5	168	48.40	0.002
T3	1500.00	63	11,887.5	119	56.40	0.005
T4	900.00	25	2,214.4	22	5.93	0.002
T5	600.00	17	614.3	6	1.04	0.001
T6	1000.00	63	11,887.5	119	35.81	0.002
TOTAL	5260m2		44,283 t/ha/yr (20,128 m3/ha/yr)	443 t/ha/yr (201 m3/ha/yr)	148.26t (67.39 m3)	0.012t (5.45 m3)



CRITICAL AREA #3 (…balance of the site…)



DIMENSION OF SEDIMENT BASINS

SB	CATCHMENT	AREA (ha)	L_1	W_1	L_B	W_B	y_1	y_2
ST-1	B3	4.65	72	22	66	17	0.75	1.0
ST-2	A5, A6	3.89	66	20	61	15	0.75	1.0
ST-3	D1	4.16	64	22	59	17	0.75	1.0
ST-4	G1	3.92	67	20	61	15	0.75	1.0
ST-5	H1	4.95	65	26	59	21	0.75	1.0
ST-6	A1 - A4	4.33	67	22	62	17	0.75	1.0
ST-7	B1, B2	6.44	66	33	61	28	0.75	1.0
ST-8	F1, F2	3.48	66	18	60	13	0.75	1.0
ST-9	F3	4.33	64	16	58	10	0.75	1.1

L_1 Settling Zone Length (m)
W_1 Settling Zone Width(m)
L_B Sediment Storage Length (m)
W_B Sediment Storage Width (m)
y_1 Settling Zone Depth (m)
y_2 Sediment Storage Depth (m)

TOTAL CATCHMENT AREA = 40.15HA (100.38AC)

MITIGATION MEASURES CRITICAL AREA #1

Preparation Work:

•Remove & Desilt existing Detention Pond

•Excavate Detention Pond to initial design capacity

•Care to not discharge sediment to outside site

MITIGATION MEASURES CRITICAL AREA #1 & #2

Preparation Work:

- **Trim & adjust slopes, slant areas, remove debris, fill holes, rills and gullies and compact to grade**

Materials for Protection:

- **Slope Erosion Control BMPs: Temporary -to- Permanent to arrest erosion**
- **Erosion Control Mattress, Erosion Control Mattress(ECM) w/seeding, Grass “Close Turfing”, Tarp, Geotextile (NWNP)**

Runoff Control BMPs:

- **Protect all Large Drainage Channels from Hydraulic Scouring & Erosion w/ECM, Tarp, Geotextile (NWNP)**
- **Slope Drains with Inlets and Outlet protection (flare ends, rocks)**
- **Slope Drains : Corrugated HDPE pipes, CSPs, PVC…(can be reused)**
- **Earth Drains : must be covered by: ECM (POF or COIR), plastic sheets, geotextiles (NWNP)**
- **Concrete Drains : permanent drainage, for clean treated waters**

Preparation Work: Trim & adjust slopes, remove debris, fill holes, rills, gullies and compact to grade

Slope Erosion Control w/Vegetation: Install ECM & Hand-Seed. Hand disperse grass seeds over prepared area. Roll ECM downhill, peg at 1.0m intervals staggered, laterally & longitudinally.

Temporary Slope Erosion Control: Installation Erosion Control Mattress w/no seeding. Prepare exposed slope as described above, fill-in rills & gullies. Roll ECM downslope, secure top berm w/wood pegs. Overlap mattress @ 100mm side & 200mm on-ends w/wood pegs. Avoid walking on installed mattress

Activity Base Strategic Plan : Pollution Reduction & Remediation Measures

RUNOFF CONTROL BMPs

MITIGATION MEASURES CRITICAL AREA #3
(balance of project area)

Preparation Work:

- **Trim adjust & grade flow "positive flow", slant areas, remove debris, fill holes, rills and gullies and compact to grade**

Materials for Erosion Protection:

- **Protect all Silt Trap Slopes with Erosion Control Mattresses BMPs: Temporary -to- Permanent to arrest erosion and rain impact:**

  ECM, Grass seeding, Grass-turfing, Tarp, Geotextile (NWNP – Non-Woven Needle Punched), ORGANIC MULCHING

Runoff Control BMPs:

- **Earth Drains : must be covered by: ECM, plastic sheets, geotextiles (NWNP)**
- **Concrete Drains : permanent drainage, for clean treated waters**

Preparation Work: SEDIMENT CONTAINMENT (Silt Traps, Sediment Ponds)

- **Trim adjust & build up Silt Traps-Sediment Pond Berms "positive containment", slant areas, remove debris, fill holes, rills and gullies and compact to grade.**

Materials for Protection:

- **SEDIMENT CONTAINMENT (SILT TRAPS-PONDS)**

- **"Open-Surface" Erosion Control BMPs: Temporary -to- Permanent to arrest sediment flow during rainfall event & impact:**

  Silt Trap Slopes : Critical, protect w/ECM, Grass seeding, Grass-turfing, Tarp, Geotextile (NWNP).

- **Inlets: Earth Drains: must be covered w/ECM, plastic sheets, geotextiles.**

- **Inlets: Slope Drains: Corrugated HDPE pipes, CSPs, PVC (can be reused), must have inlet protection for positive transition, pipe anchors**

- **PE-BMPs: Polymer Enhanced BMPs FLOCCULATION & FILTRATION SYSTEMS**

- **ACTIVE TREATMENT SYSTEMS: PAM Blocks, PAM Liquid Applications**

Preparation Work: SEDIMENT CONTAINMENT with PE-BMPs

- **Materials for Protection: SEDIMENT CONTAINMENT (SILT TRAPS-PONDS)**

- **WATER QUALITY IMPROVEMENT & POLLUTANT REDUCTION:**

    PE-BMPs: Polymer Enhanced BMPs FLOCCULATION & FILTRATION SYSTEMS

    ACTIVE TREATMENT SYSTEMS: PAM Blocks, PAM Liquid Applications

INPUT & OUTPUT DATA FOR SOIL EROSION & SEDIMENT YIELD CALCULATIONS FOR PROJECT ABC

1. INTRODUCTION

The steps involved in the soil erosion assessment are as follows:

STEP	ASSESSMENT
1	Calculation of Soil Erosion Rate using the Universal Soil Loss Equation (USLE).
2	Calculation of Sediment Yield using the Modified Universal Soil Loss Equation (MUSLE).

Assumptions made in the soil erosion assessment are as follows:

- Land clearing of the project site is carried out in one phase.
- Eroded soil during this stage will settle locally, with the finer soil particles being carried to the earth drain within the disturbed area, to the sediment basins before discharging to the drain.

2. UNIVERSAL SOIL LOSS EQUATION (USLE)

The **Universal Soil Loss Equation (USLE)** was used in the computation of current and potential erosion as shown below:

$$A = R.K.L.S.C.P$$

Where A = soil loss in tonne/ha/year

R = rainfall erosivity index ($MJmmha^{-1}h^{-1}$)

K = soil erodibility factor [(tonnes/ha/($MJmmha^{-1}h^{-1}$)]

LS = topographic factor, combination of slope steepness (S, %) and slope length (L, meter).

C = crop management factor, representing the ratio of soil loss under a given crop to that from the bare soil (dimensionless)

P = conservation practice factor, representing measures taken to what it would have been if such conservation measures have not been taken.

The values used for the different parameters in the computation are briefly discussed below.

2.1 Rainfall Erosivity Index (R)

R Factor is derived from Figure 3.5 Rainfall Erosivity Map for Negeri Sembilan and Melaka of *Guideline for Erosion and Sediment Control in Malaysia* (DID, 2010).

For this project, R Factor = 14,000 MJ.mm/ha.yr.

2.2 Soil Erodibility Factor (K)

K Factor is calculated using Tew Equation from *Guideline for Erosion and Sediment Control in Malaysia* (DID, 2010).

$$K = [1.0 \text{ X } 10^{-4} (12 - OM) M^{1.14} + 4.5(s - 3) + 8.0(p - 2)] / (100 \text{ x } 7.59)$$

Where:

K = Soil Erodibility Factor, (ton/ac.)*(100ft.ton.in/ac.hr)
for SI unit (ton/ha)(ha.hr/MJ.mm), the conversion factor is 1/7.59

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

OM = % organic matter

S = soil structure code

P = permeability class

K Factor is derived from Soil Test carried out for the project site. Results of the K-Factor are given in **Table A2.1**.

Table A2.1 – Soil Test Result for Samples from Surface Level (0 m).

BOREHOLE	DEPTH	SOIL TEST RESULT				REDISTRIBUTION			% OM	M	S	P	K	HSG	SOIL
	(m)	% Clay	% Silt	% Sand	%Gravel	% Clay	% Silt	% Sand							TYPE
S1	1.0	40.3	26.8	31.3	1.6	41	27	32	0.10	1612	4	6	**0.055**	D	Clay
S2	4.5	31.1	20.8	30.5	17.6	38	25	37	0.10	1567	4	4	**0.034**	C	Clay loam

Only two soil samples were collected and analysed for particle size distribution. As a conservative measure, the sample with the higher K Factor is used to represent the soil type for the entire site.

2.3 Topological Factor (LS)

LS Factor is derived from Equation defined by Wischmeier (1975) as given in Equation 3.9 of *Guideline for Erosion and Sediment Control in Malaysia* (DID, 2010).

$$LS = (\lambda / \Psi)^m \times (0.065 + 0.046s + 0.0065s^2)$$

Where λ = sheet flow path length (m)
Ψ = 22.13 (SI units)
S = average slope gradient (%)
M = 0.2 for $s < 1$,
0.3 for $1 \le s < 3$
0.4 for $3 \le s < 5$
0.5 for $5 \le s < 12$ and
0.6 for $s \ge 12\%$

LS factor is derived from the Surveyor's plan.

Table A2.2 – LS Factor of Each Parcel during Post Bulk Grading Stage.

Parcel	L (m)	H (m)	(H/L)	Slope (%)	m	LS Factor
A1	20	0.30	0.015	1.5	0.3	0.144
A2	20	0.30	0.015	1.5	0.3	0.144
A3	28	0.10	0.004	0.4	0.2	0.086
A4	20	0.10	0.005	0.5	0.2	0.088
A5	18	0.20	0.011	1.1	0.3	0.117
A6	20	0.20	0.010	1.0	0.3	0.114
B1	20	0.50	0.025	2.5	0.3	0.214
B2	32	3.00	0.094	9.4	0.5	1.284
B3	35	0.80	0.023	2.3	0.3	0.234
C1	28	0.30	0.011	1.1	0.3	0.131
D1	20	0.10	0.005	0.5	0.2	0.088
E1	10	0.05	0.005	0.5	0.2	0.076
F1	25	0.50	0.020	2.0	0.3	0.190
F2	25	0.50	0.020	2.0	0.3	0.190
F3	25	0.60	0.024	2.4	0.3	0.221
G1	22	0.20	0.009	0.9	0.2	0.112
H1	20	0.20	0.010	1.0	0.3	0.114
K1	29	8.00	0.276	27.6	0.6	7.387
K2	0	0.00	0.000	0.0	0	0.000
J1	20	0.20	0.010	1.0	0.3	0.114
J2	20	0.20	0.010	1.0	0.3	0.114
J3	20	0.30	0.015	1.5	0.3	0.144
P1	17	5.40	0.318	31.8	0.6	6.901
P2	160	0.20	0.001	0.1	0.2	0.105

2.4 Crop Management Factor (C)

Plant cover effectively reduces erosion due to the tree canopy which tends to minimize rainfall impact on ground while the roots provide effective binding of the soil, making it more resistant to erosive agents.

2.5 Soil Conservation Practice (P)

Soil conservation practice is important to trap as well as reduce the volume and velocity of surface runoff.

The differences in the computation of current and potential erosion are caused by the values for vegetative cover (C) and soil conservation practice factor (P), where the following CP values are used:

Table A2.3 - CP Factors of the Project Site.

Stage	Vegetative	C Factor	Support Practice	P Factor	CP
Post Bulk Grading	Bare Land	1	Sediment Basins	0.5	0.50
	RECP	0.02	Sediment Basins	0.5	0.01
Worst Case Scenario	Bare Land	1	None	1	1.00
Temporary Closure	Grass 40% cover	0.1	Sediment Basins	0.5	0.05

Reference: *Guideline for Erosion and Sediment Control in Malaysia* (DID, 2010).

The CP Factors for each parcel is tabulated in Table A2.4.

Table A2.4 - CP Factors of Each Parcel.

PARCEL	Land use	CP FACTOR		
		Post Bulk (with BMPs)	Post Bulk (No BMPs)	Temporary Closure
A1	Bare	0.50	1.00	0.05
A2	Bare	0.50	1.00	0.05
A3	Bare	0.50	1.00	0.05
A4	Bare	0.50	1.00	0.05
A5	Bare	0.50	1.00	0.05
A6	Bare	0.50	1.00	0.05
B1	Bare	0.50	1.00	0.05
B2	Bare	0.50	1.00	0.05
B3	Bare	0.50	1.00	0.05
C1	Bare	0.50	1.00	0.05
D1	Bare	0.50	1.00	0.05
E1	Bare	0.50	1.00	0.05
F1	Bare	0.50	1.00	0.05
F2	Bare	0.50	1.00	0.05
F3	Bare	0.50	1.00	0.05

PARCEL	Land use	CP FACTOR		
		Post Bulk (with BMPs)	Post Bulk (No BMPs)	Temporary Closure
G1	Bare	0.50	1.00	0.05
H1	Bare	0.50	1.00	0.05
K1	Bare	0.50	1.00	0.05
K2	Bare	0.50	1.00	0.05
J1	Bare	0.50	1.00	0.05
J2	Bare	0.50	1.00	0.05
J3	Bare	0.50	1.00	0.05
P1	Bare	0.50	1.00	0.01
P2	Bare	0.50	1.00	0.01

2.6. Estimated Erosion Rates

A = R*K*LS*CP (USLE)

Table A2.5 - Erosion Rate during Post Bulk Grading Stage (without Mitigation Measures).

Parcel	Area (ha)	R	K Factor	LS	CP	A (ton/ha/yr)	E (ton/yr)
A1	0.32	14,000	0.055	0.144	1.00	111	36
A2	2.29	14,000	0.055	0.144	1.00	111	255
A3	0.23	14,000	0.055	0.086	1.00	67	15
A4	1.49	14,000	0.055	0.088	1.00	68	101
A5	2.45	14,000	0.055	0.117	1.00	90	221
A6	1.44	14,000	0.055	0.114	1.00	88	127
B1	0.41	14,000	0.055	0.214	1.00	165	68
B2	6.02	14,000	0.055	1.284	1.00	992	5,975
B3	4.65	14,000	0.055	0.234	1.00	181	842
C1	1.69	14,000	0.055	0.131	1.00	101	171
D1	4.16	14,000	0.055	0.088	1.00	68	282
E1	1.04	14,000	0.055	0.076	1.00	59	61
F1	0.46	14,000	0.055	0.190	1.00	147	67
F2	3.02	14,000	0.055	0.190	1.00	147	443
F3	2.99	14,000	0.055	0.221	1.00	171	510
G1	3.92	14,000	0.055	0.112	1.00	87	339
H1	4.95	14,000	0.055	0.114	1.00	88	436
K1	2.49	14,000	0.055	7.387	1.00	5,707	14,219
K2	1.34	14,000	0.055	0.000	1.00	-	-
J1	2.54	14,000	0.055	0.114	1.00	88	224
J2	1.34	14,000	0.055	0.114	1.00	88	118
J3	0.75	14,000	0.055	0.144	1.00	111	84
P1	2.33	14,000	0.055	6.901	1.00	5,332	12,424
P2	0.12	14,000	0.055	0.105	1.00	81	10
	52.44						**37,027**

Table A2.6 - Erosion Rate of Project Site during Post Bulk Grading Stage (with Mitigation Measures).

Parcel	Area (ha)	R	K Factor	LS	CP	A (ton/ha/yr)	E (ton/yr)
A1	0.32	14,000	0.055	0.144	0.50	55.7	18
A2	2.29	14,000	0.055	0.144	0.50	55.7	127
A3	0.23	14,000	0.055	0.086	0.50	33.3	8
A4	1.49	14,000	0.055	0.088	0.50	33.9	51
A5	2.45	14,000	0.055	0.117	0.50	45.1	110
A6	1.44	14,000	0.055	0.114	0.50	44.0	64
B1	0.41	14,000	0.055	0.214	0.50	82.7	34
B2	6.02	14,000	0.055	1.284	0.50	495.9	2,987
B3	4.65	14,000	0.055	0.234	0.50	90.5	421
C1	1.69	14,000	0.055	0.131	0.50	50.5	86
D1	4.16	14,000	0.055	0.088	0.50	33.9	141
E1	1.04	14,000	0.055	0.076	0.50	29.5	31
F1	0.46	14,000	0.055	0.190	0.50	73.3	34
F2	3.02	14,000	0.055	0.190	0.50	73.3	221
F3	2.99	14,000	0.055	0.221	0.50	85.3	255
G1	3.92	14,000	0.055	0.112	0.50	43.3	170
H1	4.95	14,000	0.055	0.114	0.50	44.0	218
K1	2.49	14,000	0.055	7.387	0.50	2,853.5	7,109
K2	1.34	14,000	0.055	0.000	0.50	-	-
J1	2.54	14,000	0.055	0.114	0.50	44.0	112
J2	1.34	14,000	0.055	0.114	0.50	44.0	59
J3	0.75	14,000	0.055	0.144	0.50	55.7	42
P1	2.33	14,000	0.055	6.901	0.50	2,666.1	6,212
P2	0.12	14,000	0.055	0.105	0.50	40.7	5
Total	**52.44**						**18,513**

Table A2.7 - Erosion Rate of Project Site during Temporary Closure.

Parcel	Area (ha)	R	K Factor	LS	CP	A (ton/ha/yr)	E (ton/yr)
A1	0.32	14,000	0.055	0.144	0.05	5.6	2
A2	2.29	14,000	0.055	0.144	0.05	5.6	13
A3	0.23	14,000	0.055	0.086	0.05	3.3	1
A4	1.49	14,000	0.055	0.088	0.05	3.4	5
A5	2.45	14,000	0.055	0.117	0.05	4.5	11
A6	1.44	14,000	0.055	0.114	0.05	4.4	6
B1	0.41	14,000	0.055	0.214	0.05	8.3	3
B2	6.02	14,000	0.055	1.284	0.05	49.6	299
B3	4.65	14,000	0.055	0.234	0.05	9.0	42
C1	1.69	14,000	0.055	0.131	0.05	5.0	9
D1	4.16	14,000	0.055	0.088	0.05	3.4	14
E1	1.04	14,000	0.055	0.076	0.05	3.0	3
F1	0.46	14,000	0.055	0.190	0.05	7.3	3
F2	3.02	14,000	0.055	0.190	0.05	7.3	22
F3	2.99	14,000	0.055	0.221	0.05	8.5	26
G1	3.92	14,000	0.055	0.112	0.05	4.3	17
H1	4.95	14,000	0.055	0.114	0.05	4.4	22
K1	2.49	14,000	0.055	7.387	0.05	285.4	711
K2	1.34	14,000	0.055	0.000	0.05	-	-
J1	2.54	14,000	0.055	0.114	0.05	4.4	11
J2	1.34	14,000	0.055	0.114	0.05	4.4	6
J3	0.75	14,000	0.055	0.144	0.05	5.6	4
P1	2.33	14,000	0.055	6.901	0.01	53.3	124
P2	0.12	14,000	0.055	0.105	0.01	0.8	0
	52.44						**1,354**

Table 2.8 - Erosion Rate of the Project Site for Various Development Stages.

No.	Development Stage	Total Soil Loss (ton/year)
1	Post Bulk Grading Stage (without Control)	**37,027**
2	Post Bulk Grading Stage (with Control)	**18,513**
3	Temporary Closure Stage (with Control)	**1,354**

3. MODIFIED UNIVERSAL SOIL LOSS EQUATION (MUSLE)

The **Modified Universal Soil Loss Equation (MUSLE)** was used in the estimation of sediment yield per storm event as shown below:

$$T = 89.6(V*Q_p)^{0.56} (K.L.S.C.P)$$

Where T = sediment yield per storm event (tonnes)
V = runoff volume (m^3)
Q = peak discharge (m^3/s)
K = soil erodibility factor [(tonnes/ha/(MJmmha^{-1}h^{-1})]
LS = topographic factor, combination of slope steepness (S) and slope length (L). Steepness is in % while length is in meters).
C = crop management factor, representing the ratio of soil loss under a given crop to that from the bare soil (dimensionless)
P = conservation practice factor, representing measures taken to what it would have been if such conservation measures have not been taken.

3.1 Determine Rainfall Intensity (i)

Design storm = 50 mm
Duration of storm = 60 min (assumption)
Intensity of design storm, i = 50 mm/hr

3.2 Determine Peak Flow (Q)

$$Q = \frac{\mathbf{C.\ i.\ A}}{\mathbf{360}} \qquad \text{(Equation 2.3, MSMA 2)}$$

Where Q = Peak flow (m^3/s)
C = Runoff coefficient (Table 2.5, MSMA 2)
i = Average rainfall intensity (mm/hr)
A = Drainage area (ha)

3.3 Determine Runoff Coefficient (C)

Table A3.1 - Runoff Coefficient (Table 2.5, MSMA 2).

Development Stage	Land Use	C
Post Bulk Grading	Bare	0.50
Temporary Closure	Grass Cover	0.40
	Road & Detention Pond	0.95

3.4 Calculation of Peak Flow (Q)

Table A3.2 - Peak Flow (Table 2.3, MSMA 2).

Parcel	Area (ha)	C(post)	C(T-close)	i (mm/h)	Q_{post} (m^3/s)	$Q_{T\text{-}close}$ (m^3/s)
A1	0.32	0.50	0.40	50	0.022	0.018
A2	2.29	0.50	0.40	50	0.159	0.127
A3	0.23	0.50	0.40	50	0.016	0.013
A4	1.49	0.50	0.40	50	0.104	0.083
A5	2.45	0.50	0.40	50	0.170	0.136
A6	1.44	0.50	0.40	50	0.100	0.080
B1	0.41	0.50	0.40	50	0.029	0.023
B2	6.02	0.50	0.40	50	0.418	0.335
B3	4.65	0.50	0.40	50	0.323	0.258
C1	1.69	0.50	0.40	50	0.118	0.094
D1	4.16	0.50	0.40	50	0.289	0.231
E1	1.04	0.50	0.40	50	0.072	0.058
F1	0.46	0.50	0.40	50	0.032	0.025
F2	3.02	0.50	0.40	50	0.210	0.168
F3	2.99	0.50	0.40	50	0.208	0.166
G1	3.92	0.50	0.40	50	0.272	0.218
H1	4.95	0.50	0.40	50	0.344	0.275
K1	2.49	0.50	0.40	50	0.173	0.138
K2	1.34	0.50	0.40	50	0.093	0.074
J1	2.54	0.50	0.50	50	0.176	0.176
J2	1.34	0.50	0.50	50	0.093	0.093
J3	0.75	0.50	0.50	50	0.052	0.052
P1	2.33	0.50	0.95	50	0.162	0.307
P2	0.12	0.50	0.95	50	0.008	0.015

3.5 Calculation of Runoff Volume (V)

Table A3.3 – Runoff Volume

Parcel	Area (m^2)	Post Bulk Grading				Temporary Closure			
		HSG	CN	R_{post} (mm)	V_{post} (m^3)	HSG	CN	$R_{T\text{-}close}$(mm)	$V_{T\text{-}close}$ (m^3)
A1	3,233	D	94	37.5	121.2	D	80	15.6	50.4
A2	22,859	D	94	37.5	857.2	D	80	15.6	356.6
A3	2,255	D	94	37.5	84.6	D	80	15.6	35.2
A4	14,915	D	94	37.5	559.3	D	80	15.6	232.7
A5	24,476	D	94	37.5	917.9	D	80	15.6	381.8
A6	14,430	D	94	37.5	541.1	D	80	15.6	225.1
B1	4,132	D	94	37.5	155.0	D	80	15.6	64.5
B2	60,241	D	94	37.5	2259.0	D	80	15.6	939.8
B3	46,529	D	94	37.5	1744.8	D	80	15.6	725.8
C1	16,944	D	94	37.5	635.4	D	80	15.6	264.3
D1	41,577	D	94	37.5	1559.1	D	80	15.6	648.6
E1	10,352	D	94	37.5	388.2	D	80	15.6	161.5
F1	4,579	D	94	37.5	171.7	D	80	15.6	71.4
F2	30,187	D	94	37.5	1132.0	D	80	15.6	470.9
F3	29,914	D	94	37.5	1121.8	D	80	15.6	466.7
G1	39,180	D	94	37.5	1469.3	D	80	15.6	611.2
H1	49,477	D	94	37.5	1855.4	D	80	15.6	771.8
K1	24,914	D	94	37.5	934.3	D	80	15.6	388.7
K2	13,394	D	100	50.0	669.7	D	100	50.0	669.7
J1	25,414	D	94	37.5	953.0	D	80	15.6	396.5
J2	13,416	D	94	37.5	503.1	D	80	15.6	209.3
J3	7,537	D	94	37.5	282.6	D	80	15.6	117.6
P1	23,299	D	94	37.5	873.7	D	80	50.0	1164.9
P2	1,169	D	94	37.5	43.9	D	80	50.0	58.5
Total	**524,424**				**19,833.3**				**9,483.5**

3.6 Estimated Sediment Yield

Table A3.4 – Sediment Yield of the Project Site during Post Bulk Grading Stage without Mitigating Measures.

Parcel	Area (ha)	V (m^3)	Q_{post} (m^3/s)	K Factor	LS	CP	Y (tonne)
A1	0.32	121.2	0.022	0.055	0.144	1.00	1.25
A2	2.29	857.2	0.159	0.055	0.144	1.00	11.17
A3	0.23	84.6	0.016	0.055	0.086	1.00	0.50
A4	1.49	559.3	0.104	0.055	0.088	1.00	4.22
A5	2.45	917.9	0.170	0.055	0.117	1.00	9.76
A6	1.44	541.1	0.100	0.055	0.114	1.00	5.27
B1	0.41	155.0	0.029	0.055	0.214	1.00	2.44
B2	6.02	2259.0	0.418	0.055	1.284	1.00	294.35
B3	4.65	1744.8	0.323	0.055	0.234	1.00	40.21
C1	1.69	635.4	0.118	0.055	0.131	1.00	7.24
D1	4.16	1559.1	0.289	0.055	0.088	1.00	13.29
E1	1.04	388.2	0.072	0.055	0.076	1.00	2.44
F1	0.46	171.7	0.032	0.055	0.190	1.00	2.43
F2	3.02	1132.0	0.210	0.055	0.190	1.00	20.08
F3	2.99	1121.8	0.208	0.055	0.221	1.00	23.11
G1	3.92	1469.3	0.272	0.055	0.112	1.00	15.87
H1	4.95	1855.4	0.344	0.055	0.114	1.00	20.97
K1	2.49	934.3	0.173	0.055	7.387	1.00	630.07
K2	1.34	669.7	0.093	0.055	0.000	1.00	-
J1	2.54	953.0	0.176	0.055	0.114	1.00	9.94
J2	1.34	503.1	0.093	0.055	0.114	1.00	4.86
J3	0.75	282.6	0.052	0.055	0.144	1.00	3.22
P1	2.33	873.7	0.162	0.055	6.901	1.00	546.11
P2	0.12	43.9	0.008	0.055	0.105	1.00	0.29
TOTAL	**52.44**	**19,833.3**					**1,669.09**

Table A3.5 – Sediment Yield of the Project Site during Post Bulk Grading Stage (with Mitigation Measures).

Parcel	Area (ha)	V (m^3)	Q_{post} (m^3/s)	K Factor	LS	CP	Y (tonne)
A1	0.32	121.2	0.022	0.055	0.144	0.50	0.62
A2	2.29	857.2	0.159	0.055	0.144	0.50	5.58
A3	0.23	84.6	0.016	0.055	0.086	0.50	0.25
A4	1.49	559.3	0.104	0.055	0.088	0.50	2.11
A5	2.45	917.9	0.170	0.055	0.117	0.50	4.88
A6	1.44	541.1	0.100	0.055	0.114	0.50	2.64
B1	0.41	155.0	0.029	0.055	0.214	0.50	1.22
B2	6.02	2259.0	0.418	0.055	1.284	0.50	147.18
B3	4.65	1744.8	0.323	0.055	0.234	0.50	20.11
C1	1.69	635.4	0.118	0.055	0.131	0.50	3.62
D1	4.16	1559.1	0.289	0.055	0.088	0.50	6.65
E1	1.04	388.2	0.072	0.055	0.076	0.50	1.22
F1	0.46	171.7	0.032	0.055	0.190	0.50	1.21
F2	3.02	1132.0	0.210	0.055	0.190	0.50	10.04
F3	2.99	1121.8	0.208	0.055	0.221	0.50	11.56
G1	3.92	1469.3	0.272	0.055	0.112	0.50	7.94
H1	4.95	1855.4	0.344	0.055	0.114	0.50	10.48
K1	2.49	934.3	0.173	0.055	7.387	0.50	315.03
K2	1.34	669.7	0.093	0.055	0.000	0.50	-
J1	2.54	953.0	0.176	0.055	0.114	0.50	4.97
J2	1.34	503.1	0.093	0.055	0.114	0.50	2.43
J3	0.75	282.6	0.052	0.055	0.144	0.50	1.61
P1	2.33	873.7	0.162	0.055	6.901	0.50	273.06
P2	0.12	43.9	0.008	0.055	0.105	0.50	0.15
TOTAL	**52.44**	**19,833.3**					**834.55**

Table A3.6 – Sediment Yield of the Project Site during Temporary Closure with Mitigating Measures

Parcel	Area (ha)	V (m^3)	$Q_{T\text{-close}}$ (m^3/s)	K Factor	LS	CP	Y (tonne)
A1	0.32	50.4	0.018	0.055	0.144	0.05	0.03
A2	2.29	356.6	0.127	0.055	0.144	0.05	0.30
A3	0.23	35.2	0.013	0.055	0.086	0.05	0.01
A4	1.49	232.7	0.083	0.055	0.088	0.05	0.11
A5	2.45	381.8	0.136	0.055	0.117	0.05	0.26
A6	1.44	225.1	0.080	0.055	0.114	0.05	0.14
B1	0.41	64.5	0.023	0.055	0.214	0.05	0.07
B2	6.02	939.8	0.335	0.055	1.284	0.05	7.95
B3	4.65	725.8	0.258	0.055	0.234	0.05	1.09
C1	1.69	264.3	0.094	0.055	0.131	0.05	0.20
D1	4.16	648.6	0.231	0.055	0.088	0.05	0.36
E1	1.04	161.5	0.058	0.055	0.076	0.05	0.07
F1	0.46	71.4	0.025	0.055	0.190	0.05	0.07
F2	3.02	470.9	0.168	0.055	0.190	0.05	0.54
F3	2.99	466.7	0.166	0.055	0.221	0.05	0.62
G1	3.92	611.2	0.218	0.055	0.112	0.05	0.43
H1	4.95	771.8	0.275	0.055	0.114	0.05	0.57
K1	2.49	388.7	0.138	0.055	7.387	0.05	17.01
K2	1.34	669.7	0.074	0.055	0.000	0.05	-
J1	2.54	396.5	0.176	0.055	0.114	0.05	0.30
J2	1.34	209.3	0.093	0.055	0.114	0.05	0.15
J3	0.75	117.6	0.052	0.055	0.144	0.05	0.10
P1	2.33	1164.9	0.307	0.055	6.901	0.01	9.19
P2	0.12	58.5	0.015	0.055	0.105	0.01	0.00
TOTAL	**52.44**	**9,483.5**					**39.57**

Table 3.7 – Sediment Yield of the Project Site for Various Development Stages.

No.	Development Stage	Runoff Volume (m^3)	Sediment Yield (ton)
1	Post Bulk Grading Stage (without Control)	**19,833.3**	**1,669.09**
2	Post Bulk Grading Stage (with Control)	**19,833.3**	**834.55**
3	Temporary Closure Stage (with Control)	**9,483.5**	**39.57**

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