

# MANAGING URBAN STORMWATER



## Soils and Construction

Volume 2D Main road construction

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Volume 2D Main road construction

Department of **Environment & Climate Change** NSW



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# 1. Introduction

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## 1.1 Main road construction

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The construction of main roads and highways commonly involves extensive earthworks, with significant potential for erosion and subsequent sedimentation of waterways and the landscape. These impacts can be minimised by appropriate project planning and design, and the implementation of effective controls.

Main roads projects, for the purposes of this publication, include the construction and upgrading (e.g. widening) of new major roads such as motorways and arterial roads within or close to major urban centres, as well as highways outside urban centres. The term, 'main road' used in this publication includes any large road not associated with the construction of an urban subdivision and is therefore broader than the definition in the *Roads Act 1993*. Aspects of this publication are also relevant to some other roadworks, including maintenance activities involving extensive earthworks and the construction and maintenance of high-erosion-risk sealed rural roads.

## 1.2 Purpose and scope

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The purpose of this publication is to provide guidelines, principles and recommended minimum design standards for good management practice in erosion and sediment control during the construction of main roads. The target audience includes officers in State government agencies and councils as well as consultants, contractors and others who have a role in the planning, design and construction of main roads.

This publication guides the user in applying the principles and practices of erosion and sediment control to the planning, design and construction of main roads, as well as providing additional industry-specific guidelines and recommendations. These principles and practices were described in volume 1 of *Managing urban stormwater: soils and construction* (Landcom 2004b). This publication should therefore be read and used in conjunction with volume 1.

Throughout this publication, cross-references to *Managing urban stormwater: soils and construction*, volume 1 (Landcom 2004b) are shown in bold: for example, see **vol. 1**: section 5.3.

A useful additional reference is *The hip pocket handbook* (Landcom 2004a), which is a small field guide for the use of contractors and others responsible for the construction and maintenance of erosion and sediment controls.

The principles of erosion and sediment control on urban development sites as described in **vol. 1** are broadly applicable to main roads. There are, however, a number of key differences relating to the planning, design and construction of main roads that warrant special consideration. These unique characteristics of main road projects are identified in section 1.3 below.

This publication does not address broader environmental issues associated with main roads. These roads may have a range of potential environmental impacts, including impacts on flora and fauna. Many of these impacts relate to the selected route of the road, and should therefore be identified and assessed in the project-planning and environmental-assessment phase.

While the scope and focus of this publication is on the management of soil, surface water and sediment-related pollution during the construction stage of a project, information

is also provided on both the pre-construction and operational stages. This is because effective erosion and sediment control during construction effectively begins during the project-planning stage.

Stormwater-quality management during the operational phase of the project should also be considered and addressed during pre-construction. It is not, however, addressed in this publication. Officers of the Roads and Traffic Authority (RTA) are referred to the internal guidelines addressing stormwater management from roadways, entitled *Procedure for selecting treatment strategies to control road runoff* (RTA 2003). Technical guidance on the design and construction of a range of stormwater treatment measures suitable for the treatment of road runoff is provided in Austroads (2003) and IPWEA (2008).

### **1.3 The nature of road construction and maintenance projects**

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Main road construction often comprises large-scale earthworks and other activities involving:

- freeways and dual-carriageway highways with wide and straight pavements, elimination of steep grades, and extensive areas of cut and fill
- arterial roads to shorten distances and delays (e.g. to divert traffic from shopping areas)
- improvements to existing roads (e.g. duplication, widening, provision of climbing, acceleration, de-acceleration and turning lanes)
- bridges or culverts
- road tunnels
- quarries and borrow areas involving production of materials
- batch plant sites (e.g. manufacture of concrete)
- side tracks for temporary traffic diversions from works areas
- road maintenance works (e.g. patching, shoulder grading, drain and culvert cleaning).

Accordingly, issues relating to the management of soil and water during road construction may include:

- great variations in the linear size of projects, from small localised works (e.g. culverts, bridges) up to long stretches of new roads on greenfield sites (e.g. freeways)
- limited width of corridors, which may result in steep batter slopes, and restrictions on the number, type and size of control measures that may be successfully implemented
- large volumes of cut and fill, and, from a soil-and-water management perspective, a rapidly changing work site
- works across multiple catchments, with numerous discharge points and water diversion considerations
- works in and around watercourses, wetlands, flood-prone areas, acid-sulfate soils etc.
- public access onto and through construction sites (e.g. works under traffic, traffic management and safety considerations, provision of access for residents and businesses).



## **1.4 Potential impacts on the water environment**

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Large-scale disturbance associated with main road construction can significantly impact on the surrounding environment, including:

- sedimentation of waterways, affecting river health
- impacts on vegetation, potentially including threatened species.

Erosion, sedimentation and other forms of land degradation should therefore be controlled to minimise any impacts.

## **1.5 Structure of this publication**

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**Section 2** summarises statutory requirements applicable to the erosion and sediment control aspects of the planning, design and construction of main roads

**Section 3** outlines the approach that can be taken in developing an erosion and sediment control strategy for main road construction

**Section 4** summarises considerations in the design of main roads that are relevant to operational erosion and sediment control

**Section 5** provides information on relevant main road operational considerations

**Section 6** provides guidance on applicable erosion and sediment control techniques for main roads

The appendices contain guidance on erosion and sediment control plans (ESCPs) and other supporting information.



## 2. Statutory requirements

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## 2.1 Overview

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A number of State and local regulatory authorities may need to be consulted during the planning process to ensure activities associated with main roads are undertaken in accordance with all necessary statutory requirements relating to erosion and sediment control. These agencies may also need to be consulted during the preparation of various plans such as erosion and sediment control plans (ESCPs).

Several pieces of legislation may need to be considered in the planning and design stages of a road project. For example, the development assessment framework and provisions of the *Environmental Planning and Assessment Act 1979* apply to the construction or upgrading of main roads.

This section, however, focuses on the main pieces of legislation that relate specifically to the aspects of erosion and sediment control of main road projects which may also have broader applicability to the project. These are:

- *Protection of the Environment Operations Act 1997* (POEO Act)
- *Roads Act 1993*
- *Fisheries Management Act 1984*.

Other Acts which may need to be considered in the project-planning phase, and may indirectly influence aspects of erosion and sediment control (e.g. through route selection) are listed below, but not discussed in any detail in this publication:

- *Water Management Act 2000*
- *Native Vegetation Act 2003*
- *Threatened Species Conservation Act 1995*
- *National Parks and Wildlife Act 1974*
- *Soil Conservation Act 1938*.

For a more detailed description of these Acts, see **vol. 1**: appendix K.

The information below was current at the date of publication. However, statutory requirements and the roles of government agencies can change over time – proponents should check that this information is current during the planning stage of their project.

## 2.2 Relevant legislation

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### 2.2.1 Protection of the Environment Operations Act 1997

The POEO Act is the primary piece of NSW pollution control legislation. The Act defines activities that require environment protection licences (schedule 1) and the roles and responsibilities of appropriate regulatory authorities. The Act also prohibits the pollution of waters, except in accordance with an environment protection licence (section 120).

Environment protection licences are issued by the Environment Protection Authority (EPA), part of the Department of Environment and Climate Change (DECC). The EPA is normally the appropriate regulatory authority for:

- activities listed in schedule 1 of the POEO Act for which licences are issued
- activities carried on by a State or public authority (e.g. a council operating a small solid-waste landfill)
- other activities in relation to which a licence regulating water pollution is issued.

Local councils are normally the appropriate regulatory authority for other activities (e.g. operations by small to medium businesses and subdivision construction by private developers). Local councils have notice and enforcement powers under the POEO Act for these activities.

Certain freeway and tollway construction activities are prescribed in schedule 1 of the Act, for which an environment protection licence is issued by the EPA. The current schedule 1 definition is:

***Freeway or tollway construction***, being the construction of new, re-routed or additional carriageways, that as a result will have:

*(1) physically separated carriageways for traffic moving in different directions, and*

*(2) at least 4 lanes (other than lanes used for entry or exit), and*

*(3) no access for traffic between interchanges,*

*for at least 1 kilometre of their length in the Metropolitan area or for at least 5 kilometres of their length in any other area.*

*The Metropolitan area is the area of Sydney, Newcastle, Central Coast and Wollongong bounded by and including the local government areas of Newcastle, Lake Macquarie, Wyong, Gosford, Hawkesbury, Blue Mountains, Penrith, Liverpool, Camden, Campbelltown, Wollongong and Shellharbour.*

*This item does not include maintenance of any such freeway or tollway.*

At the time of publication, DECC was reviewing this definition and road proponents should therefore check the current version of schedule 1 to determine the need for an environment protection licence.

The impact on the environment of any pollution likely to be caused by the activity will be considered when determining an application for an environment protection licence. Where an environment protection licence is granted, conditions may include soil and water management requirements to avoid or minimise any potential impacts.

### **2.2.2 Roads Act 1993**

The Roads Act, among other things, establishes the authorities responsible for roads, provides for the classification of roads and sets out procedures for the opening and closing of roads. Authorities responsible for roads in NSW include:

- the Roads and Traffic Authority (RTA) – for all freeways and tollways, land held by the RTA and roads in the unincorporated area of western NSW
- local councils – for all public roads within their areas, except for any Crown public road or any public road declared under the control of some other road authority
- Department of Lands, as the roads authority for all Crown public roads
- specified public authorities (e.g. the Lake Illawarra Authority) responsible for all public roads in a declared area.

### **2.2.3 Fisheries Management Act 1994**

The NSW Department of Primary Industries (DPI) is responsible for the administration of this piece of legislation. The Act provides a comprehensive framework for the sustainable management of living aquatic resources. The former NSW Fisheries has been incorporated into the DPI.

Under the Act, a permit is required for any activity associated with main roads that involves dredging or reclamation works, or that has the potential to:

- block the passage of fish (e.g. road crossings)
- harm marine vegetation.

Further details can be obtained from *Policy and guidelines – aquatic habitat management and fish conservation* (NSW Fisheries 1999).



## 3. Erosion and sediment control strategy

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## 3.1 Management objectives

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The goal for erosion and sediment control for main road construction is to ensure that there is no pollution of surface or ground waters. Current best-practice erosion and sediment control techniques are, however, unlikely to achieve this goal, due to the limited effectiveness of most of these techniques. An appropriate management objective is therefore to take all reasonable measures (i.e. implement best-practice) to minimise water-quality impacts from erosion and sedimentation.

Given the limited effectiveness of techniques for retaining eroded sediment, a strong emphasis should be placed on pollution prevention through erosion control, rather than relying on treatment techniques to capture these sediments.

## 3.2 Management principles

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The primary principles for erosion and sediment control are firstly to minimise erosion and then to capture sediment from disturbed areas. This approach emphasises pollution prevention rather than pollution control.

**Vol. 1:** section 1.6 identifies seven general principles of effective soil and water management for land disturbance associated with urban development. This approach focuses on appropriate site planning, and the installation of appropriate erosion-control and sediment-control measures.

These principles also broadly apply to main road construction. They can be paraphrased as follows:

- assess the soil and water implications of a project at the planning stage
- plan for erosion and sediment control during the project's design and before any earthworks begin, including assessment of site constraints
- minimise the area of soil disturbed and exposed to erosion
- conserve topsoil for later site rehabilitation or regeneration (in a stabilised stockpile)
- control water flow from the top of and through the project area by diverting up-slope 'clean' water away from disturbed areas and ensuring concentrated flows are below erosive levels and sediment is retained from disturbed areas
- rehabilitate disturbed lands quickly
- maintain erosion and control measures appropriately.

These principles provide a framework for the development of an erosion and sediment control strategy for main road construction.

## 3.3 Strategic approach

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### 3.3.1 Overview

Effective erosion and sediment control for a main roads project requires appropriate activities to be carried out over the life of the road, including:

- planning and design
- construction
- operations.

The principles noted in section 3.2 can be used to guide the development of an erosion and sediment control strategy for a main road. The specific strategy adopted for a main road project will vary depending on the nature and scope of the project, type and sensitivity of receiving environments and other factors such as site rainfall characteristics, soils and topography. It is important that any erosion and sediment control strategy is consistent with, and meets any requirements of, any applicable environment protection licence, development consent or approval conditions.

The long period of disturbance associated with main road construction relative to subdivision construction, and the resulting longer operational life of many erosion and sediment controls, requires a stronger emphasis on some management principles, particularly:

- erosion control as a pollution prevention strategy
- runoff separation by diverting 'clean' stormwater runoff around the site or away from operational areas
- management and maintenance of long-term controls.

### **3.3.2 Planning and design considerations**

The effectiveness of erosion and sediment controls during the construction and operational stages can be optimised through effective main road planning and design. The effectiveness of construction phase erosion and sediment controls can be enhanced by considering potential construction-phase strategies during planning and design, while acknowledging that detailed strategies and plans will be developed during the construction period. Suitable strategies for these stages of a project include:

- designing any permanent drainage systems so that they do not cause erosion. This may involve scour protection of open drains and energy dissipaters located at drain outlets
- diverting up-slope runoff around large cut batters, where possible, to minimise external runoff flowing over batters.

These strategies should be documented on the project drawings and in the contract specifications. Section 4 contains approaches that can be used in the pre-construction phase to enhance erosion and sediment control effectiveness.

### **3.3.3 Construction phase strategies**

The magnitude of erosion problems (and therefore the effort required to control erosion) at main road construction sites is proportional to the area of soil exposed to the erosive elements and the duration of that exposure. Main road construction often involves land disturbance for up to three years. Because of this long period, the management focus should principally be on scheduling land disturbance and rehabilitation to minimise erosion occurring, rather than relying on temporary works to control erosion and sedimentation.

It is recognised that activities will vary throughout the life of a main road construction project, with erosion and sediment control measures and activities expected to evolve over time. Erosion control strategies at main road construction sites should normally comprise the following:

- minimising forward clearing, particularly areas around flow lines, drainage lines and watercourses which, in particular, should remain in their natural state until the installation of drainage works (e.g. culverts) commences



- staging construction activities where practicable so that land disturbance is confined to the minimum possible area
- completing work and stabilising disturbed areas quickly and progressively. Temporary stabilisation measures should be used if permanent stabilisation is delayed by construction activities, by scheduling problems with third-party service installation, or by unsuitable site conditions
- minimising erosion from drainage lines which can be very vulnerable to the erosive effects of concentrated flow. This particularly applies to catch, table and diversion drains, where temporary erosion protection is likely to be required.

To reduce the runoff volumes requiring treatment and to maximise the efficiency of sediment control, strategies should aim to:

- intercept, divert and safely dispose of 'clean' run-on water from undisturbed areas so that it does not flow onto the works
- pass 'clean' water through the site without mixing it with 'dirty' sediment-contaminated runoff from the works. This may require temporary solutions, such as temporary flexible pipes to convey water across a working site
- break up slope lengths and minimise catchment areas within the work area, to reduce runoff volume and velocities to manageable levels.

Where possible, permanent erosion control measures (see section 4.3) should be integrated with temporary measures during the construction phase. For example:

- catch drains located above a cut batter to minimise long-term flows over the batter should be installed before earthworks commence, to divert runoff around the earthworks area
- down drains on a fill batter designed to convey road runoff should be installed immediately after completion of the earthworks, to convey the runoff from the pavement area down the batter while the batter is being stabilised
- energy dissipaters should be installed on pipe and culvert outlets before the drainage system or culvert becomes operational.

Erosion and sediment control measures should be inspected daily (with maintenance and modification as necessary), together with more intense inspection and maintenance regimes during wet weather and wet-weather clean up (see **vol. 1**: chapter 8).

Arrangements also need to be made for inspection and maintenance during industry shutdowns for weekends and holidays (e.g. Christmas and Easter), particularly if rainfall is predicted or there is predictable seasonal rainfall.

Due to the large scale of many road construction projects, a priority system for repairs and maintenance following large storms should be developed. This should focus on initially restoring controls in areas with high erosion risk which may impact on sensitive receiving environments, followed by restoration of controls in other areas.

Due to the longer operational life of many erosion and sediment controls relative to urban subdivision construction (outlined in **vol. 1**), additional maintenance effort is often required for long-term controls. For example:

- erosion and sediment control measures should be maintained in a functioning condition until individual areas have been revegetated
- structures for diverting and conveying runoff should be inspected after significant storms so that sediment can be removed and damaged works promptly repaired and/or replaced

- inflow points and outflow structures (e.g. riser pipes and spillways) to sediment basins should be inspected after major storms and repaired as necessary.

Stormwater reuse should be considered as a management option for main road construction to reduce discharge of polluted water, as there are commonly a range of non-potable water uses such as dust suppression and irrigation of revegetation areas. This may be more cost-effective than treatment of polluted runoff and will also reduce consumption from other water sources.

Services such as water mains are often installed as part of a main road construction. Detailed guidance on erosion and sediment control for service installation is provided in *Managing urban stormwater: soils and construction, volume 2A: installation of services* (DECC 2008a).

Access tracks are often used on main road construction projects. Erosion of the tracks is a safety issue as well as a potential water-quality issue. Detailed guidance on erosion and sediment control for access tracks is provided in *Managing urban stormwater: soils and construction, volume 2C: unsealed roads* (DECC 2008b).

The strategies described above should be applied in all areas associated with the road construction. These areas include, but are not limited to:

- the principal work site
- side tracks, access tracks and haul roads
- borrow pits and spoil disposal areas
- temporary stockpiles, and laydown and storage areas
- compounds, site offices and batch plants.

Section 6 contains information on potentially suitable erosion and sediment control techniques for a main road construction.

### **Constrained sites**

Effective erosion and sediment control can be more difficult in narrow road corridors or in areas of high-conservation-value vegetation (e.g. endangered ecological communities). These constraints can impact on the ability to install conventional sediment basins designed for a five-day management period. In these circumstances, options include:

- installing smaller basin(s) designed for a two-day management period (see table 6.1 for the applicable volume reductions). This will require more intense on-site management or alternate approaches such as pumping water to a ‘turkeys nest’ dam for treatment prior to either reuse or discharge
- greater investment in erosion control. This particularly applies where sediment basins cannot be installed – see **vol. 1**: section 6.3.4(g) for a description of suitable approaches
- off-site sediment control – in some cases, land for sediment control may need to be found downstream of the site and appropriate arrangements made with the landowner
- use of non-standard sediment control techniques where enhanced erosion controls cannot be implemented and insufficient space is available for standard sediment controls such as basins. Sectors such as the stormwater and wastewater treatment industries use non-standard approaches (e.g. gross pollutant traps or vortex separators) to remove sediment from water and it is possible that some of these techniques can be applied to difficult or constrained sites.

These techniques are likely to achieve significant coarse sediment removal, although reductions in turbidity may be low. In a constrained site, removal of coarse sediment only is better than no sediment controls at all. Note, however, that these techniques may have higher capital and operating costs, which should be considered during project planning.

### **Sensitive and high-erosion-risk sites**

Some roads are constructed adjacent to sensitive receiving environments (e.g. national parks). In this situation, a greater degree of erosion and sediment control is warranted – section 6.1 outlines the larger sediment basin sizes applicable in these circumstances.

Some main roads are constructed in areas of high erosion risk with either narrow road corridors or other constraints to installing sediment basins (e.g. vegetation of high conservation value). In these circumstances, particular attention needs to be paid to erosion control as a pollution prevention strategy, given the limited opportunities for pollution control through sediment basin installation. **Vol. 1:** sections 6.3.4 (g) and 4.4.2 provide guidance on potential strategies.

In such sensitive sites, the implementation of enhanced controls should be independently audited at least fortnightly. The auditor should be a soil conservationist or an accredited erosion control specialist.

A more dynamic approach to erosion control is also recommended under these circumstances. This would involve the use of Bureau of Meteorology forecasts and rainfall radar images to assess the likelihood and severity of rainfall for the site. Where the forecast and/or radar images indicate the likelihood of moderate to heavy rainfall, additional short-term erosion controls should be used. These should focus particularly on unprotected drainage lines which will be more susceptible to erosion from concentrated flows than the susceptibility of unprotected batters to rill erosion. Standard approaches for preparing the site in the lead-up to forecast rain should be developed and included in the erosion and sediment control strategy.

### **Bridge and culvert construction**

The construction of bridges and culverts over watercourses and the installation of any associated approach embankments can present a high risk of water pollution, given the proximity of the works to the watercourse and the potential limitations of certain techniques.

*Managing urban stormwater: soils and construction, volume 2C: unsealed roads* (DECC 2008b) contains guidance on erosion and sediment control strategies for culvert and bridge construction.

### **3.3.4 Operational phase strategies**

The primary aim of soil and water management in the operational (i.e. post-construction) phase of a main road project is to minimise long-term erosion by ensuring that effective vegetation is maintained on areas disturbed during construction (e.g. batter slopes) and by addressing any erosion problems in the drainage system (e.g. scouring of unlined drains). Revegetated areas should be carefully managed for a number of years after the initial rehabilitation works, with intensive management over the first few months. This is to promote rapid vegetation growth and development, and address any problems arising with vegetation establishment.

Guidance on operational considerations is provided in section 5.

### **3.4 Documenting the adopted strategy**

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It is important that the strategy for erosion and sediment control is documented so that operational staff and regulatory authorities are aware of the approach adopted to minimising water pollution. The strategy should be documented before the start of land disturbance activities where erosion and sediment controls are needed. The strategy could be documented in an:

- environmental management plan, or
- erosion and sediment control plan.

There is generally no DECC requirement for a specific erosion and sediment control plan to be prepared for main road construction, although this is common practice. DECC does, however, expect there to be a document that is current at all times during the operational life of the project which details the current erosion and sediment control practices being implemented. In addition, staff or contractor responsibilities for implementing aspects of the strategy should also be documented to ensure clear accountability.

It is recommended that operators consider the scale and nature of their operations and any requirements to provide other plans relating to environmental management when deciding on how to document their erosion and sediment control strategy. For example, a small project may include erosion and sediment control in an environmental management plan required as a development consent condition, whereas a large project may warrant an erosion and sediment control plan as a sub-plan of the environmental management plan. Appendices B to D provide information on erosion and sediment control plans.

It is important that whatever format is adopted allows for the plan to be revised, if required, to account for monitoring results and to address any implementation problems that may arise.

### **3.5 Responsibility for strategy implementation**

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The project principal should ensure that staff or contractor responsibilities for implementing the erosion and sediment control strategy are clearly established and documented. It is recommended that a single person have overall responsibility for supervising the implementation of the strategy, while delegating particular responsibilities. The principal should ensure that all operational staff are aware of the need for effective erosion and sediment controls.

The inspection and maintenance responsibilities for erosion and sediment controls should be devolved across all persons working on the project site including managers, engineers, supervisors, overseers and gangers, as well as any environment officers. This avoids the situation where sediment control responsibility is assigned to a single employee or employee category (e.g. environment officer), resulting in other workers (including supervisors) taking little or no interest or responsibility.

### **3.6 Strategy implementation by contractors**

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Main road construction is commonly carried out by contractors on behalf of a project principal or client. Both the project principal and the contractor have responsibilities for implementing an effective erosion and sediment control strategy.

The POEO Act (parts 3.4 and 8.5) considers licence holders and occupiers of unlicensed premises to be liable for any breach of a licence condition or pollution caused by any associated person. The occupier of premises means the person (or organisation) who has the management or control of the premises. A person associated with the licence holder or occupier of the premises is taken to include an employee, agent, contractor or subcontractor.

Effectively this means that project principals cannot transfer their obligations under the POEO Act to a contractor. The *EPA prosecution guidelines* (DEC 2004) contain further information on the EPA's approach to selecting an appropriate defendant for a pollution offence and the EPA's views on the responsibility of principals and contractors.

These provisions do not, however, prevent proceedings being taken under the Act against the person who actually caused the pollution (e.g. a contractor who, in the opinion of the appropriate regulatory authority, has been clearly negligent).

The licence holder for a licensed main road construction project or the occupier of the project site for an unlicensed project (normally the project principal) therefore needs to take appropriate steps to ensure that any contractor or subcontractor does not contravene any licence condition or cause unauthorised water pollution. Potential approaches include:

- including details of the contractor's obligations in the contract, along with appropriate contract provisions enabling the principal to direct the contractor or subcontractor to address any potential licence contravention or polluting activities
- providing guidance to the contractor on the procedures to be followed to prevent any licence contravention or polluting activities
- ongoing monitoring of a contractor's activities to identify any potential licence contravention or polluting activities, with prompt directions issued to the contractor to address the inappropriate activities and a follow-up review to see that the actions have been addressed.



## 4. Before construction

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## 4.1 Overview

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The guidance provided in the following sections is focused on large main road projects, particularly those where there is a significant risk of erosion and sedimentation of sensitive environments. Where the scale of the project is relatively small (e.g. installing an extra lane on a main road for a relatively short distance) and/or the risk of environmental impacts is low, the approach described below can be modified to suit the nature of the project.

## 4.2 Route analysis

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Erosion and sediment control planning should commence in the concept phase with a preliminary erosion-hazard evaluation of the area through which the road is to pass (refer to **vol. 1**: section 4.4.1). The erosion-hazard advantages or disadvantages of a particular route can then be weighed against all other engineering, social, economic and environmental considerations.

The erosion hazard and the expected sedimentation potential of an area will rarely necessitate the abandonment or a major shift of a proposed route. However, an advance study will identify problem areas that may warrant additional attention during later detailed design and construction phases, and for any additional costs to be considered during project budgeting.

Erosion hazard is the susceptibility of a parcel of land to the prevailing agents of erosion. It is dependent on:

- topography
- drainage
- soil erodibility
- vegetation cover
- climate
- land use.

Erosion hazard is categorised qualitatively as low, moderate, high, very high or extreme. Having determined the category of erosion hazard, the following points should be considered if the category is to be lowered and potential soil loss minimised:

- identification of high-risk areas (e.g. steep and rugged terrain, erodible soils)
- avoidance of mid-slope locations on long, steep and unstable slopes
- location of roads on well-drained soil formations, avoiding poorly drained areas
- location of roads at a sufficient distance from streams to provide filter strips to trap sediment down-slope of the alignment
- resumption of sufficient land to enable construction of effective erosion and sediment control measures including catch drains and sediment basins.

These aspects of most road and highway construction projects, together with many of the issues discussed in **vol. 1**: section 3, should be further assessed as part of the project's environmental impact assessment.

### 4.3 Detailed design

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The drainage drawings are the most relevant component of a project's design plans for soil and water management purposes, with temporary erosion and sediment control during construction heavily influenced by the drainage design. Drainage drawings usually include all permanent stormwater management, erosion and sediment control measures (e.g. lined catch drains, batter chutes, culverts, outlet dissipaters and sediment basins).

Because the selection and location of temporary control measures such as sediment fences, straw bale sediment traps and temporary diversion banks are usually the responsibility of the construction contractor, designers should not attempt to pre-empt the location of these measures in design plans issued for tender. Locations are likely to be changed regularly during construction and both location and management will be specifically addressed by the contractor in their ESCPs.

In preparing design plans, road designers should be especially aware of the principles of erosion and sediment control as they relate to surface stormwater management. Provision should be made to conduct all flows along or through the route corridors by stable and permanent measures such as catch drains, lined channels and batter chutes. This applies all the way from the upper limits of the corridor catchments (e.g. top of cut batter and upstream boundary on flow line) down to the final points of discharge.

In doing this, the following issues should be addressed as appropriate:

- identification of catchment areas to determine flow paths and calculate relevant runoff data
- separation of 'clean' upper catchment run-on water from potentially contaminated road runoff during both the construction and operational stages of the project
- inclusion of catch drains and berm drains to protect cut batters, and to safely divert 'clean' run-on water through or away from the disturbed area
- location of culverts to permit a temporary stable bypass to be provided for 'clean' cross-drainage during construction (e.g. culvert slightly off-set from flow line)
- location of other drains to maximise the diversion of 'dirty' runoff into sediment traps and basins (construction phase) or stormwater treatment measures (operational phase)
- design and location of sediment basins to treat 'dirty' runoff during construction and then potentially to act as permanent water-quality protection measures during the operational stage. Operational controls should be particularly considered when stormwater may affect an area of high conservation value or a water supply catchment
- culvert inlet and outlet protection (e.g. energy dissipaters)
- batter grades and batter stabilisation treatments (refer to **vol. 1**: section 4.4.2 for constructed slope length and gradient requirements on sites of high-erosion hazard)
- kerbs, gutters or dykes discharging into batter drains to protect fill batters
- suitable drain and channel linings determined from catchment areas, grades and predicted velocities of flows
- bridges with piers and abutments not significantly impacting on flow lines
- other applicable techniques (e.g. flumes, rock mattress and gabion structures).

Road designers are particularly encouraged to seek specialist advice relating to erosion and sediment control on high-risk projects. The opportunity to influence results is greater in the early life of a project, and poor decisions are often difficult and/or costly to rectify later.



## 4.4 Specifications

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Specifications provide additional information on the requirements for a road construction project to complement the design plans. These documents should contain details of the requirements for effective erosion and sediment control and ensure that the principal's interests can be met (see section 3.5). The nature and extent of specification clauses relating to erosion and sediment control will vary depending on the scale and location of the project. Issues that can be addressed in the specifications, particularly for large projects on high-risk or sensitive sites, include:

- a requirement for contractors on high-risk projects to include suitably qualified and competent site personnel on their project team
- a requirement to schedule major ground-disturbing activities on highly sensitive or high-risk parcels of land to periods when rainfall erosivity is low. Highly sensitive lands and rainfall erosivity are discussed further in **vol. 1**: section 4.4.2(c) and (d), table 6.2, and appendix A
- a requirement for the contractor to submit a primary ESCP together with relevant progressive ESCPs, to cover preliminary site establishment, clearing and grubbing operations etc., for approval as specified in the contract, prior to the contractor undertaking any earth-disturbing activities on site. This should normally be included as a 'hold point' in the contract documentation
- a requirement that the contractor progressively submit a series of progressive ESCPs and that the contractor is to receive approval from the project superintendent (the client's on-site representative), or from the relevant authorities if required by the contract, prior to commencing work in those catchments or high-risk areas
- a requirement for the primary ESCP to include a map showing how the project site has been subdivided into smaller, separate catchment areas or high-risk areas, each of which will be the subject of a detailed progressive ESCP
- a requirement for the contractor to maintain an up-to-date register of all progressive ESCPs. This register should include date of submission, date of approval and date of commencement of works for each plan
- provision of a 'pay item' list for a wide range of temporary control measures such as temporary vegetation, mulches or geobinders (used, for example, as stockpile covers); and sediment fences, sediment traps, geotextile linings and maintenance (for de-silting) etc. This is preferred over the approach where the cost of these measures or activities will be included in the tender price as a lump sum (paid on a pro-rata basis) with little or no provision for additional payments. This unit-cost approach means that contractors are fairly reimbursed for their expenditure and that the superintendent is aware of the expected costs for any variation in the scope of erosion and sediment controls
- drawings of controls reflecting practical and up-to-date approaches (e.g. sediment traps at inlets to gutter pits, and sediment fence configurations at culvert inlets and outlets)
- inclusion of a section covering 'revegetation for erosion and sediment control', distinct from the section covering landscaping. Revegetation for erosion and sediment control should be undertaken progressively throughout the road construction program (to minimise the extent and duration of disturbance) and should not be left until the end of project when landscaping typically occurs (refer to **vol. 1**: section 7.1.2 and table 7.1). Wind erosion and dust generation will also be minimised by either temporary or progressive revegetation/stabilisation

- landscaping details, typically focusing on the provision of a suitable landscape with visual and ecological considerations along the road corridor at the end of the project
- a separate pay item to cover revegetation contractors and/or specialist equipment. This will reduce the likelihood of progressive revegetation not occurring
- detail on specific seed mixtures and fertilisers to be used, as these will vary according to location, climate and time of sowing
- appropriate cross-referencing throughout the specifications to tie in erosion and sediment control requirements with all other aspects of construction (e.g. clearing, stripping and stockpiling of topsoil, bulk earthworks, culvert construction, bridge construction, borrow areas, side tracks and batch plants).

Specifications require careful wording, and the development of a clear, accurate and workable document is essential. Sufficient flexibility should also be retained to allow the contractor to propose (and get paid for) any customised or one-off control measures.

## 4.5 Pre-tender meetings

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Pre-tender meetings can be held for the benefit of contracting companies interested in submitting tenders for proposed road construction projects, particularly for large projects. The aim of these meetings is to provide design engineers, construction engineers, geotechnical engineers, environmental personnel and contractors with an opportunity to discuss various aspects of the proposed construction, including erosion and sediment control, where a briefing can be provided on issues such as:

- the importance of erosion and sediment control and other water-quality issues
- high-hazard and sensitive areas both within and outside the corridor (e.g. watercourses, nature reserves, wetlands, oyster leases and water supply catchments)
- any specific conditions of approval placed on the project by the relevant authorities
- the requirement for ESCPs and their timing
- the necessity, where applicable, for:
  - early construction of permanent drainage works (e.g. culverts, catch drains) as a significant part of management of 'clean' or upper catchment run-on and 'dirty' construction runoff
  - a continual or progressive approach to erosion and sediment control (e.g. temporary controls, revegetation)
  - stream and drainage-line protection
  - maintenance of erosion and sediment controls
- the development and implementation of an operating system involving the preparation of ESCPs, work procedures, training, inspections, reporting, checklists etc.

The briefing can also highlight the economic advantages relevant to the contractor's own activities including:

- greatly reduced repair and maintenance resulting from on-site erosion damage, including the expensive process of de-silting stormwater drainage pipes
- a marked decrease in construction downtime following wet weather due to good surface-water management.

## **4.6 Pre-construction meetings**

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A pre-construction meeting should be held with the successful contractor prior to works commencing on-site. This is important as the personnel undertaking the actual construction will often be different from those who attended the pre-tender meetings. The principal's representative can use this opportunity to emphasise the main issues raised at the pre-tender meeting (section 4.5) and confirm any requirements for licences, permits and/or approvals.



## 5. Operational considerations

Erosion hazard and the risk of sedimentation generally diminishes following the conclusion of road construction activity. Surfaces which were disturbed and bare become less prone to erosion following the installation of surface water controls, paved surfaces and revegetated batters and verges.

However, regular maintenance inspections by roads authorities should be conducted with appropriate recording to identify and rectify general problems, including:

- areas of erosion and/or sediment deposition
- poor vegetative cover
- breached diversion banks
- blocked drains
- slumped batters
- sediment basins or other stormwater treatment measures requiring maintenance or repair.

Other more specific matters that may need to be addressed include:

- the management of sediment basins until formerly bare and disturbed surfaces achieve a C-factor (see **vol. 1**: appendix A) of 0.05 – approximately 70 per cent ground cover. This may require basin management for a period of three to 12 months into the operational period to ensure sediment pollution issues are not prematurely disregarded following the completion of construction (refer to **vol. 1**: section 7.1.2)
- ensuring that certain erosion and sediment control measures are suitably decommissioned or removed. In some cases leaving temporary controls in place, without maintenance, can cause erosion and sediment pollution
- the effective conversion of sediment basins to 'spill' basins or other permanent stormwater treatment measures, and their subsequent maintenance.



## 6. Erosion and sediment control techniques

6.1	Applicable techniques from volume 1	26
6.2	Reuse of collected runoff	28

## 6.1 Applicable techniques from volume 1

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Most of the erosion and sediment control techniques described in **vol. 1** are applicable to erosion and sediment control for main road construction. Appendix D provides a summary of these techniques and guidance on their selection.

The main variation to the techniques described in **vol. 1** relates to the sizing of diversion drains and sediment basins, to account for the longer duration of main road construction relative to urban subdivision construction.

Due to the longer operational life of sediment control measures at main road construction sites relative to urban development site construction, higher standards of design and construction should be adopted for water conveyance and storage structures on main road construction sites, particularly those that will remain after the operational life of the site.

The recommended minimum design criteria for sediment control measures for main road construction are presented in table 6.1. More stringent criteria may be adopted, particularly if considered warranted by a site-specific environmental impact assessment. Table 6.2, overleaf, presents the indicative average annual sediment basin overflow (or spill) frequency for various five-day design storms presented in table 6.1 when treating runoff from type F or D soils.

Table 6.1 notes that the minimum basin design criteria can be reduced when enhanced erosion controls are used. Enhanced erosion controls would normally be used on a main road project where site constraints preclude the installation of basins designed to the conventional criteria. These constraints may include existing development, topography or endangered ecological communities. However, implementing enhanced controls may be challenging for large main road construction projects. If enhanced controls are implemented, an independent audit of their implementation should occur at least fortnightly for these sensitive sites. The auditor should be a soil conservationist or an accredited erosion-control specialist (this is similar to the approach outlined in section 3.3.3).

It should be noted that **vol. 1**: section 6.3.2 recommends a sediment retention basin be constructed in all situations where the estimated annual soil loss exceeds 150 cubic metres per year.

The operation of basins for type F and D soils is described in **vol. 1**: section 6.3.4. This section notes that the basin should be drained or pumped out within the adopted management period (commonly five days) following rainfall. For the purposes of basin management, this requirement refers to rainfall of sufficient depth to result in runoff entering the basin. This rainfall depth will vary depending on the site conditions at the time of the event, particularly the extent of any impervious surfaces (e.g. road pavement) and the extent of any preceding rainfall. For sites at the bulk earthworks stage where there has not been significant preceding rainfall, rainfall depth of at least 5–10 mm may be needed before runoff commences.

This approach avoids the situation where the basin management period is extended for a further five days following negligible rainfall (e.g. 1 mm). This would result in the basin containing runoff for a longer period, reducing its ability to capture runoff from subsequent storm events and hence increasing the spill frequency.

**Table 6.1 Recommended minimum design criteria for temporary erosion and sediment control measures at waste landfill sites**

**Minimum average recurrence interval (ARI) of design storm event**  
(unless otherwise indicated)

Duration of disturbance	< 6 months		6–12 months		1–3 years		> 3 years	
	standard	sensitive	standard	sensitive	standard	sensitive	standard	sensitive
<b>Sensitivity of receiving environment ('standard' or 'sensitive')</b> <sup>1</sup>								
<b>Temporary drainage (erosion) controls</b> <sup>2</sup>								
– designed to have a non-erosive hydraulic capacity to convey	2 yrs	5 yrs	5 yrs	10 yrs	10 yrs	20 yrs	20 yrs	20 yrs
<b>Temporary sediment control measures</b> <sup>3</sup>								
– should be constructed to remain structurally sound in:	2 yrs	5 yrs	5 yrs	10 yrs	10 yrs	20 yrs	20 yrs	20 yrs
<b>Type C sediment retention basin</b>								
– designed to achieve required water quality for flows up to:	0.5 x 1 yr	1 yr	1 yr	2 yrs	1 yr	2 yrs	1 yr	2 yrs
– embankment and spillway designed to be structurally sound in <sup>4</sup> :	10 yrs	20 yrs	20 yrs	50 yrs	50 yrs	100 yrs	50 yrs	100 yrs
<b>Type F or D Sediment retention basin</b>								
– designed to achieve required water quality for storms up to nominated five-day duration percentile event: <sup>5</sup>	75 <sup>th</sup>	80 <sup>th</sup>	80 <sup>th</sup>	85 <sup>th</sup>	80 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>
– designed to achieve required water quality for storms up to nominated five-day duration percentile event with enhanced erosion controls <sup>6</sup> :	75 <sup>th</sup>	75 <sup>th</sup>	75 <sup>th</sup>	80 <sup>th</sup>	75 <sup>th</sup>	80 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>
– embankment and spillway designed to be structurally sound in <sup>4</sup> :	10 yrs	20 yrs	20 yrs	50 yrs	50 yrs	100 yrs	50 yrs	100 yrs

<sup>1</sup> A 'sensitive' receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality.

<sup>2</sup> e.g. diversion banks, perimeter banks, catch drains, level spreaders, check dams, batter drains and chutes.

<sup>3</sup> e.g. sediment fences, stacked rock sediment traps etc. on small catchments where used as a 'last line of defence' (i.e. without a down-slope sediment basin).

<sup>4</sup> This is indicative only – consider the risks of basin failure for each basin to determine appropriate spillway design flow.

<sup>5</sup> For a five-day management period. Adjustment factors to the five-day volumes for alternate management periods are 85% for two-days, 125% for 10 days and 170% for 20 days.

<sup>6</sup> Enhanced erosion controls are described on **vol.1** section 6.3.4(g).



**Table 6.2** Indicative average annual sediment basin overflow frequency

Design storm event	Average annual overflow frequency
75 <sup>th</sup> percentile	8–11 spills/year
80 <sup>th</sup> percentile	6–8 spills/year
85 <sup>th</sup> percentile	4–6 spills/year
90 <sup>th</sup> percentile	2–4 spills/year
95 <sup>th</sup> percentile	1–2 spills/year

Adapted from Evans and Peck (2007)

Road constructors are encouraged to record rainfall data at large-scale road construction sites in the form of either daily rainfall measurement or, if necessary, rainfall intensity and duration data (to accurately determine the magnitude of individual storm events). This should be done using appropriate measuring facilities (e.g. tipping bucket rain gauge with data logger or pluviograph) in a secure on-site location.

Appendix B presents typical arrangement diagrams illustrating how common erosion and sediment control measures and techniques described in **vol. 1** may be applied in a road construction context.

For the design of erosion and sediment control facilities, the following default soil characteristics (as described in **vol. 1**) can be adopted in the absence of site specific data:

- classification as type D (i.e. dispersive) soil based on texture and dispersibility characteristics
- soil hydrologic group D for purposes of assessing runoff characteristics
- assumed erodibility (K-factor) of 0.05.

Sediment basins should also be designed on the basis of a volumetric runoff coefficient of 0.9 for any impervious areas within the basin's catchment.

## 6.2 Reuse of collected runoff

Type F and D sedimentation basins should be drawn down to a required level within a specified period following a storm so that the basin can subsequently retain runoff from the next storm (as noted in **vol. 1**). A simple and often cost-effective means of achieving this drawdown is to reuse the water within the site. Depending on the rate at which the collected stormwater can be used within the site, or directed to an additional holding dam, there is likely to be a need, at least on occasions, to discharge the treated stormwater from the site.

On a typical main road construction project, runoff water quality following basic treatment (e.g. sedimentation) is generally adequate for uses such as dust suppression, compaction of earthworks and irrigation of rehabilitated areas. For irrigation of captured runoff, the application rate will be limited by the hydraulic loading considerations of the irrigation area and evapo-transpiration needs of its vegetation. In addition, reuse water quality needs to be considered against the requirements of the proposed use (e.g. salinity levels should be considered when irrigating rehabilitation vegetation).

Where a sediment basin also functions as a water storage for runoff prior to reuse, the capacity of a basin designed for type D or F soils should normally be the sum of the:

- required settling volume, based on the adopted design storm volume and management period, where inflows will be treated and discharged
- sediment storage volume
- the capacity required for water reuse.

This ensures that sufficient volume is available in the basin to capture runoff from storms up to the design event without overtopping. Such storages should be operated so that the storage is drawn down to the storage zone level within the adopted management period after the end of a storm, such that the basin can subsequently retain runoff from the next rainfall event.

For basins providing storage for reuse, runoff treatment and discharge will not be required where the runoff reused over the adopted basin management period (e.g. five days) is greater than the settling volume. In this situation, the basin's settling volume will be emptied within the basin management period through reuse rather than discharge. The basin will need to be designed with a reuse volume greater than or equal to the settling volume.

The requirements of the *Dam Safety Act 1978* may apply to large water storage dams.

*Managing urban stormwater: harvesting and reuse* (DEC 2006a) provides guidance on stormwater reuse.

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## Appendices

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## Appendix A: Erosion and sediment control planning

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### A.1 Background

The methodology used to develop and present soil and water-related plans for road construction and maintenance projects differs slightly from the process described in **vol. 1**: section 2. This is due largely to the linear nature of main road projects.

The guidance provided in the following sections is focused on large main road projects, particularly those where there is a significant risk of erosion and sedimentation of sensitive environments. Where the scale of the project is relatively small (e.g. installing an extra lane on a main road for a relatively short distance) and/or the risk of environmental impacts is low, the approach described below can be modified to suit the nature of the project.

### A.2 Environmental management plans

Construction and maintenance contractors on main road and highway projects are commonly required by the project's principal or client to prepare and operate a site-specific or project-specific construction/contractor's environmental management plan (CEMP). This plan should be developed by the contractor before any work physically starts on the site.

A CEMP commonly addresses:

- all limitations, constraints and/or opportunities as previously identified by the project's environmental impact assessment (e.g. review of environmental factors or environmental impact statement). DLWC 2000 provides guidance on the consideration of soil and landscape issues in environmental impact assessment. For RTA projects, these issues are addressed in the decision report and, where required, incorporated into design and contract documentation (e.g. drawings and specifications)
- general contract conditions
- statutory requirements and other specific conditions of approval as may be required by relevant government agencies
- the contractor's proposed construction activities or operations, particularly in relation to high-risk areas and activities
- current accepted standards of industry best practice.

The CEMP addresses a comprehensive range of environmental issues, including soil and water, flora and fauna, noise and air, and management of hydrocarbons, chemicals, waste, other pollutants and contaminants.

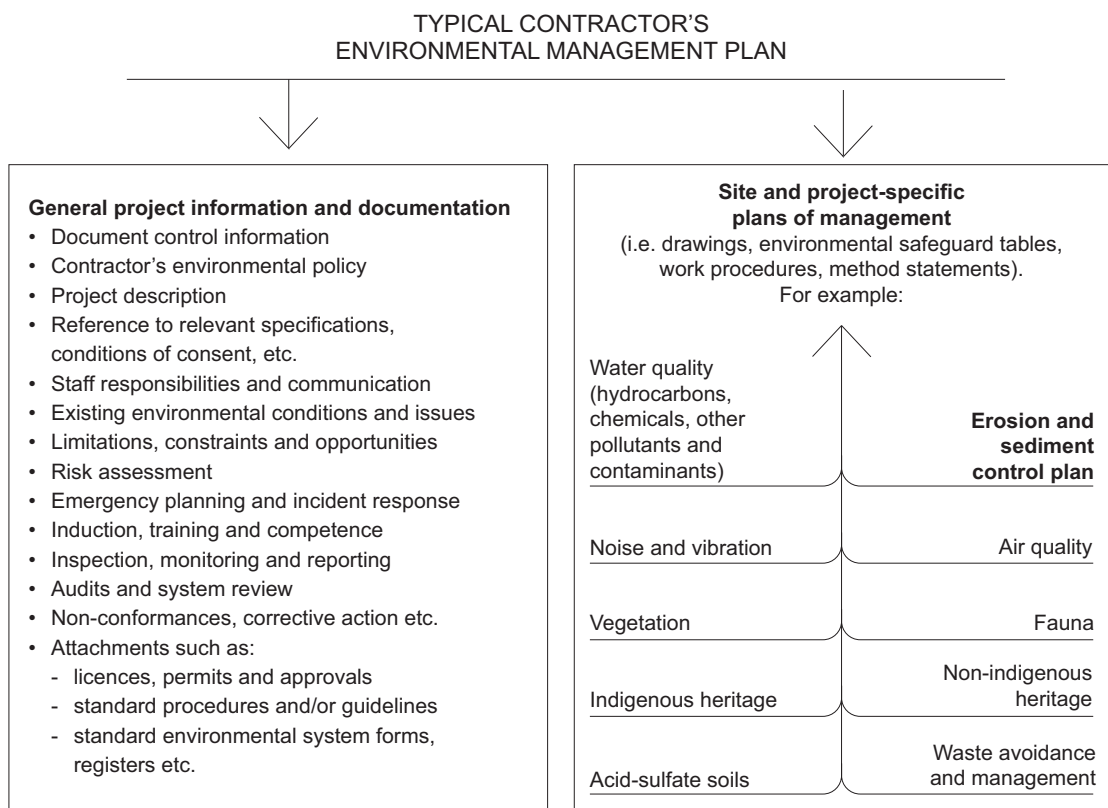
An integral component of a CEMP is usually an erosion and sediment control plan (ESCP), which focuses on specific erosion and sediment control issues during construction and maintenance-related activities.

It should be noted that this combination of CEMP and ESCP, when used on road and highway construction projects, achieves the intent and includes the content of a soil and water management plan (SWMP) for urban development projects. **Vol. 1** defines a requirement for the preparation of an ESCP for small urban development projects where an area between 250 and 2500 square metres will be disturbed, and a more broadly focused and detailed SWMP for projects with disturbed areas larger than 2500 square metres.

This precise application of this area-based approach is not considered suitable for the road construction industry. It is recommended that an ESCP be prepared to address erosion and sediment control for all road construction or modification projects, with the level of detail presented in that plan reflecting the nature and scale of the project, and the site and the surrounding environment as described in the following sections.

The actual format used to present the CEMP and ESCP will vary according to specific requirements of the contract and/or the contractor's own quality or environmental management systems. Nonetheless, most CEMPs will generally include the ESCP as a stand-alone plan of management for ease of implementation and external agency review.

The format for a typical 'global' CEMP is outlined in figure A.1, while a suggested format for ESCPs is presented above in section 3.3.



### A.3 Erosion and sediment control plans

Due to the unique nature of road construction projects (together with many of the particular issues listed below and in section 1.3), contractors have generally found that use of a multi-part ESCP allows a significant degree of operational flexibility for medium to large projects.

The primary ESCP contains detailed background information, risk assessment and discussion, while a series of subordinate progressive ESCPs provide up-to-date detail regarding location and installation of control measures.

Progressive ESCPs are typically developed as the project proceeds, as site conditions evolve and as flow paths are changed. Over the construction and/or maintenance phase of a project, a series of progressive ESCPs will be prepared to address all stages of the work and to provide the necessary levels of flexibility.

Accordingly, it is important that a register of these progressive ESCPs be maintained on site, to ensure that there is no confusion about which ESCP is current at any particular time, and to ensure that appropriate processes are followed in the planning, implementation and decommissioning of erosion and sediment controls during the life of the project.

A map or drawing should also be developed showing how the project site has been subdivided into smaller, separate sub-catchments or high-risk areas, each of which should be the subject of a detailed progressive ESCP.

A suggested format for a typical multi-part ESCP for use on road and highway construction and maintenance projects is outlined in figure A.2.

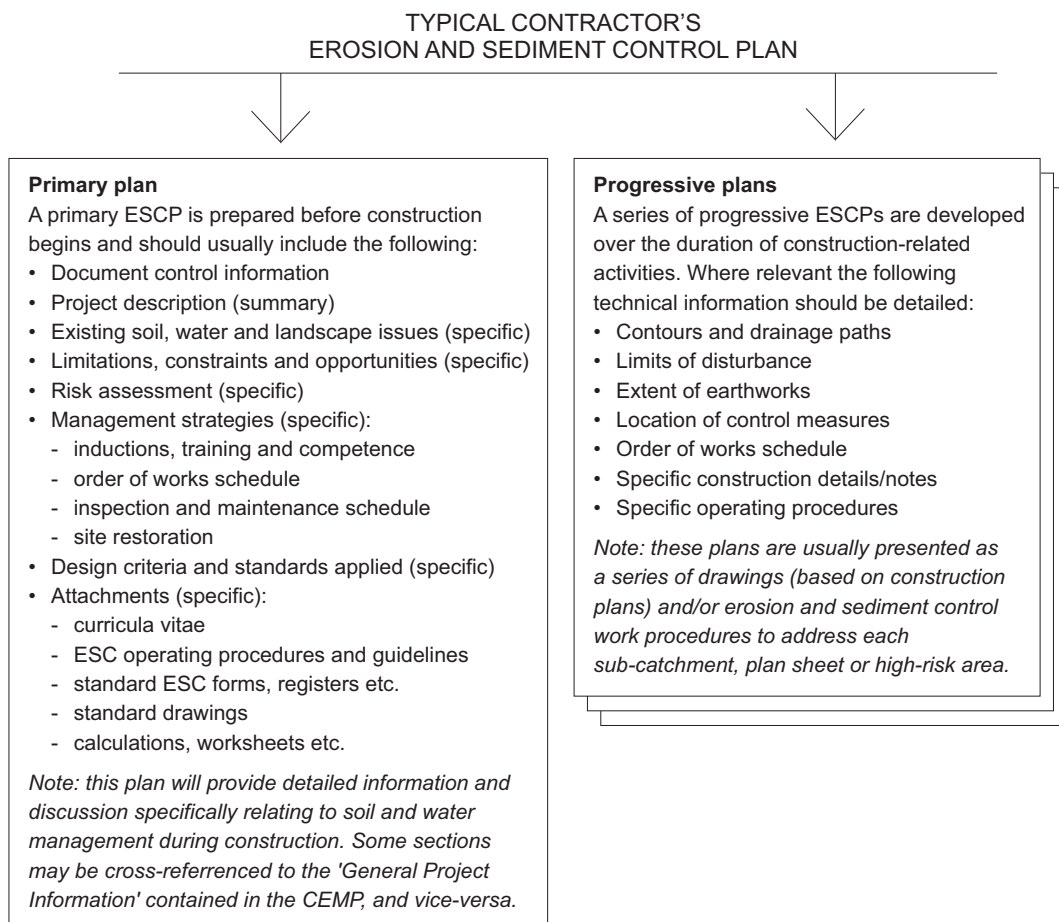


Figure A.2 Format of a typical multi-part ESCP often used on road construction projects

## **A.4 Contractor's operating and management systems**

Main roads contractors should have an internal operational quality-management and/or environmental-management system whereby their general day-to-day construction activities are fully linked to their ESCP and CEMP, and vice versa.

Accordingly, the planning, implementation and maintenance of erosion and sediment controls should be fully recorded within this system to ensure documented evidence is available at all times. As illustrated in the sample ESCP in appendix B, this system documentation for a medium-to-large project typically includes:

- an ESCP (i.e. both primary and progressive)
- a map or drawing of the project showing how the site has been subdivided for the purposes of preparing progressive ESCPs
- a register of progressive ESCPs
- work procedures, work-method statements, activity statements etc.
- inspection reports by the specialist soil conservationist (i.e. with action and close-out sections)
- routine inspection checklists used by construction personnel (i.e. with action and close-out sections)
- auditing programs
- a training and induction register
- site notes distributed internally about the project (e.g. instructions, alerts)
- formal correspondence (e.g. to and from RTA, councils, government authorities, designers, contractors)
- meeting minutes
- procedures for water-quality management in sediment basins
- water-quality monitoring results
- a flow chart of responsibilities.

The above documentation and recorded details will vary according to the nature of the project, the requirements of the contractor's environmental-management system, the contractor's quality-management system and/or the specific requirements of the contract.

Not only will a robust system be a definite advantage to a project during normal operations, but it will be particularly useful during any audit or regulatory investigation. A well-documented system will assist the contractor to demonstrate 'due diligence'.

## **A.5 Progressive erosion and sediment control plans**

While primary ESCPs are prepared prior to any construction on a project, a series of progressive ESCPs are continually prepared prior to the start of each stage (e.g. initial clearing, stripping and stockpiling topsoil, and bulk earthworks) or prior to commencement of a specific type of high-risk activity (e.g. culvert or bridge construction).

Primary and progressive ESCPs are discussed in section A.3 above, and a sample ESCP is presented in appendix B. Particular aspects of the sample ESCP that should be noted include:

- clear definition of the role and function of progressive ESCPs – see appendix B, section 3.
- format for a register of progressive plans – see appendix B, attachment 1
- samples of progressive ESCPs – see appendix B, attachment 2.



The sample progressive ESCP on bridge construction demonstrates the integration with other field-planning documents such as work procedures, work-method statements or activity statements, where a detailed level of planning is required at a sensitive site. Other situations where these detailed planning documents may be required include culvert construction, realignment and stabilisation of flow lines, and access through or around wetlands.

## **A.6 Preparation of erosion and sediment control plans**

As previously indicated in section 4.4, specifications should contain a clause requiring the contractor to submit ESCPs for approval prior to commencement of works. On high-risk projects these plans should be developed and implemented as a cooperative effort between the contractor and a soil conservationist.

On projects with a lower risk, contractors may develop and present their own plans. However, it is recommended that a soil conservationist review these prior to submission to the superintendent. Periodic review of plan implementation by the soil conservationists (where they are part of the project team) will also provide beneficial feedback to the contractor.

In this way a series of workable and practical ESCPs can be developed and implemented. These plans will result in structured forward planning, and an ordered approach to erosion and sediment control during construction, with an emphasis on being proactive and adaptive rather than being reactive.

While the use of a multi-part ESCP has been proposed and discussed in section 3.4, all plans should reflect the specific requirements of the contractor, the client organisation (e.g. RTA, local council) and any other relevant consent authorities. Accordingly, plans may be prepared in many different formats, all with the prime requisite of achieving the desired project outcomes in the field during construction.

As illustrated in section 3.4, the primary ESCP may be prepared as either a stand-alone document or included as a section of a more encompassing environmental document such as an EMP or an integrated project plan.

## **A.7 Training**

A successful erosion and sediment control program will depend on competent project personnel, including site managers, engineers, superintendents, foremen, leading hands, plant operators and labourers.

In this context, training is important and may be conducted, depending on the size and nature of the project, by one or more of the methods listed below. For example, large projects could include all methods of training, whereas smaller projects may only include site inductions and 'toolbox' meetings. To complement initial training, follow-up reviews of staff implementing these controls is also important to ensure that the training is being effectively implemented.

### **A.7.1 Site inductions**

All personnel should attend a project-specific site induction prior to commencing any work on the site. General erosion and sediment control and water quality matters should be highlighted, together with responsibilities under various pieces of legislation (e.g. POEO Act).

### **A.7.2 Toolbox meetings**

These informal on-the-job sessions should be conducted regularly (i.e. at least weekly) to address numerous issues related to operations, safety, the environment etc. Issues relevant to the stage of construction are usually highlighted (e.g. de-watering, mud tracking onto local roads, and care and maintenance of control measures).

### **A.7.3 Formal training sessions**

In situations where more intensive formal training sessions have not already occurred as part of a contractor's environmental management system (EMS) and/or environmental policy, they can be conducted early in the project. This training may include:

- awareness training, which generally covers all soil and water-related issues and should be delivered to all personnel (see the training program outline at attachment 4 of appendix B)
- advanced training which addresses site-specific and project-specific issues and is directed to relevant personnel (e.g. preparation of progressive ESCPs and sediment basin management).

## **Appendix B: Sample erosion and sediment control plan**

---

### **B.1 Introduction**

Land that has been disturbed or cleared of vegetation is potentially subject to erosion as a result of stormwater runoff. Soil particles that are eroded in such a way are transported down-slope, usually settling in watercourses, wetlands and lakes.

Erosion and sedimentation may result in many adverse environmental impacts including:

- reduction in water quality, increased turbidity and nutrient enrichment of water bodies
- damage to vegetation communities
- disturbance to aquatic flora and fauna
- increased potential for flooding
- restrictions to navigation
- reduction in recreational values
- reduction in aesthetic values
- increased maintenance costs
- promotion of weed growth
- reduced agricultural, forestry and biomass production.

This plan will form the initial 'link in the chain' to minimise on-site erosion and off-site sedimentation and therefore reduce adverse environmental impacts.

### **B.2 Project description**

*Description will vary according to the nature of the project and should be:*

- *included in this section if the plan is a stand-alone document*
- *cross referenced to the relevant section if the plan forms part of a more encompassing environmental document such as an environmental management plan or integrated project plan.*

### **B.3 Scope of this plan**

The purpose of this document is to serve as a broad based erosion and sediment control plan (ESCP) to outline the intentions and fundamental principles that will be followed in the planning and implementation of erosion and sediment control measures for the entire project.

This primary (or generic) ESCP will be supplemented by numerous progressive ESCPs detailing individual control measures. The progressive plans will be:

- prepared by the specialist soil conservationist in association with construction personnel to formulate practical documents for field reference. Additionally, this process will provide a sense of ownership of the proposals to all parties
- prepared on relevant copies of drainage drawings for:
  - different stages of construction (e.g. initial clearing, grubbing, topsoil stripping and stockpiling with revision for bulk earthworks)
  - areas of high erosion hazard (e.g. culvert construction, bridge abutments). These plans will be revised as required
  - specific areas that may occur outside the road alignment (e.g. compound, batch plant, stockpile sites and access roads). These plans will be revised when required by changing circumstances

- integrated with work procedures, work method statements, activity statements and their scheduling especially in relation to culvert and bridge construction
- site-specific and will not generally repeat the information contained in this primary ESCP and/or the contractor's EMP
- given a sequential number and recorded in the register for progressive ESCPs (see attachment 1).
- controlled and distributed in accordance with the contractor's quality system procedure for document control.

Samples of progressive plans are included at attachment 2.

## **B.4 Existing environment**

- 4.1 Landuse
- 4.2 Topography
- 4.3 Sensitive areas
- 4.4 Soil types
- 4.5 Rainfall

*The above points will vary according to the location in New South Wales. They will also depend on the extent of project information included in this section if this plan is a stand-alone document, or cross-referenced to the relevant sections if this plan forms part of a more encompassing environmental document such as an environmental management plan or integrated project plan.*

*The points should be drawn together to emphasis matters relating to erosion hazard (e.g. best season for construction).*

## **B.5 Specifications and supporting documentation**

*Provide a list of specifications relevant to the project which are designed to minimise the potential for soil erosion and to contain sediment within the construction site. Specifications will vary from project to project.*

*Additionally, list any documents which are consistent with the specifications and provide guidelines on implementation of controls.*

## **B.6 Key management strategies**

*The following list outlines principles and control measures that should be considered for inclusion in this section of the plan (i.e. only include those points relevant to the project):*

### **General**

- consider engaging a specialist soil conservationist with experience in road construction (CV included in attachment 3)
- wherever possible make specialist input into detailed design including:
  - design and location of sediment basins
  - siting sediment basins to maximise capture of runoff from construction areas
  - siting sediment basins to also contain road spillages during road operation
  - location and stabilisation of open drains (e.g. catch and berm drains)

- batter treatments
- culvert design with consideration for a stable flow path during construction
- bridge design in sympathy with maintaining the integrity of drainage lines
- dissipation of high-velocity flows
- form a specialist labour team to construct temporary controls, including sediment fences, batter drains on fill batters, and flocculate sediment basins etc.
- ensure erosion and sediment controls are installed at all sites associated with construction activities, including:
  - access roads and tracks
  - office and compound sites
  - workshop areas
  - concrete batching plants
  - crushing and screening plants
  - extraction sites
- liaise with the relevant government authorities in relation to control measures in watercourses and creeks (e.g. Department of Water and Energy, and Department of Primary Industries)
- develop relevant documentation and systems for recording erosion and sediment control activities via:
  - progressive ESCPs as detailed in section 3 of this plan
  - inspection reports completed by the specialist soil conservationist. A copy of the format for this report appears in attachment 6 and includes sections for location, control, recommendations/comment, action and 'close-out'
  - ESCP maintenance checklists completed by nominated construction personnel approximately every fortnight. A copy of the format appears in attachment 7. The checklist consists of a double-sided sheet where issues are identified on the front page and a general list of items or 'memory jogger' is provided on the reverse side. As with soil conservationist inspection reports, there is provision for 'close-out' on the actual list
  - site notes distributed internally between environmental and construction personnel
  - meeting minutes
  - formal correspondence (e.g. RTA, council, DECC, Department of Primary Industries)
  - water-quality monitoring results (e.g. sediment basins, upstream and downstream).

## **Training**

- highlight the importance of soil conservation issues during site induction
- schedule half-day awareness seminars early in the project for all personnel involved in construction. The program will cover:
  - environmental impacts
  - relevant legislation
  - principles of erosion and sediment control
  - techniques of erosion and sediment control

More detail on the program appears in attachment 4.

- conduct advanced soil conservation seminars for personnel with special responsibilities. This may include training in flocculation and water-quality management of sediment basins for the specialist labour team
- continually address relevant matters at regular 'toolbox' meetings during the course of the project.

### **Minimise extent and duration of disturbance**

- initially clear and grub to leave the soil surface in a reasonably rough condition with some surface vegetative cover
- minimise disturbance of vegetation along the road corridor with special emphasis on management of construction activities adjacent to watercourses
- leave watercourses undisturbed until culvert/bridge construction has commenced; use the cut-stump method where possible instead of stump removal to further maintain stream bank stability.

### **Control stormwater flows onto, through and from the site**

- separate 'clean' run-on water from 'dirty' (e.g. turbid) construction area runoff
- construct permanent drainage structures early in the project including:
  - sediment basins and traps
  - catch drains
  - culverts and associated inlet and outlet protection (e.g. dissipaters)
- maximise the diversion of turbid construction runoff into sediment basins
- control runoff during the construction of embankments (e.g. fill shaping and the construction of temporary dykes and batter drains)
- divert formation runoff into pits and the stormwater drainage system as soon as practical to reduce surface flow lengths.

### **Use erosion control measures to prevent on-site damage**

- site stockpiles of soil material in low-hazard areas clear of watercourses. Additional protection to be afforded with temporary vegetation, diversion banks and sediment control measures, if required
- construct a range of erosion controls within the various road sub-catchments to complement and increase the effectiveness and efficiency of sediment controls in the lower areas
- use geotextile linings to provide temporary surface protection in areas of concentrated flows (e.g. batter drains, culvert construction).

### **Use sediment control measures to prevent off-site damage**

- construct control measures as close to the potential source of sediment as possible
- ensure sediment basin management of turbid water immediately after rain as required with one or a combination of:
  - flocculation with gypsum (or approved alternative flocculant)
  - pump-out for construction purposes or dust control

- water not to be released from sediment basins prior to achieving acceptable water-quality standards. Attachment 5 contains a procedure for water-quality management in sediment basins
- manage water quality during de-watering activities (e.g. filtering techniques and flocculation with gypsum)
- control the deposition of mud and soil material onto local roads
- initiate a water-quality monitoring program in the adjacent watercourses with results analysed to determine the efficiency and effectiveness of implemented controls.

### **Stabilise disturbed areas quickly**

- ensure the success of the later revegetation program by utilising a good topsoil management program
- progressively revegetate disturbed areas utilising appropriate species
- control dust through progressive revegetation techniques, water tankers etc.

### **Inspect and maintain control measures**

- ensure the progressive and continual implementation and maintenance of temporary erosion and sediment controls (e.g. sediment fences, diversion banks, diversion drains, sediment traps)
- initiate a program to ensure regular maintenance of all erosion and sediment control measures. Sediment cleaned from structures, including sediment basins, to be deposited in a secure location where further pollution will not occur
- arrange regular inspections by a project soil conservationist or other key personnel to review and update control measures. Additional inspections will be conducted during and/or immediately following significant rainfall events to monitor the functioning of controls.

The above points collectively fulfil the principles of sound soil conservation practice as detailed in the various documents listed in section 5 of this plan. This will ensure a proactive and preventative philosophy is adopted, rather than a remedial approach to the control of erosion and sedimentation.

## **B.7 Conclusion**

The strategies presented in this plan are considered to appropriately address all issues relevant to erosion and sediment control and to minimise potential impact.

Forward planning, adherence to a system of documentation and training will be key elements to ensure good performance in the field.

## **B.8 Acknowledgments**

*Provide a list of references etc. used in the compilation of this plan.*

## **B.9 Attachments to this plan**

Attachment 1: Register of progressive erosion and sediment control plans

Attachment 2: Sample progressive erosion and sediment control plans

Attachment 3: Curricula vitae of specialist soil conservationist

Attachment 4: Program for erosion and sediment control awareness seminars

Attachment 5: Procedure for water-quality management in sediment basins

Attachment 6: Inspection report for project soil conservationist

Attachment 7: Checklist for nominated construction personnel



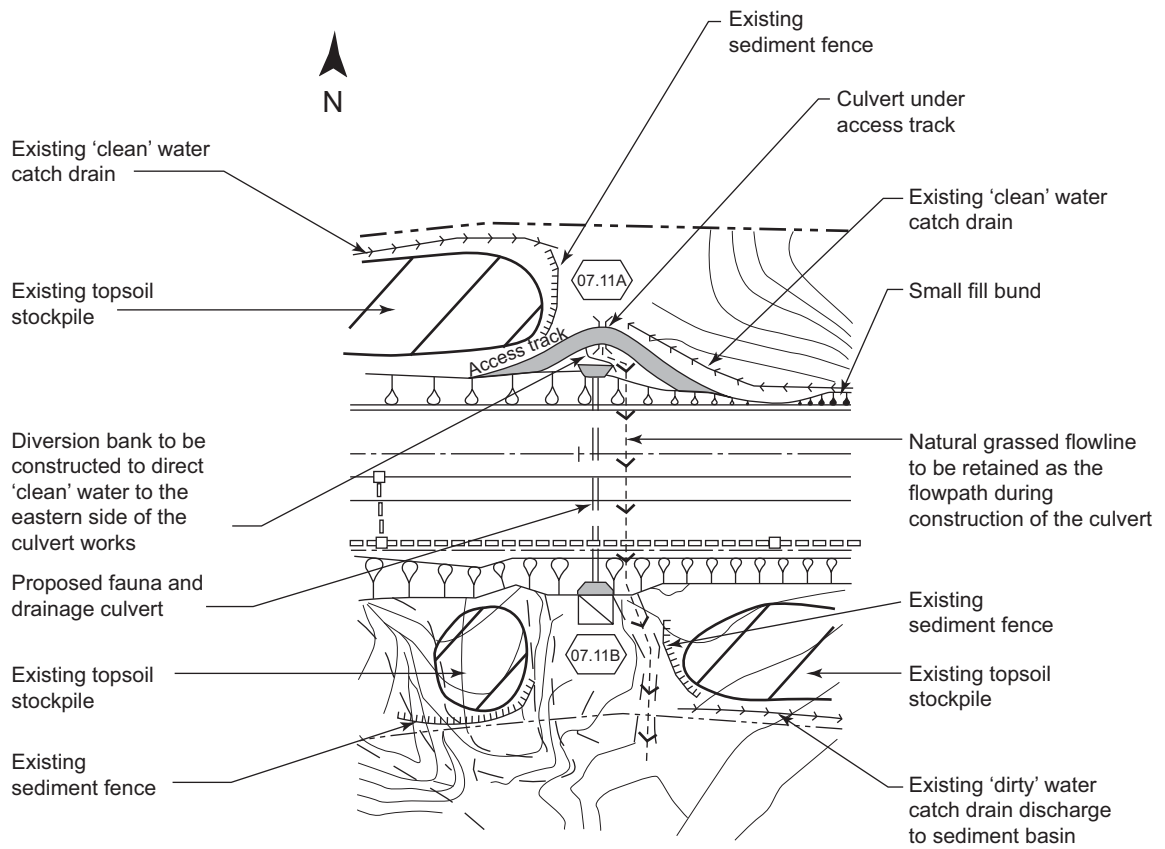
**ESCP Attachment 1 Register of progressive erosion and sediment control plans**

Plan no.	Chainage/description	Personnel involved in preparation	Date of preparation	Soil conservationist initials & date	Environmental manager initials & date	Superseded by plan no. / comment

## ESCP Attachment 2 Sample progressive erosion and sediment control plans

Figure B.1 Construction of culvert

Figure B.2 Construction of bridge over small watercourse



### Notes

1. This progressive plan is to be read in conjunction with the primary/generic plan developed for the entire project (i.e. refer to the EMP).
2. The principle of minimum disturbance to be observed.
3. 'Clean' water from the above catchment to be diverted to the eastern side of the culvert works via a bank immediately below the access track culvert discharging into the retained natural grassed flowline (i.e. culvert 'offset' to the west of the natural flowline).
4. Sediment fences, straw bale sediment traps and geotextile surface protection to be constructed at strategic locations as required.
5. Culvert inlet and outlet protection to be constructed after pipe laying without delay.
6. All controls to be inspected regularly with maintenance provided as required.

### Legend

	Proposed boundary
	Lined catch drain
	Unlined catch drain
	Rock-lined channel
	Rock-lined channel label
	Lined berm drain
	Unlined berm drain
	Grass-lined diversion channel
	Existing sediment fence
	Headwall and concrete apron
	Headwall and rock mattress
	Headwall and rock mattress and Type A dissipater
	Headwall and rock mattress and rock transition apron
	Transverse structure label
	Basin refer to schedule for basin type
	Spillway/outlet
	Basin label

Figure B.1 Progressive ESCP – construction of culvert

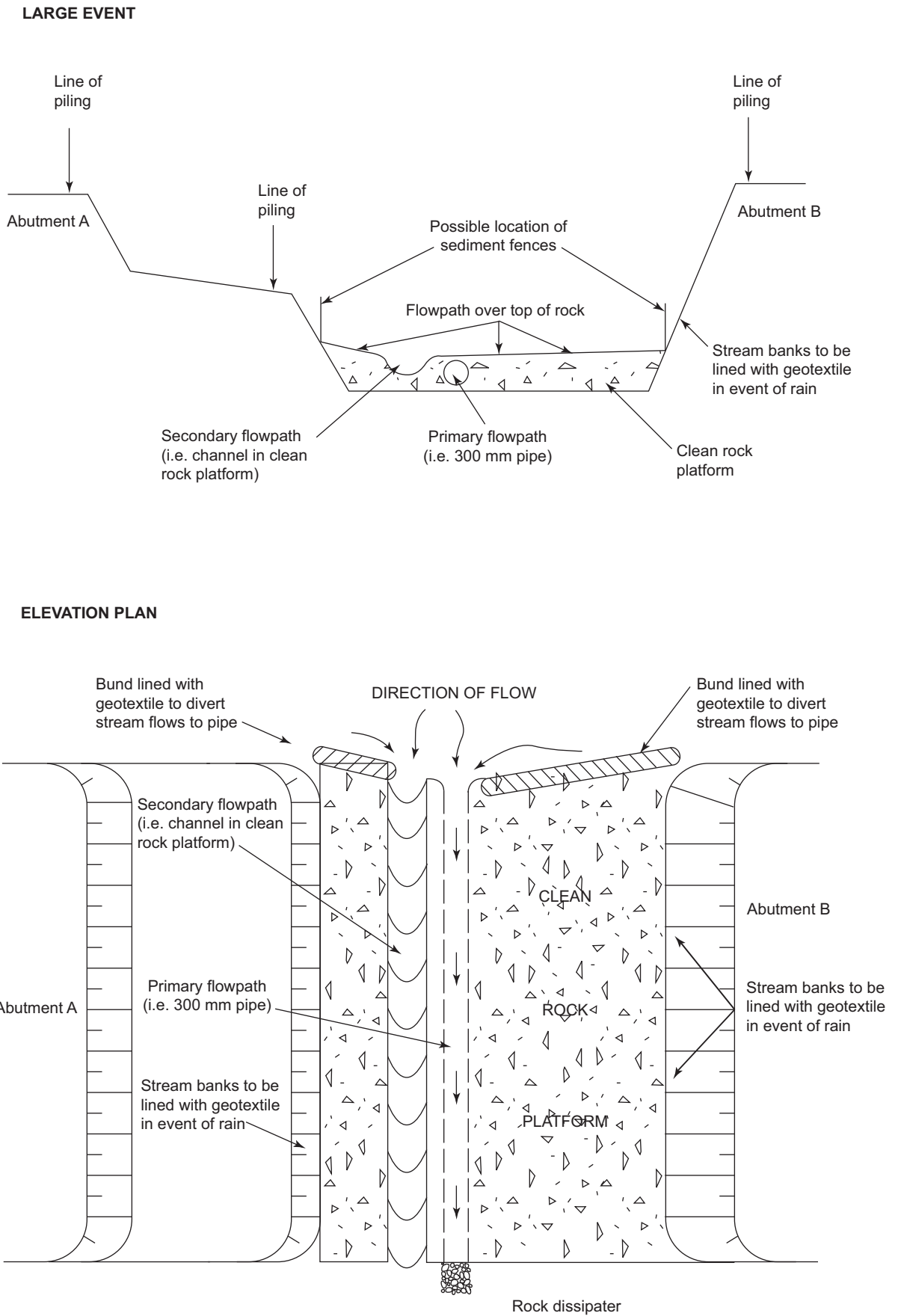


Figure B.2 Progressive ESCP – construction of bridge over small watercourse

This progressive plan should be read in conjunction with the generic plan developed for the entire project.

The following methodology will be implemented to minimise erosion and sedimentation:

- 1 The creek banks to be partially cleared of vegetation for survey. This initial disturbance to be minimal via 'trampling' with any bare areas to be protected with sediment fence.
- 2 Existing small creek flow to be pumped around the site from the upstream side of the existing crossing to beneath the existing highway bridge.
- 3 The creek bed and banks to be fully cleared of vegetation.
- 4 The creek bed and banks to be excavated to foundation level.
- 5 All excavated unsuitable material to be stockpiled well clear of the creek in a protected locality (i.e. so as not to cause pollution).
- 6 The following cross-section and elevation plans illustrate:
  - (i) proposed creek water diversion measures, and
  - (ii) temporary erosion and sediment controls to be used during piling and laying of rock mattresses on the bed and banks.
- 7 The time to implement points 2, 3, 4, 5 and 6 is estimated to be 2 days. Weather forecasts to be perused prior to construction to reduce risk. In the event of rain, bare and disturbed areas of the stream bed and banks to be lined with geotextile as an interim protective measure.
- 8 Displaced water from the piling operation to be pumped directly into a water cart or adjacent sediment basin.
- 9 Immediately piling operations are completed, the platform and pipe to be removed from the creek bed and final shaping and trimming to be completed.
- 10 The disturbed/bare creek bed and banks to be immediately covered with geotextile which will provide interim protection until installation of rock mattressing is completed.
- 11 Sediment fence and/or straw bale sediment traps to be constructed at strategic locations if required.
- 12 Interim protection of bare areas with geotextile lining to be used as required.
- 13 At completion of works, any bare or disturbed areas are to be seeded and fertilised.
- 14 All erosion and sedimentation controls to be inspected regularly and maintained when necessary (e.g. geotextile linings, sediment fences).
- 15 Creek stabilisation works should be completed over an 8–10 week period. All creek works to be completed prior to laying of bridge beams.

**Figure B.2 (cont'd)**

## **ESCP Attachment 3 CV of specialist soil conservationist**

*Include relevant CV here.*

## **ESCP Attachment 4      Program for erosion and sediment control awareness seminars – half day**

### **1      Introduction**

### **2      Environmental impacts**

This session focuses upon the on-site and off-site environmental impacts of erosion and sedimentation (e.g. water quality, fauna, flora). It concludes with an exercise listing all impacts.

### **3      Environmental legislation**

This session examines:

- relevant legislation (e.g. POEO Act)
- practical application in the field.

### **4      Principles of erosion and sediment control**

This session covers the following nine principles:

- investigation of site features
- planning
- minimum disturbance
- topsoil
- control of runoff
- minimisation of erosion
- trapping sediment
- progressive rehabilitation
- maintenance.

### **5      Techniques of erosion and sediment control**

This session includes the most common techniques including:

- clearing
- topsoil management
- drainage and installation of permanent structures (culverts, catch drains etc.)
- diversions banks
- drains and channels
- batter protection
- revegetation
- sediment basins and management
- sediment traps
- sand bags and their application
- maintenance
- miscellaneous matters (mud on local roads, de-watering, dust etc.)

### **6      Field inspections**

This session examines techniques constructed in the field together with associated discussions on impact, legislation and principles.

## ESCP Attachment 5 Procedure for water-quality management in sediment basins

*Insert project title*

### Why sediment basin management is required

An important component of water-quality control is effective management of sediment basins throughout the construction phase.

Under the *Protection of the Environment Operations Act 1997*, there is a legal responsibility to ensure that runoff leaving a construction site, including water being discharged from sediment basins after storm events, has an acceptable water quality.

On this project the parameters and limits to be monitored in the management of sediment basins include<sup>1</sup>:

- total suspended solids (TSS) – less than 50 mg/L
- pH – 6.5 to 8.5
- oil and grease – less than 10 mg/L.

It is these water-quality parameters that are addressed in this procedure.

### Pipe outlets

Sediment basins on this project been designed and constructed with:

- a low-flow pipe through the wall with a perforated riser at the inlet within the water storage area and a valve at the outlet below the structure
- a negatively graded pipe strategically placed through the wall (an 'Ellis pipe'). This pipe allows the basin to be easily converted to a chemical spill trap for road operation.

The Ellis pipe has no function during construction and is capped to prevent water flow. The valve on the low-flow pipe remains closed to trap runoff from construction areas and is only opened to release water that meets the required water-quality standards.

### Emergency outlets

Every sediment basin has an emergency outlet, which overflows when a rainfall event exceeds the design capacity. An oil baffle is constructed across each outlet to contain floating oil or hazardous material during any such event.

### Procedure

To effectively manage the sediment basins the following procedure should be undertaken:

- 1 All sediment basins to be inspected for capacity and water quality immediately following cessation of any rain period resulting in runoff.
- 2 If water is to be reused for construction purposes (e.g. compaction, dust control) no treatment is required. However, the water should be removed to re-secure design capacity within five days of the cessation of rain.
- 3 If sediment accumulates to a level above the sediment storage zone marker then de-silting should be immediately scheduled with water treatment as per the procedure below.

<sup>1</sup> Actual discharge limits may vary from these for different projects.

- 4 If the water level has risen above the level of the sediment storage zone marker, then the parameters of pH, TSS and oil and grease to be tested and addressed are as follows:
  - i) pH
    - test basin water with a pH meter
    - no action if pH reading between 6.5 and 8.5
    - lime (or suitable alternative) to be added if pH below 6.5
    - hydrochloric acid (32% Muriatic) (or suitable alternative) to be added if pH above 8.5
    - determine volume of water in basin
    - determine percentage of lime or acid required by taking a 10-litre sample of basin water and adding a known amount of lime or acid (initially 0.004%). If the pH is still not acceptable, vary the amount of lime or acid until within the limits
    - once the required percentage has been determined, calculate the actual amount of lime or acid to be added by multiplying the volume of water in the basin by the determined percentage
    - add the required amount of lime or acid to the basin
    - mix the water in the sediment basin well
    - treat for pH prior to TSS.
  - ii) TSS
    - test basin water by comparing with water samples contained in jars with representative readings up to 100 mg/L created through laboratory testing. This will enable a relatively accurate comparison which will be verified by laboratory testing approximately every six rainfall events
    - no action if TSS reading less than 50 mg/L
    - if basins require flocculation (e.g. TSS greater than 50 mg/L), bulk gypsum as a flocculant to be immediately applied evenly across the top of the water at an acceptable rate (i.e. trial and error as different for each basin). Methods of application to include:
      - a) broadcast by hand or shovel on small basins (i.e. less than 200 m<sup>3</sup>)
      - b) mixing in a drum with water and pumping through a hose on large basins (i.e. greater than 200 m<sup>3</sup>) (See **vol. 1**: appendix E.1 for further guidance on this technique).
  - iii) oil and grease
    - examine surface of water for evidence (e.g. sheen, discolouration)
    - no action if no visual contamination
    - oil-absorbent material to be spread if there is contamination.
- 5 Leave basins to compensate for 24 to 48 hours.
- 6 After re-testing, and once the above field tests indicate the water quality is acceptable, the stop valve should be opened by two or three notches (i.e. approximately 10%) for discharge to enable emptying within a 24-to-36-hour period to prevent sediment being stirred up by fast release of water and erosion at the outlet.
- 7 Steps 4, 5 and 6 may need to be repeated if acceptable water quality is not achieved initially.
- 8 Once water in the basins has been released the stop valve should be closed for the next rainfall event.
- 9 Records to be kept of the rainfall events, inspections undertaken, field tests undertaken, dosage rates, timing of basin-water release etc. (see Figure B.3 overleaf).
- 10 The whole process of water-quality management in sediment basins should be completed within five days of cessation of any rain period resulting in runoff entering the basin.



**Project title:** \_\_\_\_\_

**SEDIMENT BASIN MANAGEMENT CHECKLIST**

Rainfall event mm: \_\_\_\_\_  
 Days: \_\_\_\_\_

Allowable limits: TSS <50 mg/L  
 pH 6.5 to 8.5  
 Oil and grease max. 10 mg/L (by observation)  
 De-silting if sediment accumulates above marker

Basin no.	Design capacity m3	Is water to be used for construction?	Water quality before treatment			Rate of lime added	Rate of gypsum added	Oil absorbment added	Water quality after treatment		Date valve opened	Date valve closed	De-silting required	Date de-silted	Comments
			TSS	pH	Oil & grease				TSS	pH					

**Figure B.3** Inspected by / position  
 Sediment basin management checklist

\_\_\_\_\_ Date

**ESCP Attachment 6 Inspection report for project soil conservationist**

**Project title:** \_\_\_\_\_  
**Erosion and sediment control**  
**INSPECTION REPORT FOR SOIL CONSERVATIONIST** **Date of inspection:** \_\_\_\_\_

Location	Control	Recommendations/comments	Action * who and when	Close-out date

\_\_\_\_\_ Date  
 \_\_\_\_\_ Soil conservationist

\* This column must include person responsible and proposed completion date of action.

## ESCP Attachment 7 Checklist for nominated construction personnel

**Project title:** \_\_\_\_\_

**Erosion and sediment control plan**

**MAINTENANCE CHECKLIST**

**ESCP No:** \_\_\_\_\_

Current weather conditions: \_\_\_\_\_

Chainage: \_\_\_\_\_

To \_\_\_\_\_

Location	Date inspected	Comments	Date rectified	Initials when rectified

Inspected by / position \_\_\_\_\_

Date \_\_\_\_\_

## **Appendix C: Typical arrangements diagrams**

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This appendix presents the following 'typical arrangement' diagrams illustrating how common erosion and sediment control measures and techniques may be applied in a road construction context.

Figure C.1: Temporary diversion banks – typical arrangement

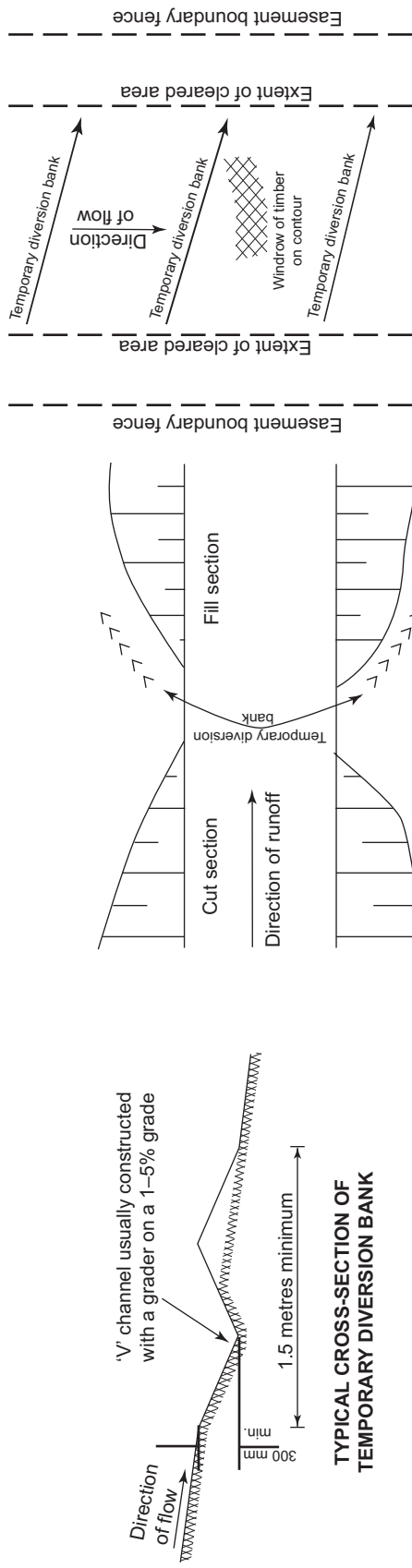
Figure C.2: Temporary batter drains – typical arrangement

Figure C.3: Check dams in drains and gullies – typical arrangement

Figure C.4: Temporary median banks – typical arrangement

Figure C.5: Sediment traps at drop inlets – typical arrangement

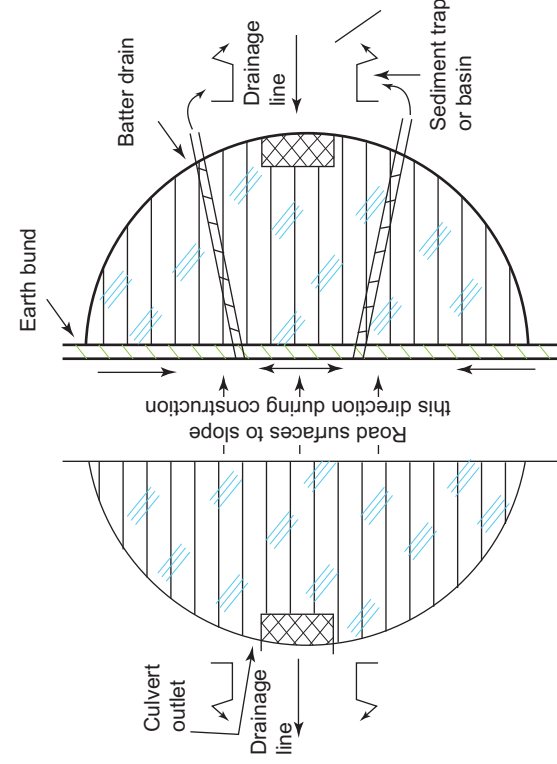
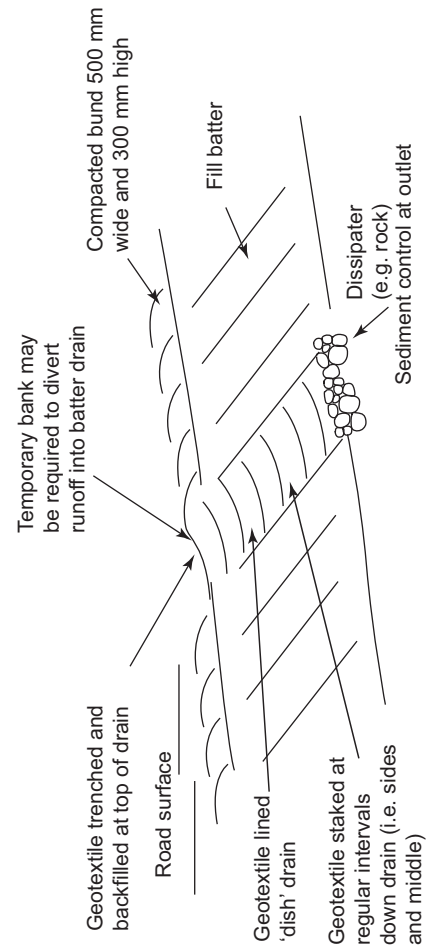
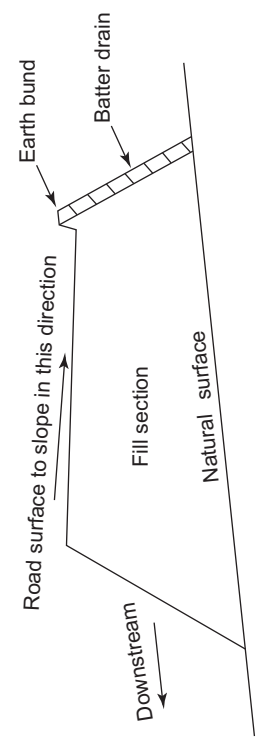
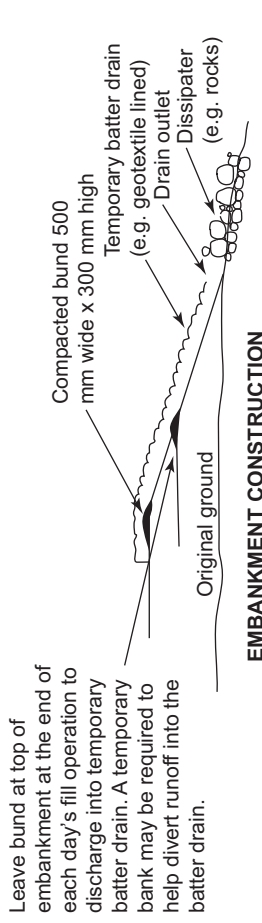
Figure C.6: Sediment fence – typical arrangement



**Notes**

- 1 Locations selected continually during construction to protect works (i.e. may regularly change).
- 2 V-shaped channels are acceptable as the banks are usually constructed by a grader to function over a short period (e.g. overnight, weekend).
- 3 The removal of trees and shrubs to be avoided where possible.
- 4 Channel grades to be 1–5%.
- 5 Channel to be free of projections or other irregularities that will impede normal flow.
- 6 Banks to be adequately machine-compacted to prevent failure.
- 7 Spacing between banks to be dependent upon slope and soil type.
- 8 Outlets from banks to discharge onto stable areas (e.g. rocks, natural undisturbed ground, timber windrow, sediment trap, geotextile batter drain).
- 9 Bank outlets to extend past disturbed areas and not be too short.
- 10 Banks to be inspected after rain and maintained as required.

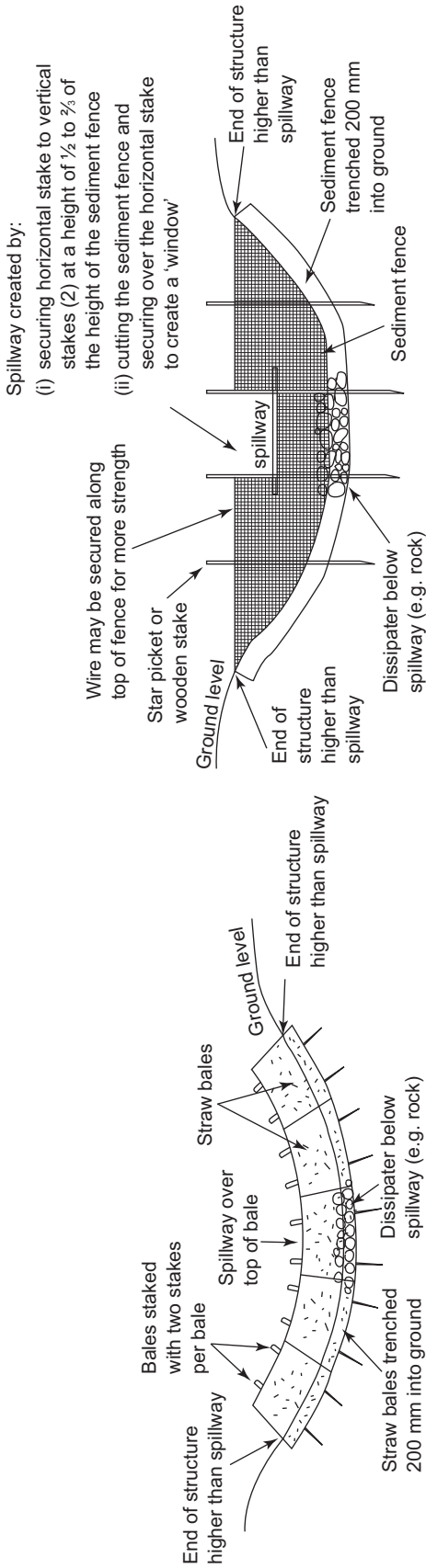
**Figure C.1 Temporary diversion banks – typical arrangement**



Note: a temporary bank may be required to divert formation runoff into a batter drain

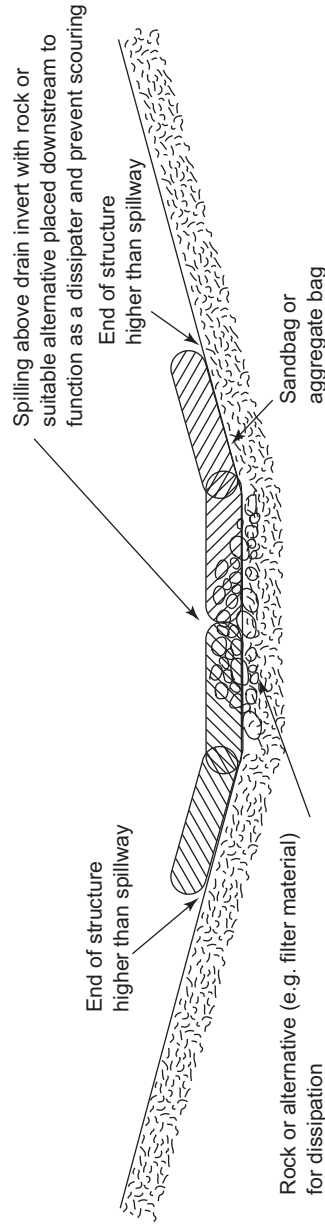
**PROTECTION OF EMBANKMENTS BY THE USE OF SUPER-ELEVATION DURING CONSTRUCTION**

**Figure C.2 Temporary batter drains – typical arrangement**



CROSS-SECTION OF STRAW BALE CHECK DAM

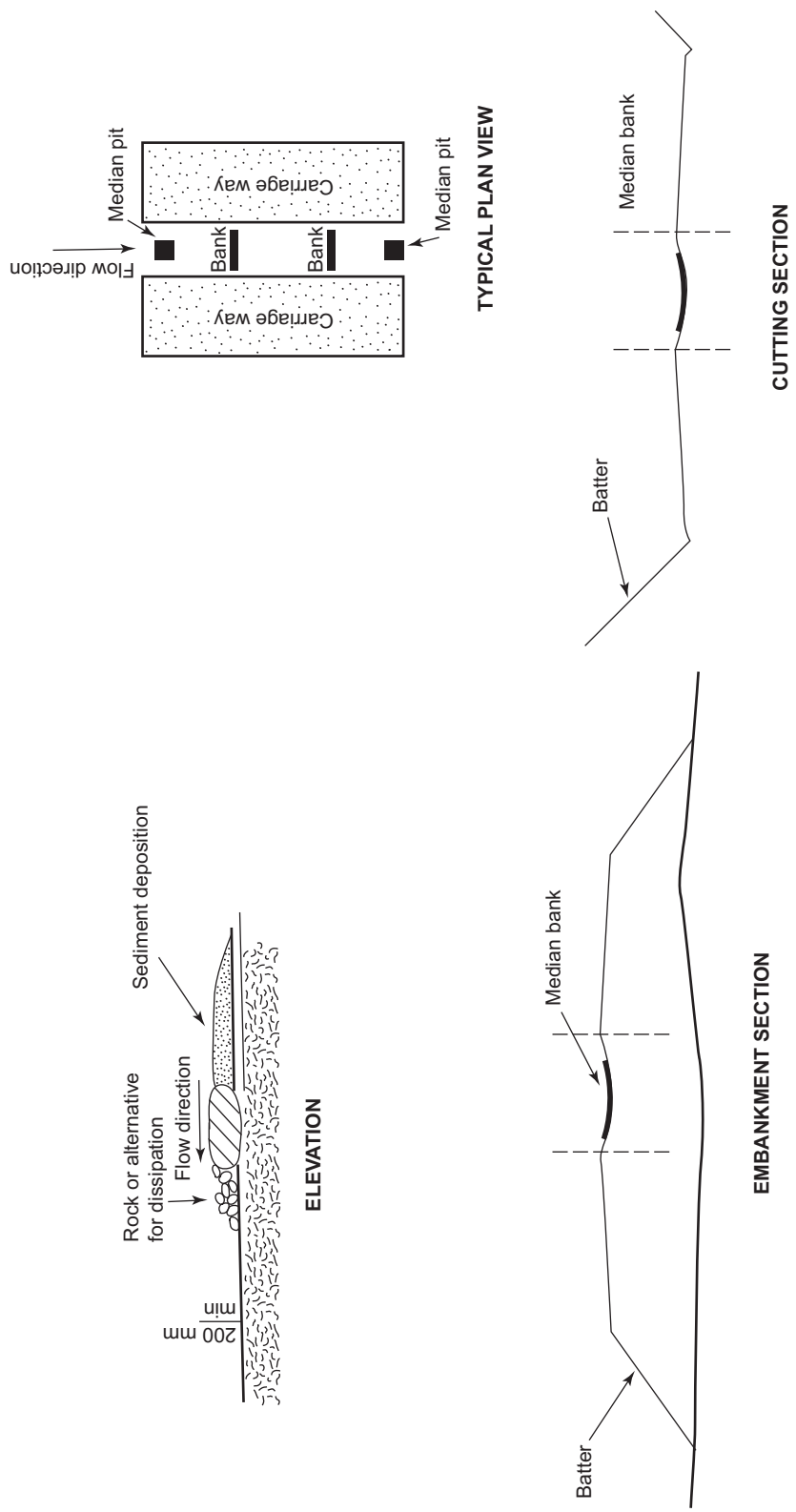
CROSS-SECTION OF SEDIMENT FENCE CHECK DAM



**Notes**

- 1 Check dams may be constructed of a variety of materials (e.g. straw bales, sediment fence, rock and geotextile, sheet piling).
- 2 Check dams to be trenched 200 mm into ground surface on base and sides and securely backfilled.
- 3 Spillway to be over invert of drain with discharge not permitted to flow around ends.
- 4 Spillway to be less than 1 m above invert of drain.
- 5 Some form of dissipation may be required below spillways of check dams (e.g. rock, sandbags).
- 6 Check dams to be spaced so the toe of the upstream check is level with the spillway of the next downstream check.
- 7 Check dams to be inspected after rain and maintained as required.

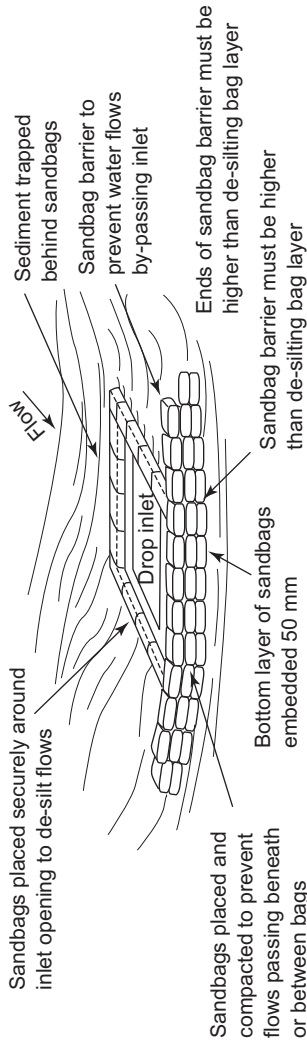
**Figure C.3 Check dams in drains and gullies – typical arrangement**



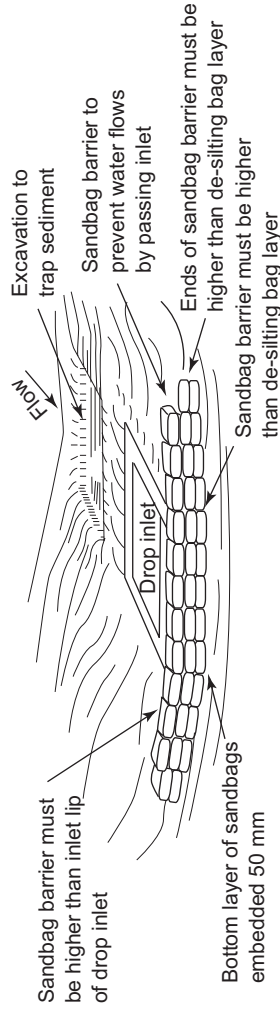
**Note**  
 Providing the above principles of construction are implemented, sandbags may be substituted with other materials (e.g. rock wrapped in geotextile, straw bales)

**Figure C.4** Temporary median banks – typical arrangement

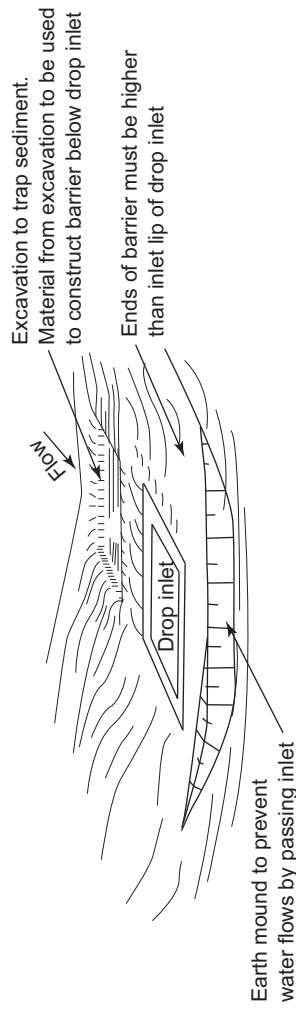




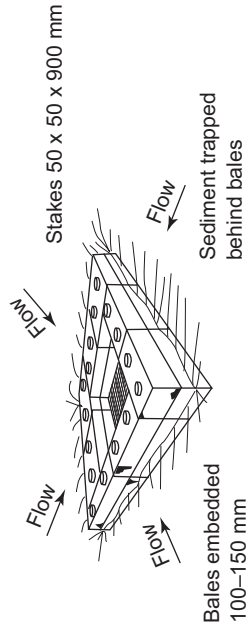
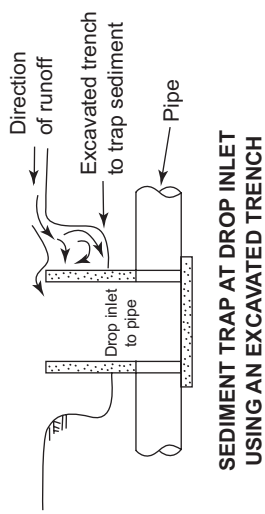
**SEDIMENT TRAP AT DROP INLET USING SANDBAGS**



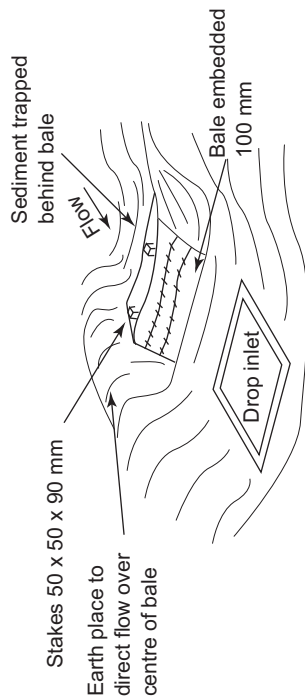
**SEDIMENT TRAP AT DROP INLET USING SANDBAGS AND EXCAVATION**



**SEDIMENT TRAP AT DROP INLET USING AN EARTH MOUND AND AN EXCAVATION**

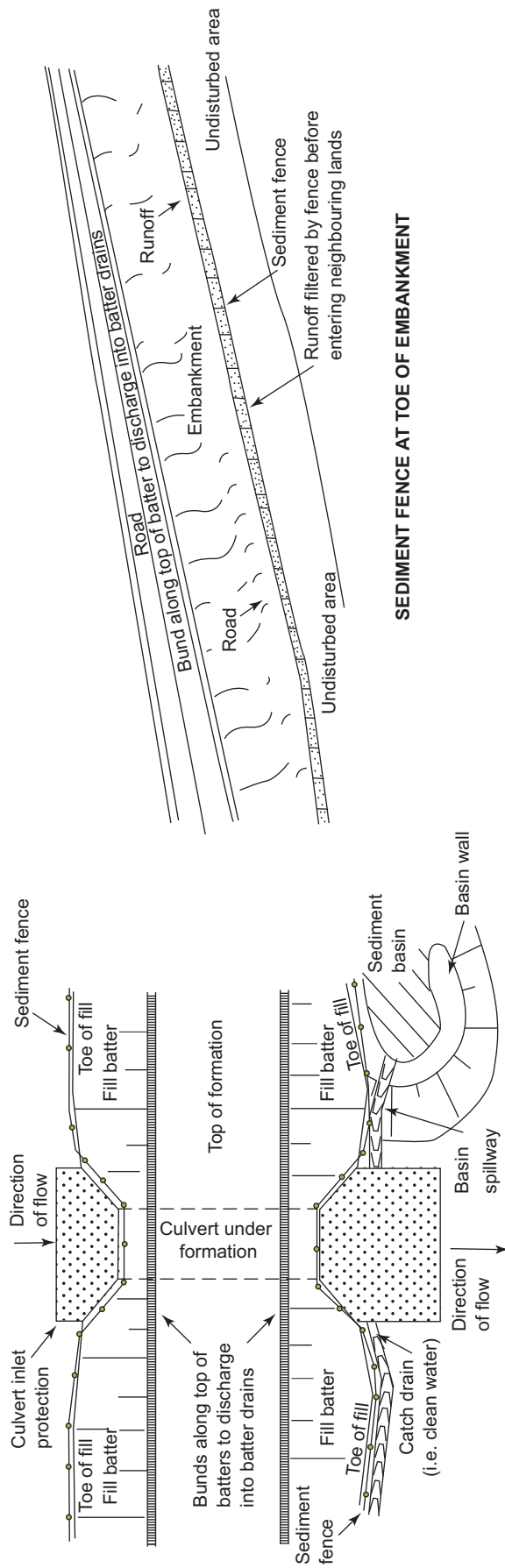


**SEDIMENT TRAP AT DROP INLET USING STRAW BALES WITH A CATCHMENT FROM ALL DIRECTIONS**



**SEDIMENT TRAP AT DROP INLET USING STRAW BALES IN NARROW CHANNEL**

**Figure C.5 Sediment traps at drop inlets – typical arrangement**



#### SEDIMENT FENCE AT CULVERT INLET AND OUTLET

##### Notes

- 1 Sediment fences to be erected along a terrain contour to filter runoff uniformly along the fence.
- 2 The ends of fences to be tapered uphill to contain the build up of sediment.
- 3 Concentrated flows to a small area of the fence to be avoided so that capacity along the entire length is maintained.
- 4 Fences to have a stable overflow point in the event flow rates exceed the capacity to filter water.
- 5 Fences to have the following design limits for optimum function:
  - (i) the area draining to the fence is 0.6 ha. or less
  - (ii) the maximum slope length above the fence is 60 m.
- 6 If it is necessary to construct a fence across the slope, turn-ups should be installed.
- 7 Fences to be inspected after rain and maintained as required.

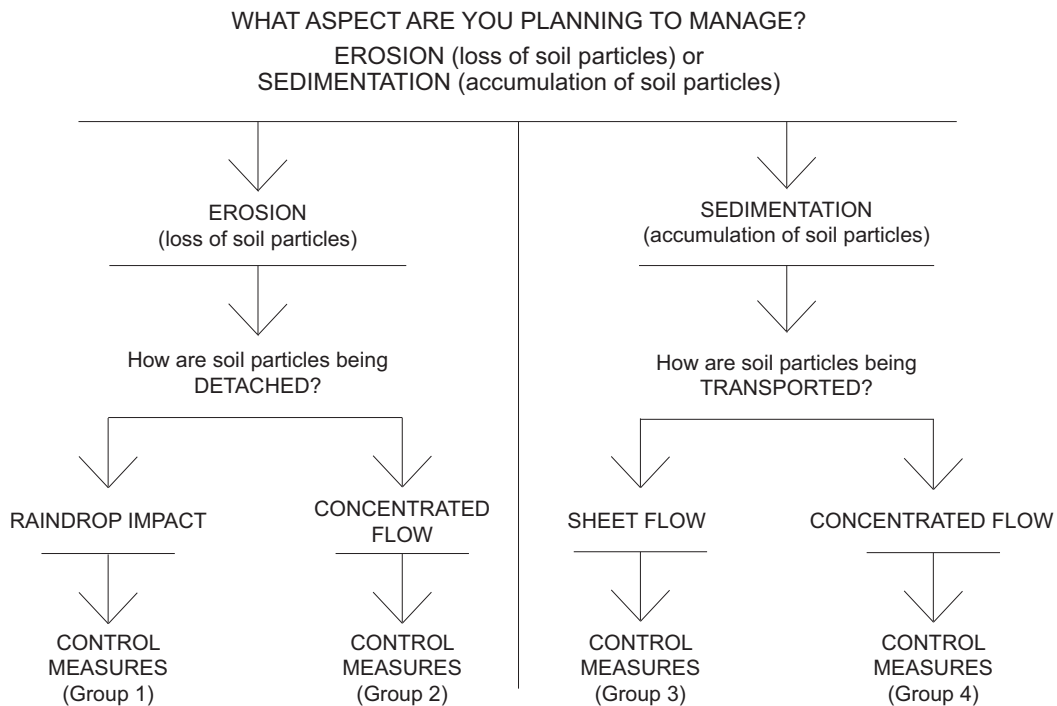
**Figure C.6 Sediment fence – typical arrangement**

## Appendix D: Selection of control measures

This appendix, based on an approach developed by the Queensland Department of Mains Roads, provides a step-by-step guide to the selection of erosion and sediment control measures.

The steps involve:

- identifying the problem – erosion or sedimentation – to be managed (see figure D.1)
- where the problem is erosion, identifying whether it is caused by raindrop impact or concentrated flow
- where the problem is sedimentation, identifying if sediment is conveyed by sheet or concentrated flow
- selecting the appropriate techniques (see table D.1) depending on the identified specific nature of the problem.



**Figure D.1** A step-by-step decision-support flowchart for selection of erosion and sediment control measures (modified from Soilcon Pty Ltd and used with permission)

**Table D.1 Group 1 – Erosion control RAINDROP IMPACT**

**Vegetation**

- temporary vegetation (cover crop only)
- permanent vegetation – introduced (exotic) pasture species or native (endemic) species
- refer to **vol. 1:** sections 4.3.2, 7.1 and 7.2; appendices A6 and G



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**Batter blankets**

- vegetation promotion blankets
- vegetation suppression blankets
- needle-punched geotextile membrane
- builder's plastic membrane
- refer to **vol. 1:** section 5.4.2; SD5-2; appendices A6 and D



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**Soil surface mulching**

- hydromulch or hydraulic bonded-fibre matrix
- blown straw, hay, crop residue, with bitumen tack
- tub-ground or chipped organic mulch
- brush-matting
- rock or gravel mulch
- refer to **vol. 1:** section 7.4; figure 7.3; appendices A6 and D



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**Geocellular containment systems**

- Non-woven geotextile type material
- Polypropylene material (perforated and non-perforated)
- refer to **vol. 1:** section 5.4.2; SD5-3; appendix D



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**Surface roughening**

- roughening parallel to contour
- contour ripping or scarifying
- 'track walking'
- refer to **vol. 1:** section 4.3.2; figures 4.3(a) and (b)



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**Geobinders**

- organic tackifiers
- co-polymer emulsions
- bitumen emulsion
- cementitious products
- refer to **vol. 1:** section 7.1.2; appendices A6 and D



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**Table D.1 Group 2 – Erosion control CONCENTRATED WATER FLOW**

**Up-slope diversions**

- excavated channel-type bank
- backpush-type bank or windrow
- catch drains
- shoulder dyke
- refer to **vol. 1**: section 5.4.4; SD5-5 and SD5-6



**Mid-slope diversions**

- berms and benches
- temporary diversions (at cut/fill line)
- cross banks
- refer to **vol. 1**: section 4.3.1; figure 4.2; appendix A4



**Soft armour channels**

- trapezoidal or parabolic shape
- consider channel grade and maximum permissible velocity
- establish vegetative ground cover
- standard (un-reinforced) or re-inforced turf
- biodegradable erosion control mat (temporary) or synthetic erosion control mat (permanent)
- refer to **vol. 1**: sections 5.4.3, 7.3; SD5-7; appendix D



**Hard armour channels**

- loose rock
- rock-filled wire mattresses
- articulating concrete block systems
- grouted rock
- cast in-situ concrete
- builder's plastic lining or geotextile lining
- refer to **vol. 1**: section 5.4.4; table 5.2; figure 5.4; appendix D



**In-stream diversions**

- temporary coffer dams
- water-filled structures
- temporary lined channel (stream diversion)
- refer to **vol. 1**: section 5.3.5; appendix I



**Table D.1 Group 2 – Erosion control CONCENTRATED FLOW (cont'd)**

**Check dams**

- stacked rock
- sandbags and geotextile sausages
- straw bales
- logs
- proprietary products
- refer to **vol. 1**: section 5.4.3; SD5-4; figures 5.3(a) and (b)



**Batter drains**

- concrete (pre-cast or on-site)
- half 'armco' pipe
- sandbags
- rock-filled wire mattresses
- loose-rock rip rap
- builder's plastic or geotextile lined chutes
- refer to **vol. 1**: section 5.4.4; appendix D



**Grade control structures and flumes**

- gully pits and field inlets
- sandbag drop structures
- rock-filled wire gabions and mattress structures
- driven sheet piling
- concrete chutes
- inclined pipe spillways
- builder's plastic-lined chutes



**Outlet dissipation structures**

- loose-rock rip-rap aprons
- rock-filled wire mattresses
- roughness elements
- hydraulic jump-type structures
- impact-type structures
- refer to **vol. 1**: section 5.4.5; figures 5.8, 5.9, 5.10, 5.11 and SC5-8



**Revetments and retaining walls**

- rip rap
- rock-filled wire gabions and mattresses



**Table D.1 Group 3 – Sediment control SHEET FLOWS**

**Vegetative buffers**

- well established sward with good groundcover
- refer to **vol. 1**: section 6.3.8; table 6.4; SD6-13; appendix G



**Sediment barriers/filters**

- sediment fences
- vegetation, brush, rock or gravel windrows
- straw bale barriers
- refer to **vol. 1**: section 6.3.7; SD6-7 and SD6-8; figure 6.10; appendix D



**Site exit points**

- shaker ramps
- rock aprons
- wheel wash systems
- refer to **vol. 1**: section 6.3.9; SD6-14



**Table D.1 Group 4 – Sediment control CONCENTRATED FLOWS**

**Sediment curtains / turbidity barriers**

- floating geotextile
- proprietary polypropylene products
- temporary coffer dams
- water-filled structures
- refer to **vol. 1**: section 6.3.7; SD6-10; appendix D



**Sediment traps**

- stacked rock/timber with geotextile
- excavated sumps
- straw bale or sand bag structures
- gully pit, field inlet and kerb inlets
- refer to **vol. 1**: section 6.3.6, figure 6.11; SD6-11 and SD6-12



**Sediment retention basins**

- Type C (riser type) basin
- Type F (extended settling) basins
- Type D (flocculation) basins
- refer to **vol. 1**: sections 6.3.3, 6.3.4 and 6.3.5; SD6-3 and SD6-4; appendices E and J









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