Construction

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PART F

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CONSTRUCTION

F1 Construction

Goal

Construct roads in the wet tropics region efficiently with minimal impacts on the environment and community.

Principles

Construction of roads in the wet tropics region should be based on the following principles:

- Comply with contract documentation.
- Ensure contractors are familiar with and experienced in the necessary environmental protection techniques.
- Prevent and minimise accidental environmental harm through exercising environmental due diligence.
- Assess contractor performance and record areas of non-performance through implementation of an auditing process.
- Ensure the Contractors EMP (Construction) outlines an action strategy and establishes a due diligence system adhering to environmental regulations and contract conditions.
- The EMP (Construction) is to reflect best practice environmental management and to enhance environmental performance.
- Minimise disturbance to vegetation, watercourses, soil and the community.
- Ensure Construction activities minimise sedimentation and erosion through implementing effective control measures.
- Minimise the generation of dust, noise and disturbance by light.
- Progressively revegetate disturbed areas during road corridor construction using native species.
- Ensure construction activities utilise uncontaminated materials by inspecting prior to use, and maintain material hygiene at all times.
- Minimise visual impacts and environmental disturbance at site camps.
- Schedule construction activities to achieve efficiency and minimal risk of environmental harm.
- Dispose of wastes in an environmentally friendly manner.

F2 Construction Process

Overview of the Construction Process

The environmental aspects of the construction process are set out in section four. Essentially the construction process involves:

- **Construction Quality Plan:** The Construction Quality Plan sets out the quality requirements, safety requirements and environmental requirements during construction.

- **EMP (Construction):** The EMP Construction is prepared by the construction contractor and sets out the specific undertakings for the necessary environmental protection responsibilities, measures, monitoring and auditing to be undertaken by the Contractor in order to achieve the environmental requirements set out in the contract.

Considering Planning and Design Outcomes

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The desired outcome is to ensure planning and design outcomes are incorporated in construction approaches.

For the Contractor and contract administrators to successfully undertake the work they need to have a sound knowledge of the reasons for the various design components and the planning basis of the project. This is particularly important where there are significant environmental protection measures.

Best Practice Guidelines:

Provide a construction contract which reflects environmental measures.

Conduct on site briefings for the contractor and the contract administrators, attended by the designers and any environmental consultants, to cover the various details in the contract documents.

Contractor Selection (Tendering Process)

The desired outcome is to consider environmental management experience and commitment in contractor selection.

The contractor undertaking the work in environmentally sensitive areas should be competent to undertake the work and have experience in successfully undertaking similar work.

Best Practice Guidelines:

Base the selection of a contractor not only on price but also on ability and previous successful experience in undertaking environmentally sensitive work.

It is desirable that the non-price weighting should be assessed, based on the extent of environmentally sensitive work within the contract.

Ultimately the need for an environmental management system will become a prequalification requirement and a component of the tendering process. This is expected to be phased in.

Training/Education

The desired outcome is to ensure that all relevant construction personnel are aware of the environmental requirements for the project.

In order for contractors, plant operators and contract administrators to effectively undertake the construction it is necessary for them to have a good understanding of exactly what is required, but to also understand the reasons for the various environmental design elements within the contract. Understanding environmental controls will be divided into two parts:

- the contract specification and drawings will detail the work to be undertaken including controls on clearing etc. This will provide the what, how, when and where; and

- through the Environmental Design Report this will provide information and background data on why certain elements have been included in the design. This will be used to convey the need for the various design elements (the 'why').

It is therefore important that prior to construction commencing or early in the construction process training courses are run to bring the awareness of all personnel on the site to an appropriate level.

Best Practice Guidelines:

Prestart training courses on this Manual and EMP (Construction) for all personnel to be a condition of contract.

For larger or longer duration project provide small guide booklets on environmental management for all personnel.

Subcontractors entering the site have to be briefed and aware of the EMP requirements.

Ensure contract documents adequately detail the necessary work to be undertaken, training needs and responsibilities set out in the EMP.

Use the Environmental Design Report as a basis for training in order to outline the need for environmental procedures and the reasons for them.

Ensure a training program is in place for new, replacement and temporary staff.

Training is to stress that the contractor/road owners will regard breaches of environmental conditions similar to poor performance in other contractual areas.

Contractual Obligations

The desired outcome is to include environmental requirements as contractual obligations.

The contract documents should be prepared and in sufficient detail that the contractor is aware of their environmental obligations and responsibilities. For the development and implementation of environmental management plans, there are essentially two approaches that can be made:

- contractor is responsible for the preparation, implementation and performance of the EMP (Construction); or
- Road Owner develops the EMP and provides schedule items for its implementation.

The Road Owner should develop the environmental elements to be included in the EMP based on the REF and/or IAS and the Design Report.

The first approach puts the risk on the contractor usually with no separate payment for the implementation of the EMP. However, not all contractors may provide effective plans, nor properly scope the environmental protection work required, and hence may underbid this item resulting in a more competitive bid price. Those contractors who diligently prepare a plan may be disadvantaged in the tender process if it is based solely on price.

The second method requires the Road Owner to develop the EMP and provide standard items to cover the cost. The responsibility for the plan and its implementation would be with the Road Owner. However, it may ensure that the Road Owner achieves an acceptable plan and would place all contractors on an equal footing in the tender process.

The method to be adopted will depend on the experience of the contractors and the risk the Road Owner is prepared to undertake.

Other areas that may be considered include requirements for the contractor to rehabilitate any clearing undertaken outside the allowed limit of works.

Best Practice Guidelines:

Provide severe contract penalties for operations which are not consistent with the EMP (Construction) particularly any additional disturbance of vegetation or creeks.

Provide contract incentives for construction which meets all environmental performance requirements.

Ensure each contract and subcontract contain provisions for repair and revegetation of areas cleared outside the limit of earthworks at the contractor's expense.

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Provide sufficient and full detail in the contract documents on the requirements for the EMP (Construction).

Ensure all aspects are covered in the specification including:

- erosion and sediment control;
- training of personnel;
- dust control;
- clearing;
- revegetation;
- noise control;
- land contamination;
- acid sulphate soils;
- weed control;
- rehabilitation;
- waste management;
- fauna conservation;
- flora conservation;
- water quality;
- social impact; and
- storage and maintenance of construction machinery on site.

Contracts are to provide for 'force majeure'.

Environmental Responsibilities and Due Diligence

The desired outcome is to have established and communicated environmental responsibilities and a due diligence process.

The Queensland Environmental Protection Act establishes a general environmental duty. This is defined as:

"*A person should not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm...*"

There are a number of criteria to be used to decide the reasonable and practicable measures required:

a) *"the nature of the harm or potential harm;*

b) *the sensitivity of the receiving environment;*

c) *the current state of technical knowledge for the activity;*

d) *the likelihood of successful application of the different measures that might be taken; and*

e) *the financial implications of the different measures as they would relate to the type of activity."*

The general environmental duty is further strengthened and clarified by establishing a duty to notify environmental harm. The Act requires that a person (while carrying out an activity) who becomes aware that "*serious or material environmental harm*" is occurring (other than when sanctioned by the Act eg., in accordance with an EMP) should "*as soon as reasonably practicable*" tell the "*employer*" or the "*administrating authority*" (either DMR or in some cases the Local Government). In the case of an employee (which includes being employed, engaged, contracted or acting as an agent), the employer should immediately give written notice to the "*administering authority*".

Of specific relevance are the Due Diligence provisions of the EPA 1994. Due Diligence is defined as:

"*exercise of all reasonable care by the establishment of a proper management system designed to prevent commission of the offence and ability to demonstrate that all reasonable steps to ensure the effective operation of the system*".

Demonstrating due diligence is one reason for adopting and implementing an Environmental Management System (EMS). The Department of Environment has set out principles of due diligence, all of which are addressed by an EMS.

An international standard ISO 14001, provides guidelines for the development and implementation of environmental management systems. Construction entities can set out and implement an environmental management system for all their relevant operations. There does not have to be a unique environmental management system prepared for each construction project, the site specific environmental requirements are set out in the EMP (Construction).

Best Practice Guidelines:

Best practice for all construction entities (both head contractors and sub-contractors) is to have a documented and implemented environmental due diligence systems in place. As a minimum, the road construction authority (DMR, Local Government etc.), any consultant project manager, engineer, or superintendent and contractors should have a documented reporting process between them.

Install a pollution prevention system to ensure compliance with environmental legislation.

Plan to establish a pollution prevention system for a specific enterprise.

Plan to operate a pollution prevention system which is evaluated regularly for its effectiveness.

Ensure that the ultimate responsibility is recognised (for a company is the Board of Directors, for Government bodies, the Chief Executive Officer). Regular reports are to be provided on compliance of the system.

Directors and Executive Officers need to be aware of the environmental standards in their industry and other industries which deal with similar environmental pollutants or risks.

Directors and Executive Officers need to be aware of all environmental laws covering their enterprise.

Ensure those with ultimate responsibility deal personally with system failures.

Auditing

The desired outcome is to measure compliance with environmental management requirements throughout the construction process and correct problems before environmental impacts occur.

Auditing is required to ensure that the various design elements, including the construction techniques being adopted, are working effectively and are achieving the design objectives.

Best Practice Guidelines:

Develop an auditing program that measures the performance of the EMP (Construction). The extent of auditing will depend on the size and nature of the contract and should be developed for each job. Items that may be considered include:

- monitoring of water quality both upstream and downstream;
- inspection of log book of sediment structures, including installation dates, clearing dates and volumes;
- inspection of records of daily rainfall; and
- extent and timing of environmental audits.

It is desirable for the auditor to be accredited with the Register of Certified Auditor. Auditing can usually be undertaken by the contractor (either staff trained in audits or specialist consultants).

Where an audit does find that the EMP is not producing the desired outcomes (where an environmental impact is occurring despite compliance with the measures set out in the EMP) it should be immediately amended to rectify the problem and ongoing corrective actions identified.

Environmental auditing processes are to be linked with performance assessment. It should provide feedback to the contractor to allow flexibility in achieving the end point objectives. This is in contrast to simply completing a series of procedures which may or may not achieve the end point objectives. The auditing program is to confirm the timing of further assessment and maintenance work required after all contracted work is completed.

F3 Construction Procedures

Minimising Disturbance

The desired outcome is to minimise disturbance to natural areas, vegetation and soil during construction.

Disturbance to areas with intact soil and vegetation can result in a number of effects. Invasion by weed species is one of the most common concerns as competition between weed and native species can lead to outbreaks of exotic species. This is due to the greater amounts of light along the road corridor which encourage exotic rather than native species.

Where inspections have discovered sites along the route where soil/plant pathogens are active (eg areas of dieback), soil should not be moved beyond the existing area of infestation and strict hygiene measures should be adopted to restrict the spread of the pathogens.

By minimising disturbance there is potential to reduce the amount of soil erosion outside the construction zone. By achieving this, there is a reduced need for revegetation and implementation of soil erosion and sedimentation measures.

Best Practice Guidelines:

Restrict areas of disturbance to the construction zone. Establish boundaries to the construction area and tape off - all imports to be confined to this area.

Set out and fence areas to confine disturbance away from native vegetation, drainage lines and any identified cultural sites.

Set out and fence the entrance of the construction area, stockpile sites, storage areas and camp before any clearing begins.

Maintain as much canopy closure as possible minimising light penetration along the road corridor.

Ensure all site workers, subcontractors, delivery companies and their drivers are fully aware of their responsibilities with regards to all environmental issues especially, erosion and sedimentation issues.

Ensure access to the site is controlled or restricted to legitimate traffic.

Avoid paving, grading, or the placing of stockpiles within the drip line of trees. Only when this cannot be avoided, apply the following conditions. As a minimum have no closer than 1.5 m to tree trunks and place a coarse gravel bed under all fill layers to allow air and water to circulate through the root zone.

When felling trees ensure that they fall parallel to or towards the roads centrelines. This may require trees to be manually cut down with a chainsaw, or pulled over by machinery. In confined areas, use vertical demolition, where trees are felled gradually through lopping branches. This can be done such that all the tree falls within its original canopy extent.

If practical creek, stream and gully crossings should be constructed first or constructed before the next earthwork area is commenced on the opposite bank, to reduce the disturbance to the watercourse and also the number of temporary crossings.

Ensure that all vegetation to be removed is clearly marked and all vegetation to be retained is clearly indicated. Also, ensure that (sub)contractors understand marking protocols.

Temporary crossings should only be constructed away from the position of the permanent culvert to allow for movement of construction traffic and the construction of the permanent culverts where there are no prudent and feasible alternatives.

As a minimum, temporary crossings should have cellular confinement (a three dimensional material which, when extended, can have ballast size rocks and or sand placed within the honeycomb like cells) placed on the banks and bed

Strip and stockpile the topsoil along the tops of cuts and the bases of fills (in areas which will need to be cleared anyway) where practicable, instead of large stockpiles requiring separate cleared areas away from any drainage lines.

Choose machinery consistent with the minimal disturbance constraints which will be enforced in particular areas eg., loader and trucks versus scrapers and dozers. While the scrapers and dozers have a high output, the constraint may be there are no areas designated which can be cleared for turning areas.

Where possible, plants and propagules from on site (ie epiphytes) should be recovered and stored for later reintroduction to the site.

Earthworks

The desired outcome is to minimise environmental impacts from earthworks.

Protecting earthworks is one of the most important factors in undertaking road corridor construction. During construction, sedimentation and erosion techniques should be implemented to satisfy appropriate standards. Adequate drainage should ensure that all runoff over the construction zone is collected and disposed of in a suitable manner. Further, all clean stormwater entering the site should be diverted away. Topsoil stockpiles, road cuttings, batters and benches, embankments, spoil and borrow should all require the implementation of erosion and sedimentation control techniques.

Best Practice Guidelines:

Shape the fill during construction with cross-fall towards the upstream edge of the formation.

Shape the fill over cross-drainage structures so runoff is directed to sedimentation devices on both sides of the structures inlet.

There should be no disturbance to topsoil outside the road construction zone.

Vegetation should be retained in areas likely to be subject to landslides as assessed by geotechnical studies.

Where practical, blasting of rock should be undertaken before the overburden is removed to reduce the noise to an absolute minimum. Where possible use expanding 'explosives' rather than blasting.

Works undertaken to treat ground water should consider potential for erosion and sedimentation. Outfall points of open drains which are excavated should utilise erosion and sedimentation techniques.

When embankment material is spread over the construction zone, the outer edges of the fill should generally be higher than that of the remainder to ensure scouring and erosion does not occur when water crosses the surface. In order to avoid ponding, temporary drainage structures such as drop pipes can be used to drain the earthworks without causing erosion (ensure adequate measures at discharge point).

Drains should be cut into the edge of fills to ensure runoff does not cross undisturbed areas.

Ensure identification of all potential areas of acid sulfate soils by using the Department of Natural Resources map. If potential acid sulfate soils are found, works should only proceed once a treatment regime has been established based on specialist advice.

Construct berms on the edge of fills after the sub-base and base-course pavement have been constructed to contain runoff inside the construction area.

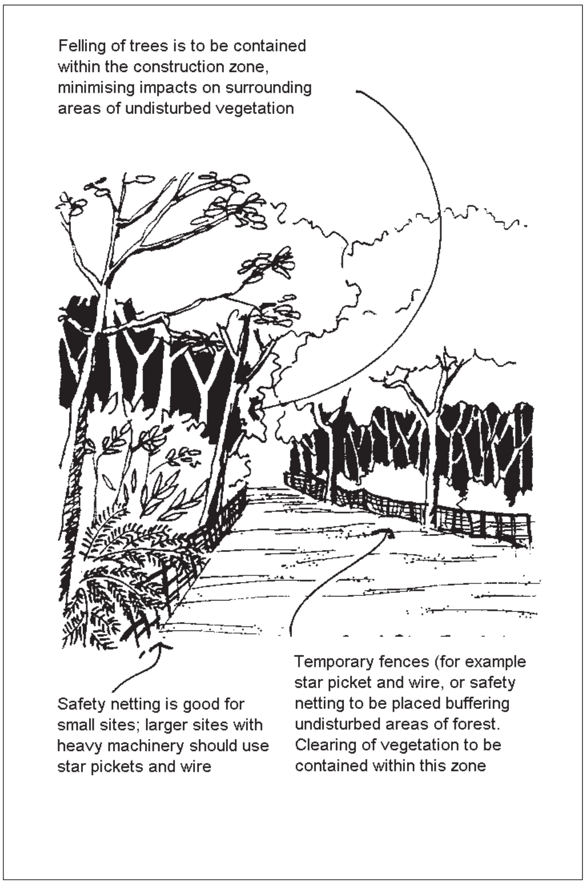


Figure 44 Minimising Clearing

Survey and Construction Markings

The desired outcome is to ensure survey and construction markings are not visually obtrusive in the long term.

As survey markings, both permanent and temporary are essential before, during and after construction they need to be easily found and identified. However, the permanent survey marks are the only ones which need to be retained for later use and as such all temporary markings should be removed on completion of the project.

Best Practice Guidelines:

Do not use permanent paint on rock faces and ensure that any essential temporary markings are removed from the rock face on completion. After construction, remove all picks, stakes and flagging used as temporary markers.

Identify and clearly mark on fences the areas set aside for accesses, stockpile areas and wash down bays. Only temporary, non-damaging methods and materials to be used to mark vegetation where it is to be retained.

Keeping the Top Soil

The desired outcome is that disturbed top soil is kept alive and placed in areas for revegetation.

Topsoil is often the most important factor in successful rehabilitation, particularly where the objective is to restore a native ecosystem. The topsoil contains the majority of the seeds and other plant propagules (such as rhizomes, lignotubers, roots etc.), soil micro-organisms, organic matter and much of the available plant nutrients.

Once removed topsoil should be directly returned to areas for use in revegetation rather than storing it in stockpiles for later use. The advantages of this are that it reduces the land requirement of stockpiles, it avoids double handling and avoids the loss in quality of the soil resource brought about by stockpiling. Stockpiles become anaerobic, soil structure deteriorates, organic matter and nutrients may be lost, seeds deteriorate, other plant propagules die and populations of beneficial soil micro-organisms are reduced.

Furthermore, research has shown that both the density and number of species of native plants are significantly decreased when an area is rehabilitated with stockpiled rather then directly returned top soil.

Best Practice Guidelines:

When removing topsoil the complete A1 soil horizon (the layer of mineral/organic material) should normally be removed. Avoid stripping deeper soils which have poor structure or high clay content.

Cleared vegetation should be windrowed on the contour away from flow lines and water courses. Cleared vegetation should be respread on disturbed areas along the contour to reduce erosion, aid vegetation removal provide habitat for fauna and to discourage access to rehabilitating areas.

In cases where the A1 horizon is not obvious the top 100-300 mm of soil should be recovered. Geotechnical surveys should give an indication of soil depth.

Soils should not be stripped or replaced when either too wet or too dry, as this can lead to compaction, loss of structure, and loss of viability of seeds and *mycorrhiza inoculum*.

It is preferable to reuse the topsoil immediately rather than storing it in stockpiles. Progressive rehabilitation works may allow for this.

If the top soil should be stockpiled then it should be for as short a time as possible and:

- the stockpiles need to be as long and low as possible with a large surface area around 1.5 m high;
- the stockpiles should be revegetated to protect the soil from erosion, discourage weeds and maintain active populations of beneficial soil microbes;
- the stockpiles should be located where they will not be disturbed as excessive handling will adversely affect soil structure;
- ensure stockpiles are not located in areas such as drainage lines;
- locate stockpiles on flat ground, away from areas subject to concentrated

overland flow;

- construct a perimeter bank or catch drain around the top of the stockpile to protect it from upslope runoff;
- construct a perimeter bank or catch drain or sediment fence around the bottom of the stockpile to trap sediment or direct sediment-laden runoff to a sediment trap;
- perimeter banks should be located so as to allow access to the stockpile, preferably from the side;
- cover stockpiles which will be stored for over one month with sprayed papermix mulch. This keeps moisture in and reduces erosion; and
- stockpile areas should be rehabilitated as soon as possible after the topsoil has been removed.

Identify and clearly mark or fence accesses, stockpile areas and wash down bays.

The area to be stripped should be cleared of all debris including fences, wire, timber, rocks, etc. Timber, rocks should be stockpiled for later reintroduction to the site.

Reduce vegetative cover prior to stripping, by slashing or mowing.

Excessive vegetative growth makes topsoil removal more difficult. Also, large quantities of green matter in stockpiles promotes chemical and biological degradation of plant material such as runners and root stocks, which would otherwise be a source of regrowth when topsoil is respread.

Stockpiles and spoil dumps should be free draining.

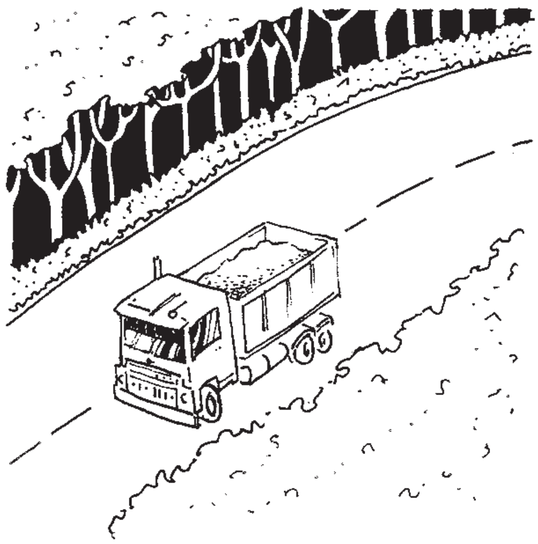
Vehicles should not be allowed to travel over the stockpile. Stripped topsoil from onsite is generally preferable to imported topsoil.

Soil testing should be undertaken on all imported topsoil used in revegetation programs. Soil ameliorants should be added, if necessary, to correct pH or soil structure.

Any imported topsoil should definitely be weed free.

As a guide, topsoil should preferably be:

- neutral in pH, friable, sandy loam, and have a good texture and structure ;
- free from large clods, lumps of subsoil, nut grass, perennial weeds and their roots, and any other deleterious material;
- free of stones larger than 25 mm (maximum dimension) with no more than 5% of the material retained by a 1.2 mm AS sieve, and contain not less than 2% organic matter; and
- within a suitable pH range when laid.



Excess earthworks material must not be dumped on roadside or in forested areas and should be transported to an approved site to be stored or stockpiled... for example, at old quarries

Figure 45 Disposal of Material

Topsoil should be handled only when in a moist condition. Many topsoils lose their texture, structure and consistency if they are handled when too dry. Conversely, some soils will pug (set very hard in large clods when dried) if they are too wet when handled.

Weed-infested soil from low lying areas should not be moved up slope where drier conditions have previously discouraged or prevented weed dispersal and development.

Ideally, topsoil should be re-spread in the reverse sequence to its removal so that the organic layer, containing any seed or vegetative parts, is returned to the surface.

Topsoil should be spread over a scarified surface to a compacted depth of about:

- 40 to 60 mm on lands where the slope exceeds 4(H):1(V), or
- 75 to 100 mm on lesser slopes.

If possible, on moderate slopes, topsoil should be tapered from a thickness of 100 mm at the top of the slope, to 75 mm at the bottom to allow for downward creep of the soil.

Generally, topsoil should not be applied to constructed slopes steeper than 2(H):1(V) where keying is not possible. Alternative bioengineering methods of revegetation/rehabilitation should be considered (refer to Coppin & Richards 1990; Maccaferri 1990; and US Soil Conservation Service 1992).

Compaction can be done by dozer tracks. On low slopes the first few runs can be done across the slope, but the final runs should be up and down the slope.

After spreading topsoil, ensure the surface is left in a scarified (roughened) condition to assist moisture infiltration and inhibit soil erosion.

Drainage/Stormwater

The desired outcome is to establish a drainage system during construction which prevents erosion and allows only clean stormwater to leave the site.

Drainage structures are designed to catch, control and dispose of water. Catch drains, diversion drains, drainage culverts, bridges and energy dissipators are drainage structures which not only dispose of runoff, but assist in preventing erosion. Subsurface drainage structures are used to intercept and remove ground water ensuring that the road surface itself is not damaged.

Catch drains are generally located at the top of proposed cuttings to direct runoff towards diversion drains and inlets of cross-drainage culverts. Diversion drains tend to divert water from catch drains to an outlet at a stable location that prevents scouring and erosion. Drainage culverts and bridges are used in areas where the road corridor crosses creeks, depressions and other natural drainage channels. By using these drainage structures the flow of water should enter and discharge at the natural surface. Energy dissipators can be used with all of the above drainage structures as a general technique to reduce the flow velocity and energy of the water and thus minimise the potential for scouring and erosion.

Other drainage measures which can be implemented to reduce the effects of erosion and sedimentation include sediment traps and basins, batter toe drains, median drains, table drains and pavement drainage culverts. Sediment traps and basins are used to still and filter runoff from the construction site before entering culverts, channels and natural watercourses. Batter toe drains are located at the toes of fill batters and are designed to collect runoff from batter slopes and direct it to drainage culverts and other watercourses. Median drains direct roadway runoff from medians to pavement drainage culverts via drop inlet structures.

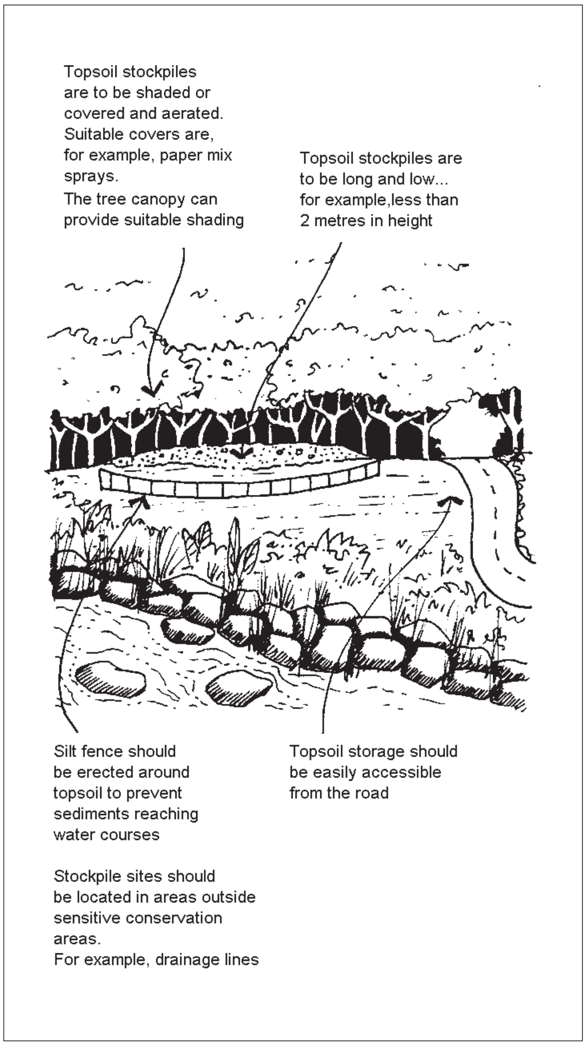


Figure 46 Topsoil Storage

Table drains are located at the sides of road corridors and collect runoff from the road surface and direct it to pavement drainage culverts which return the runoff to natural watercourses.

Best Practice Guidelines:

Plan construction activities in stages to reduce the amount of exposed, erodable area to a minimum.

On unsealed roads and roadside ditches, properly spaced cross-drains should be constructed to channel water away from the road structure and into surrounding stable areas.

During the wet season or at any other times of the year when rain is a frequent occurrence, installation of temporary catch drains upslope of exposed areas are required. This may involve increased vegetation clearance, the impact of which must be balanced against erosion /sedimentation impacts.

Ensure monitoring and maintaining temporary and permanent drainage devices is a continual activity during construction. Note that in some areas where cuttings are required the temporary drains may require lining with plastic as infiltration of water may cause the batters to be unstable.

When crossing a creek the maximum width used should be 6 m across a stable section, removing the minimum amount of vegetation. Do not divert or store water in the crossing; angle the access ramp downstream and provide erosion and sediment traps. Do not disturb natural stream banks. The maximum allowable cut and fill in the creek is 0.6 m. When the stream bed is not boulders or base rock, use cellular confinement material with rock placement on top to protect the running surface of the bank soil bed.

Erosion and Sediment Control

The desired outcome is to minimise erosion and ensure only clean stormwater leaves the site.

Soil erosion and sedimentation can have the potential to impact upon many areas outside and within the construction zone of a road corridor. Erosion and sedimentation can result from the clearing of vegetation; the installation of drainage structures; removal, storage and reuse of topsoil, during earthworks and whilst revegetation is being undertaken. During each of these stages, techniques have been developed to control the extent and frequency of erosion and sedimentation.

By implementing best practice roadworks development, construction activities and work methods which involve soil conservation practices the potential for erosion and sedimentation will be minimised. The following principles should be applied:

- avoid uncontaminated runoff from outside the construction area passing through the work zone;
- expose the smallest practical area of land for the shortest possible time;
- divide runoff from the construction area into manageable portions which can either be diverted to stable areas or treated by suitable sediment trapping or settlement devices before entering natural watercourses;
- reduce runoff velocities at drainage outlets to non-erosive levels; and
- progressively revegetate exposed areas during construction (NSW Department of Main Roads 1984).

Figure 47 Cellular Confinement

Best Practice Guidelines:

Ensure the EMP (Construction) includes an erosion and sediment control program and that this is implemented.

The IEAUST Soil Erosion and Sediment Control Engineering Guidelines for construction sites section on monitoring should be implemented where practicable.

On larger projects, clear progressively to minimise exposure of soil.

Undertake clearing on areas that are programmed to have works undertaken at particular phases. Only clear areas actively being worked on.

Establish erosion and sedimentation control measures prior to undertaking work activities in new areas.

Where feasible roads should be constructed only during the dry season (major works in particular).

Exposed areas should be suitably contoured and roughened to reduced velocity of runoff, delay stormwater runoff and increase the potential of stormwater infiltration.

Establish a drainage system which allows runoff from outside the works area to pass through the site uncontaminated. This can be achieved by providing catch and diversion drains, check banks, sediment stilling basins and cross-drainage culverts with energy dissipators to provide protection against erosion.

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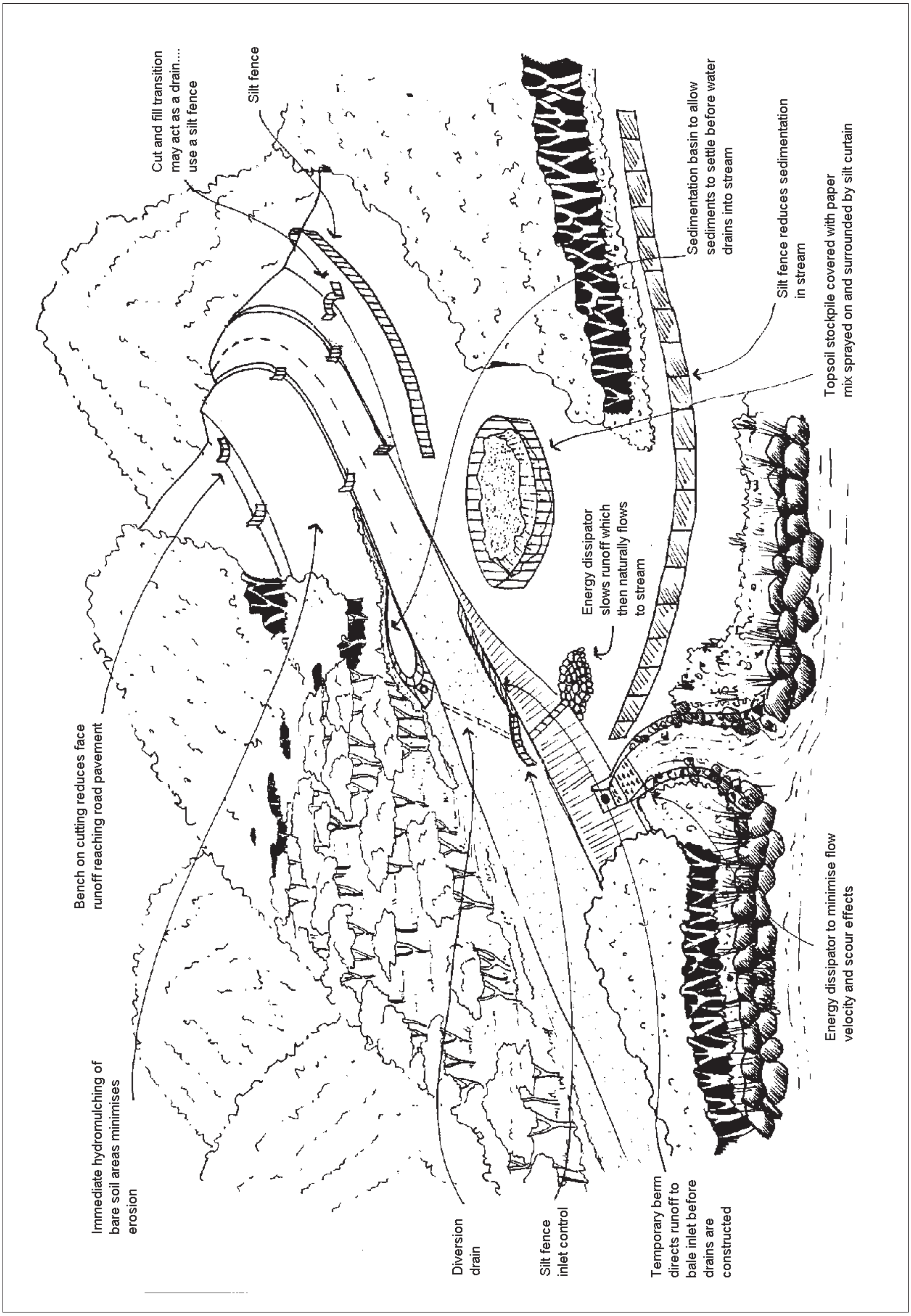

Figure 48 Temporary Sediment Control

Implement erosion and sedimentation control measures prior to vegetation clearance and removal of topsoil. Sediment basins should be constructed at this stage of construction. Clear only the area required for construction of these devices and to gain access to them.

Median and table drains should (if possible), be introduced prior to earthworks operations as this will provide a more permanent drainage system.

Implement measures to control runoff from exposed slopes if required. This will help in filtering the surface runoff.

Topsoil should not be removed until appropriate measures are introduced to control erosion and sedimentation. Topsoil removal should only occur in areas ready for earthworks commencement.

Maintain and repair drainage, erosion and sediment control devices.

Ensure correct and constant use of temporary sediment traps and bank stabilisation works.

During earthworks divert runoff to more stable areas such as cross-drainage culverts which have a sediment filtering system in place.

Ensure this work is undertaken prior to the commencement of earthworks.

During earthworks, slopes are exposed and are most vulnerable to erosion and sedimentation. If cleared areas cannot be actively worked with, temporary erosion and sedimentation measures should be implemented such as mulch and other temporary vegetation.

Coordination between earthworks operations and permanent drainage systems should be established such that runoff is disposed of from the work area as construction proceeds.

Progressively revegetate exposed areas as earthworks operations proceed.

Remove temporary drainage and sediment structures upon installation of permanent measures and stabilisation of the site.

The EMP requires monitoring of the erosion and sediment controls such as:

- amount of rainfall and date;
- depth of sediment basin;
- all maintenance activities undertaken; and
- total volume of sediment captured.

Dewatering devices should discharge water in a manner which will not adversely affect any downstream watercourse, drainage system, or neighbouring property. Turbidity controls may be required if adequate buffer zones do not exist.

All disturbed areas should be stabilised within 14 days of completion of works.

Place notices advising that erosion and sediment control measures exist on this site. All soil disturbances are to be minimised. All sediment is to be contained on site.

Remove and dispose of any spilt material in overland and defined drainage paths.

Investigate and take necessary actions to rectify any areas where excessive sediment runoff is occurring.

Dust, Noise, Vibration and Light

The desired outcome is to minimise dust, noise, vibration and light pollution.

Dust, noise and light have the potential to impact on the environmental and social values of the area as well as the safety and health of construction staff. Dust can -be generated from earthworks operations which

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include clearing and grubbing, cut and fill, haulage and general machinery use on the construction site. Dust can create air pollution which can visually impact the construction zone and the surrounding areas. Dust can also create biological impacts as it can impede the growth of vegetation and the activity of fauna in the area. The impact of noise from machinery, vehicles and other associated equipment can disturb local residents and communities of wildlife nearby.

The use of lighting for camp sites and areas of construction may have the potential to disturb the activities of local wildlife communities.

The noise, dust and light likely to be generated from a number of sources during the construction phase should comply with Workplace Health and Safety Guidelines and other appropriate standards.

Best Practice Guidelines:

The EMP (Construction) should set out specific practices required to minimise dust noise and light. Measures considered should include:

- Maintain acceptable levels of noise from the construction works.
- Maintain efficient operation of equipment and machinery. This will assist in minimising noise generation.
- Undertake construction activities during approved hours of the day as specified in the contract documents.
- Avoid haulage activities through exposed areas of soil. If work is necessary on these areas water should be applied to the exposed surface in a manner which suppresses dust generation whilst avoiding the potential for soil erosion.
- In order to reduce noise, vibration and dust, set maximum speeds for various types of machinery and equipment on site.
- Lighting should not be placed in areas which contain wildlife sensitive to disturbance by light.
- Implement a management plan for the control of noise generation. This should comply with appropriate standards.
- Plan to minimise the economic and environmental implications of road dust on adjacent land use.
- Ensure vibration resulting from blasting or vibrating rollers is minimised.

Revegetation

The desired outcome is to promptly and efficiently revegetate (with appropriate species) all areas of bare soil.

Revegetation of disturbed areas can decrease the risk of erosion and sedimentation.

These areas include construction sites, roadside drains and road batters, disused sites and other areas with disturbed vegetative cover. Mulch and grasses dissipate the force of raindrops, stabilise the soil, disperse and retard surface flow thereby reducing damage to downstream areas from runoff and sediment (NSW Department of Main Roads 1983).

By encouraging revegetation during construction, the long term effectiveness of erosion and sediment control will improve. Temporary measures include the covering of bare areas with mulch chipped from site vegetation and the progressive revegetation of batters, slopes and other construction areas which promote the long term establishment of native species.

Revegetation can be seen as a three stage process which firstly assesses the constraints and opportunities for revegetation by reviewing soil structure (physical and chemical), climate and the construction site specifics. During the second stage, appropriate techniques are designed for the specific construction site. By designing effective erosion and sedimentation control measures it is possible to establish a sediment control plan which can be implemented for the short and long term. Finally, the implementation stage should achieve set criteria tested through appropriate compliance auditing.

For the purpose of rehabilitation and revegetation, a range of bioengineering techniques have emerged. These techniques rely on sound scientific/horticultural advice if they are to be successful.

Rock/Tree Placement

In many instances, the strategic placement of rock in combination with either newly established plants or vegetative debris can have major impacts on water flow, either direction of or intensity of flow and therefore bank stability.

Trash Blanketing

Trash blanketing is the use of cut vegetation strategically placed to protect the soil surface and provide a protected environment for germination. Seed collection from the species in the specific habitats traversed by the road construction should be stockpiled and sown into the trash blanket in suitable weather. This technique is especially relevant in dry sclerophyll communities in gravelly soils.

Willowing

This is the technique of placing cut branches and other vegetative parts in either banks or other disturbed sites, knowing that the vegetative material will take root, stabilising the soil surface or embankment.

Stiff Grass Barriers

This is the placement of stiff grass plants along the contour or just off, to either hold water or direct surface water away.

Stiff grass barriers have also been used to repair eroded surfaces by planting as a weir in either a gully or waterway. The grass currently used for this purpose is Vetiver grass - Vetiveria zizanoides.

The use of stiff grass barriers in natural areas in the wet tropics needs to consider the likelihood of introducing the grass as a weed.

In all cases, the local native species are recommended as the final vegetative cover to be achieved.

Cover Crops and Grasses

In order to avoid soil erosion the planting of a quick cover crop for stabilisation is often required. The planting of selected grass species is often undertaken for long term revegetation with a low growing species. Where grasses are required, then the following recommendations are made.

- Any introduced grasses/vines which trail or climb are NOT recommended (for example):
  - Centro – *Centrosema pubescens*
  - Sirator – *Macroptilium atropurpureum*
  - Singapore daisy – *Wedilia trilobata*
  - Molasses grass – *Melinis minutiflora*
  - Para grass – *Brachiaria mutica*
- Introduced grasses which are erect are NOT recommended.
  - Panicum – *Panicum maximim*
  - Blady Grass – *Imperata cylindrici*
- The only exception to this is the vetiver hedge grass which is only produced vegetatively and is not tolerant of shade.
- Recommended grasses/legumes for the tropics are low prostrate grasses with little shade tolerance (for example):

- Green Couch – *Cynodon dactylon*
- Carpet grass – *Axonopus affininis*
- Shadegrow – *Hybrid grass*
- Stylo – *Stylosanthes spp*

Revegetation Techniques

Revegetation can use a number of techniques:

- hydrostolonising;
- drill seeding;
- hydromulching;
- haymulching;
- tree planting;
- soil protective blankets; and
- organic mats.

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These techniques are described and their suitable applications are identified in Tables 16, 17 and 18.

Best Practice Guidelines:

Ensure that bare areas are protected and successively revegetated as construction proceeds.

60% vegetation cover is required for gentle slopes less than a 5% grade. 100% ground vegetation cover is required for slopes greater than 5% grade.

Topsoil should be respread in such a way that the surface soil which contains seed and vegetative matter is returned to the surface. The topsoil should be spread over to provide a uniform cover. A furrowed surface parallel with the contours will assist in decreasing the velocity of surface runoff and increase moisture penetration hence assisting germination.

Revegetation should begin as soon as practicable and temporary protection used if areas are to be exposed for more than 14 days after earthworks cease.

Before undertaking revegetation works, control of factors which are causing erosion and sedimentation should be implemented. This may involve measures to divert, control and reduce the flow velocity of water and runoff. By controlling factors such as these an area may re-establish itself naturally.

Initial stabilisation with native grass species provides native vegetation with a surface that assists in regrowth. This ground preparation acts as a suitable seed bed. Loosening of the soil allows for water infiltration and root penetration. Areas with no topsoil should be ripped and combed to provide for suitable seed germination. These areas should encourage the retention of water to assist in germination. This can be achieved by measures such as ponding banks and other moisture holding techniques.

Subsoil should be ripped to ensure topsoil adheres to the surface. Top soil should be broken up and loosened and spread such that any seed or vegetative matter is on the surface.

Seeding is a standard technique. To encourage germination, the native seed should be covered by soil or mulch and treated with an appropriate fertiliser or nitrogen source.

Mulching generates a surface which retains moisture and assists in seed germination. Mulching can also provide a surface which can hold seeds and other vegetative matter thus promoting growth. The hay used in mulching should be weed free and contain no other contaminants to avoid introduction of exotic species.

Hydromulching uses a mixture of seed, fertiliser mulch and binder to provide a revegetative surface that promotes growth. The mulch retains moisture and can be applied to areas on steep slopes which cannot be accessed by conventional techniques.

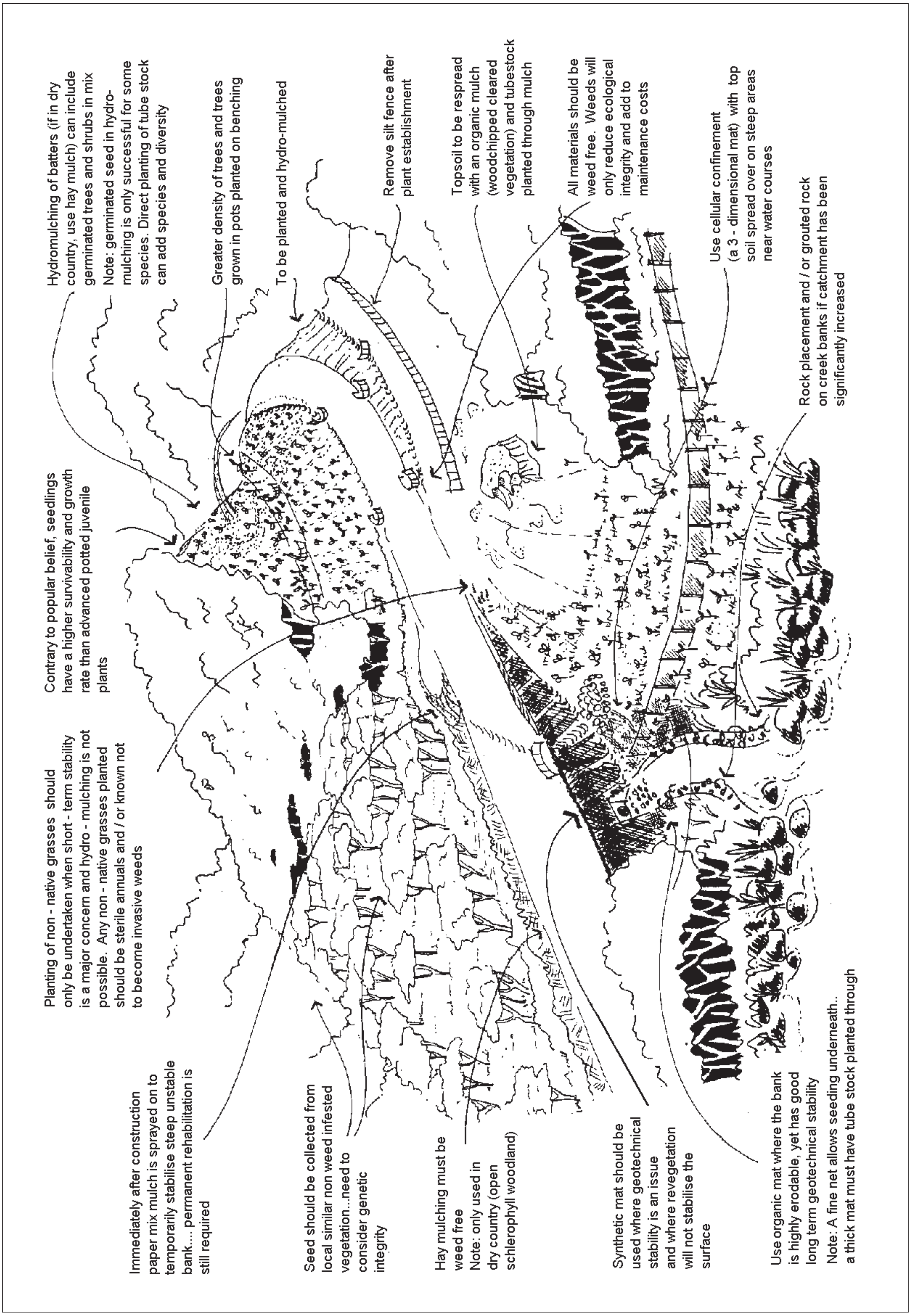

Figure 49 Revegetation Techniques

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Matting can be used to promote regrowth and stabilise exposed earthworks. A number of matting techniques are available which protect the soil surface from erosion and sedimentation whilst breaking down to provide a surface which can promote growth and germination of seeds and other vegetative material.

Monitor and manage rehabilitated areas until the vegetation is self sustaining.

Areas which are undergoing revegetation and rehabilitation works should be protected and monitored. Appropriate signage and fencing should increase awareness of residents and tourists and define revegetation areas sensitive to disturbance. Use of fencing and other barriers should not impede or restrict wildlife movement and other fauna activities. Trees in the work area should be protected from accidental damage by fencing, plastic barricade or fluorescent netting.

Determine techniques necessary to achieve objectives based on the early site assessment.

Select the most appropriate rehabilitation/ revegetation/ soil stabilisation/ waste management technique to achieve the desired result. This is related to:

- conservation values to be protected;
- ease of application;
- accessibility;
- cost;
- scale (small or large);
- timing (temporary or permanent stabilisation);
- physical condition of the soil (use a mat where the surface is well prepared but not on a very rough surface as the mat will be held up off the ground surface (tenting);
- vegetation type; and
- stability.

Table 15 Revegetation Techniques

Method of Revegetation	Suitability	Site Preparation	Installation	Benefits
HydroStolonising Is a process where 'runners' or stolons of specified grasses have been cut from turf and then placed in a mixture of fertiliser, mulch and binder. This mixture is thoroughly mixed with water before being sprayed by a hydromulching unit on to the site to be grassed.	Best suited for well prepared surfaces. Such as football fields, sporting fields and golf courses - which all require quick or immediate vegetation cover - with high grade hybrid grasses.	For best results a friable soil surface measures the hydrostolonising establishes successfully.	Maintenance watering and fertilising is essential for the establishment and survival of the runners.	The process makes it possible to revegetate an area with hybrid grasses which cannot be grown from seed. The greatest benefit, however is that the site can gain immediate or a nominated percentage of vegetation cover. Hydrostolonising is also significantly cheaper than turfing and obtains the same results within a week.
Hydromulching Is a process where a mixture of seed, fertilisers, mulch and binder are thoroughly mixed with water before being sprayed on to the site to be revegetated.	Hydromulching is for sites with limited access for machinery. It is particularly suited to revegetating steep banks such as road batters and the awkward slopes of creeks and drains. The special binders added to the slurry ensure the mixture adheres to the slope.	Before applying the hydromulching a soil test should be conducted. A rough planting surface improves water infiltration and this may be achieved by scarifying the surface with a comb blade on the grader.	If maintenance work such as irrigation is necessary it should be set up prior to the mulch being sprayed. The irrigation should be designed to apply the water evenly without eroding the mulch. Applying maintenance fertiliser to the site after six weeks will provide the best results.	The process ensures the soil surface is offered immediate protection whilst providing an ideal environment for vegetation growth. Hydromulching can be applied to sites up to 300 metres away from vehicle access.
Haymulching Is a process which blows a stream of cut hay and binder immediately on to a site which has been revegetated by a mixture of seed and fertiliser. The binder applied to the hay ensures the hay remains intact as a protective covering over the seed mixture.	Haymulching is particularly suited to sites where maintenance watering cannot be implemented. Its high moisture retention properties also make it a preferred technique for sites that experience dry conditions.	Before applying Haymulching a soil test should be conducted. A rough planting surface improves water infiltration and this may be achieved by scarifying the surface with a comb blade on a grader.	Whilst haymulching eliminates the need for maintenance watering there is no doubt that many sites will benefit significantly from water application. Applying maintenance fertiliser to the site after 6 weeks will further promote vegetation growth.	Haymulching is suitable for both steep and flat terrain and can be used in combination with a hydro mulcher if required. The binder applied to the hay remains intact as a protective covering over the seed mixture. Cost savings can be gained due to elimination of maintenance watering.

Table 15 Revegetation Techniques (cont.)

Method of Revegetation	Suitability	Site Preparation	Installation	Benefits
Tree Planting Is an important technique of revegetation and rehabilitation.	Tree planting is suitable for a wide range of environments, including old mine sites, vegetation buffers, subdivisions and creek restorations.	Initially a soil analysis is conducted to determine the chemical and physical properties of the soil. The site should also be examined to ensure it is free of competitive grasses. Successful tree planting requires careful selection of the species to be planted in the particular area. Cross ripping the soil prior to planting trees aids plant establishment.	All tree planting projects benefit from some form of maintenance watering. At least one follow up maintenance check is recommended to address any 'stress problems' the plants may experience due to lack of water or competition from grasses.	Tree planting provides immediate vegetation cover and allows for the establishment of species that are difficult to germinate through direct seeding techniques.
Soil Protective Blankets(Dimensional Polyamide)Three dimensional or two dimensional random polyamide matting which when buried in soil, is specially designed to protect the root structure of grass against the detrimental effects of rapid water flows bulky in size. The matting consists of nylon threads fused together at the points at which they cross each other. The resulting web that is formed is very open in its formation. Leaving approximately nine-tenths of its volume to be filled with soil/gravel or other appropriate material.	Ideal for lining waterways and channels as it provides stability for vegetated surfaces.	It is important to have an evenly graded surface so that the matting can closely contour the soil surface.	It is important to secure the matting by means of pins or pegs. All edges of the matter are firmly anchored or 'keyed' into spade deep trenches with pins.	A dense, thick rooted vegetation is the best possible protection for an embankment or waterway. When the roots of the vegetation intertwine with the mattings crinkly structure the vegetation is firmly anchored to the soil surface, thus reinforcing the top soil. When covered with soil matting does not deteriorate, nor does it disintegrate upon contact with fertilisers or other soil dressings.

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Table 15 Revegetation Techniques (cont.)

Method of Revegetation	Suitability	Site Preparation	Installation	Benefits
Organic Mat Is mainly used to stabilise banks, suppress weeds and to promote the growth of vegetation. The geotextile is available both as a fine mat and as a thick mat.	Organic mats are designed to allow vegetation to grow through at the same time protecting the earth surface against rainfall erosion. This allows vegetation to establish a root system which stabilises the slope surface. The thick mat is recommended as a weed barrier as it inhibits growth of unwanted broadleaf weed and most narrow leafed plants.	It is important to have an evenly graded surface so that both forms of organic matting can closely contour the soil surface.	It is important to secure organic mats by pegs or pins. All edges of the matter are firmly anchored or 'keyed' into spade deep trenches with pins.	Organic matting is beneficial as it offers immediate protection against erosion, whilst allowing vegetation cover to establish. Another advantage is that unlike other geotextiles, it becomes very flexible when wet, allowing it to take on a ground hugging quality. It is easy to install and therefore economical in small areas.

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Table 16 Hydromulching

Base Organic Material	Application	Suitability	Site Preparation	Installation	Benefits
1. Bonded fibre matrix (eg., soilguard, enviroguard, RC Bagasse mix).	Mixture of fibres bonded to form a strong organic matrix for erosion control.Minimum application rate is 4 500 kg/ha.	Suitable for:-very steep slopes;-highly erosive soils; and- cut and fill batters.	A rough surface is best. Where practical topsoil will assist with water retention and germination.	Installation is by purpose built equipment. The viscous BFM mulches require considerable expertise in application, often requiring accreditation by the applicators.	BFM's are the strongest of the Hydromulch products being particularly suited where surfaces are erosion prone surfaces due to high rainfall impact.
2. Woodfibre/ Bagasse(e.g., Silvafibre;-Ecofibre; or-Australian Wood Fibre.	Mixture of cellulose fibres from wood or cane husks. Minimum application rate is 3 000 kg/ha.	Suitable for gently to mildly steep slopes.	A rough surface is best. Where practical topsoil will assist with water retention and germination.	Installation by purpose built machinery.	Woodfibre/ bagasse mixed due to their range of fibre lengths, provide protective mulch cover to all germinating seed.The fibres provide strong bonds for surface protection.
3. Paper Mulches	Mixture of paper mulched to provide a protective surface cover.Minimum application rate is 2 000 kg/ha.	Suitable for gently sloping surfaces. Temporary surface protection for topsoil mounds.	A rough surface is best. Where practical topsoil will assist with water retention and germination.	Installation by purpose built machinery.	Paper pulp mulches, although limited due to handling properties, are relatively cheap and ideal for temporary protection works such as topsoil stockpiles. Temporary < 3 months.

Table 17 Soil Protective Blankets

Synthetic Blankets	Application	Suitability	Site Preparation	Installation	Benefits
1 Three Dimensional (3D) Mats (eg., Enkamat)	These are 3D mats for the purpose of root protection. Applied as surface blankets, filled with soil or aggregate and later seeded or turfed.	Synthetic mats are ideal in waterways, embankments or against unstable soil surfaces. These are permanent mats.	Surface must be prepared to a relatively smooth surface so the mat can hug the surface without tenting.	3D mats are applied as part of soil and not as a surface cover unless filled with some other material. Mats are trenched, pegged and overlapped.	3D mats provide support to the root structure of vegetation, the surface may wear by trampling or erode through water - yet allow re-establishment due to protected root structure. Used as part of permanent works.
2. Two Dimensional (2D) Mats (eg., Multimat, Tensamat and Stayturf).	2D mats reinforce vegetation on slopes or waterways.	Synthetic mats are ideal in waterways, embankments or against unstable soil surfaces. These are permanent mats.	2D mats are applied as a surface cover protecting the soil surface. In some instances it can be applied as part of the turf sod. Mats are pegged.	2D mats provide protection to vegetation, assisting establishment, handling and soil protection.	2D mats provide protection to vegetation, assisting establishment, handling and soil protection.
3. Organic Mats (eg., Jutemaster and Terramat).	Organic mats are suitable as temporary soil surface protection until vegetation is established. Thick mats suitable for weed prevention and overplanting. Thin mats are suitable for assisting germination.	Synthetic mats are ideal in waterways, embankments or against unstable soil surfaces. These are permanent mats.	Organic mats are applied to the surface soil. Mats are trenched, pegged and overlapped.	Organic mats are applied to the surface soil. Mats are trenched, pegged and overlapped.	Organic mats are ideal in small area requiring surface stabilisation without reliance on machinery.

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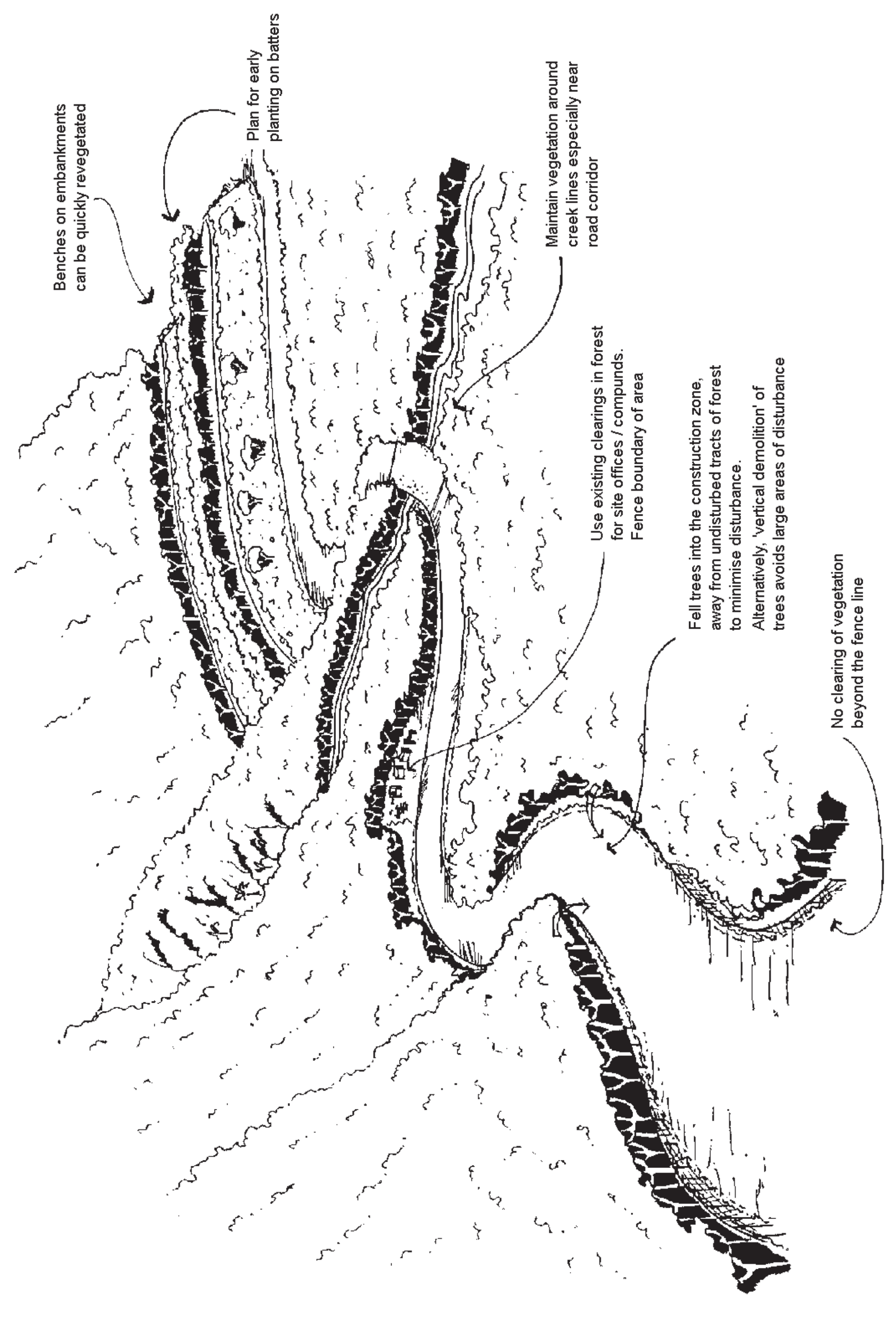

Figure 50 Vegetation Management

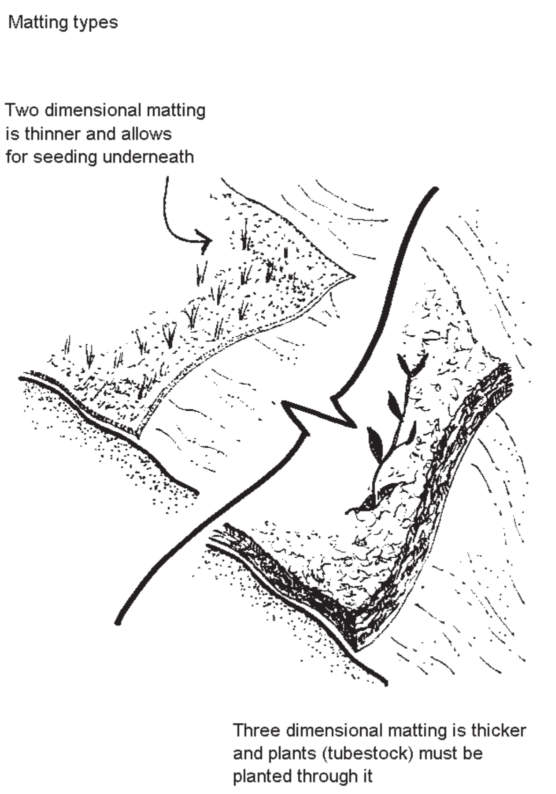

Figure 51 Matting Types

Maintenance requirements, for particular species type taken from a particular area, may require determination whether the species is best propagated by seed or direct seeding as opposed to transplanting as small tube stock. The plant's physiology may limit options to the technology that can be utilised to establish that particular vegetation type.

Timing is an important issue in determining the most appropriate revegetation/ rehabilitation techniques and measures. It is essential to go through the process of establishing the final objectives for revegetation in the design phase to schedule the works knowing that it may take up to twelve months to prepare, that is to collect the appropriate species and propagate them.

Develop measures necessary to achieve the objectives for all the procedures on site, including:

- staged development or staged rehabilitation (moving from temporary to permanent);
- staged as an area becomes available during the construction process;
- staged in the way of phases of the rehabilitation, ie., preparation, planning and maintenance etc. at different time frames; and
- other procedures including seed collection and top soil placement and availability.

The revegetation program to be implemented should be set out in the Environmental Design Report, construction contract documents and the EMP (Construction). Specialist expertise should be sought in determining appropriate techniques.

In the wet tropics region, the experience of the Wet Tropics Tree Planting Scheme (contact the relevant shire) or Department of Environment Nursery at Lake Eacham may assist in determining propagation techniques for native species and sources of seed.

Some techniques which should be considered in the wet tropics region are:

- hydromulching a range of products including bonded fibre matrices (BFM), paper mulches, woodfibre mulches;
- hydroseeding;
- hay mulching/straw mulching;
- grassing;
- drill seeding;
- brush matting;
- synthetic matting;
- organic matting;
- cellular confinement;
- rock confinement, gabions/mattressing etc.;
- bioengineered techniques - "Willowing" with natives;

- wood and organic structure;
- rock placement "rip rap";
- concrete;
- tree planting; and
- tube planting, virotube, virocell planting.

Table 18 Application Rates for Hydromulching

APPLICATION RATES - HYDROMULCHING
(Minimum Rates of Application)

ITEM / Defined Period	RATE November-March	April-October
Mulch		
Water	32 000 l/ha	32 000 l/ha
Polymer binder, either liquid or powder form	300 kg/ha	250 l/ha
Combined organic material (dry wt)	6 000 kg/ha	4 500 kg/ha
Grass Seed Mix		
Japanese Millet	20 kg/ha	5 kg/ha
Annual Rye Grass	5 kg/ha	30 kg/ha
Green Couch	20 kg/ha	25 kg/ha
Carpet Grass	10 kg/ha	10 kg/ha
Fertiliser		
Crop King 88	400 kg/ha	400 kg/ha

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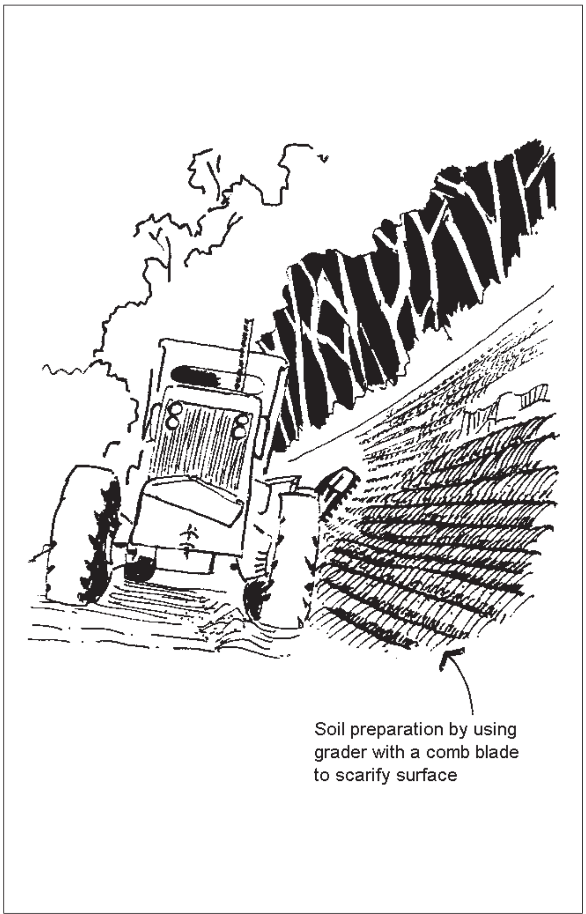

Figure 52 Batter Preparation

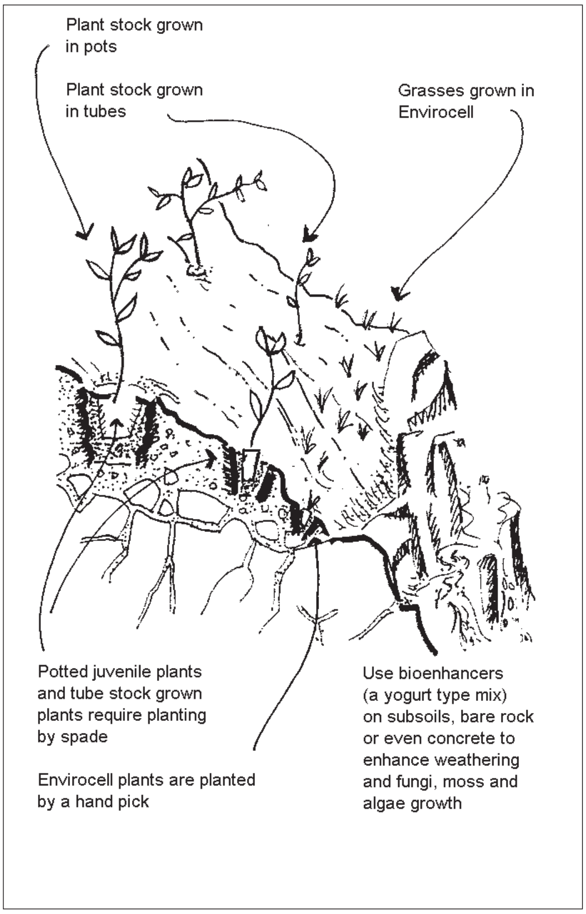

Figure 53 Planting Techniques

Installation of viro cells is a proven technique for establishing native plants in harsh conditions. A viro cell is an Australian native grass (or tree/shrub etc.), grown in an upside down pyramid like cell, which is air trimmed.

The viro tube should be a minimum of 50 mm x 50 mm at the top, a minimum of 90 mm deep with a square profile from both top and bottom views. The hole at the bottom should allow for efficient air trimming of the roots..

Hydromulching should be undertaken in accordance with the application rates (as a minimum) set out in Table 18.

Stockpiles and Storage

The desired outcome is to minimise the environmental impacts of stockpiles and storage of materials.

The storage of stockpile materials should be undertaken in areas already cleared of native vegetation. Areas destined for stockpiles should be marked out and fenced off to prevent the stockpile areas spreading. When stockpiles are stored in previously disturbed areas, this minimises the potential for vegetation disturbance.

Machinery and other construction equipment should also be stored in a manner which minimises harm to the surrounding environment (use oil absorbent matting under etc.) As with stockpile storage, using presently cleared areas reduce the potential of vegetation disturbance and other environmental impacts.

Best Practice Guidelines:

The location of stockpile sites and relevant environmental protection should be determined in the EMP (Construction).

Stockpile sites should be located away from drainage lines and water courses and should be arranged to minimise damage to natural vegetation and trees. The stockpile sites should be positioned so that the stockpiled material may be transported away at any time. Clearing and grubbing should be undertaken according to appropriate standards. Temporary erosion and sedimentation control measures should be implemented.

If machinery is refuelled and routine services performed on-site, the area should be bunded to ensure no contaminants leave the site.

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Material Sources

The desired outcome is that no weeds, pathogens or non-endemic animal species are introduced in material brought onto construction sites.

Material sources should generally be uncontaminated and weed-free. The importation of material sources from sites external to the construction zone has the potential to introduce weed species into the area. This can result in competition between introduced and native species and invasions of species which can colonise an area more rapidly than the local native species.

Material sources should be sited and stockpiled in such a way that reduces the vulnerability of the material to erosion and sedimentation. This requires a drainage system that diverts and controls water around stockpiled material and ensures the wash down of machinery does not introduce weeds into stockpiled material.

Best Practice Guidelines:

Generally, materials should not be sourced from within the Wet Tropics World Heritage Area.

Wash down machinery away from creeks and vegetated areas. This will avoid the introduction of soil and weeds into these sensitive areas. Machinery should be washed down on cleared sites. Avoid introduction of machinery to new areas prior to being washed.

Control runoff in such a way that erosion and sedimentation are minimised. This should involve drainage structures that divert water and runoff around stockpiles and other material storage areas. Machinery should not be washed down in areas near stockpiles as water can transport weeds into stored material.

If weed or pathogen infected soils are identified implement strict separation of infected and uninfected soils and access restrictions and protocols.

In the event that infected soils are detected investigate the possibility of using control measures such as mulching and herbicide treatments.

Site Camps/ Housekeeping

The desired outcome is to minimise environmental impacts from site camps.

The location of site camps for construction works can have an impact upon the environmental values of the area. The visual intrusion of site camps within the surrounding areas of the road corridor can be seen as one of the major impacts associated with site camps. Disturbance to vegetation, loss of topsoil and impacts upon downstream watercourses can also result from site camp locations.

Site camps should generally minimise environmental and visual disturbance by being located in a central area to the construction site where vegetative buffers can be planted. The number of site camps should be minimised to assist in reducing the level of disturbance within an area.

Best Practice Guidelines:

Preferably site camps should be located outside the Wet Tropics World Heritage Area and other natural areas.

Place camp sites away from creeks and drainage paths.

Locate camp sites only in areas which have been previously cleared, disturbed or are not covered with native vegetation.

Reduce the potential for weed introduction through machinery and other equipment stored within site camps through rigorous hygiene (wash down etc.).

Site camps should implement an efficient drainage system that diverts, controls and disposes of water and runoff thereby avoiding erosion and sedimentation.

It is better not to use open fires. Where they are used ensure clearing of at least 5m.

Ensure bunding of any chemicals, fuels and oil storage and of washdown bays.

Site camps should be kept free from litter and wastes for aesthetic reasons and to minimise potential for waste, hygiene and storage problems. Litter and wastes to be stored in appropriate containers.

Ensure that there is an adequate system of offsite disposal of sewage, greywater, rubbish and other wastes. It is not appropriate to dispose of food and cooking scraps in the bush.

Time Schedule

The desired outcome is to schedule works in an order and at a time of year which minimises potential for environmental impacts.

Timing of rehabilitation and revegetation protection measures and techniques is crucial to success.

Suitable timeframes are based on whether work is undertaken during the dry season (April through to October) or the wet season (November through to April). Different procedures are required during the different wet and dry periods. During the wet season, the results of poor timing can mean the rebuilding of structures and development works. The wet season, requires stabilisation/revegetation work, immediately works are completed on a construction site, as soon as areas become available. During the dry period it may not be so crucial to implement this work immediately. This is all related to the level of risk of erosion which is acceptable depending upon the conservation values of the area.

The simple rules apply - the greater the time between finalisation of earthworks, and stabilisation, the greater the risk of significant damage due to extreme rainfall events. Best Practice both from an environmental and economic perspective requires earthworks to be stabilised as soon as practical after final grades have been achieved. All stabilisation works during the wet season ie., November to April should be completed within three (3) days, while during the dry season it is recommended that works be completed within seven (7) days.

Efficiency in staging of the works will result in the least amount of exposed area at any one time. This reduces the amount of erosion and sedimentation significantly.

Works should be undertaken as part of a staged program, and as areas become available.

Due to the intensity of the rainfall expected during the period November to March, the timeframe by which work should be completed after construction works is less than two weeks. Work during this period may require more temporary works to be undertaken for stabilisation purposes.

Best Practice Guidelines:

The timing and order of works must be set out in the EMP (Construction). It should be based on detailed timing strategies identified in the Environmental Design Report.

Ideally, major earthworks should be scheduled for the dry season.

Construct permanent drainage structures in each stage before commencing the earthworks or clearing of the next stage. This reduces the need for temporary stream crossings.

Begin rehabilitating the exposed batters as soon as practicable.

Place base and seal as each earthworks section is completed. Do not wait until all the base is laid before commencing sealing.

Prepare a site plan as part of your soil and water management plan that shows each of the measures and techniques.

List timeframes by which works should be undertaken, that is during low rainfall periods of the year, for example April to October.

Stabilisation/rehabilitation works should be undertaken within two weeks of road sections being completed onsite. If this is in a dry period, allowance for watering or other maintenance may be necessary.

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Waste Management

The desired outcome is to minimise construction wastes and dispose at an approved, environmentally sustainable location.

Waste management in the wet tropics region is essential and proper care should be taken when storing waste. All waste should be handled in a manner which satisfies the criteria in the EMP and the statutory obligations of the Environmental Protection Act. Waste may not be buried or otherwise left within the Wet Tropics World Heritage Area.

Waste includes all food stuffs, paint tins, machinery parts, grease cartridges, drink bottles and cans etc.

Best Practice Guidelines:

Wherever possible minimise waste, reuse it or recycle.

Provide portable toilets on site for all works and maintain in an environmentally friendly condition.

Remove all waste materials from the construction area to a licensed land fill.

Waste should be stored in a skip or truck or by other means which does not require a hole in the ground.

Do not bury any waste.

Establish a waste collection system which separates oily materials (rags and filters) and used oils, batteries, tyres, scrap metal, recyclable and putrescible wastes.

Chemical Management

The desired outcome is to provide for environmentally sound management of chemicals used during road construction.

Extreme care should be taken when using chemicals, particularly in natural areas such as the Wet Tropics World Heritage Area. Spillage in streams or the use of incorrect or unapproved chemicals could prove devastating to the ecological system in that area.

Best Practice Guidelines:

Remove all hazardous materials from and store bulk amounts of chemicals outside the Wet Tropics World Heritage Area.

If storage of chemicals is required bund walls with a capacity of 110% of the total volume to be stored should be used in accordance with AS1940 and the EMP (which should address the volumes, risks and handling storage procedures of chemicals).

Bunding should have a layer of impervious material in the internal area of the bund.

Storage of chemicals, oils, fuels etc. should not be located near streams or in drainage paths.

Ensure separation of different types of chemicals.

Provide a system where the chemical can be retrieved and transported off site easily and rapidly if there is a spill.

Ensure storage and use of chemicals are in accordance with the Environmental Protection and Workplace, Health and Safety Acts.

Ensure when performing maintenance on machinery all waste and chemical products are collected and transported off site and disposed of in an approved manner.

Hygiene

The desired outcome is to ensure that weeds, pathogens and non-native animals are not brought on or off the site.

Importation or export of soils, weeds or flora that are not native to the area may result in adverse effects on the environment, such as threatening rare or endangered species. All machinery from motorcycles to scrapers should be washed down before entering or leaving the site. In some cases, a wash down bay may be required between areas within the site. Possible positioning of wash down bays will have been determined in the planning and design phases.

Best Practice Guidelines:

Plan to wash down all vehicles and machinery prior to and after working in the Wet Tropics World Heritage Area or other natural ecosystems to avoid the spread of environmentally threatening processes eg., exotic weeds, soil borne diseases.

Ensure a thorough wash down of machinery takes place.

Ensure sediment from wash bay areas is disposed of in an approved manner. Specifically, ensure the waste which may contain weed seeds, material or diseases is not discharged to the natural environment.

Ensure all staff, subcontractors and personnel are advised of the hygiene requirements and that they adhere to them.

Where the presence of harmful pathogens is detected and may be spread, chemical treatments may be applied after seeking expert advice in their application.

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