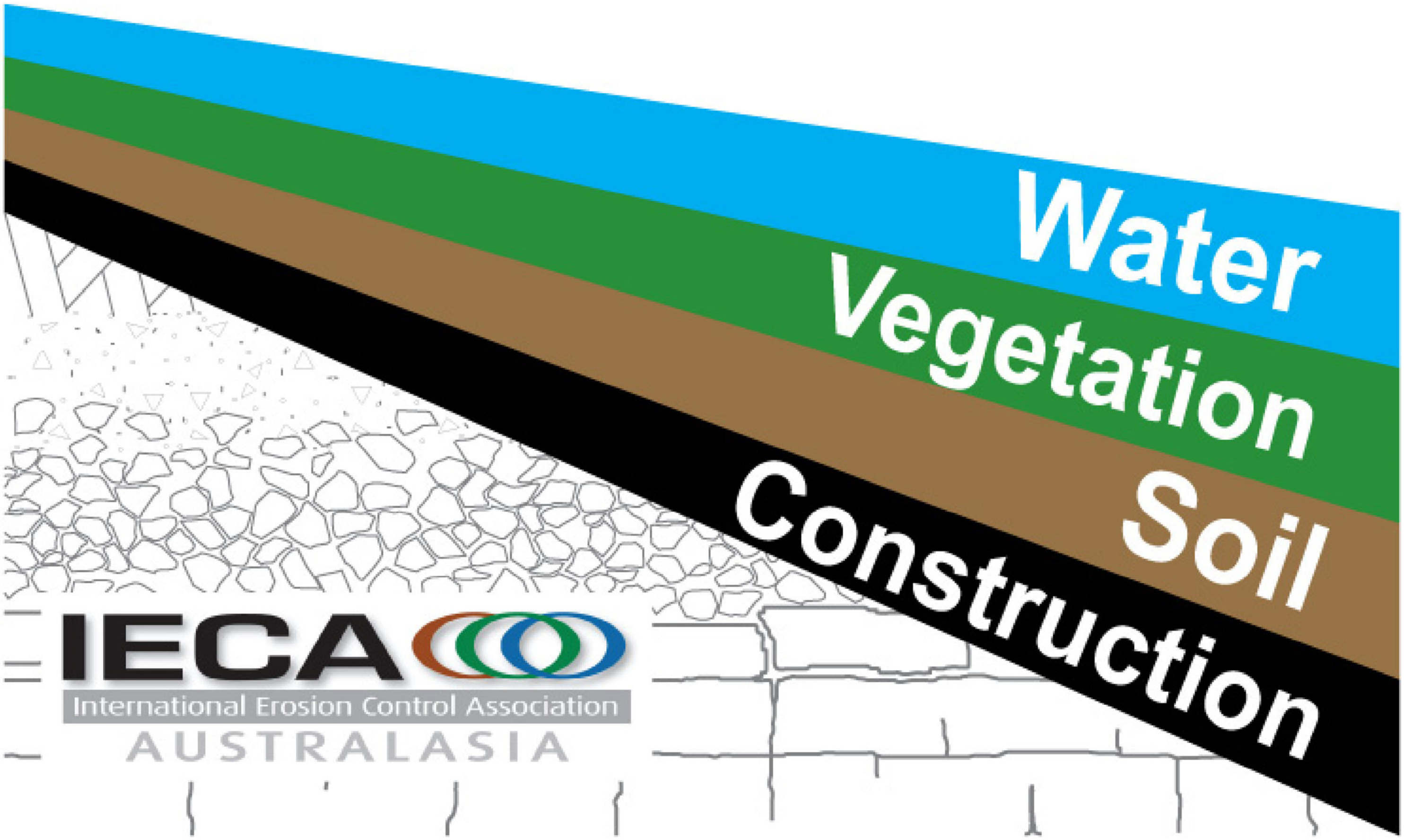
Best Practice
Erosion & Sediment Control

Book 1 – Chapters

November 2008



Best Practice Erosion & Sediment Control

– for building and construction sites

Book 1 – Chapters

November 2008

International Erosion Control Association (Australasia)

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Key-words: ESC, erosion and sediment control plans, soil erosion, erosion control, sediment control, soil management, land management, construction practices, building sites.

The following organisations, including the *Society for Sustainability and Environmental Engineering*, a technical society of *The Institution of Engineers Australia* (trading as *Engineers Australia*), support the continued development and application of best practice erosion and sediment control measures on building and construction sites. The *"Best Practice Erosion and Sediment Control"* document has been developed by the author for general information only and does not constitute professional advice. These organisations do not warrant the accuracy, content, completeness or suitability of the information for any purpose and will not be liable for any claims or damages resulting from reliance on the actual methodologies and/or recommendations contained within the document.

Stormwater
INDUSTRY ASSOCIATION (QLD) INC.

ENVIRONMENT INSTITUTE OF AUSTRALIA AND NEW ZEALAND

ENGINEERS AUSTRALIA

DISCLAIMER

Significant effort has been taken to ensure that this document is representative of current (2008) best practice erosion and sediment control; however, the authors and the International Erosion Control Association, Australasia (IECA) cannot and do not claim that the document is without error, or that the recommendations presented within this document will not be subject to future amendment. When using this document, users should ensure that they are aware of the latest (i.e. post-2008) requirements of best practice erosion and sediment control.

Use of this document, including all books and electronic media, requires professional interpretation and judgement. Appropriate investigation, planning, and design procedures must be applied in a manner appropriate for the given work activity and site conditions.

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The authors and IECA shall have no liability or responsibility to the user or any other person or entity with respect to any liability, loss, or damage caused, or alleged to be caused, directly or indirectly, by the adoption and use of the methods and recommendations of any part of the document, including, but not limited to, any interruption of service, loss of business or anticipatory profits, or consequential damages resulting from the use of the document.

Specifically, the adoption of these best practice procedures will not guarantee:

(i) compliance with any statutory obligations;

(ii) compliance with specific water quality objectives;

(iii) avoidance of environmental harm or nuisance.

Contents

Foreword

IECA (Australasia) are proud to publish **Best Practice Erosion and Sediment Control**. This publication has had a long gestation. Its origin lies in the "Soil Erosion and Sediment Control, Engineering Guidelines for Queensland Construction Sites" published by the then Institution of Engineers, Australia (Queensland Division) in 1996.

In the years since the publication of the original document the author Grant Witheridge has comprehensively and selflessly developed **Best Practice Erosion and Sediment Control** in consultation with industry peers and experts to form a receptacle of erosion and sediment control best practice that is applicable Australia wide.

Historically, strategies for the reduction of soil erosion and land degradation have primarily been developed by the agricultural sector and soil scientists. However, soil erosion and land degradation is not restricted to just agricultural areas. Uncontrolled sedimentation, pollution and hydrological changes resulting from construction sites are one of the largest contributors to land and water quality degradation in Australia.

Best Practice Erosion and Sediment Control is indicative of the significant contribution currently being made to the practice of urban soil erosion and sediment control by other professions, including engineers, ecologists and civil contractors. It contains the necessary strategies and techniques to assist erosion and sediment control practitioners to reduce the degradation of land and water from uncontrolled erosion and sedimentation.

Best Practice Erosion and Sediment Control is an essential reference for erosion and sediment control professionals nationally.

Michael Frankcombe
President
IECA (Australasia)

Acknowledgments

Preparation of this document was an initiative of Grant Witheridge of Catchments & Creeks Pty Ltd with full support by the International Erosion Control Association, Australasia.

Acknowledgment is graciously given to the Reference Group who voluntarily gave of their time in the review of this document.

Reference Group:

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Peter Curley (Environment Protection Agency Qld)

Bill Gardyne (Oxbow Consulting, International Erosion Control Association Australasia)

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Chris Mountford (Civil Contractors Federation)

Scott Paten (Brisbane City Council)

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Bradley Ventra (Moreton Bay Regional Council, Institute of Public Works Australia Queensland Branch)

Jeremy Wagner (Gold Coast City Council)

Bill Weeks (Department of Main Roads, Water Panel)

Grant Witheridge (Catchments & Creeks Pty Ltd)

Thanks are also given to these following external reviewers for their contributions:

Geoff Farrant (Brisbane City Council) – Appendix I

Iain Gibson (Department of Natural Resources and Water) – Chapter 3

Dr Rob Loch (Landloch) – Appendices C & E

Bill Manners (Brisbane City Council) – Chapter 6

Dr Mark Silburn (Department of Natural Resources and Water) – Chapter 3 and Appendices C & E

Hannah Middleton – Appendix C

Dr George Smith – Appendix C

Thanks are also given to Dr Ross Coventry (Soil Horizons) for the supply of material used in Appendix C.

Editorial support provided by Rosemary Lancaster (Bookera Services).

All figures supplied courtesy of Catchments & Creeks Pty Ltd and remain the property of Catchments & Creeks Pty Ltd.

Funding for the printing of this document was achieved through the support of Natural Resource Assessments Pty Ltd (NRA), Cairns.

Purpose of document

This document has been developed to provide assistance to erosion and sediment control practitioners in the planning, design, installation, and maintenance of erosion and sediment control measures on construction and building sites.

The *intent* of this document is to facilitate the minimisation of environmental harm through the identification of best practice (2008) erosion and sediment control on building and construction sites.

The document as a whole is not intended to constitute a code; however, aspects of the document may be adopted as a code of practice by Regulatory Authorities.

The document advocates the adoption of erosion and sediment control practices appropriate for the site conditions and the potential risks to receiving environments. The document provides both educational materials for use by inexperienced practitioners and technical information that requires interpretation and application by competent soil erosion and sediment control practitioners.

The appropriate interpretation and application of this document should:

- increase the awareness and skill levels (capacity) of soil erosion and sediment control practitioners;
- facilitate the identification of those issues that should be considered when formulating and evaluating strategies for best practice erosion and sediment control;
- facilitate best practice stormwater management on construction and building sites;
- facilitate the active avoidance or minimisation of soil erosion resulting from construction and building activities; and
- facilitate best practice soil and sediment management on construction and building sites.

This document does not:

- override or replace regional or local guidelines, manuals or codes where such documents are expected to achieve similar or better outcomes;
- provide advice on permanent erosion and sediment control within drainage channels and waterways; or
- provide advice on the design and operation of permanent drainage, erosion and sediment control measures for the operational phase of urban development.

Use of document

The target audience for this document includes builders, development and construction consultants and contractors, erosion and sediment control practitioners, and construction and building site managers and regulators, whether or not the works are associated with private or public, building or construction activities.

Collectively the audience will be referred to as the erosion and sediment control (ESC) practitioners involved in the planning, design, installation, and maintenance of the erosion and sediment management practices of construction and building sites.

It is assumed that users of this document have a basic knowledge of the land development processes, construction activities, and relevant legislative requirements.

Application of this best practice document will vary from region to region depending on legislative requirements and locally adopted design standards. In the absence of locally adopted design standards, Sections 4.3, 4.4 and 4.5 of Chapter 4 of this document provide **default** design standards for drainage, erosion and sediment control.

Interpretation of this document shall be consistent with state and/or local government requirements on enhancing or maintaining water quality within receiving waters during the construction phase of development activities in accordance with endorsed water quality objectives. Erosion and sediment control practitioners should aim to achieve these water quality objectives.

Further details on water quality discharge objectives applicable to the construction phase and water quality indicators for receiving waters are available in various state government and regional/local council documents.

Queensland

The Queensland Water Quality Guidelines and Schedule 1 of the Environmental Protection (Water) Policy establish environmental values (EVs) and water quality objectives (WQOs) for waters in Queensland through community consultative processes. The WQOs provide planning targets for receiving water quality in ambient conditions.

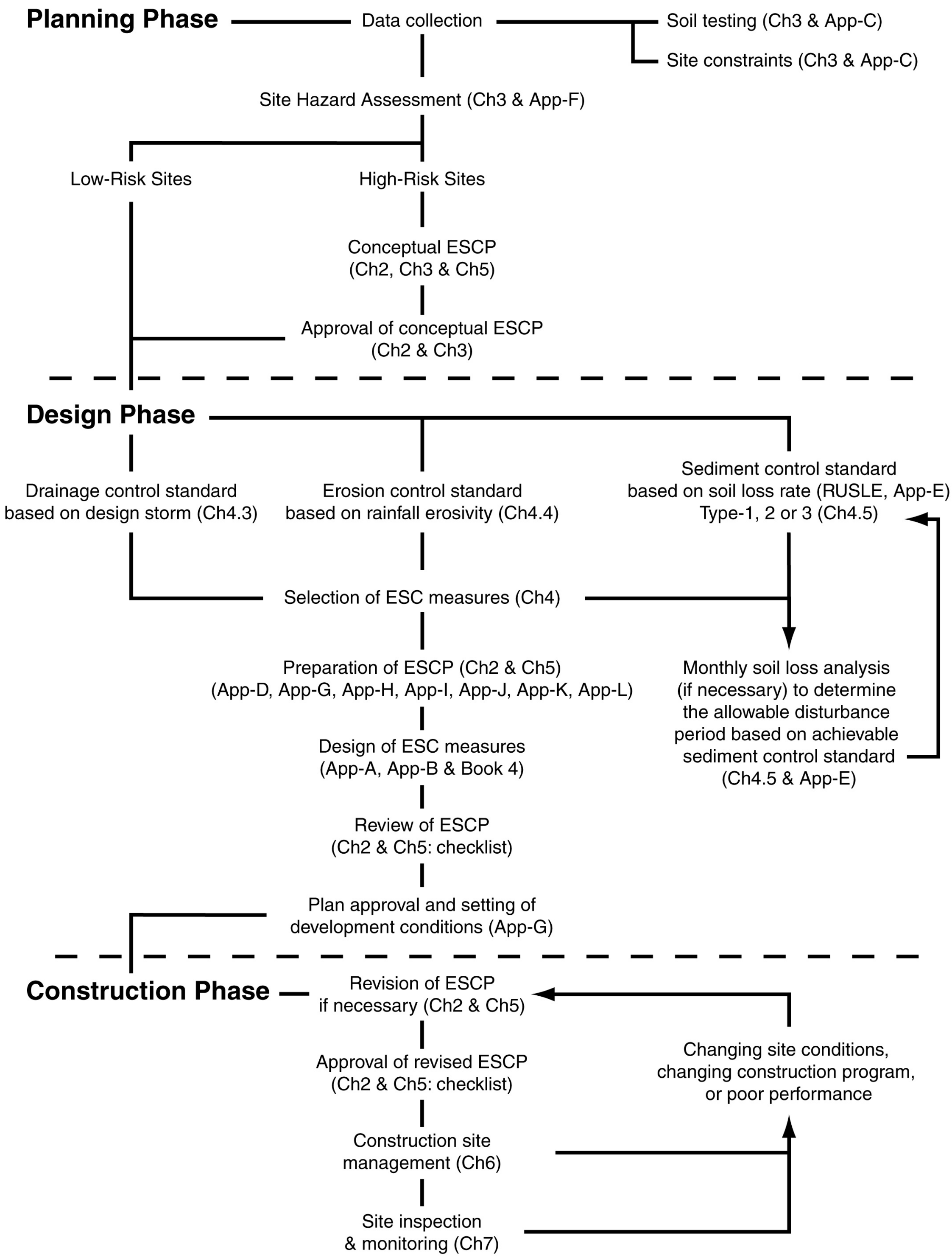
In some jurisdictions design objectives might have been established (per-2009) specifically for the construction phase of development based on achievable designs for the local soils, landscape, and regional climate. These design objectives most often include a total suspended solids (TSS) criterion that will need to be factored into the design and implementation of erosion and sediment control measures.

Design objectives for the construction phase of development typically focus on suspended solids and gross pollutants objectives. These objectives may differ from the operational phase design objectives because of the risk of exposing large areas of bare soil, timing of the exposure in the context of rainfall, and the relative range of activities on the site.

For example, Gold Coast City Council have established construction phase concentration discharge criteria including TSS 90th%ile <50 mg/L. These criteria are applicable to defined runoff events and pumped discharges (such as de-watering of sediment basins). Construction phase water quality monitoring is usually required to demonstrate compliance with the discharge criteria.

Application of the document to the planning, design and construction process

The following flow chart outlines the typical phases of site planning, design and construction and how aspects of this document can be used to appropriately integrate erosion and sediment control into each phase of the building or construction process.



About this publication

Book 1:

Chapter 1 Introduction

Discusses the potential impacts of soil erosion and sediment runoff on various receiving waters, and introduces the key principles of erosion and sediment control.

Chapter 2 Principles of Erosion and Sediment Control

Discusses the key principles of best practice erosion and sediment control as applied to construction sites. The principles presented in this chapter shall be used as a means of interpreting the intent of the rules, design/management procedures, and guidelines presented throughout the document (including all associated books and electronic media).

Chapter 3 Site Planning

Discusses the key elements of site investigation and the planning of construction sites (including large building sites) with respect to data collection and the appropriate integration of effective erosion and sediment control issues into the investigation and planning process.

Chapter 4 Technique Selection and Design Standards

Presents the recommended drainage, erosion and sediment control design standards, and provides rules and guidelines on the selection of appropriate drainage, erosion and sediment control measures.

Chapter 5 Preparation of Plans

Presents an approach to the preparation and checking of Erosion and Sediment Control Plans (ESCPs). It includes an extensive list of example technical notes that can be used to supplement and enhance these plans, as well as a detailed plan checklist.

Chapter 6 Site Management

Outlines the key rules, procedures, and guidelines for the management of construction sites and large building sites so as to best facilitate the appropriate integration of erosion and sediment control measures into a work site.

Chapter 7 Site Inspection

Outlines the key rules, management procedures, and guidelines for the inspection and monitoring of construction sites and large building sites with respect to best practice erosion and sediment control.

Chapter 8 Bibliography

Publications used in the development of this document.

Books 2 and 3 (see over page) contain 14 appendices providing design procedures, rules, and guidelines on specific issues.

Book 4 (as of June 2012) contains 137 individual design fact sheets (PDF) for various erosion and sediment control (ESC) techniques. Throughout this document “Title Case” (i.e. full capitalisation) will be used to identify those techniques for which Fact Sheets are available in Book 4.

Book 5 (as of June 2012) contains two separate Field Guides (PDF) one for construction sites and one for building sites.

Book 6 (as of June 2012) contains 136 individual A4 standard drawing sheets (PDF).

Book 2:

Appendix A **Hydraulics and Hydrology**
Data and procedures for assessing construction site hydrology and hydraulics.

Appendix B **Sediment Basin Design**
Design procedure, rules and recommendations for Sediment Basins.

Appendix C **Soils and Revegetation**
The planning and management of site revegetation activities, soil testing and soil management procedures.

Appendix D **Example Plans**
Example Erosion and Sediment Control Plans. Note, these example plans are **not** of the detail or scale required for submission to a regulatory authority.

Appendix E **Soil Loss Estimation**
Data and procedures for application of the Revised Universal Soil Loss Equation (RUSLE).

Appendix F **Erosion Hazard Assessment**
Example soil erosion hazard assessment procedures.

Appendix G **Model Code of Practice**
A Model Code of Practice for erosion and sediment control for general construction activities.

Book 3:

Appendix H **Building Sites**
Key rules, design/management procedures, and guidelines for the management of soil erosion and sediment control on building sites. Includes a model Code of Practice for erosion and sediment control on building sites.

Appendix I **Instream Works**
Key rules, design/management procedures, and guidelines for the management of soil erosion and sediment control procedures for instream works. Includes a model Code of Practice for instream works.

Appendix J **Road and Rail Construction**
Key rules, design/management procedures, and guidelines for the management of soil erosion and sediment control for road and rail construction.

Appendix K **Access Tracks and Trails**
Key rules, design/management procedures, and guidelines for the management of soil erosion and sediment control on unsealed access tracks and trails.

Appendix L **Installation of Services**
Key rules, design/management procedures, and guidelines for the management of soil erosion and sediment control during the installation of services such as water supply, sewerage, stormwater, or power.

Appendix M **Erosion processes**
An overview of the mechanics of soil erosion.

Appendix N **Glossary of Terms**
Definition of terms used within the document.

Book 4: (may vary from time to time)

Drainage Control – Channel/Chute Lining Techniques

Cellular Confinement System	Grass Lining	Rock Mattresses
Erosion Control Mats	Hard Armouring	Turf Reinforcement Mats
Geosynthetic Lining	Rock Lining	

Drainage Control Techniques

Catch Drain	Outlet Structure	Temporary Bridge Crossing
Chute	Recessed Rock Check Dam	Temporary Culvert Crossing
Diversion Channel	Rock Check Dam	Temporary Downpipe
Flow Diversion Bank	Sandbag Check Dam	Temporary Ford Crossing
Level Spreader	Slope Drain	Triangular Ditch Check

Erosion Control Techniques

Bonded Fibre Matrix	Gravelling	Rock Mulching
Cellular Confinement System	Heavy Mulching	Soil Binders
Compost Blanket	Light Mulching	Surface Roughening
Dust Control	Polyacrylamide (soil binder)	
Erosion Control Blanket	Revegetation	

Sediment Control Techniques

Buffer Zone	Filter Sock	Sediment Fence
Check Dam Sediment Trap	Filter Tube Dam	Sediment Trench
Coarse Sediment Trap	Grass Filter Strip	Sediment Weir
Compost Berm	Modular Sediment Trap	Stiff Grass Barrier
Construction Exit (Rock Pad, Vibration Grid & Wash Bay)	Mulch Berm	Straw Bale Barrier
Fibre Roll	Rock Filter Dam	U-Shaped Sediment Trap
Filter Fence	Sediment Basin	

Sediment Control Techniques – Stormwater Inlets

Block & Aggregate Drop Inlet Protection	Filter Sock Drop Inlet Trap	Rock & Aggregate Drop Inlet Protection
Excavated Drop Inlet Protection	Gully Bag Sediment Trap	Sag Kerb Inlet Trap
Fabric Drop Inlet Protection	Mesh & Aggregate Drop Inlet Protection	
Fabric Wrap Drop Inlet Protection	On-Grade Kerb Inlet Trap	

De-watering Sediment Control Techniques

Filter Bag	Filter Tube Dam	Stilling Pond
Filter Fence	Grass Filter Bed	Sump Pit
Filter Pond	Portable Sediment Tank	
Filter Tube	Settling Pond	

Instream Flow and Sediment Control Techniques

Cofferdam	Isolation Barrier	Sediment Filter Cage
Filter Tube Barrier	Modular Sediment Barrier	Sediment Weir
Floating Silt Curtain	Rock Filter Dam	
Geo Log	Sediment Fence Isolation Barrier	

Reprint text alterations

Editorial changes made for the 1st reprint, 2009.

Book 1

Contents, page (i), “Index” added to contents list.

About this publication, page (vii), last paragraph, 2nd sentence, replace ‘add” with “added”. Page (viii), Appendix D, replace “regulating” with “regulatory”.

Detailed contents list, page (xviii), correction to page numbers 7.17, 7.18, 7.19.

Detailed contents list, page(xxii), change “J5.2 Diversion channels” to “J5.2 Diversion drains”; plus, add “Index” to listing.

Chapter 1:

Section 1.1, page 1.3, 2nd paragraph, insert “(deposition on roads),” after “traffic safety issues”.

Section 1.2, page 1.4, Table 1.4, replace “Slash erosion” with “Splash erosion”.

Section 1.2, page 1.5, 3rd paragraph, insert “cannot” after “on their own,”.

Section 1.3, page 1.6, 2nd paragraph, 4th sentence, replace “along” with “alone”.

Section 1.4, page 1.7, 2nd paragraph, replace 3rd sentence with: “It can be demonstrated through hydrologic analysis that setting a design target suspended solids concentration of 50mg/L would, in most regions of Australia, limit soil loss rates from construction sites to less than the commonly adopted natural soil loss rate of 0.5 to 1.0t/ha/yr.”

Chapter 2:

Section 2.1, page 2.1, 3rd paragraph, replace “greater” with “general”. Page 2.3, principle 5.7, replace “a” with “as” before the word “practicable”.

Principle 5, page 2.18, last paragraph, last sentence, replace “can” with “should”.

Technical Note 2.15, page 2.32, last paragraph, 2nd sentence, replace “Anonic” with “Anionic”.

Principle 8, page 2.49, 2nd last paragraph, 2nd sentence, replace “bests” with “best”.

Chapter 4:

Section 4.3.7, page 4.8, Table 4.3.8, Rock Check Dam, 1st sentence, replace “Used in drains” with “Best used only in drains”. Recessed Rock Check Dam, 2nd sentence, insert “maximum” after “maintain”; and remove “Can also be used as a minor sediment trap.” Sandbag Check Dam, replace 1st sentence with “Typically used in drains less than 500mm deep, with a gradient less than 10%.” Note [1], replace ‘rather” with “instead”.

Section 4.4.3, page 4.20, 3rd dot point, insert “or” after “drought”.

Section 4.4.3, page 4.20, 4th dot point, replace “not the plant root system” with “not the vegetation”.

Section 4.5, page 4.21, 2nd paragraph, insert “(p. 4.27)” after “Note 4.1”.

Section 4.5.4, page 4.30, Table 4.5.8, Filter Sock Drop Inlet Protection, replace “Type 2” with “Type 2 or 3”.

Section 4.5.5, Table 4.5.9, page 4.31, insert the following into the table.

Stiff Grass Barrier	SGB	SGB	• Supplementary sediment trap • Most suited to sandy soils. • Typically used as a component of long-term gully stabilisation in rural areas.

Section 4.5.9, Table 4.5.15, page 4.35, replace "Grass filter area" with "Grass Filter Beds".

Section 4.5.9, Table 4.5.16, page 4.36, insert the following after "Grass Filter Bed" in low flow section:

Low	*Compost Berm*	• Can provide good filtration and turbidity control. • Compost-filled socks (*Filter Socks*) can also be used.

Chapter 5:

Section 5.8, page 5.32, point #59, replace "rainfall erosivity is" with "rainfall is".

Section 5.8, page 5.33, point #73, replace "rainfall erosivity is" with "rainfall is".

Chapter 7:

Section 7.5, page 7.4, 6th paragraph, 2nd sentence, insert "(or equivalent)" to end of sentence.

Book 2

Appendix A:

Section A5.4, page A.32, 2nd paragraph and Equation A25, replace the term "b" with "W".

Section A5.6, Table A23, bottom row, replace "Table 4.19c" with "Table A25".

Section A5.6, Table A24, 2nd & 3rd rows, replace "Table 4.19c" with "Table A25".

Section A7, remove term "R_h" and refer only to "R" for hydraulic radius.

Appendix B:

Step 5b, page B.14, Equation B7, definition of C_v, replace "Table F10" with "Table B7".

Appendix C:

Section C4, page C.3, 1st paragraph, 2nd sentence, replace "is" with "are".

Section C9, page C9, 3rd paragraph, 2nd sentence removed as it specifically refers to NSW testing standards and thus was misleading from an Australian-wide perspective.

Explanatory Notes, page 22, Exp-C17, "the most common being a 1:5 soil:water ratio" removed from 2nd sentence as it specifically refers to NSW testing standards and thus was misleading from an Australian-wide perspective.

Appendix G:

Section G3.12, page G.21, point #164, replace "rainfall erosivity is" with "rainfall is".

Section G4, page G.45, A64, change points to (i), (ii), (iii), & (iv).

Book 3

Appendix J:

Section J5.2, page J.10, replace all reference to "diversion channels" and replace with "diversion drains", including within the section heading.

Editorial changes made for the 2nd reprint, 2012.

Book 1

Within those chapters where changes have occurred, double spaces between sentences have been replaced with a single space, and a space have been inserted between the units and the preceding numerical number in accordance with the National Measurement Guidelines (1999).

Preliminary text, page XV, Application of document by regulatory authorities, replace reference to S4.4.9 and Tables 4.4.20 & 4.4.21, with App-I, Section I7, Step 10, Tables I9, I10 & I11.

Chapter 1:

Section 1.2, page 1.4, 1st dot point, replace the word “flow” with “flows”.

Chapter 3:

Section 3.5.4, page 3.13, Table 3.4a & b, Particle size distribution (fine) soil test identified separately to the dispersion index soil test.

Section 3.5.4, page 3.14, Table 3.4c, replace the word “topsoil” with “subsoil” in relation to the particle size distribution (AS1289 – 3.6.1).

Chapter 4:

Section 4.4, page 4.12, 3rd paragraph, 2nd sentence, insert the word “of” after “timing”.

Section 4.5, Table 4.5.3, page 4.25, various field (drop) inlet techniques moved from ‘sheet flow’ section of table to the ‘concentrated flow’ section.

Chapter 6:

Section 6.2, page 6.1, 1st sentence, remove the word “of” after “incorporate”.

Appendix A:

Section A3.1, page A.19, the words “for low to medium gradient slopes (i.e. < 10%)” inserted after “catchment conditions”; and the words “or the basin receives runoff from a steep catchment” inserted after “*Sediment Basin*”.

Appendix B:

Step 5b, page B.18, 1st paragraph, 1st sentence, insert the words “with a low to medium gradient (i.e. < 10% slope)” after “ pervious surfaces”.

Step 8, page B.22, replace “Figure B10(d)” with “Figure B10(b)” within the figure title.

Step 9, page B.26, replace “F12” with “B12”.

Step 10, page B.29, Section E, 2nd paragraph, replace” inflow” with “intake” (twice).

Step 10, page B.30, Section (c), 2nd paragraph, replace “F20” with “B20”.

Step 10, page B.30, Section (d), 2nd paragraph, replace “F10” with “B10”.

Step 11, page B.35, 3rd paragraph, replace “Table B14” with “Table B12”.

Step 11, page B.35, 3rd paragraph, 2nd dot point, the following note added: “(note; significant wind-generated waves can form on the surface of large basins)”.

Section B3, page B.51, note 29, insert the word “at” after “basin”.

Appendix E:

Section E2, page E.2, point (b), replace the word “access” with “assess”.

Appendix H:

Step 7, page H.5, replace the word “of” with “or” after “permanent”.

Section H5, page H.9, 6th dot point, insert the words “but must still be suitably buried (anchored)” after “(if available)”.

Section H5, page H.10, 1st dot point, insert the words “(suitable anchored)” after “*Sediment Fence*”.

Section H6, page H.15, replace the word “stabilise” with “stabilised”.

Appendix I:

Table I8, page I.25, Clayey material, 1st dot point, insert the word “water” after “turbid”.

Table I14, page I.33, replace the word “provision” with “prevention”.

Table I10.5, page I.67, insert the words “can be achieved” after “bypassing”.

Key components of the document for various professional groups

The following table outlines key sections of the document likely to be of most relevance to various professional groups.

Profession	Relevant Section	Purpose
Town planners	Chapter 3, Section 3.1 to 3.4	• Identification of critical ESC issues
	Appendix F	• Assessment of erosion hazard risk
Designers of civil works	Chapter 3, Section 3.1 to 3.4	• Identification of site constraints
	Appendix J	• Road and embankment design
	Appendix K	• Design of access tracks and trails
Preparers of Erosion and Sediment Control Plans (ESCPs) and Plan reviewers	Chapter 2	• Principles of ESC
	Chapter 3	• Consideration of site constraints • Collection of site and soil data
	Chapter 4	• Selection and design of ESC measures
	Chapter 5	• Preparation of ESCPs
	Appendix A	• Catchment hydrology and hydraulic design
	Appendix B	• Design of sediment basins
	Appendix C	• Interpretation of soil data and site revegetation
	Appendix D	• Example ESCPs
	Appendix G	• Preparation of ESCPs in accordance with model code of practice
	Appendix I	• Design of instream works
Development assessors	Chapter 2	• Principles of ESC
	Chapter 4	• ESC design standards
	Appendix F	• Assessment of erosion hazard risk
	Appendix G, Section G3	• Setting of development approval conditions
Project managers	Chapter 2	• Principles of ESC
	Chapter 6	• Management of construction sites
	Chapter 7	• Conducting site inspections

Profession	Relevant Section	Purpose
Site managers and Site inspectors	Chapter 2	• Principles of ESC
	Chapter 6	• Management of construction sites
	Chapter 7	• Conducting site inspections
	Appendix G	• Operation of a site in accordance with model code of practice
	Appendix I	• Management of instream works (Code of Practice)
	Appendix J	• Management of road and rail construction
	Appendix K	• Management of access tracks
Builders	Chapter 2	• Principles of ESC (large sites)
	Chapter 4	• Selection and design of ESC measures (large sites)
	Chapter 5	• Management of large sites
	Appendix H	• Preparation of ESCPs
Services providers (water supply, sewerage, stormwater, power, telecommunications)	Chapter 2	• Principles of ESC
	Chapter 4	• Selection and design of ESC measures (large sites)
	Chapter 6	• Management of construction sites
	Appendix L	• Erosion and sediment control practices (Code of Practice)
Soil testers	Chapter 3, Section 3.5	• Soil testing
	Appendix C	• Minimum soil tests
Regulators	Chapter 2	• Principles of ESC
	Chapter 4	• Selection and design standards
	Chapter 5	• Preparation of ESCPs
	Chapter 5 (Section 5.10)	• Checking ESCPs
	Chapter 6	• Management of construction sites
	Chapter 7	• Conducting site inspections
	Appendix F	• Adoption of an erosion hazard assessment procedure
	Appendix G	• Code of practice for general civil works
	Appendix H	• Code of Practice for building sites
	Appendix I	• Code of Practice for instream works
	Appendix J	• Road and embankment design

Application of document by regulatory authorities

Local governments and other regulatory authorities may use this document to generate various local government codes and regulations as outlined in the following table.

<table>
<tr><th>Task</th><th>Section</th><th>Possible actions</th></tr>
<tr><td rowspan="5">Adoption of ESC design standards</td><td>Section 4.3</td><td>• Adopt a local drainage design standard
• Alternatively, adopt Table 4.3.1.</td></tr>
<tr><td>Section 4.4</td><td>• Adopt local erosion control standard.
• Alternatively, adopt either Table 4.4.1 (default), or Tables 4.4.2 or 4.4.3.</td></tr>
<tr><td>Section 4.5</td><td>• Adopt local sediment control standard.
• Alternatively, adopt either Table 4.5.1 (default), or Table 4.5.2.</td></tr>
<tr><td>Section 4.6</td><td>• Adopt local stockpile management standard.
• Alternatively, adopt either Tables 4.6.1 and/or Table 4.6.2.</td></tr>
<tr><td>App-I, Section I7, Step 10</td><td>• Adopt an erosion risk rating system for instream works, alternatively adopt either Table I9 (default), or Table I10.
• Adopt local erosion control standard for major drainage channels and watercourse revegetation, alternatively adopt either Table I11.</td></tr>
<tr><td>Reviewing Erosion and Sediment Control Plans (ESCPs)</td><td>Section 5.9</td><td>• Adopt a local ESCP Checklist.
• Alternatively adopt the Plan Checklist presented in Section 5.10.</td></tr>
<tr><td>Site inspections</td><td>Chapter 7</td><td>• Adopt a local site Checklist.
• Alternatively adopt the site Checklists presented in Chapter 7.</td></tr>
<tr><td>Adoption of ESC Codes of Practice or ESC Standard</td><td>App-G, Sections G3 and G4
App-I, Section I9
App-L, Section L2</td><td>• Development of a local ESC Code of Practice from the model code presented in the Appendices G, I and L.
• Alternatively, develop an ESC Standard or Code of Practice from the various development conditions presented in Section G3.</td></tr>
<tr><td>Adoption of development approval conditions</td><td>App-G, Section G3</td><td>• Select and/or modify development conditions from Section G3 on a case-by-case basis.</td></tr>
</table>

Notation

A	Flow area (cross-sectional area perpendicular to direction of flow) [m^2]
A	Catchment area [ha]
A	Annual soil loss due to erosion (RUSLE analysis) [t/ha/yr]
A	Total area of soil disturbance [m^2]
A_c	Surface area at top of volume [m^2]
A_i	Area of subcatchment "i" [ha]
A_{imp}	Impervious catchment area, or equivalent impervious catchment area [ha]
A_m	Surface area of sediment basin at mid depth [m^2]
A_0	Surface area of primary drainage holes [m^2]
A_s	Surface area of settling pond at the base of the settling zone [m^2]
ARI	Average recurrence interval [yr]
B	Top width of combined channel and floodplain flow [m]
b	Channel bed width perpendicular to direction of flow [m]
C	Coefficient of discharge used in the Rational Method [-]
C	(C-factor) Cover and management factor used within RUSLE soil loss analysis
C_d	Orifice discharge coefficient [-]
C_v	Volumetric runoff coefficient [-]
$C_{v(comp)}$	Composite volumetric runoff coefficient for a non-uniform catchment [-]
C_Y	Coefficient of discharge for the "Y" year ARI storm [-]
D	Internal pipe diameter [m]
D	Channel depth [m]
d	Diameter of sediment particle [m]
d_{50}	Mean rock size [mm]
d_{90}	Rock size of which 90% by weight are smaller [mm]
d_x	Rock size of which X% by weight are smaller [mm]
d/s	Downstream
F	Froude number [-]
F_Y	Frequency factor for an average recurrence interval of "Y" years [-]
f	Friction factor used in the Darcy-Weisbach equation [-]
g	Acceleration due to gravity [m/s^2]
H	Total energy level immediately upstream of a weir relative to the weir crest [m]
H	Water level immediately upstream of a weir relative to the weir crest, but at a location where the water velocity is zero or near-zero [m]
H	Head of water above orifice [m]
H	Numerical value of the TASK Number
H_c	Total head (energy level) at the spillway crest = $y_c + V_c^2/2g$ [m]
H_e	Hydraulic efficiency correction factor used in the sizing of sediment basins [-]
H_e	Entry loss [m]
H_{exit}	Exit loss [m]
H_f	Energy (head) loss due to friction [m]
$H_{fittings}$	Energy (head) loss due to pipe fitting [m]
HI	Horizontal spacing of drains or flow diversion banks [m]
ΔH	Total head loss [m]

h_f Friction loss within the approach channel and across the crest width [m]

h_s Depth of settling zone [m]

I Average design storm rainfall intensity used in the Rational Method [mm/hr]

$^{T}I_{Y}$ Average design storm rainfall intensity for a design storm of duration “T” (hours), and average recurrence interval of “Y” years [mm/hr]

$I_{(1yr,\ 120hr)}$ Average rainfall intensity for a 1 in 1 year ARI, 120hr storm [mm/hr]

K Factor used in the equation for the spacing of drains or flow diversion banks [-]

K Constant used in rock sizing equation [-]

K (K-factor) Soil erodibility factor used within RUSLE soil loss analysis

K_n Constant

K_e Energy loss coefficient for pipe entry [-]

K_{exit} Energy loss coefficient for pipe exit [-]

$K_{fittings}$ Energy loss coefficient for pipe fittings [-]

K_{sat} Saturated hydraulic conductivity [mm/hr]

L Length of outlet rock pad [m]

L Length of kerb, pipe or channel flow path [m]

L Length of the approach channel upstream of the spillway crest [m]

L Design life of a structure [years]

LS (LS-factor) Topographic factor derived from slope length and slope gradient used within RUSLE soil loss analysis

L_n Average flow length of settling pond “i” measured along flow path [m]

m Slope of channel bank relative to a rise of 1 vertical unit (m:1) being (H:V)

n Manning’s roughness [-]

n Horton’s roughness [-]

O_{95} Fabric pore size [:m]

P Wetted perimeter [m]

P Probability of an event [%]

P Circumference of volume [m]

P (P-factor) Erosion control practice factor used within RUSLE soil loss analysis

Q Discharge [m^3/s]

Q_f Bankfull discharge [m^3/s]

QX Peak discharge during the 1 in X year design storm [m^3/s]

QY Estimated peak discharge for a given storm ARI “Y” years [m^3/s]

q Flow per unit width (rectangular flow only) [m^3/s/m]

R Hydraulic radius (= A/P) [m]

R Total rainfall within a given rainfall event [mm]

R (R-factor) Rainfall erosivity factor used within RUSLE soil loss analysis

$R_{(Y\%,\ 5\text{-day})}$ Total rainfall depth for a Y-percentile, 5-day storm [mm]

S Land slope on which regularly-spaced cross drainage is established [%]

S Slope of energy line associated with fluid [m/m]

S Slope of drain/channel bed [m/m]

S Spacing of parallel pipes [m]

S Slope factor used within determination of the TASK number

S_e Equal area slope used in the Bransby-Williams and Modified Friend’s eqns [%]

s Specific gravity of sediment particle [-]

s_{gr} Specific gravity of rock [-]

T — Thickness of rock protection [m]
T — Top width of the water surface [m]
T — Sediment basin de-watering time [hours]
T — Duration of soil disturbance [months]
t — Flow travel across a given segment of a drainage path [minutes]
t_c — Time of concentration used in the Rational Method [minutes]
t_H — Particle travel time across the basin [minutes]
t_p — Time for sediment particle to fall the full depth of settling pond [minutes]
u/s — Upstream
V — Average flow velocity at a given location or cross-section [m/s]
V_{allow} — Allowable (design) flow velocity [m/s]
V_{ave} — Average flow velocity [m/s]
V_b — Required basin volume [m^3]
V_c — Average flow velocity at location of critical depth [m/s]
V_H — Average forward velocity through settling pond [m/s]
V_p — Particle falling velocity [m/s]
V_s — Volume of the settling zone within a sediment basin [m^3]
V — Volume (such as design volume of sediment basin) [m^3]
V — Stormwater runoff volume [m^3]
W — Width of settling pond transverse to the dominant flow direction [m]
W_e — Effective width of a settling pond or sediment basin [m]
Y — Average recurrence interval of the design storm [years]
Y% — Y-percentile event determined from statistical analysis [%]
y — Depth of flow, or maximum depth of flow [m]
y_c — Critical flow depth [m]
μ — Kinematic viscosity of the water at a given temperature [m^2/s^2]

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1. Introduction

1.1 Potential impacts of soil erosion and sedimentation

Soil erosion is the wearing away of earth surfaces by the action of external forces. This includes erosion caused by running water, rainfall, wind, ice and other geological agents. It includes such processes as detachment, entrainment, suspension, transportation and mass movement. Sedimentation is the deposition of sediment displaced by the various erosion processes.

Sediment, in its *natural* location and *natural* concentration, is a natural part of the environment, but when found in un-natural quantities or concentrations, within natural and un-natural locations, it is considered a "pollutant" or "contaminant" that needs to be managed to the best of our abilities. As a form of pollution, fine sediments (clays) have the added ability of transporting (piggybacking) other key pollutants such as phosphorus and metals.

Table 1.1 outlines potential impacts of soil erosion and sedimentation commonly associated with inappropriate construction and building practices.

Table 1.1 – Potential impacts of soil erosion and sedimentation on the built environment

Environment	Impact of soil erosion	Impact of sedimentation
Work site	• Loss of topsoil. • Undermining roads and services. • In-filled excavations and trenches. • Decrease in water quality.	• Generation of mud. • Blocked drainage systems. • Increased down-time. • Increase clean-up costs.
Off-site urban landscape	• Altered drainage conditions within the work site can cause soil erosion within adjacent properties and receiving waters. • Costs associated with the rehabilitation of off-site soil erosion.	• Safety issues associated with sedimentation on roads. • Damage to adjoining properties. • Social and economic costs associated with increased drainage and flooding problems. • Economic cost of de-silting pipes and drains. • Social stigma associated with turbid water flows.

It is important to acknowledge that as a pollutant, "sediment" may be divided into two key forms:

- the finer sediment fraction consisting of clay-sized particles and fine silts; and
- the coarser sediment fraction consisting of coarse silts and sand particles.

Fine and coarse sediments have the potential to cause significantly different social, economic and environmental problems, and consequently they should be considered as two separate pollutants. Table 1.2 outlines common problems associated with the two forms of sediment runoff.

Table 1.2 – Potential impacts of fine and coarse sediment runoff

Environment	Fine sediment (turbidity)	Coarse sediment
Minor waterways such as creeks	• Health and bio-diversity issues for aquatic life within permanent pools. • Water quality and aquatic health issues associated with de-silting operations, especially if the deposited sediment contains significant metal concentrations. • Turbid water retained in pools. • Reduced light penetration into water column.	• Loss of aquatic habitats. • Increased potential for creek erosion. • Water quality and aquatic health issues associated with de-silting operations. • Social cost of increased drainage and flooding problems. • Economic cost of de-silting and rehabilitating waterways. • Ecological damage resulting from de-silting activities.
Wetlands	• Health and biodiversity issues for aquatic life. • Water quality and aquatic health issues associated with de-silting operations, especially if the deposited sediment contains significant metal concentrations.	• Potential for a significant change in plant species. • Economic cost of de-silting and rehabilitating waterways. • Ecological damage resulting from de-silting activities. • Water quality and aquatic health issues associated with de-silting operations.
Lakes and dams	• Health and biodiversity issues for aquatic life. • Water quality and water supply issues associated with nutrients and metals attached to settled and suspended clay-sized particles. • Water quality and aquatic health issues associated with de-silting operations. • Social stigma associated with turbid water flows.	• Water quality and aquatic health issues associated with de-silting operations. • Reduction in effective dam storage capacity.
Major waterways such as rivers, estuaries and bays	• Health and biodiversity issues for aquatic life. • Reduced light infiltration into water column. • Smothering of sessile biota. • Water quality and aquatic health issues associated with nutrients and metals attached to settled and suspended clay-sized particles, and consequent de-silting operations. • Economic impacts on community stakeholders reliant upon healthy waterways such as recreational and commercial fisheries, and eco-tourism. • Social stigma associated with turbid water flows.	• Economic cost of dredging operations. • Water quality and aquatic health issues associated with de-silting operations. • Ecological issues associated with dredging operations. • Smothering of sessile biota.

The finer sediment fraction usually travels as suspended sediment and is directly related to water turbidity. Turbid runoff primarily results from raindrops impacting on exposed soils. Without the benefits of a protective cover, clay-sized particles are easily washed from the soil surface by the destructive force of raindrops.

As demonstrated in Table 1.2, the deposition of coarse sediment is most commonly associated with social problems such as traffic safety issues (deposition on roads), creek instabilities and drainage and flooding problems, while turbidity is more commonly associated with environmental problems, such as water contamination, poor aquatic health and reduced biodiversity.

Turbidity issues are generally best managed through the use of erosion control measures, specifically the control of raindrop impact erosion. Coarse sediment issues are generally best managed through the control of soil erosion (i.e. the minimisation of all forms of soil erosion) and the use of sediment control measures.

1.2 Erosion control vs sediment control

“Erosion and sediment control” should not be viewed as a single exercise or activity. Erosion control is a very different activity from that of sediment control. As a consequence, the techniques used to control soil erosion are very different from those used to trap sediment.

Erosion control measures concentrate on preventing, or at least minimising, soil erosion, especially raindrop impact erosion. Sediment control measures concentrate on trapping sediment displaced by up-slope soil erosion. In general, the most efficient and cost-effective way of minimising sedimentation is to minimise the extent, duration, and severity of soil erosion.

At specific times during the construction phase it may be necessary to focus on the application of sediment control measures, for instance during major earthworks when it may be impractical to incorporate effective erosion control measures across the site. However, this does **not** mean that appropriate erosion control measures should be absent during these periods. The key principle of minimising soil erosion is always applicable, for example, through the application of such measures as:

- the appropriate management of stormwater flow through the site;
- the diversion of up-slope stormwater runoff around soil disturbances; and
- the appropriate staging of soil disturbances and site stabilisation measures.

The application of best-practice sediment control measures cannot, on their own, provide adequate protection of major waterways such as rivers, estuaries and bays. *Sediment Basins* may represent the most important and effective form of sediment control, but current design procedures result in the sizing of basins that are likely to be overtopped or bypassed several times a year. As a result, significant quantities of sediment-laden water are still likely to be released from most construction sites.

Sediment Basins actually provide the greatest protection to minor waterways such as creeks. The **only** way of providing adequate protection to major waterways is to minimise the initial source of soil erosion, particularly raindrop impact erosion, by applying effective erosion control measures across a work site. Thus, the application of effective erosion control measures **must** always stand as the highest priority.

Technically, *“erosion control”* refers to the control of soil erosion caused by both sheet and concentrated flow. Thus, those temporary drainage control measures placed on a construction site to appropriately manage stormwater runoff are considered part of the erosion control process. However, not all aspects of *"drainage control"* relate solely to the erosion control process. As can be seen in Table 1.3, some drainage control measures function to reduce soil erosion, while others benefit the sediment control process.

Table 1.3 – Classification of drainage control measures

Aspects applicable to erosion control	Aspects applicable to sediment control
• Diversion of up-slope stormwater runoff around soil disturbances. • Division of a site into manageable drainage areas. • Control of flow velocity and soil erosion within drainage channels and *Chutes*.	• Diverting up-slope runoff around excavations. • Diversion of "clean" water around sediment traps, thus improving their sediment-trapping efficiency and reducing the size of major sediment traps, such as *Sediment Basins*.

Within this document the term *"drainage control measures"* primarily refers to the temporary management of stormwater during the construction and building phase. These measures are presented in a separate category to that of *erosion control* and *sediment control*. Drainage control measures, however, should always be viewed as a basic component of effective erosion and sediment control. Thus, throughout this document the term "erosion and sediment control" implies the adoption of drainage, erosion and sediment control measures.

The three cornerstones of the erosion and sediment control industry are *drainage control*, *erosion control*, and *sediment control*. The function of drainage, erosion, and sediment control as applied throughout this document is presented below.

- Drainage control measures aim to prevent or reduce soil erosion caused by concentrated flows—including the management of rill and gully erosion—and to appropriately manage the movement of "clean" and "dirty" water through the site.
- Erosion control measures aim to prevent or reduce soil erosion caused by raindrop impact and sheet flow (i.e. the control of splash and sheet erosion).
- Sediment control measures aim to trap and retain sediment either moving along the land surface (bed load) or contained within flowing water (suspended sediment).

Table 1.4 outlines the primary control measures used to manage the various forms of soil erosion. A more detailed discussion on the various erosion processes is contained in Appendix M – *Erosion processes*.

Table 1.4 – Management of soil erosion within urban areas

Form of soil erosion	Primary control measure
Splash erosion	Erosion control
Sheet erosion	
Rill erosion	Drainage control
Gully erosion	Management of stormwater during the operational phase
Tunnel erosion	Soil management and detailing of the earthworks and drainage
Mass movement	Vegetation, stormwater and land management
Watercourse erosion	Permanent stormwater and sediment control
Coastal erosion	Vegetation and land use management
Wind erosion	Erosion control

The higher the sand content of the exposed soil, the greater the **benefit** normally obtained from sediment control measures. Conversely, the higher the clay content of the exposed soil, the greater the **benefit** obtained from erosion control measures.

Figure 1.1 demonstrates how the general benefits of drainage, erosion, and sediment control measures vary for various rainfall, soil type and drainage conditions. The diagram, however, does **not** imply that drainage, erosion, and sediment control measures should be used in isolation from each other.

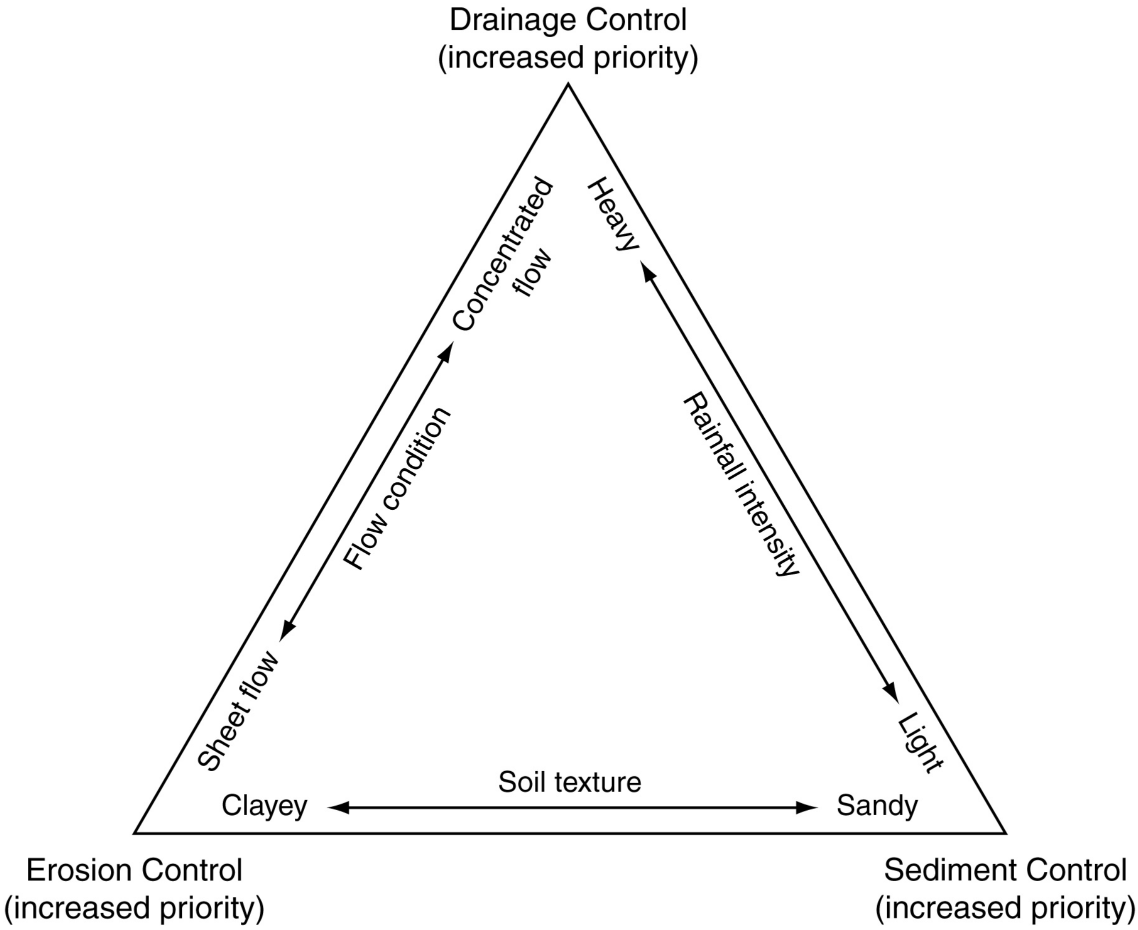


Figure 1.1 – Relative importance of drainage, erosion, and sediment control measures for different site conditions

Remember that on any site subject to stormwater discharge, best practice sediment control measures cannot, on their own, be relied upon to provide adequate environmental protection. Therefore, appropriate drainage and erosion control measures must also be applied, at all times, especially on clayey soils.

The primary function of **most** *sediment control measures* is to trap the coarser sediment fraction. *Sediment Basins* and some filtration systems used during de-watering operations are possibly the only sediment control techniques that have any significant ability to trap the finer sediment particles such as silts and clays. Due to the difficulty of trapping these finer sediments, priority should be given to the use of effective *erosion control* measures wherever practical.

Typical drainage control, erosion control, and sediment control measures are listed in Table 1.5.

Table 1.5 – Typical drainage, erosion, and sediment control measures

Drainage control	Erosion control	Sediment control
Catch drains Check dams Chutes Diversion channels Flow diversion banks Level spreaders Outlet structures Slope drains Temporary watercourse crossings	Bonded fibre matrix Compost blankets Dust control measures Erosion control blankets Gravelling Mulching Revegetation Soil binders and surface stabilisers Surface roughening	Buffer zones Check dam sediment traps Compost/mulch berms Construction exits Drop inlet protection Grass filter trips Rock filter dams Sediment basins Sediment fences Sediment weirs

1.3 Principles of erosion and sediment control

The principles of effective erosion and sediment control (ESC) as detailed within Chapter 2 are based on the following "key principles".

1. Appropriately integrate the development into the site.
2. Integrate erosion and sediment control issues into site and construction planning.
3. Develop effective and flexible Erosion and Sediment Control Plans based on anticipated soil, weather, and construction conditions.
4. Minimise the extent and duration of soil disturbance.
5. Control water movement through the site.
6. Minimise soil erosion.
7. Promptly stabilise disturbed areas.
8. Maximise sediment retention on the site.
9. Maintain all ESC measures in proper working order at all times.
10. Monitor the site and adjust ESC practices to maintain the required performance standard.

Construction site erosion and sediment control is said to be at "the cutting edge of common sense". In reality, however, development of this "common sense" usually takes many years of site experience and professional training. Some of the regularly used ESC measures function very differently from the manner commonly perceived within the profession. It is now clear that site experience alone (i.e. without professional training) cannot adequately develop a practitioner's understanding of best practice ESC.

Some commonly accepted past practices, such as *Straw Bale Barriers*, are now considered grossly ineffective and thus inappropriate for most construction site applications. Even the widely used *Sediment Fence* is now seen as an example of one of the lowest standards of sediment control. Though often best replaced by alternative, higher-standard sediment control techniques on most construction sites, the humble Sediment Fence will likely continue to be an important part of best practice sediment control on most building sites.

Building and construction sites should not be judged solely on how much sediment they stop, but also on how they protect, develop, and/or restore sustainable ecosystems and environmental values both on-site and downstream of their works. Thus, highest priority must be given to those ESC practices that minimise overall environmental harm, rather than those measures that simply maximise the capture of sediment. Of course, one of the most effective ways of minimising environmental harm is to minimise the release of sediment.

There is an important though subtle difference between minimising environmental harm and minimising pollution. People who focus on minimising pollution will tend to focus on capturing the maximum tonnage of sediment, and thus will focus on the application of sediment control measures. People who focus on minimising environmental harm will tend to focus on both minimising soil erosion and maximising the trapping of both coarse **and** fine sediment.

Unfortunately, it is often impractical to apply effective erosion control measures over all areas of an active work site, thus some degree of soil erosion is expected on most sites. Consequently, the degree of sediment control applied to a site must reflect both the potential for soil erosion, and the potential for displaced sediment to cause environmental harm. This requires a coordinated approach to the application of erosion and sediment control measures during all phases of building and construction. This document embraces this coordinated approach to erosion and sediment control.

In addition to the above, since all sediment control measures have a design flow limit after which their effectiveness is expected to diminish, effective erosion control should always be the preferred management option simply because of its greater potential to reduce environmental harm during a wide range of storm events. The additional benefit of this approach is that reduced soil erosion will result in a corresponding reduction in sediment loads.

1.4 Allowable soil loss rate and suspended solids concentration

It is generally accepted that there needs to be a long-term balance between the rates of soil formation and soil loss in order to maintain soil productivity within rural areas. Such a requirement, however, does not necessarily exist for urban areas. Natural soil formation rates within Australia are poorly defined, but are almost certainly less than 1.0t/ha/yr and more likely to be less than 0.5 t/ha/yr (Charman and Murphy, 2007).

In urban areas allowable soil loss rates are normally governed by the need to maintain environmental values within receiving environments. It is generally accepted that in order to maintain aquatic health within most pristine receiving waters, the 90 percentile suspended solids concentration should not exceed 50 mg/L. It can be demonstrated through hydrologic analysis that setting a design target suspended solids concentration of 50 mg/L would, in most regions of Australia, limit soil loss rates from construction sites to less than the commonly adopted natural soil loss rate of 0.5 to 1.0 t/ha/yr.

It is generally considered impractical to require **all** discharge from building and construction sites to achieve a suspended solids concentration of 50 mg/L. It is however considered reasonable to set a design target of 50 mg/L for the 90 percentile suspended solids concentration for water discharged from a *Sediment Basin* under controlled conditions after a storm event. Such a water quality objective is therefore adopted within this document.

It is noted that a suspended solids concentration of 50 mg/L would represent the equivalent of 50 kg, or approximately three and a half, domestic buckets of soil, evenly dispersed throughout a standard (1000 m^3) Olympic swimming pool.

2. Principles of erosion and sediment control

This chapter provides an overview of the principles of best practice (2008) erosion and sediment control as applied to building and construction sites. The function of this chapter is both educational and prescriptive. Persons operating within the erosion and sediment control industry, or wishing to apply erosion and sediment control measures to a specific site, are expected to be familiar with the following principles.

2.1 Key principles of erosion and sediment control

The **objective** of erosion and sediment control (ESC) practices is:

To take all reasonable and practicable measures to minimise short and long-term soil erosion and the adverse effects of sediment transport.

This objective is consistent with the general **environmental duty**, that being:

To take all reasonable and practicable measures to prevent or at least minimise environmental harm.

The principles of effective erosion and sediment control as outlined within this chapter are based on the following key principles.

1. Appropriately integrate the development into the site.
2. Integrate erosion and sediment control issues into site and construction planning.
3. Develop effective and flexible Erosion and Sediment Control Plans based on anticipated soil, weather, and construction conditions.
4. Minimise the extent and duration of soil disturbance.
5. Control water movement through the site.
6. Minimise soil erosion.
7. Promptly stabilise disturbed areas.
8. Maximise sediment retention on the site.
9. Maintain all ESC measures in proper working order at all times.
10. Monitor the site and adjust ESC practices to maintain the required performance standard.

Further discussion on principles 1 and 2 is provided in Chapter 3, principle 3 in Chapter 5, principle 9 in Chapter 6, and principle 10 in Chapter 7.

One of the most notable features of the erosion and sediment control profession is that there is almost always an exception to every rule and guideline. The fact that a control measure is observed to work well on one site does not mean that it will work well on all sites. Similarly, the fact that a control measure has repeatedly failed within one region of Australia does not mean that the technique will not be useful within another region. Even though the above key principles are applicable to all sites, their application can vary significantly from site to site, and region to region.

Erosion and sediment control practices must represent an appropriate balance between the application of the recommended design philosophy and the application of *common sense*. No rule or recommendation should be allowed to overrule the application of unique, site specific solutions where such solutions can be demonstrated to satisfy the principle objective and the specified performance standard.

In the event that a conflict exists between the application of any two or more principles, then priority must be given to the outcome that best achieves the objective of *minimising short- and long-term soil erosion and the adverse effects of sediment transport*.

The 10 key principles listed above can be expanded into the fundamental principles of erosion and sediment control presented below. These principles must be given appropriate consideration during the preparation and implementation of an Erosion and Sediment Control Plan.

1 Appropriately integrate the development into the site.

1.1 Developments should aim to utilise the existing topography to minimise the need for extensive land reshaping and surface modifications.

2 Integrate erosion and sediment control issues into site and construction planning.

2.1 Ensure the extent and complexity of data collection during the planning phase is commensurate with the potential environmental risk, and the extent and complexity of the soil disturbance.

2.2 Identify high-risk areas and high-risk construction activities during site planning.

3 Develop effective and flexible Erosion and Sediment Control Plans based on anticipated soil, weather, and construction conditions.

3.1 Appropriately amend the adopted erosion and sediment control measures, and where appropriate, revise the Erosion and Sediment Control Plan (ESCP), if the implemented works fail to achieve the "objective" of the ESCP, the required performance standard, or the State's environmental protection requirements.

4 Minimise the extent and duration of soil disturbance.

4.1 Construction schedules should aim to minimise the extent to which and duration that any and all areas of soil are exposed to the erosive effects of wind, rain and flowing water.

4.2 Wherever reasonable and practicable, land clearing and site rehabilitation must be appropriately staged to minimise the duration of soil exposure and the area of exposure at any given instant.

4.3 As long as the risks of rainfall or strong winds exist on a site, land disturbances should be restricted to those areas required for the current stage of works.

4.4 Wherever reasonable and practicable, major land disturbances should be scheduled for the least erosive periods of the year.

4.5 Disturbances to high and extreme erosion risk areas should be minimised, if not totally avoided, especially during the most erosive periods of the year.

4.6 Wherever reasonable and practicable, the disturbance of dispersive or potential acid sulfate soils should be minimised, if not totally avoided.

4.7 Disturbances to the existing ground cover should be delayed as long as possible.

4.8 Construction procedures should aim to minimise the extent of unnecessary soil disturbance, including any disturbances outside the designated work area.

5 Control water movement through the site.

5.1 The permanent and temporary drainage requirements of a site need to be appropriately considered during development of the Erosion and Sediment Control Plan.

5.2 Flow velocities need to be limited to the maximum allowable velocity for each individual drainage system.

5.3 All drainage channels, temporary or permanent, need to be constructed and maintained with sufficient gradient and surface conditions to maintain their required hydraulic capacity.

5.4 Wherever reasonable and practicable, up-slope stormwater runoff, whether “dirty” or “clean”, needs to be diverted around soil disturbances and unstable slopes in a manner that minimises soil erosion, and the saturation of soils within active work areas.

5.5 To the maximum degree reasonable and practicable, “clean” water needs to be diverted around sediment traps in a manner that maximises the sediment trapping efficiency of the sediment trap.

5.6 On disturbances exceeding 1500m^2, Construction Drainage Plans need to be prepared for each stage of earth works.

5.7 The construction schedule and ESC installation sequence should allow for the installation of the temporary drainage system, and preferably the permanent stormwater drainage system, as soon as practicable.

5.8 Long slopes of disturbed or otherwise unstable soil should be divided into small, manageable drainage areas to prevent, or at least minimise, rill erosion.

5.9 In regions containing dispersive soils, construction details of drainage systems and bank stabilisation works need to demonstrate how these soils are to be stabilised and/or buried under a layer of non-dispersive soil.

5.10 Appropriate outlet scour protection needs to be placed on all stormwater outlets, *Chutes*, spillways and *Slope Drains* to dissipate flow energy and minimise the risk of soil erosion.

5.11 Building and construction sites need to employ appropriate short-term drainage control measures to deal with impending storms.

5.12 Clean, sealed surfaces, such as roofs, should be connected to the permanent underground drainage system (if available) as soon as they are constructed.

5.13 Adequate drainage controls need to be applied to all permanent and temporary, unsealed roads and tracks to minimise environmental harm caused by runoff from such surfaces.

5.14 Disturbances to natural watercourses and riparian zones need to be minimised wherever possible, and all temporary watercourse crossings need to employ appropriate drainage, erosion, and sediment controls to minimise sediment inflow into the stream.

5.15 All drainage systems, whether temporary or permanent, need to be designed to the appropriate drainage standard.

6 Minimise soil erosion.

6.1 Wherever reasonable and practicable, priority needs to be given to preventing, or at least minimising soil erosion (i.e. drainage and erosion control measures), rather than allowing the erosion to occur and trying to trap the resulting sediment. Where this is not practicable, then all reasonable and practicable measures need to be taken to minimise soil erosion even if the adopted sediment control measures comply with the required treatment standard.

6.2 The standard of erosion control needs to be appropriate for the given soil properties, expected weather conditions, and susceptibility of the receiving waters to environmental harm resulting from turbid runoff.

6.3 Appropriate erosion control measures need to be incorporated into all stages of a soil disturbance.

6.4 The timing and degree of erosion control specified in the Erosion and Sediment Control Plan(s) needs to be appropriate for the given soil properties, expected weather conditions, and susceptibility of the receiving waters to environmental harm resulting from turbid runoff.

6.5 If tree clearing is required well in advance of future earthworks, then tree clearing methods that will minimise potential soil erosion need to be employed, especially in areas of unstable or highly erodible soil.

6.6 Erosion and Sediment Control Plans need to specify the required application rates for mulching and revegetation measures.

6.7 Erosion control measures need to be appropriate for the slope of the land and the expected wind and surface flow conditions.

6.8 Wherever reasonable and practicable, the use of synthetic reinforced *Erosion Control Mats* and *Erosion Control Blankets* needs to be avoided within bushland and other areas where they could endanger wildlife such as ground-dwelling animals.

6.9 Wherever reasonable and practicable, measures need to be taken to apply appropriate erosion control practices around the site office area and on temporary access roads to minimise raindrop impact erosion and the generation of mud.

6.10 Finished soil surfaces need to be left in an appropriate roughened state and quality to encourage revegetation where required.

6.11 Where appropriate, Erosion and Sediment Control Plans need to incorporate technical notes on suitable dust control measures.

7 Promptly stabilise disturbed areas.

7.1 The construction schedule or ESC installation sequence needs to ensure that soil stabilisation procedures, including site preparation and revegetation, are commenced as soon as practicable after each stage of earthworks is completed.

7.2 Topsoil needs to be appropriately managed to preserve its long-term value.

7.3 Plant species need to be appropriate for the site conditions, including compatibility with local environmental values, and anticipated erosive forces.

8 Maximise sediment retention on the site.

8.1 All reasonable and practicable measures need to be taken to protect adjacent properties and downstream environments from the adverse effects of sediment and sediment-laden water displaced from the site.

8.2 Work sites must not rely solely on the application of sediment control measures to provide adequate environmental protection.

8.3 Sediment control measures need to be appropriate for the given soil properties, expected weather conditions, required treatment standard, and the type, cost and scope of the works.

8.4 *Sediment Basins* need to be designed and constructed under the supervision of appropriate experts.

8.5 On-site sediment control practices should not rely on off-site sediment control systems.

8.6 The use of straw bales to form sediment traps should be avoided, unless site conditions prevent the use of other more appropriate sediment control systems.

8.7 Suitable construction access needs to be provided to allow for the installation and maintenance of all sediment traps.

8.8 Sediment traps, including *Sediment Basins*, need to be appropriately designed for the required hydraulic (flow) conditions.

8.9 Optimum benefit needs to be made of every opportunity to trap sediment within the work site.

8.10 Wherever reasonable and practicable, sediment should be trapped as close to its source as possible.

8.11 Sediment traps need to be designed, constructed and operated to collect and retain sediment, not just divert the sediment and sediment-laden water to another location.

8.12 The potential safety risk of a proposed sediment trap to site workers and the public needs to be given appropriate consideration and management, especially those devices located within publicly accessible areas.

8.13 To the maximum degree reasonable and practicable, sediment needs to be contained within appropriate sediment traps before entering a sealed roadway, whether or not the road is part of the construction site.

8.14 Roadside kerb inlet sediment traps need to be appropriate for the type of inlet (i.e. “sag” or “on-grade” inlets).

8.15 Site entry and exit points need to be limited to the minimum practical number, and need to be appropriately designed and stabilised to minimise sediment being washed off the site by stormwater and/or being transported off the site by vehicles.

8.16 Appropriate sediment control measures need to be applied to all temporary building and construction works, including the site office and stockpile areas.

8.17 Wherever practicable, *Sediment Fences* need to be located along the contour to maintain “sheet” flow conditions down-slope of each fence. Where this is not practicable, the Erosion and Sediment Control Plan needs to indicate appropriate installation measures (i.e. regular “returns”) to allow water to pond at regular intervals along the length of the fence.

8.18 *Sediment Fences*, installed in the standard (i.e. straight) manner, must not be placed across concentrated flow.

8.19 As a general guide, sediment-laden water should not pass through more than one *Sediment Fence* within a given work area. If further treatment is required after passing through a *Sediment Fence*, then wherever reasonable and practicable, the sediment-laden water needs to be directed to a suitable Type 1 or Type 2 sediment trap.

8.20 Sediment control measures employed during de-watering operations need to be appropriate for the expected site conditions, soil type, potential environmental risk, and the type, cost and scope of the works.

8.21 When constructing works or causing soil disturbances in or around a watercourse, priority must first be given to construction practices that avoid contamination of stream flows. Where such practices are not practical, priority must then be given to the treatment of sediment-laden water within off-stream sediment traps. The use of instream sediment traps must only be considered as a management option when all other options can be demonstrated to be ineffective, unreasonable, or impracticable.

8.22 The ESC installation schedule and/or Supporting Documentation must clearly indicate which sediment control measures need be functional before up-slope soil disturbances commence, and what degree of site stabilisation is required prior to the decommissioning of each sediment control device.

8.23 Site managers and/or the nominated responsible ESC personnel need to maintain a good working knowledge of the correct installation and operational procedures of all ESC measures used on the site.

9 Maintain all ESC measures in proper working order at all times.

10 Monitor the site and adjust ESC practices to maintain the required performance standard.

2.2 List of Technical Notes presented in Section 2.3

2.3 Discussion on the principles of erosion and sediment control

In this section the principles outlined in Section 2.1 are discussed in detail. It is again emphasised that even though collectively these principles are applicable to all sites, their specific application will likely vary from site to site, and region to region.

Principle 1 Appropriately integrate the development into the site.

Best practice development planning involves the determination of the appropriate land use for a given site and how best to accommodate that land use within a development layout. To achieve this, it is essential to investigate and appropriately address potential site constrictions including the soil, water, vegetation and topographic features of the property.

Principle 1.1

Developments should aim to utilise the existing topography to minimise the need for extensive land reshaping and surface modifications.

Wherever reasonable and practicable, the development layout should:

- utilise the existing topography and avoid extensive land reshaping to minimise the potential for soil erosion; and
- incorporate elevated pole homes, or suspended slab construction on steep sites, thus avoiding significant land reshaping; and
- allow for construction practices that minimise soil erosion and sediment discharge from the site.

Urban Capability Mapping can be used to assist in identifying appropriate land uses for specific sites. When used by local governments, this planning tool can assist in the assessment of land use applications and the development of appropriate Planning Schemes.

Further discussion on development planning, Urban Capability Mapping, and the identification of site constraints, is provided in Chapter 3 – *Site planning*.

In addition to integrating the development into the existing site conditions, the stormwater drainage and water quality requirements of the site need to be appropriately integrated into the development. Consideration of such issues needs to occur during site planning to avoid the inappropriate placement of buildings and other services within critical overland flow paths. Failure to do such planning may result in the design of a land development that cannot be built without causing unnecessary environmental harm.

Principle 2 Integrate erosion and sediment control issues into site and construction planning.

The construction phase is generally relatively short compared to the design life of the development, but its potential impact on the land and surrounding environment can be significant. Construction planners, including those involved in the preparation of Erosion and Sediment Control Plans (ESCPs), must consider the potential environmental impacts of the construction phase and the means of appropriately managing these impacts.

Best practice construction site planning involves the early recognition and management of those components of a development layout and construction process that can significantly influence the impacts a construction or building site might have on the surrounding environment. To achieve this, it is essential to assemble and analyse all pertinent site information, and to recognise the dimensional requirements of essential erosion and sediment control measures such as *Sediment Basins*.

During the planning of a building or construction project, consideration must be given to how the works will be constructed, and how—without unreasonably altering the project's aims—the development layout and construction process can best achieve the following:

(i) Minimise short- and long-term environmental harm resulting from both the construction and operational phases of the project.

(ii) Allow sufficient land area within and around construction activities for the placement and operation of necessary drainage, erosion and sediment control measures, especially major sediment traps such as *Sediment Basins*.

(iii) Allow sufficient land area for the short-term stockpiling of building and construction materials, operational equipment, and site facilities, such that these stockpiles and facilities do not negatively impact on designated non-disturbance areas or protected vegetation, and are retained within the site's sediment control zone.

(iv) Allow areas of disturbance to be effectively stabilised against erosion as soon as land reshaping has been completed, i.e. before building activities commence.

(v) Allow for the early installation and operation of the permanent drainage system to assist in the diversion of up-slope stormwater and/or the effective separation of "clean" and "dirty" water (refer to Technical Note 2.1 for definition of clean and dirty water).

(vi) Allow sediment-laden runoff to be directed to the designated sediment traps during all stages of the construction.

(vii) Avoid the placement of buildings and other construction activities in locations that will prevent the appropriate management of "clean" and "dirty" water flow paths during all stages of construction.

(viii) Avoid the placement of buildings and other construction activities too close to recognised environmental values (refer to principle 4.1).

(ix) Avoid the necessity for extensive earthworks or construction/building activities at or near the lowest point in the property where such works could interfere with the establishment and operation of essential sediment traps.

Technical Note 2.1 – Clean and dirty water

The term "clean" water refers to water that either:

(i) Enters the property from an external source and has not been further contaminated by sediment within the property.

or

(ii) Water that has originated from the site and is of such quality that it either does not need to be treated in order to meet the required water quality objective, or would not be further improved if it was to pass through the type of sediment trap specified for the site. An example of the latter case would be sediment-laden water pumped from an excavation on a site (at say, 70mg/L suspended solids) where the sediment control standard only requires a Type 3 sediment trap that would not be capable of further improving the water quality.

The term "dirty" water refers to any water that is not classified as clean water.

Principle 2.1

Ensure the extent and complexity of data collection during the planning phase is commensurate with the potential environmental risk, and the extent and complexity of the soil disturbance.

Site data may be obtained from a variety of sources including existing soil, topographic and vegetation maps. Where necessary land surveys and soil testing will be required to complete the data set.

Appropriate soil data is necessary to:

- assess the site's erosion risk and/or environmental risk;
- identify the existence of potential soil problems such as unstable, dispersive, or acid sulfate soils;
- assist in the selection, design and operation of various drainage, erosion, and sediment control measures;
- assist in the design of site stabilisation works including site revegetation;
- identify necessary soil amendments to facilitate site revegetation.

Further discussion on data collection and soil testing is provided in Chapter 3 – *Site planning,* and Appendix C – *Soils and revegetation*.

Principle 2.2

Identify high-risk areas and high-risk construction activities during site planning.

High-risk areas may include those areas of a work site that:

- have a high potential for soil loss;
- have a high potential to cause environmental harm;
- are located within, or within close proximity to, critical habitats such as wetlands, creeks and waterways.

High-risk construction activities may include those activities that:

- disturb natural wetlands or flowing streams;
- disturb threatened species, habitats or environmental values;
- disturb protected vegetation;
- have the potential to cause significantly more soil loss and/or environmental harm compared to alternative construction practices.

Mapping exercises, such as Erosion Risk Mapping, can be used to identify areas of low, medium, high and extreme erosion risk. Such mapping exercises should aim to identify:

- zones of varying erosion risk;
- areas where soil disturbances should be avoided during given periods of the year, or periods of known erosion risk;
- a well-defined link between the assessed erosion risk and the required erosion and sediment control performance standard.

Construction or building sites that contain high-risk areas or potentially high-risk construction/building activities are collectively known as “high-risk sites”.

High-risk sites may require the preparation of a conceptual Erosion and Sediment Control Plan (ESCP) to assist in the appropriate planning of developments and construction activities.

The purposes of preparing conceptual ESCPs are listed below:

- Ensure appropriate soil data is collected and site constraints are identified.
- Ensure appropriate consideration of erosion and sediment control requirements, site constraints and environmental issues occurs during the planning phase.
- Allow regulatory authorities to raise any concerns before a development proposal progresses too far through the planning phase.
- Demonstrate to the regulatory authority that there is a feasible means of constructing the project while still protecting environmental values.

Principle 3 Develop effective and flexible Erosion and Sediment Control Plans based on anticipated soil, weather, and construction conditions.

Best practice erosion and sediment control involves clearly identifying local issues and concerns, including:

- the nature of the land disturbance;
- anticipated site constraints (e.g. topography, soils, vegetation, water availability);
- local environmental values—possibly identified within an existing Stormwater Management Plan, or Catchment Management Plan; and
- potential risks to environmental values as a result of the project.

Where appropriate, a *Soil Map* should be prepared for the site, identifying (as a minimum) areas of sandy, clayey, dispersive, and potential acid sulfate soils.

Technical notes attached to the Erosion and Sediment Control Plans (ESCPs) can be used to specify any temporary ESC measures required in the event of rain or strong winds. These temporary measures are not meant to replace those longer-term ESC measures shown on the ESCP, but are used to supplement these control measures, or to assist site personnel deal with varying soil, weather and construction conditions.

Temporary ESC measures may include the use of straw bales or compacted-soil berms as temporary *Flow Diversion Banks* around trenches and unstable earth batters, or to direct “dirty” water to a sediment trap.

Principle 3.1

Appropriately amend the adopted erosion and sediment control measures, and where appropriate, revise the Erosion and Sediment Control Plan (ESCP), if the implemented works fail to achieve the “objective” of the ESCP, the required performance standard, or the State’s environmental protection requirements.

Approval of an ESCP by a regulatory authority does **not** imply that the plan is without error, that the plan will achieve the authority’s treatment standard, or that the plan will not require further review and amendment if implementation of the plan fails to achieve the desired treatment standard. Additional erosion and sediment control measures must be implemented and a revised ESCP needs to be prepared in the event that:

(i) site conditions have significantly changed from those considered within the current ESCP;

(ii) the implemented works fail to achieve the “objective” of the ESCP, the required performance standard, or the State’s environmental protection requirements.

Where there is a high probability that environmental harm might occur as a result of sediment leaving the site, all reasonable and practicable measures must be taken to prevent, or at least minimise the risk of such harm. However, only those works necessary to minimise or prevent imminent environmental harm should be implemented prior to the development and approval (if necessary) of an amended ESCP.

Principle 4 Minimise the extent and duration of soil disturbance.

Principle 4.1

Construction schedules should aim to minimise the extent to which and duration that any and all areas of soil are exposed to the erosive effects of wind, rain and flowing water.

The environmental harm that results from soil erosion and sediment runoff can generally be categorised as:

- harm caused to humans and the built environment (e.g. sediment on roadways, sediment blockage of stormwater drains, damage to commercial and recreational fishing and eco-tourism);
- harm caused to wildlife and the natural environment (e.g. ecological harm and damage to wildlife habitats).

Most of the "ecological" harm resulting from soil erosion specifically relates to the displacement of clay-sized particles, usually in the form of turbid water. Unfortunately it is very difficult to capture these clay-sized particles. Therefore, the key to minimising ecological harm is to minimise the *extent* and *duration* that soils, especially clayey soils, are exposed to wind, rain and flowing water.

Technical Note 2.2 – Agricultural industry vs construction industry

This principle is representative of one of the main differences between the agricultural industry and the construction industry. Agricultural activities normally expose topsoils to rainfall. These soils are generally less erodible and contain less erodible clay than the subsoils typically exposed by construction activities. Thus the exposure of topsoils normally has a lower potential to cause ecological harm compared to the equivalent exposure of most subsoils.

Best practice construction site planning involves minimising the area of disturbance and the duration of exposure. The extent of soil disturbance can be reduced by placing restrictions on the allowable width of soil disturbance relative to the construction footprint. Wherever reasonable and practicable, soil disturbances should be limited to no further than 2 to 5 metres from the edge of the building works, thus minimising the overall construction footprint.

It must be emphasised, however, that the aim of *minimising the extent and duration of soil disturbance* cannot be achieved solely by minimising the area of disturbance. It is essential to also minimise the *duration* for which any and all areas of soil disturbance are exposed to the erosive forces of wind, rain and flowing water. For example, a 1ha development fully exposed for 12 months normally has the potential to cause more soil erosion than a 10ha development that is appropriately managed such that less than 1ha is exposed at any given time over the same 12-month period.

In practical terms, the aim should be to reduce the *total area-time-exposure* of the development. The total area-time-exposure is defined as the sum of the product of the area (ha) of each sub-area of disturbance times the duration (days) of exposure of that sub-area.

The relative erosion hazard of various site layouts or construction methods may be assessed by comparing the total area-time-exposure for each layout or construction method.

Principle 4.2

Wherever reasonable and practicable, land clearing and site rehabilitation must be appropriately staged to minimise the duration of soil exposure and the area of exposure at any given instant.

While the *extent* of soil disturbance can be minimised by appropriately integrating the development into the existing topography, the *duration* of soil disturbance is primarily managed through the following activities:

(i) adoption of appropriate construction practices;

(ii) staging of land clearing and site rehabilitation activities;

(iii) the setting of appropriate development approval conditions that achieve items (i) and (ii) above;

(iv) the writing of effective contract documents and construction specifications that achieve items (i) and (ii) above.

Two aspects of a construction program that can affect the total area-time-exposure are the *Staging of Works* and the *Construction Sequence*. If the objectives of erosion and sediment control are to be achieved, then considerable attention must be given to the appropriate planning and supervision of these site management tools.

Appropriately staged earth works and revegetation programs can reduce the duration of soil exposure and the total area of soil exposed at any instant. Such activities can also reduce construction delays during wet weather. For example, the stabilisation of cut and fill batters should ideally be staged such that no more than 3 vertical-metres of a slope are exposed at any given time. This can be achieved by placing a *Hold Point* in the construction contract specifying that cutting and filling operations must not continue until the previous 3 vertical-metres of the batter are suitably stabilised (e.g. mulched).

Recommendations on the staging of land clearing and best practice site rehabilitation are provided in Chapter 4 – *Design standards and technique selection*.

Principle 4.3

As long as the risks of rainfall or strong winds exist on a site, land disturbances should be restricted to those areas required for the current stage of works.

Restrictions on land clearing and the total area of exposure generally only apply during periods of the year when there is a risk of significant rainfall or strong winds given the anticipated weather conditions. In this context, "significant rainfall" refers to sufficient rainfall to produce surface runoff, and "anticipated weather conditions" refers to likely weather conditions given reliable weather forecasting or normal seasonal weather patterns, whichever represents the worst case.

In regions where there are significant periods of a year when rainfall is unlikely to occur (i.e. a well-defined dry season), then greater areas of exposure can be tolerated during such periods. In any case, best practice site management would require that the area of exposure is limited to the minimum possible to complete the current stage of works.

Principle 4.4

Wherever reasonable and practicable, major land disturbances should be scheduled for the least erosive periods of the year.

Where conditions allow, major land disturbances and disturbances to high-risk areas should be scheduled for the least erosive periods of the year (i.e. during periods of low rainfall volume and intensity). Large developments should be appropriately staged so that land-disturbances are confined to manageable areas, especially during the wet season.

In this context, confining land disturbances to manageable areas means ensuring that any area of open soil can be managed (at any given time) within the limits of the drainage and sediment control standard without the need for the placement of erosion control measures (e.g. mulching) on any part of the soil.

Principle 4.5

Disturbances to high and extreme erosion risk areas should be minimised, if not totally avoided, especially during the most erosive periods of the year.

The disturbance of land designated as having a *high* or *extreme erosion risk* (Section 3.3 in Chapter 3, and Section 4.4 in Chapter 4) should be avoided wherever possible. Any soil disturbances must attract high-level erosion and sediment control requirements, and strict rehabilitation scheduling and design standards.

Principle 4.6

Wherever reasonable and practicable, the disturbance of dispersive or potential acid sulfate soils should be minimised, if not totally avoided.

Dispersive soils are highly susceptible to deep, narrow rilling on exposed slopes. These soils must be appropriately treated or buried under an appropriate layer of non-dispersive soil (usually 100mm minimum) before placing any revegetation or erosion control measures.

Wherever possible, avoid cutting *Catch Drains* into dispersive soils. Instead, *Flow Diversion Banks* should be used to temporarily divert stormwater across the site.

Acid sulfate soils occur naturally over extensive low-lying coastal areas, predominantly below an elevation of 5m Australian Height Datum (AHD). In low coastal regions these soils are normally found close to the natural ground level, but at higher elevations they may also be found at depth in the soil profile.

In areas of potential acid sulfate soils it is preferable to maintain groundwater levels in a steady state. Works to be avoided within potential acid sulfate soils include the construction of water storages, or *Sediment Basins*, and the construction of drains which unnecessarily lower the groundwater table during operational or maintenance activities such as de-silting.

In situations where the soil survey has identified high levels of sulfides in the soil, expert advice must be obtained on appropriate site and soil management activities.

Principle 4.7

Disturbances to the existing ground cover should be delayed as long as possible.

Delaying disturbances to existing ground covers (such as grasses, fallen leaves, and mulches) is one of the most effective forms of erosion control. If tree clearing is required well in advance of future earthworks, then tree clearing methods that will minimise potential soil erosion need to be employed, especially in areas of unstable or highly erodible soils. Further discussion on best practice land clearing is provided in principle 6.5.

Principle 4.8

Construction procedures should aim to minimise the extent of unnecessary soil disturbance, including any disturbances outside the designated work area.

Wherever reasonable and practicable, site office facilities and stockpiles need to be located in areas that would have eventually been disturbed as part of the essential works. Reducing the area of unnecessary soil disturbance also reduces the cost of site rehabilitation.

Buffer zones and non-disturbance areas need to be protected from unnecessary disturbance through the use of physical barriers such as marker tape or light fencing, and/or through detailed instruction and supervision of site personnel.

All buffer zones and non-disturbance areas need to be clearly identified within the Erosion and Sediment Control Plans.

Technical Note 2.3 – Buffer zones

In the above context, the term "buffer zone" applies to both formal land buffers—often permanent—established between to areas of potentially conflicting land usage, and the grassy *Buffer Zones* used as temporary sediment control measures.

Permanent buffer zones include the vegetative buffers often used to separate urban development from a waterway, protected bushland, or other sensitive environmental habitat.

Sediment control *Buffer Zones* typically consist of a significant area of vegetation—principally long grass—located down-slope of a soil disturbance.

Principle 5 Control water movement through the site.

The proper management of stormwater runoff during the construction phase is critical to the implementation of effective erosion and sediment control. The importance of stormwater management generally increases with increasing rainfall intensity.

Technically, *"erosion control"* refers to the control of soil erosion caused by both sheet and concentrated flow. Thus, any drainage control measures placed on a work site to appropriately manage stormwater runoff are normally considered part of the overall erosion control process.

Even though *drainage control* measures are discussed separately from *erosion control* and *sediment control* measures throughout this document, the term *"erosion and sediment control"* implies the integrated use of drainage, erosion and sediment control measures. Further discussion on the differences between drainage control, erosion control, and sediment control is provided in Chapter 1 – *Introduction*.

Principle 5.1

The permanent and temporary drainage requirements of a site need to be appropriately considered during development of the Erosion and Sediment Control Plan.

The stormwater drainage requirements of a site need to be appropriately incorporated into all stages of construction. Failure to recognise the requirements of such things as the diversion of up-slope "clean" water, or the efficient delivery of sediment-laden water to sediment traps, can severely limit the overall efficiency of an erosion and sediment control program.

The effective management of stormwater within building and construction sites lies in the appropriate control of runoff velocity, volume and location. This usually requires the establishment of *temporary* drainage control measures, separate to the site's permanent drainage system. The temporary nature of these drainage controls often means that they are designed to a lower drainage standard compared to the permanent drainage system; however, the need for appropriate hydrologic and hydraulic design is just as important.

The primary function of these *drainage control measures* is to:

- minimise the risk of rill and gully erosion;
- minimise the risk of hydraulic damage to the adopted erosion and sediment control measures;
- control the velocity, volume and location of water flow through the site; and
- appropriately manage the movement of "clean" and "dirty" water through the site.

Principle 5.2

Flow velocities need to be limited to the maximum allowable velocity for each individual drainage system.

Drainage channels, whether temporary or permanent, need to be designed and constructed at a gradient that limits the maximum flow velocity to a value not exceeding the maximum allowable flow velocity for the given channel surface conditions, whether lined or unlined. In cases where a lined channel is required (e.g. grass, rock or *Erosion Control Mats*), the newly constructed channel must be appropriately stabilised as soon as practicable.

Excessive flow velocities can cause channel erosion, usually along the invert (bottom) of the drain. Such erosion is most prominent in newly formed or recently seeded drains. Invert erosion is a common concern in the stabilisation of newly formed roadside table drains because the bed slope is usually governed by the gradient of the road.

The allowable flow velocity for grass-lined channels is normally around 1.5 to 2.0m/s, for medium rock (say 100 to 350mm) the allowable velocity is around 1.5 to 3.0m/s, and *Erosion Control Mats* the allowable velocity can vary from 1.3 to 5.0m/s depending on the type of synthetic reinforcing used in the mat. Refer to Tables A23 to A28 in Appendix A – *Construction site hydrology and hydraulics* for further information.

Flow velocities within drainage channels can be reduced by:

- reducing the depth of flow (i.e. increasing the width of the channel); and/or
- reducing the bed slope; and/or
- reducing the peak discharge (i.e. reducing the effective catchment area, or diverting water away from the channel); and/or
- increasing the channel roughness.

Technical Note 2.4 – Manning's equation

The mathematical relationship that links flow velocity (V), channel roughness (Manning's n), effective flow depth (hydraulic radius, R), and bed slope (S) is represented by the Manning Equation:

$$V = (1/n)\, R^{2/3}\, S^{1/2}$$

If the channel width, depth, or gradient cannot be altered, then there are two options for controlling invert erosion, either:

- reduce the flow velocity through the placement of *Check Dams*; or
- increase the effective scour resistance of the drain through the placement of a suitable channel liner, such as rock or *Erosion Control Mats*.

Technical Note 2.5 – Blankets and mats

When used in areas of concentrated flow, fabric channel linings are normally referred to as "mats". When used on banks to control erosion from raindrop impact and sheet flow, these fabrics are normally referred to as "blankets". Both products can also be referred to as Rolled Erosion Control Products (RECPs).

Many of the products sold as *Erosion Control Mats* can also be used as blankets, but not all *Erosion Control Blankets* are suitable for use within drainage channels.

Check Dams are most effective when used in channels with a gradient less than 10% (1 in 10). In steeper channels it is usually more economical to line the channel with turf, rock or *Erosion Control Mats*. Guidance on the selection of channel liners is provided in Chapter 4 – *Design standards and technique selection*.

There are basically three types of *Check Dams*, sandbags, rock, and synthetic open-mesh check dams (triangular silt berms). Sandbags are generally used in shallow drains less than 500mm deep. Rock check dams should only be used in deep drains more than 500mm deep.

Principle 5.3

All drainage channels, temporary or permanent, need to be constructed and maintained with sufficient gradient and surface conditions to maintain their required hydraulic capacity.

The Erosion and Sediment Control Plan and/or its supporting documentation must clearly identify the size and gradient of all drainage channels, whether temporary or permanent. If these drainage channels are constructed at a flatter gradient at any point along their length, then the drain may overtop during storms less than the "design storm", potentially causing severe erosion and/or drainage/flooding problems.

Similarly, if these drainage channels are not adequately maintained, then sediment deposits and embankment damage (usually caused by construction vehicles) can result in hydraulic failure of the drain.

Technical Note 2.6 – Flow Diversion Banks

The above discussion applies equally to *Flow Diversion Banks*. Damage to *Flow Diversion Banks* (e.g. wheel-track damage) or excessive sediment deposits immediately up-slope of the banks can limit their hydraulic capacity.

Flow Diversion Banks need to be constructed at a slight gradient to the land contour in order to maintain flow in the desired direction.

Principle 5.4

Wherever reasonable and practicable, up-slope stormwater runoff, whether "dirty" or "clean", needs to be diverted around soil disturbances and unstable slopes in a manner that minimises soil erosion, and the saturation of soils within active work areas.

One of the best ways of achieving cost-effective erosion and sediment control is to divert "clean" stormwater runoff around sediment traps, exposed soil surfaces, active work areas, excavations, and trenches. *Flow Diversion Banks, Diversion Channels, Catch Drains, Chutes* and *Slope Drains* can be used to direct water through a work site or around a soil disturbance.

Wherever reasonable and practicable, "dirty" and "clean" water should flow along separate flow paths through the work site in order to reduce the contamination of "clean" water.

Diverting up-slope "clean" water around active work areas can:

- reduce the generation of mud on a work site, thus reducing potential safety risks for site personnel;
- reduce site clean-up costs and down-time following storms;
- reduce damage to the walls of trenches and excavations;
- reduce damage to the soil structure resulting from the soil being worked when it is too wet; and
- reduce the volume of "dirty" water pumped from trenches and other excavations.

Some flow diversion systems may form part of the site's permanent drainage system, such as catch drains placed up-slope of road cuttings, while others are temporary devices used to control water movement, minimise site wetness, and reduce soil erosion.

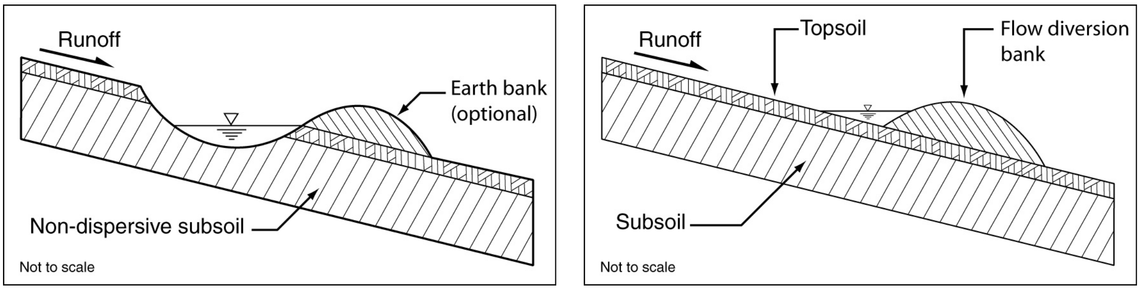
Technical Note 2.7 – Permanent catch drains

Permanent catch drains need to be designed to different drainage standards to that of temporary construction site *Catch Drains.*

Some short-term flow diversion systems may not appear on the Erosion and Sediment Control Plan (ESCP), but are simply used as a response to an impending storm, or used as an end-of-day drainage control measure to protect unstable soil from possible overnight rain. The appropriate application of such short-term drainage measures must be identified within technical notes attached to the ESCP.

In any case, all reasonable efforts must be taken to appropriately identify all necessary drainage control systems within the ESCP and/or Construction Drainage Plans, either as items directly identified on the plans, or as technical notes.

The temporary diversion of stormwater can be achieved by either cutting a drain into the soil (e.g. *Catch Drain*), or forming a *Flow Diversion Bank* on top of the soil. Cutting a drain into the soil usually results in the exposure of the subsoil to concentrated flows (Figure 2.1(a)). This should only be done if the subsoils are non-dispersive. If the subsoils are dispersive, or otherwise highly erodible, then temporary flow diversion is usually best achieved through the use of *Flow Diversion Banks* (Figure 2.1(b)) formed from non-dispersive soil, straw bales, or a variety of geosynthetic products.



(a) Catch Drain cut into the soil **(b) Flow Diversion Bank**

Figure 2.1 – Flow diversion options

A practice becoming increasingly common is to use the stripped topsoil to form *Flow Diversion Banks* up-slope of the soil disturbance, instead of placing the topsoil in stockpiles.

Principle 5.5

To the maximum degree reasonable and practicable, "clean" water needs to be diverted around sediment traps in a manner that maximises the sediment trapping efficiency of the sediment trap.

The efficiency of most sediment traps can be improved by reducing the peak discharge and/or total volume of flow passing through the device. The volume of water requiring treatment by a sediment trap can be reduced by:

- minimising the area of disturbance at any given instant; and/or
- diverting "clean" water around the sediment trap; and/or
- promoting the infiltration of water by minimising soil compaction; and/or
- promptly installing the permanent underground drainage system (if any) so that "clean" roof water and runoff from other clean surfaces can be discharged safely off the site.

The size of many sediment traps, including *Sediment Basins*, is directly related to the effective catchment area up-slope of the sediment trap. Therefore, reducing this catchment area by diverting "clean" water around the sediment trap will reduce the cost of constructing and operating the device.

Principle 5.6

On disturbances exceeding 1500m^2, Construction Drainage Plans need to be prepared for each stage of earth works.

During preparation of Erosion and Sediment Control Plans it is very important to consider both the location of overland flow paths and the travel path of bypass flows that may result from the blockage of sediment traps. Bypass flows can cause significant property flooding and soil erosion if allowed to discharge down unstable or unprotected slopes.

Due to the potential property and environmental damage caused by flows bypassing kerb inlet sediment traps, these traps must be used with extreme caution, especially during the wet season, and only when there are no other suitable erosion and sediment control options. Consideration must always be given to the potential adverse effects (e.g. property flooding) caused by the hydraulic failure of any proposed drainage, erosion, or sediment control device.

Technical Note 2.8 – On-grade vs sag kerb inlets

"On-grade" kerb inlets are roadside stormwater inlets located on a road gradient as opposed to an inlet located at a "sag" point (i.e. the bottom of a hill). The placement of sediment traps across or around on-grade inlets will cause water to bypass the inlet and continue flowing down the road. Similarly, if sediment traps are allowed to block the entrance of sag inlets, then flow bypassing can occur through adjacent properties.

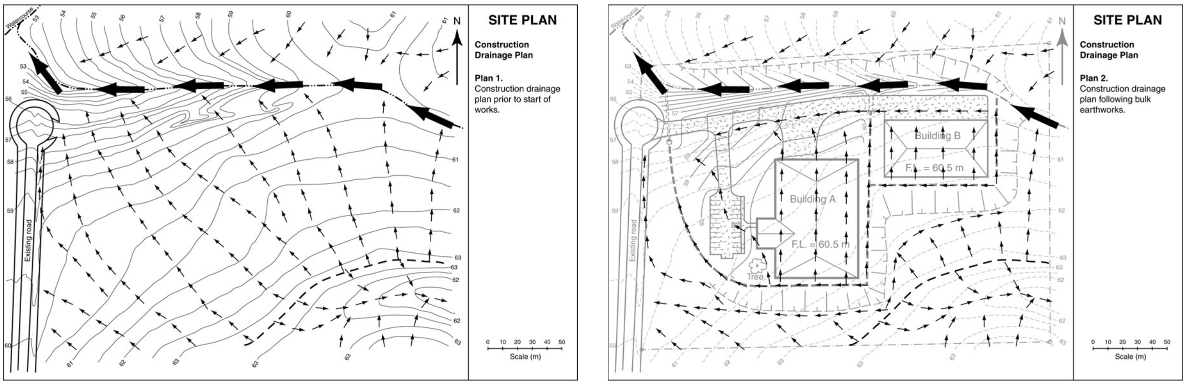
If stormwater is not allowed to enter kerb inlets at an appropriate rate, then stormwater will accumulate within the road reserve eventually overtopping the kerb, potentially flooding residential properties and/or causing soil erosion.

The successful incorporation of temporary drainage systems into a construction site requires careful consideration of the drainage requirements during **all** stages of construction. Problems can occur if the layout of temporary drainage controls is only based on the final site layout or final contour plan. For example, the flow of water to a *Sediment Basin* may be interrupted by the existence of a temporary construction road passing between the soil disturbance and the basin. If significant earthworks or land reshaping is to occur during construction, then a separate Construction Drainage Plan needs to be prepared for **each** stage of earthworks.

Site drainage patterns generally have two major components: overland sheet flow and concentrated channel flow. Both components must be addressed if effective drainage and erosion control is to be achieved.

Both existing and proposed site drainage patterns must be identified, especially the points of flow entry into, and exit from, a work site. If existing and final flow paths are clearly defined within Construction Drainage Plans, then they are more likely to be successfully incorporated into the planning and design phases of the development.

Construction Drainage Plans (Figure 2.2) can be separate from the Erosion and Sediment Control Plan (ESCP) or incorporated into the ESCP. In any case, the intent is to clearly define drainage flow paths to ensure that the proposed ESC measures are appropriate for each stage of earthworks.



(a) Stage 1 **(b) Stage 2**

Figure 2.2 – Example Construction Drainage Plans

Construction Drainage Plans need to show:

- flow entry and exit points;
- areas of sheet flow and lines of concentrated flow (including all drainage channels);
- sub-catchment boundaries;
- all permanent and temporary roads.

Principle 5.7

The construction schedule and ESC installation sequence should allow for the installation of the temporary drainage system, and preferably the permanent stormwater drainage system, as soon a practicable.

The early construction of the temporary drainage system, and preferably also the permanent stormwater management system, should be considered a primary objective when planning a development layout and the construction program.

Drainage controls should be functional and stable before earthworks commence. This will reduce damage to completed down-slope works, and will allow up-slope sediment-laden runoff to be directed to appropriate sediment traps.

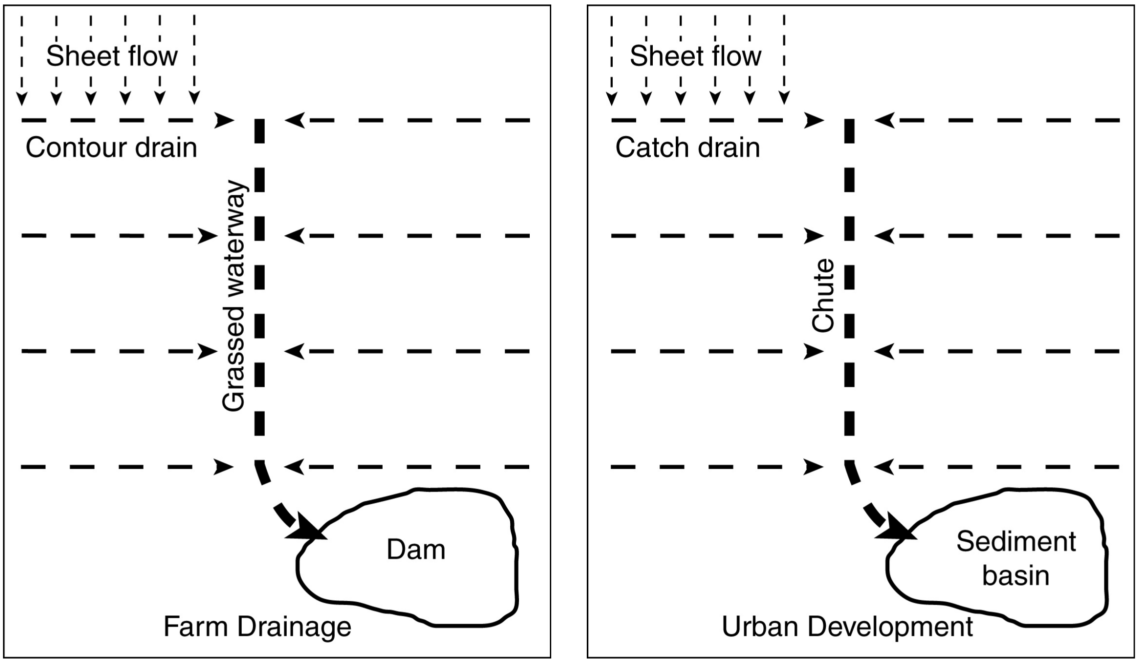
Principle 5.8

Long slopes of disturbed or otherwise unstable soil should be divided into small, manageable drainage areas to prevent, or at least minimise, rill erosion.

On long continuous slopes, *Catch Drains* and *Flow Diversion Banks* can be used to break slope lengths up into manageable drainage areas, thus reducing the risk of the rill erosion caused by the concentration of flow. On steep slopes, benching can be used to collect runoff and move it laterally across the slope to a stable outlet.

Information on the recommended maximum spacing of drains and benches is provided in Chapter 4 – *Design standards and technique selection*. It is important to note that these are recommended **maximum** spacings. The actual spacing of the drainage system may need to be reduced in areas of high rainfall intensity, or on sites containing highly erodible soils.

In general, drainage control within large construction sites follows the same principles of best practice farm drainage (Figure 2.3). Sheet flow is allowed to pass down a slope until just before it gains sufficient strength to cause rill erosion. This sheet flow is then collected by a drain or bank and moved across the slope eventually discharging into a stable *Chute*, drain or overland flow path. The concentrated flow is then directed down the slope to a stable outlet, treatment pond, or water storage structure.



(a) Farm drainage **(b) Development drainage**

Figure 2.3 – Typical drainage terminology and usage within the agricultural and construction industries

The spacing of drains down the slope primarily depends on the strength of the soil (i.e. soil properties and vegetation cover). If significant rill erosion is possible during the revegetation of recently formed slopes, then it is normal practice to adopt a drain spacing appropriate for a non-vegetated slope. Alternatively, turf strips can be placed along the contour at an appropriate spacing to help maintain "sheet" flow conditions down the slope. In such cases the drain spacing should not exceed that recommended for an equivalent grassed slope.

Principle 5.9

In regions containing dispersive soils, construction details of drainage systems and bank stabilisation works need to demonstrate how these soils are to be stabilised and/or buried under a layer of non-dispersive soil.

Drains cut into dispersive soils are highly susceptible to deep invert erosion. These soils must be appropriately treated or buried, usually under a minimum 100mm layer of non-dispersive soil, before placing any revegetation or channel liner. Wherever possible, avoid cutting *Catch Drains* into dispersive soils. Instead, *Flow Diversion Banks* should be used to temporarily divert stormwater across the site.

Technical Note 2.9 – Protection of dispersive soils

In areas of sheet flow or minor concentrated flow, it is usually sufficient to bury dispersive soils under a minimum 100mm layer of non-dispersive soils. However, in major drainage channels and watercourses it may be necessary to increase the minimum depth to 200mm or even 300mm depending on the likelihood of ongoing erosion problems.

At the base of grassed road batters formed in dispersive soils it may be necessary to bury the dispersive soil under a depth of non-dispersive soil that exceeds 300mm in order to deal with the anticipated soil disturbance caused by grass cutting vehicles (refer to Section J6.2 of Appendix J – *Road and rail construction*).

Principle 5.10

Appropriate outlet scour protection needs to be placed on all stormwater outlets, Chutes, spillways and Slope Drains to dissipate flow energy and minimise the risk of soil erosion.

All drainage structures need to discharge flows at non-erosive velocities onto stable land. A suitable, stable drainage outlet requires:

(i) a legal point of discharge (i.e. water must not be released in an unauthorised manner);

(ii) a stable surface that can withstand the erosive forces of the water; and

(iii) a discharge condition that releases the water in a non-erosive manner and flow condition (i.e. "sheet" or "concentrated" flow) appropriate for the receiving waters, and in a manner that does not cause a nuisance to the environment or public.

A *Level Spreader* (Figure 2.4) may be used to convert minor concentrated flows from a *Catch Drain* or *Flow Diversion Bank* into "sheet" flow so it can be released onto an even grassed surface, or into undisturbed bushland.

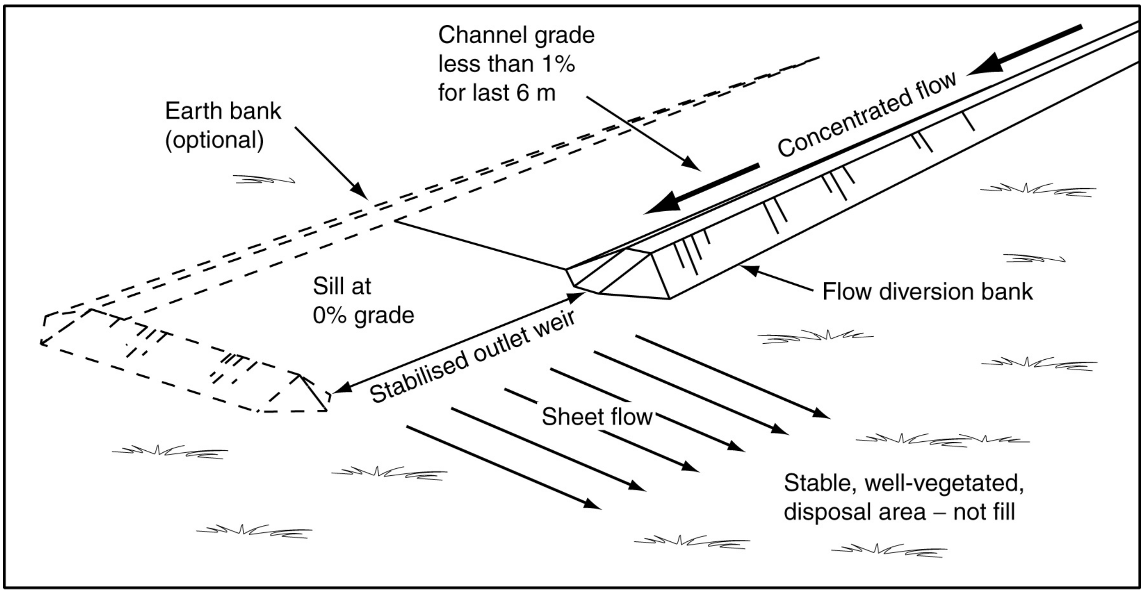


Figure 2.4 – Level spreader

Outlet protection is typically required on pipe and channel outlets to reduce the discharge velocity and minimise downstream bed and bank erosion. *Outlet Structures*, usually consisting of rock pads, are normally required on the outlets of all *Chutes,* flumes, spillways and *Slope Drains*.

Technical Note 2.10 – Chutes and flumes

In engineering fields, "chutes" are narrow confined channels, usually carrying water from one elevation to another (e.g. drop chute), but possibly just between two water bodies. "Flumes" usually incorporate more hydraulic components than a simple chute, such as flow measuring flumes (e.g. Parshall Flume), or a drop chute incorporating an energy dissipater. In general, the terms are interchangeable, but some documents make a clear distinction between the terms.

When rock is used for outlet protection, a minimum rock size of 200mm is normally recommended because rocks smaller than 200mm can be readily dislodged by flows and move downstream where they can damage aquatic vegetation or cause bed erosion. In any case, disturbances to natural watercourses and riparian zones should be minimised wherever possible.

Principle 5.11

Building and construction sites need to employ appropriate short-term drainage control measures to deal with impending storms.

Exposed high and extreme erosion risk areas should be protected from possible rainfall by installing temporary *Flow Diversion Banks* or *Catch Drains* at the end of each day's work. End-of-day temporary drainage controls include reinstating any drainage control measures moved or damaged during the day's work activities.

Straw bales can be used to form a temporary (i.e. overnight) *Flow Diversion Bank* to divert stormwater around recently constructed works or excavations. After the storm, the bales can be broken open and spread over the soil as mulch.

Principle 5.12

Clean, sealed surfaces, such as roofs, should be connected to the permanent underground drainage system (if available) as soon as they are constructed.

Non-contaminated sealed surfaces, such as roofs, should be connected to the "clean" water drainage system as soon as practical after their construction. Roof drainage can be connected with permanent or temporary downpipes depending on the construction sequence and the final drainage arrangement. In either case, the objective is to divert "clean" water away from exposed soils and to prevent this water from being contaminated with sediment.

Principle 5.13

Adequate drainage controls need to be applied to all permanent and temporary, unsealed roads and tracks to minimise environmental harm caused by runoff from such surfaces.

Drainage controls will be required on all unsealed roads subject to rainfall, whether the road is permanent or just a temporary access road. Guidelines on the treatment of unsealed roads and tracks are provided in Appendix J – *Road and rail construction* and Appendix K – *Access tracks and trails*.

When constructing permanent roads and driveways up steep slopes, temporary *Flow Diversion Banks* (cross drains) should be used to direct runoff to one side of the roadway. This allows vehicular access along the roadway without interfering with road runoff. Alternatively, for short roads, consideration should be given to the placement of a *Flow Diversion Bank* across the top of the road such that the diverted water can be directed down a temporary *Chute* or *Slope Drain* constructed to the side of the road.

Principle 5.14

Disturbances to natural watercourses and riparian zones need to be minimised wherever possible, and all temporary watercourse crossings need to employ appropriate drainage, erosion, and sediment controls to minimise sediment inflow into the stream.

Temporary watercourse crossings include temporary culvert, ford, causeway and bridges. These temporary crossings must be constructed and maintained in a manner that minimises harm to the watercourse and its associated habitat values. Where appropriate, consideration will need to be given to the requirements of fish passage along the stream during the construction phase. All temporary crossings should be removed as soon as practicable once they are no longer needed.

Technical Note 2.11 – Fish passage

Maintaining fish passage along waterways is most important during periods of fish migration (that is fish passage for reasons of breeding or life cycle requirements). Specialist advice can be obtained from the relevant State Fisheries office.

Temporary culvert crossings typically require a cross sectional flow area approximately equal to the channel's cross-sectional area below the crest of the crossing. These culvert crossings are normally formed from recycled steel or concrete pipes.

Fords and causeways should only be used in shallow, intermittent streams that are expected to have negligible base flow during the construction period. Bridge crossings have the potential to cause the **least** disturbance to a stream and its habitat values. Bridges are also less likely to interfere with fish passage.

Temporary ford crossings of wide, dry, sandy-bed channels can be stabilised with the use of *Cellular Confinement Systems*.

The approach roads to all watercourse crossings must be appropriately stabilised and have appropriate flow diversions (i.e. cross banks) to prevent untreated stormwater runoff from entering the stream. Stormwater runoff from unsealed road surfaces should pass through an appropriate sediment trap and then, if conditions allow, filter through adjacent grassland or bushland before entering the stream.

Principle 5.15

All drainage systems, whether temporary or permanent, need to be designed to the appropriate drainage standard.

Temporary drainage control measures are designed to a variety of hydraulic standards depending on the expected life of the structure, the risk of environmental harm, and the potential for risk to life or property. The recommended design standards for temporary drainage works are presented in Chapter 4 – *Design standards and technique selection*.

Principle 6 Minimise soil erosion.

Soil erosion is the process through which the effects of wind, water, or physical action displace soil particles, causing them to be transported. The main factors affecting surface erosion are rainfall erosivity, soil erodibility, slope length, slope steepness, soil cover, and the surface flow conditions (i.e. flow type, velocity, duration, and frequency).

In this context, the term "soil erosion" includes the displacement of soil, earth, gravel, sand, silt, clay, mud, sediment, cement, and contaminated liquid wash-off resulting from such activities as equipment cleaning and material-cutting activities (e.g. concrete cutting).

Principle 6.1

Wherever reasonable and practicable, priority needs to be given to preventing, or at least minimising soil erosion (i.e. drainage and erosion control measures), rather than allowing the erosion to occur and trying to trap the resulting sediment. Where this is not practicable, then all reasonable and practicable measures need to be taken to minimise soil erosion even if the adopted sediment control measures comply with the required treatment standard.

Controlling the initial erosion of soils is often the only feasible strategy for minimising environmental impacts resulting from disturbances of soils with a high clay or fine silt content. Preventing soil erosion is also generally more cost-effective than concentrating on trapping the sediment somewhere down the slope.

The presence of on-site sediment controls that comply with the recommended sediment control standard does **not** negate the requirement of taking all reasonable and practicable measures to actively minimise soil erosion throughout all stages of construction.

It should be noted that complying with the sediment control standard does **not** guarantee that environmental harm will be avoided, or that sediment-laden water will not be released from the site during severe storms. For example, a *Sediment Basin* operating in accordance with the performance standard prescribed within this document will likely release sediment-laden water during storms significantly less than the 1 in 1 year ARI. Therefore, taking all reasonable and practicable measures to minimise soil erosion is essential if environmental harm is to be minimised.

Sediment Basins actually provide the greatest protection to minor waterways such as creeks. The **only** way of providing adequate protection to major waterways, such as rivers, estuaries and bays, is to minimise the initial source of soil erosion, particularly raindrop impact erosion, by applying effective erosion control measures across a work site. Thus, the application of effective erosion control measures **must** always stand as the highest priority.

It should also be noted that drainage control measures cannot control soil erosion resulting from raindrop impact erosion, which is one of the primary causes of high turbidity levels within stormwater runoff. Thus, the application of effective drainage control measures also does **not** negate the need for effective erosion control measures.

Therefore, it is important to ensure that effective drainage, erosion and sediment control measures are appropriately integrated into all work sites during all phases of building and construction.

Principle 6.2

The standard of erosion control needs to be appropriate for the given soil properties, expected weather conditions, and susceptibility of the receiving waters to environmental harm resulting from turbid runoff.

In general terms, the runoff of coarse sediment primarily causes human-related problems such as traffic safety issues, drainage and flooding problems. On the other hand, the runoff of finer sediment particles generally causes most of the ecological harm, such as damage to aquatic ecosystems and reduced bio-diversity. The displacement and subsequent runoff of the finer sediments, including fine silt and clay-sized particles, is closely linked to turbidity levels within stormwater runoff.

Technical Note 2.12 – Protection of ephemeral stream

In most cases, a greater ecological benefit will be obtained from the control of runoff turbidity than from the trapping of coarse sediments. When working upstream of minor clear-water streams, the smaller the rainfall depth, the greater the need to minimise turbidity levels within stormwater released from building and construction sites. This is because the turbidity released into minor ephemeral streams during such light rainfall is unlikely to be flushed from the stream's permanent water bodies (pools) by spring flows entering the stream after the storm.

This does **not** mean that erosion control is not required during moderate to heavy rainfall, in fact the need for effective erosion control measures increases with increasing rainfall intensity. The above statement simply indicates that during light rainfall it is important to prevent, or at least minimise, turbidity within waters discharged from a work site. Therefore, it is beneficial to capture and treat all runoff from minor storms in *Sediment Basins*, and/or to maximise the infiltration of stormwater runoff such that there is little or no discharge from work sites during light rainfall.

Effective erosion control is required even on flat or low gradient land. The fact that runoff flow velocities are low does not mean that erosion is low. One of the major contributors to suspended sediment (i.e. turbidity) within stormwater runoff is raindrop impact erosion, which is effectively independent of land slope.

It can be extremely difficult and expensive to remove clay-sized particles from stormwater. The best way to control turbidity levels within stormwater runoff is to control raindrop impact erosion, and the best way to control raindrop impact erosion is to place something between the rain and the soil.

For many clayey soils, the control of erosion at its source is the only feasible means of minimising downstream environmental impacts. Of course there are some highly organic clayey soils that are so erosion resistant that they do not cause highly turbid runoff, but such soils are rare in most regions of the Australian landscape.

Technical Note 2.13 – Soil erodibility

Of the four basic mineral components that make up soil (clay, silt, sand and gravel), silty soils (i.e. loam, silt loam, sandy clay loam, clay loam, and silty clay loam) are generally the most erodible and therefore generally attract the highest RUSLE K-factors (Appendix E).

Clayey soils, however, can become highly erodible with increasing sodium content (sodic or dispersive soils) and decreasing organic content (i.e. subsoils are usually more erodible than organic-rich topsoils).

Dispersive (sodic) soils are highly unstable when immersed in water. These soils are highly susceptible to tunnel erosion, and are often evidenced by deep, frequent rilling (fluting erosion) where the depth of the rills is usually greater than the top width of the rill.

Principle 6.3
Appropriate erosion control measures need to be incorporated into all stages of a soil disturbance.

All reasonable and practicable measures must be taken to incorporate erosion control measures into each stage of site disturbance and rehabilitation. Erosion control should **not** be restricted to just the post-construction activities.

"Erosion control" is **not** another term for "landscaping". If the intention is to delay site revegetation until the end of the construction phase (an action not considered to represent best practice), then appropriate alternative erosion control measures must be incorporated into the construction phase. If such measures include the temporary mulching of earth batters, then this should be treated as a separate activity to any additional mulching required during later site revegetation.

It is acknowledged that on an active construction site it can be impractical to place a protective cover over all areas of exposed soil. However, all reasonable and practicable measures must still be taken to minimise the duration that all soils are exposed to water flow, wind and rainfall, especially high intensity rainfall. This can be achieved by:

- appropriately staging earthworks;
- finalising earthworks as soon as reasonable and practicable;
- stabilising finished surfaces and/or covering such surfaces as soon as reasonable and practicable;
- preventing earthwork machinery and other traffic from passing over finished soil surfaces;
- utilising temporary erosion control measures to minimises erosion resulting from imminent storms; and
- employing appropriate temporary soil stabilisation measures in the event of construction delays.

Principle 6.4
The timing and degree of erosion control specified in the Erosion and Sediment Control Plan(s) needs to be appropriate for the given soil properties, expected weather conditions, and susceptibility of the receiving waters to environmental harm resulting from turbid runoff.

The degree of erosion control required on a site is primarily linked to the erosivity of the rainfall and the resulting amount of raindrop impact erosion. This is reflected in the erosion control standard presented in Section 4.4 of Chapter 4, which is linked to either the monthly rainfall erosivity (preferred), or the average monthly rainfall depth.

If the timing of the proposed construction activity is not known during development of the Erosion and Sediment Control Plan (ESCP), and if rainfall erosivity varies significantly throughout the year, then the erosion control specifications placed on the ESCP must specify appropriate erosion control measures for each level of rainfall erosivity. For example, light mulching may be appropriate during periods of light rainfall, hydromulching during periods of light to moderate rainfall, and *Erosion Control Blankets* or *Bonded Fibre Matrix* during those periods of the year when moderate to heavy rainfall is either occurring or expected to occur.

Erosion control specifications placed on ESCPs must **not** assume that soil disturbances will only occur during certain times of the year, unless the management of the construction period can be rigorously controlled through the development approval process and current legislation.

Principle 6.5
If tree clearing is required well in advance of future earthworks, then tree clearing methods that will minimise potential soil erosion need to be employed, especially in areas of unstable or highly erodible soil.

Minimising the extent and duration of disturbance to existing ground covers is one of the most effective forms of erosion control. Tree preservation may have high ecological value, but the preservation of ground covers (e.g. grasses, leaves and mulches) generally provides a far greater erosion control benefit. Trees provide their greatest erosion control benefit on steep slopes where their root system can help to anchor the slope, especially when the soils are saturated following prolonged rainfall.

Best practice land clearing includes the following options:

- Appropriate staging of works to delay all tree clearing and grubbing as long a possible (i.e. land clearing in accordance with best practice recommendations presented in Chapter 4 – *Design standards and technique selection*).
- Bulk tree clearing with minimal disturbance of existing ground covers (i.e. no removal of ground cover mulch and vegetation, and no grubbing), followed by appropriately staging of works to delay final clearing and grubbing as long a possible (i.e. final clearing and grubbing in accordance with best practice recommendations presented in Chapter 4).
- Bulk tree clearing and grubbing of the site immediately followed by temporary stabilisation of all disturbed areas (e.g. temporary grassing or mulching) prior to commencement of staged construction works (i.e. disturbance of the temporary stabilisation in accordance with best practice recommendations presented in Chapter 4).

Principle 6.6
Erosion and Sediment Control Plans need to specify the required application rates for mulching and revegetation measures.

The cost of many erosion control measures, such as mulching, primarily depends on the specified application rate. Unless application rates are specified within the tender documentation, then the lowest tender price often means the lightest application rate, which usually results in the lowest probability of successful erosion control and revegetation.

To avoid poor performance, application rates (i.e. the minimum application rates acceptable to the contractor/project manager and regulatory authority) need to be specified within Erosion and Sediment Control Plans and/or the supporting documentation.

The term "mulching" is often mistakenly understood to refer only to the relatively thick mulching used on garden beds. Mulching can be either "light" or "heavy" depending on the desired outcomes. There are numerous types of mulch, all of which perform different tasks. Table 2.1 outlines the general attributes of various types of mulches.

Table 2.1 – Attributes of various mulches

Type	Attribute	Typical use
Straw or sugarcane	Light mulching	Protection of newly seeded areas.
Hydromulch and Bonded Fibre Matrix	Light mulching	Grass and plant establishment.
Dead or dormant grass cover	Light mulching	In certain situations, a rapid and complete cover of "annual grass" cover can act as an effective mulch layer on embankments, batters and table drains. The grass may be allowed to die off after initial establishment, thus avoiding the need for ongoing watering during times of drought.
Brush, bark, and woodchip mulch	Either light or heavy mulching	Used on garden beds and for temporary protection of exposed soils prior to the completion of earthworks or other construction activities.
Compost blankets	Heavy mulching	Used during the revegetation of steep slopes either incorporating grass and/or other plant seed. Particularly useful when the slope is too steep for the placement of topsoil, or sufficient topsoil exists.
Rock mulching and gravelling	Heavy mulching	Used in arid areas, high traffic areas (such as tracks and temporary access roads), steep batters or garden beds subject to concentrated overland flows, or heavily shaded areas (e.g. under bridges and suspended slabs).

Technical Note 2.14 – Grass species

Grass species consist of fast growing "annual grasses" that complete their life cycle and die within one year (often used as a temporary cover crop); "perennial grasses" with a life cycle longer than two years; "mat-forming grasses" that are individual plants which interconnect to form an erosion-resistant ground cover (i.e. normal lawn-forming grasses); and "tussock grasses" that grow as an individual tuft or clump of grass (visually similar to sedge-like plants).

Grass-seeded areas should be lightly mulched immediately after seeding to protect the soil surface from raindrop impact erosion and to aid seed germination and plant growth. Mulching holds the seed and fertiliser in place, protects the soil from erosion, conserves essential surface moisture (to assist in seed germination and growth) and reduces overall water usage.

Technical Note 2.15 – Hydroseeding vs hydromulching

Hydroseeding involves the application (hydraulic spray) of a water/seed/fertiliser slurry that is homogeneously mixed in a purpose-built truck-mounted tank. This treatment has no erosion control capabilities and is only suitable for spreading seed prior to an application of a straw mulch or hydromulch.

Hydromulching involves the application of a water/organic-mulch/seed/fertiliser slurry that is also mixed in a purpose-built truck/trailer-mounted tank.

The thicker hydromulch slurry has several advantages over hydroseeding, including:

- erosion control
- greater retention of the seed or sprigs during germination
- better retention of soil moisture
- increased surface roughness, which reduces stormwater runoff
- better "microclimate" for greater seed germination and growth

The mulches used in hydromulching may consist of wood, plant fibres, or recycled paper. The fibre texture is important in achieving an erosion-resistant product that can be easily pumped with a hydromulcher. The mulch fibre is sometimes dyed green for aesthetic reasons (more common in hydroseeding), but the colour is also important because it assists the monitoring of the thickness and extent of the application.

Northern Territory, Western Australia, South Australia, Tasmania and Victoria predominantly use cellulose (e.g. recycled paper) mulch. Wood fibre has been the principal mulch used in New South Wales. Most of these wood fibre mulches are imported, but more recently sugarcane mulch has been introduced. In Queensland, sugarcane mulch is usually preferred because it can withstand the heavier tropical rainfall. Sugarcane mulch is usually blended with cellulose mulch in varying percentages to improve the water absorbing characteristics.

Tackifiers are an important addition to the hydromulch process, especially on slopes greater than 15%. The most common tackifiers may be categorised as follows:

- Natural starch and gum based products: These products are derived from corn, Plantago, and the Indian Guar plant. These are mostly available as a rare powder product, which forms a viscous slippery slurry that assists in pumping and also helps bind the slurry to the soil surface.
- Chemically produced polymers (Polyacrylamides or PAM): These are available in powder, granule, and liquid form. They have more durable binding properties, which is desirable in high rainfall areas. A blending of PAM and natural tackifiers is sometimes useful.

Bitumen-based tackifiers are generally only used to secure straw mulches from displacement by minor sheet flow and mild winds. Anionic (negative-charged) bitumen emulsions are alkaline and are widely used within the erosion control industry. Straw mulches can also be anchored (crimped) by running a tracked vehicle up and down the treated slope.

Principle 6.7

Erosion control measures need to be appropriate for the slope of the land and the expected wind and surface flow conditions.

The choice of erosion control measure depends on the slope of the land, and the shear stress caused by wind and stormwater runoff.

Soil disturbances on relatively flat land may not result in significant soil loss in terms of tonnes per hectare simply because the sediment-laden runoff is unlikely to contain significant quantities of coarse sediment. This, however, does **not** mean that soil erosion is not a problem. If left uncontrolled, raindrop impact erosion can still result in the displacement of significant quantities of fine sediments such as clay-sized particles. Such erosion can result in high turbidity levels within stormwater runoff, especially if the exposed soils are dispersive.

On exposed **flat areas** (say, less than 1 in 10 grade), erosion protection can be achieved with the use of *Soil Binders, Erosion Control Blankets, Light or Heavy Mulching, Gravelling* or vegetation. While vegetation is one of the best long-term options, it can also provide instantaneous protection if turf is used.

On **medium grade slopes** (say, 1 in 10 to 1 in 4) protection from both raindrop impact and possibly concentrated rill-forming runoff will be required. Typical erosion control measures on medium slopes include *Erosion Control Blankets*, appropriately anchored *Light or Heavy Mulching*, *Rock Mulching*, *Compost Blankets* and turf. On such slopes, loose organic mulch may not be appropriate if moderate to heavy rainfall is expected, or if stormwater runoff is allowed to concentrate down the slope.

On **steep slopes** (say, greater than 1 in 4) erosion control measures usually include *Erosion Control Blankets*, *Compost Blankets*, rock armouring and turf.

Technical Note 2.16 – Blankets, mats, and mesh

The term "blanket" generally refers to erosion control fabric used on soils subjected to sheet flow such as a road batter. These products may also be referred to as *Rolled Erosion Control Products (RECPs).*

The term "mat" generally refers to erosion control fabric used on soils subjected to concentrated flow such as in a *Catch Drain* or table drain.

The term "mesh" refers to erosion control fabric with an open weave (like a net) usually formed from jute, coir, or synthetic twine.

The term "hydraulically-applied" blanket refers to the liquid spray-on products (not soil binders) that dry to form a solid, continuous blanket with a thickness approximating that of an Erosion Control Blanket.

In areas of strong winds or significant overland flow, *Erosion Control Blankets* can be used as an alternative to loose mulching. "Thick" and "thin" blankets are available. Thin blankets perform a task similar to *Light Mulching*, while thick blankets perform a task similar to *Heavy Mulching*.

Erosion Control Blankets generally fall into one of four following categories:

- 100% biodegradable blankets;
- semi-permanent, non UV-stabilised composite blankets;
- permanent reinforced blankets (typically *Turf Reinforcement Mats*);
- hydraulically applied blankets (e.g. *Bonded Fibre Matrix, Compost Blankets*).

In most applications of *Erosion Control Blankets*, vegetation is meant to grow either up-through, or down-through the blanket. In such cases it is important for the blanket to be placed over a well-prepared soil surface with the fabric in good contact with the soil (i.e. no air pockets that could limit initial plant growth). If the soil surface cannot be suitably prepared (i.e. all rills and irregularities removed) then consideration should be given to the application of a "hydraulically applied blanket".

Hydraulically applied blankets include *Bonded Fibre Matrix* (BFM) and *Compost Blankets*. These blankets have the benefit of requiring less surface preparation (i.e. removal of surface irregularities) prior to their application.

Unlike most hydromulches, the bonding of the BFM fibres includes the use of non-wettable glues. This practice enables the product to be used during the wetter months and in the revegetation of minor drainage channels. *Compost Blankets* are generally a suitable alternative to BFM products on steep cut and fill batters where topsoils are limited or non-existent.

Principle 6.8

Wherever reasonable and practicable, the use of synthetic reinforced Erosion Control Mats and Erosion Control Blankets needs to be avoided within bushland and other areas where they could endanger wildlife such as ground-dwelling animals.

Semi-permanent blankets and mats usually consist of a biodegradable fabric reinforced with a non UV-stabilised synthetic reinforcing mesh. The mesh provides temporary anchorage and reinforcing during the vegetation establishment period. These blankets have a limited working life and therefore, if the revegetation is not successful, the blankets will need to be replaced.

Extreme caution should be taken when using synthetic reinforced blankets because birds and small ground-dwelling animals can become entangled in the synthetic mesh. Generally these blankets should **not** be used in close proximity to wildlife habitats, waterways, or bushland.

Principle 6.9

Wherever reasonable and practicable, measures need to be taken to apply appropriate erosion control practices around the site office area and on temporary access roads to minimise raindrop impact erosion and the generation of mud.

Appropriate consideration should be given to the gravelling of long-term car parks, the site office compound, and other common traffic areas to minimise the exposure of any clayey soils to rainfall, and to reduce the generation of mud during wet weather.

Where appropriate, roof water from the site offices should be directed away from the office area and any common walking/access areas to minimise the generation of mud.

Principle 6.10

Finished soil surfaces need to be left in a suitably roughened state and quality to encourage revegetation where appropriate.

On recently vegetated or exposed earth surfaces, erosion protection can be increased by roughening the soil surface to increase water infiltration and delay the formation of rutting. *Surface Roughening* can be applied by walking a tracked vehicle up and down the slope, but in some cases special equipment is required.

The benefits of increased slope roughness include:

- increased detention of water on the slope;
- increased water infiltration into the soil;
- reduced runoff volume and flow velocity generated from slopes.

Surface Roughening can be used on subsoils and topsoils, either before and/or after seeding.

A roughened soil surface is, however, not always desirable. In some cases it may be undesirable to promote the infiltration of water into the soil, such as prior to the soil (earth) being used as embankment fill.

Principle 6.11

Where appropriate, Erosion and Sediment Control Plans need to incorporate technical notes on suitable dust control measures.

Site generated dust problems are usually controlled with the use of water trucks; however, their use may be restricted during periods of drought. Dust may also be controlled with temporary vegetation, *Mulching, Erosion Control Blankets,* or *Soil Binders.*

Some surface roughening techniques are also known to delay the initiation of wind erosion.

The U.S. Soil Conservation Service (1983) presented the following potential outcomes:

- Covering the soil surface with a 30% cover of non-erodible material will reduce soil loss by approximately 80%.
- Roughening the soil by forming 150mm high ridges perpendicular to the prevailing winds will reduce soil loss by approximately 80%.
- A protected zone of approximately 2.4 to 3.0 metres width is achieved for each 300mm in vertical height of a wind barrier.

Other dust control measures include:

- adopting speed limitations for site vehicles;
- stabilisation of stockpiles (*Erosion Control Blankets* or vegetation cover);
- watering unsealed roads and open soil areas;
- minimising total soil exposure at any given time;
- application of *Soil Binders* (chemical surface stabilisers).

Wherever water is used to suppress dust, it is important to ensure that its application does not cause drainage or erosion problems.

Principle 7 Promptly stabilise disturbed areas.

Principle 7.1

The construction schedule or ESC installation sequence needs to ensure that soil stabilisation procedures, including site preparation and revegetation, are commenced as soon as practicable after each stage of earthworks is completed.

One of the most effective forms of long-term erosion control is the retention or prompt re-establishment of a healthy and continuous vegetative cover. Vegetation can provide effective surface roughness and protection against raindrop impact erosion. It binds the underlying soil to improve its structural strength, improves the soil's infiltration capacity, and reduces evaporation losses thereby decreasing stormwater runoff.

During those periods of the year when there is a risk of significant rainfall or strong winds, finished soil surfaces, as well as those areas that are not expected to be further disturbed in the near future, need to be appropriately stabilised as soon as reasonable and practicable. In this context, the term "significant rainfall" refers to sufficient rainfall to produce surface runoff, and the risk of such weather conditions either relates to reliable weather forecasting or normal seasonal weather patterns, whichever represents the worst case.

Approximately 40% cover is required to anchor the soil; however, such a light cover would **not** provide adequate protection against raindrop impact erosion, thus runoff from such lightly covered surfaces would likely still cause harm to receiving waters. Around 70 to 80% ground cover is considered necessary to provide a satisfactory level of erosion control in most urban areas. On some highly erodible clayey soils, however, a minimum 90 to 100% cover would be required to adequately protect downstream environments.

Recommendations on the staging of land clearing and best practice site rehabilitation are provided in Chapter 4 – *Design standards and technique selection*. As a general rule, down-slope sediment control measures should be maintained until at least 70 to 80% coverage is achieved on all up-slope surfaces. It is noted that the percentage cover is a measure of the percentage of soil surface covered by vegetation, blankets or mulch, as observed in plan view; it is **not** a measure of how much of the site's revegetation program has been completed.

Principle 7.2

Topsoil needs to be appropriately managed to preserve its long-term value.

Best practice topsoil management includes:

(i) testing topsoils for their nutrient properties and revegetation potential;

(ii) appropriate stripping and stockpiling of topsoils;

(iii) appropriate scarification and treatment of subsoils prior to topsoil application;

(iv) appropriate application of necessary soil ameliorants prior to revegetation.

Stripped topsoil should be preserved for reuse wherever possible. Topsoil should not be stripped in these conditions:

- excessively wet (i.e. water can be squeezed from the soil); or
- excessively dry (i.e. the soil readily crumbles when handled, or if the soil cannot be formed into a clump when compressed).

Topsoil contains living matter; it has physical, biological, and chemical properties that can be damaged if inappropriately managed. The soil's physical properties may be damaged through excessive compaction, over-working the soil, or working the soil at the wrong moisture content. Damage to the soil's biological and chemical properties can occur through inappropriate stockpiling.

Topsoil can provide a useful seed source (though not always desirable), nutrients and micro-organisms. Stripped topsoil should be used as soon as possible, and preferably not stockpiled for more than 12 months. Long-term stockpiling can degrade its value.

Ideally the top 50mm of soil should be stockpiled separately and respread as the top layer. However, if the soil contains excessive weed seed, then this top 50mm layer may need to be buried or otherwise treated to prevent the spread of weeds.

In those circumstances when it is desirable to retain the seed content of the soil, such as in mining operations, then the stockpiling should consist of long low mounds, no higher than 1.5m. Long-term stockpiles (i.e. more than 28 days) may need to be vegetated to prevent weed infestation and erosion problems. Best practice stockpile management is outlined in Section 4.6 in Chapter 4.

When stripping topsoils, avoid mixing the stripped topsoil with the underlying subsoil, especially if the subsoils are dispersive because this might introduce dispersive characteristics to the topsoil.

The long-term success of a site revegetation program usually depends more on what happens to the soil **before** seeds or seedlings are planted, rather than what happens after planting.

Further discussion on the management of topsoils and subsoils is presented in Chapter 6 – *Site management*.

Principle 7.3

Plant species need to be appropriate for the site conditions, including compatibility with local environmental values, and anticipated erosive forces.

Selecting the most suitable plant establishment techniques, plant species, seeding rates, planting densities, fertilisers, watering rates, and maintenance techniques, requires the guidance of experts such as local bushland groups, landscape and revegetation consultants, and government bodies. Successful long-term revegetation usually requires the scientific analysis of all existing and imported soils used within revegetation areas.

Guidance on the selection of the type of plants that best address certain types of soil erosion is provided in Table C1 of Appendix C – *Soils and revegetation.*

Guidance on the selection of the type of plants that best address certain types of watercourse erosion is provided in Tables I13 and I14 of Appendix I – *Instream works.*

Weed control is best managed through the use of certified seed and seedlings, appropriate topsoil management (including stockpile management and avoiding the use of imported topsoil), and appropriate cleaning of earthmoving equipment prior to site relocation.

Principle 8 Maximise sediment retention on the site.

Principle 8.1

All reasonable and practicable measures need to be taken to protect adjacent properties and downstream environments from the adverse effects of sediment and sediment-laden water displaced from the site.

The primary purpose of most sediment control measures is to trap the coarser sediment fraction; however, some sediment traps, such as *Sediment Basins*, can also capture very fine sediments and even reduce turbidity levels within stormwater runoff.

Technical Note 2.17 – Coarse and fine sediment

The control or trapping of "coarse" sediment is best achieved through sediment control measures. On the other hand, the control of water turbidity is best achieved through the effective control of raindrop impact erosion (i.e. erosion control). Even though *Sediment Basins* can significantly reduce turbidity levels within treated water, most *Sediment Basins* have insufficient capacity to collect and treat all runoff from all storms, therefore it is generally not appropriate to rely solely on the operation of *Sediment Basins* to minimise environmental harm.

Depending on the type of receiving waters, significant environmental harm can be caused by both coarse and fine sediment particles. The adopted erosion and sediment control measures must adequately address all forms of sediment (e.g. cement, clay, silt and sand) in a manner that best protects downstream receiving environments.

Potential environmental harm is not the only issue for consideration. Sedimentation on adjacent properties can also lead to social and economic problems. Sediment deposits on a neighbour's lawn, or across the carpet of their home, may not be classified as environmental harm, but it can result in considerable social stress and financial restitution.

The trapping of coarse sediment on construction sites is possibly the easiest task in on-site erosion and sediment control. While it can be difficult and often impractical to stop the release of **all** fine-grained sediment, particularly clay-sized particles, it is usually both economically and technically feasible to trap the bulk of the coarse sediment.

Principle 8.2

Work sites must not rely solely on the application of sediment control measures to provide adequate environmental protection.

On any site subject to stormwater discharge, best practice sediment control measures on their own cannot be relied upon to provide adequate environmental protection; therefore, appropriate drainage and erosion control measures must be applied, at all times, especially on clayey soils.

Generally the most efficient and economical means of controlling the release of the finer sediment fraction is through the application of best practice site and soil management practices, especially the application of effective drainage and erosion control.

Principle 8.3

Sediment control measures need to be appropriate for the given soil properties, expected weather conditions, required treatment standard, and the type, cost and scope of the works.

Sediment controls can be grouped into four categories based on their ability to trap a specified grain size. The adopted classifications are Type 1, Type 2, Type 3 and Supplementary sediment traps. The determination of the minimum sediment control standard (i.e. Type 1, 2 or 3) primarily depends on the area of disturbance and the estimated soil loss rate, as indicated in Table 4.5.1 of Chapter 4 – *Design standards and technique selection*. The soil loss rate depends on the rainfall erosivity, soil erodibility, slope length and grade, and the effective soil cover. Appendix E – *Soil loss estimation,* outlines the procedures for using the RUSLE analysis to estimate soil loss rates.

Technical Note 2.18 – USLE and RUSLE

The Universal Soil Loss Equation (USLE) and its replacement, the Revised Universal Soil Loss Equation (RUSLE) can be used to estimate soil loss from uniform slopes subject to sheet (including raindrop impact) and rill erosion. The equations do not consider erosion resulting from tunnel, mass movement, watercourse or wind erosion.

RUSLE calculates annual erosion rates based on: $A = R \, . \, K \, . \, LS \, . \, C \, . \, P$, where:

- A = annual soil loss due to erosion (tonnes/ha/yr)
- R = rainfall erosivity factor
- K = soil erodibility factor
- LS = topographic factor derived from slope length and slope gradient
- C = cover and management factor
- P = erosion control practice factor

Type 1 sediment traps are designed to collect sediment particles smaller than 0.045mm. These sediment traps include *Sediment Basins* and some of the more sophisticated filtration systems used in de-watering operations.

Type 2 sediment containment systems are designed to capture sediments down to a particle size of between 0.045 and 0.14mm. Type 2 sediment traps include *Rock Filter Dams, Sediment Weirs* and *Filter Ponds.*

Type 3 sediment containment systems are primarily designed to trap sediment particles larger than 0.14mm. These systems include *Sediment Fences, Buffer Zones* and some stormwater inlet protection systems.

Some sediment traps, such as *Grass Filter Strips* and most kerb inlet sediment traps, have such limited effectiveness that they can only be classified as *supplementary* systems. Even though these sediment traps have a relatively low effectiveness, their use throughout most construction sites is still considered to be a component of best practice sediment control.

Table 2.2 summarises the adopted sediment trap classification system.

Table 2.2 – Classification of sediment traps

Classification	Minimum particle size	Typical trapped particles
Type 1	< 0.045mm	Clay, silt & sand
Type 2	0.045 – 0.14mm	Silt & sand [1]
Type 3	> 0.14mm	Sand
Supplementary	> 0.14mm	Sand

Note: [1] Technically, silt particles have a grain size of 0.002 to 0.02mm which means that only Type 1 sediment traps are likely to capture silt-sized particles. However, for general discussion purposes, it can be assumed that Type 2 systems capture a significant proportion of silt-sized particles.

Technical Note 2.19 – Sediment traps vs sediment barriers

The term "sediment trap" most commonly refers to the larger, Type 2 sediment containment systems. The term "sediment barrier" is often used to describe the less effective sediment traps such as Type 3 sediment traps and supplementary sediment traps.

Throughout this document the term "sediment trap" applies to any sediment control containment system, while the term "sediment barrier" applies to any sediment control device that prevents the passage of coarse sediment either by filtration, or physical blockage of a potential flow path, such as the impervious sealing of a stormwater inlet to prevent the inflow of sediment.

Wide, vegetated *Buffer Zones*, especially flat grassed areas, can be effective Type 3 sediment traps as long as flow through the buffer remains as "sheet flow". *Grass Filter Strips*, however, should only be used as a supplementary sediment trap.

If the soil is open and dry, then *Buffer Zones* can be used to reduce turbidity levels through a process of water infiltration; however, once the underlying soil becomes saturated, *Buffer Zones* quickly lose their efficiency. Therefore, *Buffer Zones* and *Grass Filter Strips* are considered most effective when used on sandy soils.

Technical Note 2.20 – Buffer zones

Buffer Zones used in erosion and sediment control practices should not be confused with permanent buffer zones used in the protection of waterways and those used in land use planning to separate areas of potentially conflicting land use. Refer to Appendix N – *Glossary of terms* for the definition of *Buffer Zones*.

Erosion problems often occur when *Grass Filter Strips* are placed along the edge of impervious surfaces that do not lie along the contour (i.e. at an angle to the slope). This can cause stormwater runoff to be deflected along the edge of the turf rather than passing through the grass. To avoid these problems, strips of turf should be placed at a transverse angle at regular intervals along the upper edge of the turf as shown in Figure 2.5.

An important soil attribute that can influence the effectiveness of sediment containment systems is the proportion of particles finer than 0.02mm. Particles finer than 0.02mm are difficult to trap in *Sediment Basins* without sufficient settlement time and possibly the use of chemical dosing. In addition, these particles readily pass through most Type 2 and Type 3 sediment traps.

When working on soils that contain a high proportion of fine particles (e.g. greater than 33% of the soil finer than 0.02mm) a greater emphasis is usually required on the use of effective erosion control measures. Such measures are used to offset the expected low efficiency of the sediment control measures, even if *Sediment Basins* are incorporated into the site.

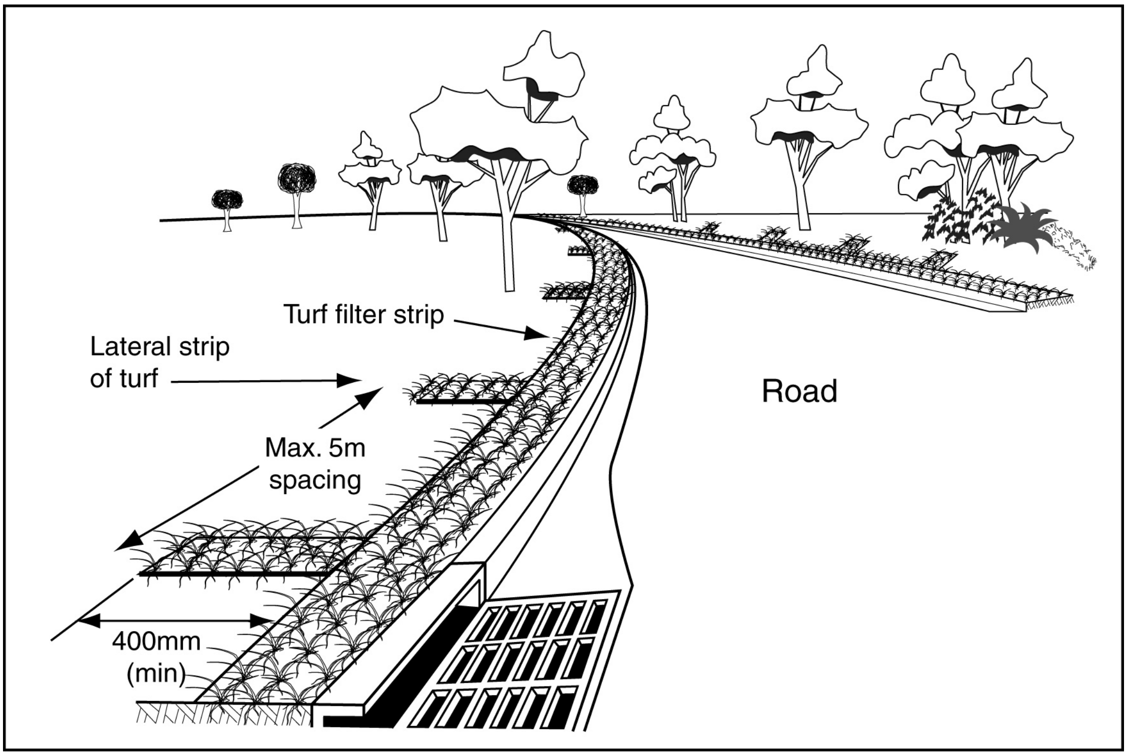


Figure 2.5 – Application of *Grass Filter Strips* down a slope

The critical design features of most sediment traps are:

- the ability to pond water—the surface area of the settling pond being the critical design feature (see Technical Note 2.21);
- adequate retention time to allow sufficient settlement—usually related to the pond surface area;
- the capacity to collect and retain a specific volume of sediment;
- adequate hydraulic capacity prior to flow bypassing;
- allowance for the safe bypassing of flows in excess of the design discharge; and
- appropriate geometry and/or use of flow control banks to control the maximum depth of ponding in locations where public safety issues exist.

Excavating a sediment collection pit immediately up-slope of a Type 2 sediment trap can reduce the risk of sediment blockage of geotextile filtration systems. However, most aggregate-based filters rely on the partial blockage effects of the sediment to enable the aggregate to properly filter the finer silt particles from the passing flow.

In some circumstances it may be necessary to construct earth bunds (flow control banks) down-slope of the sediment trap to control the extent and depth of ponding, and to control the passage of bypassed flows. Limiting the depth of ponding in sediment traps can be important for the following reasons:

- potential safety risk to children that access the site;
- minimising the risk of flood damage to adjacent properties;
- minimising the risk of the ponded water causing the aquaplaning of passing traffic.

Technical Note 2.21 – Pond surface area

It can be demonstrated that maximising the **surface area** of the settling pond is critical in maximising the efficiency of a gravity-based sediment trap.

Most sediment traps have two modes of operation. Initially low-flows enter the settling pond, filling the pond's storage volume, before passing through the outlet filtration system (if such a system is integrated into the design). Secondly, as flows increase beyond the hydraulic capacity of the sediment trap, excess flows either overtop the sediment trap or bypass around the trap. Therefore, the overall efficiency of a sediment trap depends on the design flow rate (i.e. hydraulic capacity) at which point water begins to overtop or bypass the sediment trap.

During the second mode of operation it is important to ensure that all sediment-laden water entering the sediment trap continues to pass through the settling pond to allow the continued removal of coarse sediment from the passing water.

This is different from the design of "permanent" sediment traps, such as Gross Pollutant Traps and wetlands, where it is usually better to design the trap so that high flows bypass the trap to avoid the re-suspension and removal of previously settled material.

Dispersive soils are structurally unstable in water and readily disperse into their constituent particles (sand, silt and clay) with those particles finer than about 0.005mm (clays and fine silts) staying in suspension for extended periods. Chemicals such as gypsum, alum and polyelectrolytes are often needed to induce flocculation and particle settlement. Disturbance of such soils usually results in the reliance on effective erosion control measures and Type 1 sediment control systems.

Technical Note 2.22 – Dispersible vs dispersive

The term "dispersible" soil is most commonly used within the soil science profession; however, the author of this document has mostly used the term "dispersive" because of its common usage within the engineering profession. Both terms are interchangeable within this document.

The choice of which sediment control technique (Type 1, 2 or 3) to use should primarily be based on the erosion risk and ability of the device to perform the required tasks within the given site conditions; however, the type, cost and scope of works are also important factors.

Cost comparisons of treatment options must consider both the installation and ongoing maintenance costs of the various sediment containment systems to ensure selection of the most cost-effective solution. For example, the adoption of some high-tech filtration systems may initially seem cost effective until consideration is given to the labour time and financial cost of their ongoing maintenance.

Discussion on the selection of sediment control treatment standard (Type 1, 2 or 3) is provided in Chapter 4 – *Design standards and technique selection*.

Principle 8.4

Sediment Basins need to be designed and constructed under the supervision of appropriate experts.

A *Sediment Basin* is a purpose built dam usually containing an inlet structure, settling pond, controlled or free-draining de-watering system, and an emergency spillway. *Sediment Basins* are usually classified as Type 1 sediment traps and are designed to retain a wide range of sediment particle sizes.

A constructed *Sediment Basin* which does **not** have the ideal dimensions in accordance with the recommendations of this document (i.e. "surface area" or "volume" as appropriate for the type of basin), must be classified as either a Type 2 or Type 3 system in accordance with its effective sediment trapping capabilities.

There are basically three types of operating systems for *Sediment Basins*: Type C, Type F and Type D basins. Type C basins are appropriate when working in coarse grain soils. These basins can be operated as either free-draining dry basins, or non-draining wet basins—which are designed to retain water between storms so the water can be used for dust control or site revegetation.

Type F basins are used when working in fine grain soils. Type D basins are used when the disturbed soils are dispersive. Type F and Type D basins are designed to retain the water for long periods (up to 5 days) allowing extended time for the settlement of clay-sized particles, possibly with the aid of chemical flocculation. However, these basins must be fully drained between storm events to ensure the basins have the maximum water retention capacity prior to the start of the next storm.

Technical Note 2.23 – Wet and dry basins

A “dry” basin is a basin that freely drains, i.e. discharge from the basin begins to occur the moment water approaches the outlet riser pipe (or other free-draining outlet system).

A “wet” basin is a basin that is discharged only under controlled conditions, usually using a pump or outlet pipe with a control valve. Wet basins may or may not need to be drained between storms depending on the soil conditions within the catchment.

Sediment Basins are usually the last line of defence and thus their location on a work site is critical. Due to their size and potential to release large quantities of sediment if damaged, the design and operation of all *Sediment Basins* requires specialist hydraulic and geotechnical advice. Guidance on the design of *Sediment Basins* is provided in Appendix B – *Sediment basin design*.

Principle 8.5

On-site sediment control practices should not rely on off-site sediment control systems.

A site’s sediment control system should not rely on off-site sediment control systems, especially those systems operated by other organisations, and especially if the off-site system consists of an instream sediment trap such as a permanent gross pollutant trap. Exceptions to this rule apply only with the agreement of the regulatory authority and the owner/manager of the off-site sediment trap.

Principle 8.6

The use of straw bales to form sediment traps should be avoided, unless site conditions prevent the use of other more appropriate sediment control systems.

Experienced erosion and sediment control professionals generally agree that sediment traps should **not** be constructed from straw bales. Straw bale sediment traps regularly fail and are rarely effective in the long term (i.e. if subjected to more than one storm).

In some circumstances, however, straw bales can be used as short-term sediment control systems placed downstream of Type 1 and Type 2 sediment traps during their installation. Straw bale sediment traps have also been used in poorly accessible locations where it is impractical to transport and construct any other type of sediment trap. If used for sediment control, the straw bales should be wrapped in filter cloth.

Straw bales can also be used as short-term *Flow Diversion Banks* (i.e. as a drainage control measure) to direct up-slope runoff around newly opened trenches and other excavations.

Principle 8.7

Suitable construction access needs to be provided to allow for the installation and maintenance of all sediment traps.

Prior to selecting a particular sediment control system and locating it on an Erosion and Sediment Control Plan (ESCP), appropriate steps need to be taken to ensure that the installation of the sediment trap will be possible given the expected site conditions. On steep slopes it can be very difficult to install certain sediment traps, especially if rock or aggregate is required.

One of the errors often found on ESCPs is the placement of *Sediment Fences* across land that is intended to remain as undisturbed bushland. This is one of the reasons why it is important to clearly identify all non-disturbances areas prior to drafting an ESCP.

Most sediment control measures will require some degree of maintenance, including sediment removal. Thus, suitable maintenance access must be provided to all sediment control measures.

Principle 8.8

Sediment traps, including Sediment Basins, need to be appropriately designed for the required hydraulic (flow) conditions.

Most sediment control systems are hydraulic structures that need to be designed for a specified hydraulic condition or design storm in accordance with the specified drainage and sediment control standards.

Sediment control devices should be designed so as not to divert flows from their desired flow path during all storms, even when the device is blocked with sediment or debris. Recommended best practice design standards are provided in Section 4.5.1 of Chapter 4 – *Design standards and technique selection*.

Principle 8.9

Optimum benefit needs to be made of every opportunity to trap sediment within the work site.

Depending on the erosion risk, a major sediment trap, such as a *Sediment Basin*, is usually required at or near the primary discharge points from a work site. Consideration, however, must also be given to the trapping of sediment at all suitable locations throughout the site.

The existence of a *Sediment Basin* at or near the lowest point of a sub-catchment does **not** remove the need for the appropriate use of additional Type 2, Type 3 and supplementary sediment traps throughout the work site.

When locating sediment traps the following principles should be considered.

(i) Avoid placing sediment traps in locations that would introduce a safety risk.

(ii) Ensure all sediment traps are located within the property managed by the principal builder/contractor.

(iii) Avoid placing sediment traps in areas where they could contaminate "clean" water passing by the trap.

(iv) On steep slopes, say steeper than 10% (1 in 10) the focus should firstly be on preventing the initial soil erosion; and secondly on controlling the flow of water across and down the slope in a non-erosive manner. Wherever practical, the trapping of sediment should primarily occur at the base of the slope, or any other location where it is safe and convenient to temporarily pond water.

(v) Without necessarily contradicting the above point, sediment traps should be located such that sediment is trapped as close to the source of soil erosion as is practical.

Principle 8.10

Wherever reasonable and practicable, sediment should be trapped as close to its source as possible.

Locating the sediment trap close to the source of the sediment reduces the breakdown of the soil particles (i.e. the breaking apart of soil crumbs into smaller particles of sand, silt and clay). This in turn reduces the risk of fine silts and clay-sized particles being released into the water.

In the past it has been common practice on steep slopes for several parallel *Sediment Fences* to be installed across the slope at a regular intervals. This practice can be highly risky, especially in regions of high rainfall, and should generally **not** be promoted as best practice.

Principle 8.11

Sediment traps need to be designed, constructed and operated to collect and retain sediment, not just divert the sediment and sediment-laden water to another location.

Using the following scenario as an example, before placing any sediment trap or barrier on a road, especially a public road, the following questions should be addressed:

Will the device cause a safety or flooding problem?

Water retained on roadways by kerb inlet sediment traps can cause passing vehicles to aquaplane, or can backup and flood adjacent properties. Sediment deposited on roads by these devices can also represent a safety risk to pedestrians and traffic. Even the sediment trap itself can represent a safety hazard to traffic.

Safety concerns must always take priority. However, this of course does not excuse the ESC designer or contractor from their legal obligations to incorporate appropriate sediment controls and environmental protection.

Where is the water going to flow?

If the water is unable to enter a particular stormwater inlet, then it must be allowed to flow to a suitable location along a suitable flow path. If the sediment-laden water is simply directed down the road to the next stormwater inlet, then there must be a suitable sediment trap at that inlet.

Where is the sediment going to end up?

If the sediment settled from stormwater runoff collects on a road where it is allowed to later wash down the road into an unprotected stormwater inlet, then the sediment control system has failed. It is important to note that the aim is to stop the sediment entering downstream receiving waters, **not** to just stop the sediment entering those stormwater pipes that remain under the control of the principle contractor.

How will the trapped sediment be removed from the roadway?

It is highly unfortunate, but on more than one occasion sediment has been removed from a roadway by an operator simply removing the trap and washing the sediment down the drain. Such practices are both illegal and inappropriate.

If sediment traps are placed adjacent to stormwater inlets on roadways, then it is imperative that an appropriate maintenance procedure is adopted that will prevent, or at least minimise, the quantity of sediment released into receiving waters.

Principle 8.12

The potential safety risk of a proposed sediment trap to site workers and the public needs to be given appropriate consideration and management, especially those devices located within publicly accessible areas.

Some sediment traps, especially those located within publicly accessible areas such as roadways, can represent a safety risk if inappropriately installed or maintained. Safety issues, relating to both the public and site personnel, must be given appropriate consideration when designing and operating sediment control measures.

Principle 8.13

To the maximum degree reasonable and practicable, sediment needs to be contained within appropriate sediment traps before entering a sealed roadway, whether or not the road is part of the construction site.

Due to the damage that can be caused by bypass flows, roadside kerb inlet sediment traps should only be used with extreme care and caution. Generally speaking, sediment should be trapped **before** it is allowed to enter a roadway, and wherever reasonable and practicable, the site's sediment control strategy should not rely on kerb inlet sediment control measures.

Most roadside sediment traps generally aim to prevent sediment from entering stormwater pipes. However, inappropriately designed sediment traps can also prevent stormwater from entering the kerb inlet, possibly resulting in drainage or flooding problems on adjacent properties or somewhere else down the roadway. Some kerb-side sediment traps can also cause traffic safety problems.

Principle 8.14

Roadside kerb inlet sediment traps need to be appropriate for the type of inlet (i.e. "sag" or "on-grade" inlets).

An "on-grade" kerb inlet (or gully inlet) is an in-kerb stormwater inlet located on a part of a roadway that has a positive gradient such that water would flow past the inlet if the inlet was blocked or sealed. A "sag" kerb inlet is an in-kerb stormwater inlet located at a low point in a roadway where water would collect and pond if the inlet was blocked or sealed.

A "sag" inlet must allow water to pond on the road adjacent to the inlet in order to achieve particle settlement. Sag inlet sediment traps should not block the inlet opening, but should be set back from the inlet (normally using spacers) to allow the drain to function even during periods of moderate to heavy rainfall. The exception to this rule is when it is necessary or desirable to prevent water entering the stormwater drainage system, for example, when the pipes are used to convey "clean" water through a site and the road is used to convey "dirty" water to a down-slope sediment trap.

An on-grade kerb inlet sediment trap consists of one or more U-shaped sandbag dams constructed up-slope of the inlet. Typically more than one sediment trap is required up-slope of such inlets.

It is not uncommon for site operators to incorrectly install "sag" type sediment traps around on-grade kerb inlets. Such inappropriate practice will cause stormwater runoff to be diverted around the inlet and down the roadway, possibly towards an unprotected stormwater inlet.

Gully Bag Sediment Traps (i.e. special filter bags installed below the inlet grate) can be used on both "sag" and "on-grade" kerb inlets.

Appropriate consideration must always be given to the likely flow path of any flows bypassing all kerb inlet sediment traps.

Public safety must always take priority. If the installation of the sediment trap is likely to represent an unmanageable and/or unacceptable safety risk, then an alternative sediment trap must be used, such as a *Gully Bag Sediment Trap*. Roadside sediment traps can also be damaged by road traffic, thus operators must exercise extreme care and caution when placing these devices on public roadways.

Principle 8.15

Site entry and exit points need to be limited to the minimum practical number, and need to be appropriately designed and stabilised to minimise sediment being washed off the site by stormwater and/or being transport off the site by vehicles.

The tracking of sediment onto public roads by construction vehicles is one of the most common sources of public complaint. Off-site sedimentation can also occur because of inadequate drainage controls placed along construction access roads. The resulting sediment deposition can cause traffic safety hazards as well as problems to the stormwater network and receiving environments.

Site entry and exit points should be limited to the minimum practical number. These locations should be stabilised with *Rock Pads, Vibration Grids* or *Wash Bays* depending on their usage and the type of exposed soil. *Rock Pads* are typically used in clayey soil areas, while *Vibration Grids* are normally best used in sandy soil regions.

If the work site is elevated above the public road, then stormwater runoff from the site could wash sediment off the entry/exit pad onto the public road. To avoid this problem, stormwater runoff should be diverted off the *Rock Pad* into a suitable sediment trap. This is usually done by forming a cross-bank or "speed bump" across the *Rock Pad* as shown in Figure 2.6.

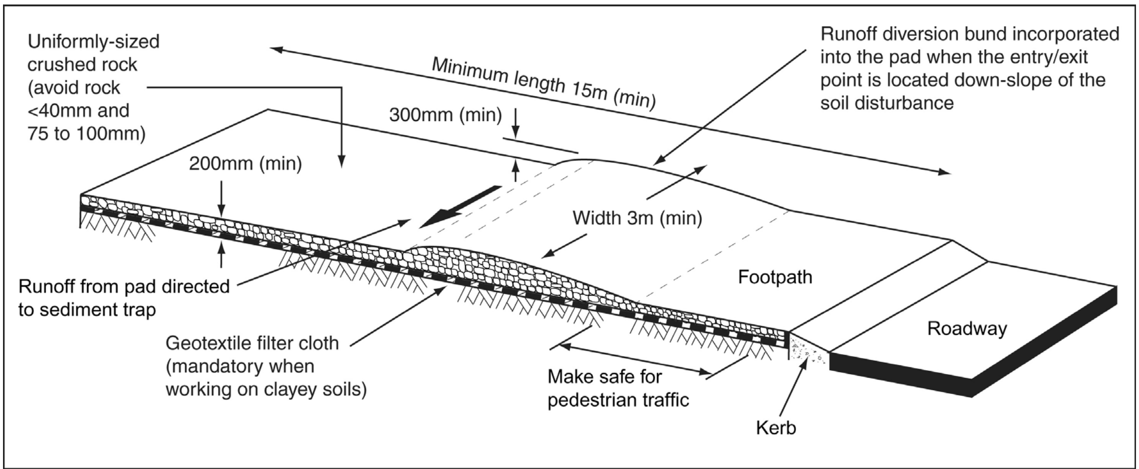


Figure 2.6 – Entry/exit pad for construction sites

On building sites these rock entry/exit pads perform a slightly different function and are primarily used as all weather parking bays. Their sediment trapping efficiency is often less critical (compared to construction sites) because there is usually less movement of trucks across the rock pads. Thus for building sites the design standard normally allows for a smaller pad length and width, and a smaller rock size. Further discussion on erosion and sediment control practices for building sites is provided in Appendix H – *Building sites*.

On long-term construction sites, sites containing heavy clayey soils, and construction sites located near sensitive receiving waters, it may be necessary to install an automatic or manually operated *Wash Rack* or *Wash Bay* to limit the tracking of sediment off the site.

Principle 8.16

Appropriate sediment control measures need to be applied to all temporary building and construction works, including the site office and stockpile areas.

It is important to ensure the work site's office and car park areas do not become a source of sediment runoff. Appropriate drainage control measures placed up-slope and within the site office and car park areas can significantly reduce the generation of mud. Sediment-laden runoff from these areas must be directed to an appropriate sediment trap.

On long-term construction sites it may be appropriate to cover the car park and office areas with gravel to minimise damage to the soil and the generation of mud during extended periods of wet weather.

Best practice stockpile management includes:

- drainage controls placed up-slope of stockpiles where necessary; and
- sediment controls placed down-slope of stockpiles.

Stockpiles of erodible material should be located within the site's sediment control zone. As a minimum, if the stockpile is likely to be affected by either rainfall or flowing water, then an appropriate sediment trap, such as a *Compost Berm, Filter Fence or Sediment Fence*, should be located down-slope of the stockpile. The choice of *Sediment Fence* fabric placed down-slope of stockpiles can be critical as discussed in Chapter 4 – *Design standards and technique selection*.

Stockpiles should not be located within the pathway of concentrated flow. This especially applies to stockpiles of fine, non-cohesive (i.e. sandy) material. It is important, therefore, to identify all overland flow paths before locating stockpile areas. If a stockpile must be located in an area where water will flow, then a flow diversion device, such as a *Catch Drain* or *Flow Diversion Bank*, should be placed up-slope of the stockpile to divert water around the stockpile.

Stockpiles may also need to be protected from wind and rain. Stockpiles of clayey soil are more susceptible to rainfall erosion then stockpiles of sand. Long-term stockpiles (i.e. more than 28 days) may need to be vegetated (as appropriate) to prevent weed infestation and erosion problems.

Technical Note 2.24 – Stockpile management

The higher the clay content of the stockpiled material, the greater the need to control the erosive effects of rainfall on the stockpile, thus the greater the benefit obtained from the use of an impervious cover.

The greater the sand content of the stockpile, the greater the need to divert stormwater runoff around the stockpile.

Erodible materials must not be stored within a road reserve without obtaining permission from the appropriate road authority. Materials placed within the road reserve must not block traffic or cause safety problems. If erodible materials are to be temporarily stored within a road reserve, then an appropriate waterproof cover should be stored on site for use in the event of rain.

Theft of stockpile covers can be a problem, and this must be appropriately managed as part of the process of taking all reasonable and practicable measures to prevent or minimise environmental harm.

Further discussion on stockpile management is provided in Chapter 6 – *Site management*.

Principle 8.17

Wherever practicable, Sediment Fences need to be located along the contour to maintain "sheet" flow conditions down-slope of each fence. Where this is not practicable, the Erosion and Sediment Control Plan needs to indicate appropriate installation measures (i.e. regular returns) to allow water to pond at regular intervals along the length of the fence.

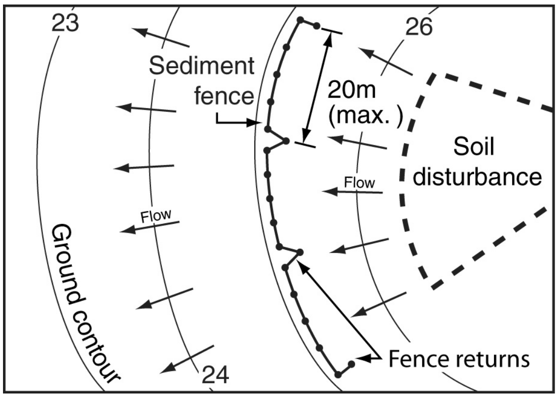
Sediment Fences primarily trap the coarser sediments, such as sands. In general, these sediment traps have little impact on silts and clay-sized particles, and as such, the term "silt fence" is now considered misleading.

A *Sediment Fence* should **not** be viewed as a "filtration" system. It is best to consider a *Sediment Fence* as a porous dam wall. Its principal job is to temporarily pond water during a storm, not to filter the water. However, there are some circumstances where *Sediment Fences* need to act as filters, such as *Sediment Fences* placed down-slope of stockpiles during de-watering operations. In such cases, a non-woven composite fabric or heavy-duty filter cloth attached to wire mesh (i.e *Filter Fence*) is normally used.

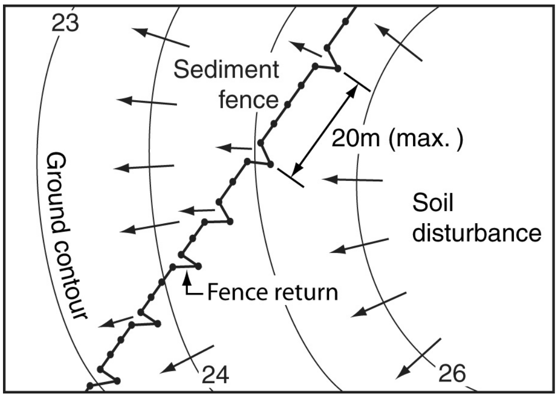
A *Sediment Fence* must be constructed in a way that temporarily ponds water at regular intervals along the fence. Wherever reasonable and practicable, the fence should be located along the contour with the ends of the fence turned up the slope to prevent or limit water bypassing around the fence (Figure 2.7(a)).

If the *Sediment Fence* is located across the contours (i.e. at an angle to the slope) then a "straight" fence will simply cause water to be diverted along the fence. This may lead to failure of the *Sediment Fence* and the release of concentrated sediment-laden flow from the end of the fence.

If it is necessary to locate a *Sediment Fence* at an angle to the slope, then regular returns must be installed along the fence to allow water to pond at regular intervals as shown in Figure 2.7(b).



(a) Placement along contour

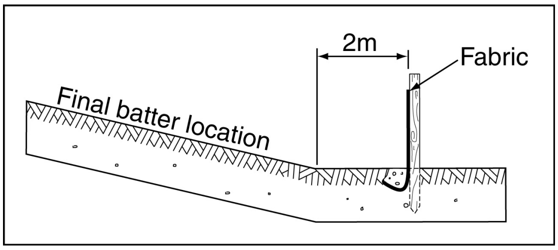


(b) Placement off grade

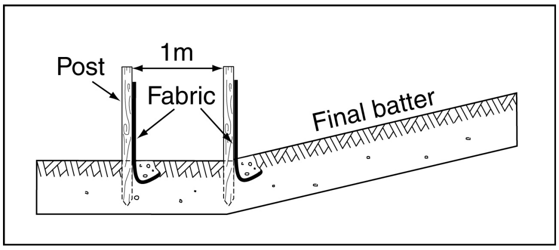
Figure 2.7 – Placement of *Sediment Fence*

The maximum allowable spacing of the support posts is 2m unless the fence is supported by an upper tie wire or wire mesh (both being tied to the back of the fabric at 1 m spacings) in which case the maximum spacing is 3m.

If located at the base of a fill slope, the *Sediment Fence* should ideally be placed at least 2m from the toe of the embankment to prevent any soil and rocks displaced by the filling operations from damaging the fence (Figure 2.8(a)). Alternatively, a *Double Sediment Fence* may need to be used as shown in Figure 2.8(b).



(a) Placement of *Sediment Fence* at base of fill slope



(b) Use of a *Double Sediment Fence* at the base of a fill slope

Figure 2.8 – Location of *Sediment Fence* at base of fill slope

All *Sediment Fences* must be inspected regularly for damage and sediment blockage of the fabric, and de-silted, repaired or replaced where necessary.

Principle 8.18

Sediment Fences, installed in the standard (i.e. straight) manner, must not be placed across concentrated flow.

As a general rule, *Sediment Fences* should not be used in concentrated flow. When used in minor drainage lines, such as table drains, the *Sediment Fence* must **not** be placed straight across the drain, instead, a special *U-Shaped Sediment Trap* must be installed with an appropriate spill-through weir installed.

U-Shaped Sediment Traps can only be used in relatively steep table drains. When the drain geometry is not suitable for the installation of a *U-Shaped Sediment Trap*, then an alternative sediment containment system must be used, such as a *Check Dam Sediment Trap.*

Principle 8.19

As a general guide, sediment-laden water should not pass through more than one Sediment Fence within a given work area. If further treatment is required after passing through a Sediment Fence, then wherever reasonable and practicable, the sediment-laden water needs to be directed to a suitable Type 1 or Type 2 sediment trap.

As a general rule, most sediment-laden runoff should pass through no more than one *Sediment Fence* during its passage through a site. If further treatment is required after passing through a *Sediment Fence*, then the water should ideally be directed to a Type 1 or Type 2 sediment trap. Of course, in this context, a *Double Sediment Fence* is considered as a single device.

The practice of placing several parallel *Sediment Fences* down long exposed slopes is highly risky, especially in regions of high rainfall, and should generally **not** be promoted as best practice.

Principle 8.20

Sediment control measures employed during de-watering operations need to be appropriate for the expected site conditions, soil type, potential environmental risk, and the type, cost and scope of the works.

If de-watering activities are likely to occur on site (e.g. de-watering excavations or material stockpiles) then appropriate technical notes must be supplied on the Erosion and Sediment Control Plan defining appropriate sediment control measures based on expected site conditions.

Appropriate water treatment is required for all sediment-laden water discharged from de-watering operations. De-watering sediment control systems primarily use filtration processes, rather than gravity-induced settlement, in order to achieve the desired treatment standard.

Further discussion on the selection of appropriate de-watering sediment control measures is provided in Chapter 4 – *Design standards and technique selection*.

Principle 8.21

When constructing works or causing soil disturbances in or around a watercourse, priority must first be given to construction practices that avoid contamination of stream flows. Where such practices are not practical, priority must then be given to the treatment of sediment-laden water within off-stream sediment traps. The use of instream sediment traps must only be considered as a management option when all other options can be demonstrated to be ineffective, unreasonable, or impracticable.

Disturbances to existing watercourses must be avoided, or at least minimised, wherever reasonable and practicable. Where such disturbances must occur, then priority must be given to the use of *Isolation Barriers* that prevent, or at least minimise, the contamination of passing stream flow.

Wherever reasonable and practicable, the treatment of sediment-laden water must occur within off-stream sediment traps rather than instream sediment traps. Only in extremely exceptional circumstances should a sediment control device be placed within a natural watercourse. Guidelines on the use of temporary instream sediment control measures and construction practices within and around waterways are provided in Appendix I – *Instream works*.

When working adjacent to a watercourse, the existence of a permanent instream sediment control device, such as gross pollutant trap or instream sedimentation basin, should **not** be used as the primary sediment control measure for the construction activity. These instream sediment traps generally have a very low sediment trapping efficiency and are extremely limited in their ability to capture the finer sediments typically discharged from construction sites.

Principle 8.22

The ESC installation schedule and/or Supporting Documentation must clearly indicate which sediment control measures need be functional before up-slope soil disturbances commence, and what degree of site stabilisation is required prior to the decommissioning of each sediment control device.

Appropriate sediment control measures must be functional before significant earthworks commence on a site. Of course some degree of initial land clearing is usually required to enable the installation of both drainage control and sediment control measures, but this clearing should be limited to the minimum necessary to allow access and installation of these control measures.

Sediment control measures should not be decommissioned until up-slope areas are appropriately stabilised. Exceptions to this rule would apply if a particular sediment control measure is considered to represent a safety hazard. In such cases, alternative sediment and/or erosion control measures will need to be employed so as to maintain the required treatment standard.

Recommendations on the staging of land clearing and best practice site rehabilitation are provided in Chapter 4 – *Design standards and technique selection*. As a general rule, down-slope sediment control measures should be maintained until at least 70 to 80% coverage is achieved on all unsealed soil surfaces. It is noted that the percentage cover is a measure of the percentage of soil surface covered by vegetation, blankets or mulch as observed in plan view, it is **not** a measure of how much of the site's revegetation program has been completed.

Principle 8.23

Site managers and/or the nominated responsible ESC personnel need to maintain a good working knowledge of the correct installation and operational procedures of all ESC measures used on the site.

The key elements of best practice site management vary from site to site, but generally incorporate the following concepts:

- The appointment of a responsible on-site ESC officer.
- Ensuring the supply of necessary ESC materials at the time of site establishment.
- Maintaining a stockpile of emergency erosion and sediment control materials throughout the construction period.
- Adopting flexible work procedures that can accommodate necessary amendments to the site's ESC measures.
- Ensuring appropriate staff training and the control of subcontractors, including the appropriate use of notice boards and educational posters relating to ESC issues.
- Controlling traffic movements within the site and at the site's entry/exit points to minimise sediment runoff, dust generation, and undesirable soil compaction outside designated access paths.
- Coordination of the installation of services and any soil disturbances caused by service providers.
- Adopting appropriate clean-up procedures for off-site sediment deposits and spills.
- Regularly monitoring the site and all erosion and sediment control measures, and maintaining such measures in proper working order at all times.
- Maintaining a good working knowledge of relevant Erosion and Sediment Control issues, including the ability to recognise poor ESC outcomes, and knowledge of the correct installation and operational procedures for the full range of ESC measures adopted on the site.

Further discussion on site management practices is presented in Chapter 6 – *Site management*.

Principle 9 Maintain all ESC measures in proper working order at all times.

All ESC measures must be maintained in proper working order at all times until their function is no longer required. To assist in achieving this requirement, technical notes and/or construction specifications attached to the Erosion and Sediment Control Plan must specify the maintenance requirements of all sediment traps.

The term “Proper working order” means taking all reasonable and practicable measures to sustain all ESC measures in a condition that:

- will best achieve the site’s required environmental protection, including specified water quality objectives for all discharged water (principal objective);
- is in accordance with the specified operational standard for each ESC measure, where such a standard is consistent with the site’s required environmental protection including specified water quality objectives for all discharged water, or where such a standard is not specified, is consistent with current best practice for each individual ESC measure; and
- prevents or minimises safety risks.

Safety issues must be given the highest priority on work sites. All ESC measures must be maintained in a manner that prevents or minimises safety risks.

All water (clean or dirty), debris and sediment removed from ESC measures must be dispose of in a manner that will not create an erosion or pollution hazard.

Upon decommissioning any ESC measures, all materials used to form the control measure must be disposed of in a manner that will not create an erosion or pollution hazard. The area upon which the ESC measure was located must be properly graded and rehabilitated as required.

Principle 10 Monitor the site and adjust ESC practices to maintain the required performance standard.

Erosion and Sediment Control Plans (ESCPs) are living documents that can and should be modified as site conditions change, or if the adopted measures fail to achieve the required treatment standard. When a site inspection detects a notable failure in the adopted ESC measures, the source of this failure must be investigated and appropriate amendments made to the site and the plans.

Monitoring the effectiveness of an ESCP through a combination of site inspections and water quality monitoring, is part of responsible site management. On some small, low-risk sites, say smaller than 0.5 ha, reporting requirements may only need to consist of simple diary notes listing inspection times, field observations and maintenance activities. On larger or high-risk sites, monitoring is likely to include specific water quality sampling and detailed logbook entries of the site's monitoring and maintenance activities.

Best practice site management procedures and duties are outlined in Chapter 6 – *Site management*. The *due diligence* associated with the management of a development site, or any other soil disturbance that could potentially cause environmental harm, requires site managers to ensure that appropriately trained and experienced personnel are incorporated into the process at all times. Such personnel must, collectively, have the following capabilities:

(i) An understanding of the local environmental values that could potentially be affected by the proposed works.

(ii) A good working knowledge of the site's ESC issues, and potential environmental impacts, that is commensurate with the complexity of the site and the degree of environmental risk.

(iii) A good working knowledge of current best practice ESC measures for the given site conditions and type of works.

(iv) Ability to appropriately monitor, interpret, and report on the site's ESC performance, including the ability to recognise poor performance and potential ESC problems.

(v) Ability to provide advice and guidance on appropriate measures and procedures to maintain the site at all times in a condition representative of current best practice, and that is reasonably likely to achieve the required ESC standard.

(vi) A good working knowledge of the correct installation, operational and maintenance procedures for the full range of ESC measures used on the site.

The work site and all erosion and sediment control measures should be inspected in accordance with the requirements outlined in Section 7.3 of Chapter 7 – *Site inspection*. These site inspections must be conducted only when it is safe to do so, and only in a manner that minimises safety risks to site personnel and the general public.

3. Site planning

This chapter outlines best practice (2008) development and construction site planning with respect to the application of erosion and sediment control during the construction phase. Its function within this document is both educational and prescriptive. Unless otherwise stated, the chapter does not address those ongoing erosion and sediment control issues applicable during the operational phase of land developments.

3.1 Introduction

"Development planning" involves the determination of appropriate land uses for a given site, and a development layout that best accommodates those land uses. To achieve this, it is essential to assemble and analyse all pertinent site information—social, ecological, cultural, economic and political—to determine the ultimate design and feasibility of the project.

"Construction site planning" involves the early recognition and management of those components of a development layout and construction process that can significantly influence the social, ecological, cultural, economic and political impacts of the construction phase of the development. To achieve this, it is essential to assemble and analyse all pertinent site information on the local soils, topography and hydrology, while giving appropriate recognition to the land requirements of essential erosion and sediment control measures.

Those aspects of development and site planning reviewed in this chapter include:

- Planning issues relating to the layout, design and rehabilitation of land developments, including those issues that may influence:
  - (a) the ongoing erosion potential of that land;
  - (b) required space allocations for temporary erosion and sediment control measures.
- Planning issues relating to the design of the Erosion and Sediment Control Plan (ESCP) with particular focus on data collection and analysis.

Site planning must not be limited to those issues relating only to the long-term outcomes and impacts. Short-term impacts associated with the construction phase must also be given appropriate consideration. Even though the construction phase may be relatively short compared to the design life of the development, its impact on the land and surrounding environment can be significant.

Planners and designers must consider the potential environmental impacts of the construction phase of land developments, and must consider appropriate ways of managing these impacts.

During the planning phase of a building or construction project, consideration must be given to "how the works will be constructed" and how—without unreasonably altering the project aims—the development layout can best achieve the following aims:

- Minimise short and long-term environmental harm resulting from both the construction and operational phases of the project.

- Allow sufficient land area within and around construction activities for the placement and operation of necessary erosion and sediment control measures, including temporary drainage control measures.
- Allow sufficient land area for the short-term stockpiling of construction materials, equipment and site facilities such that these stockpiles and facilities do not negatively impact on designated non-disturbance areas and protected vegetation, and are retained within the site's sediment control zone.

3.2 Development Planning

Erosion and sediment control issues are not limited to just the short-term control measures implemented during the construction phase. The layout of a land development, and even the very existence of the land development, can result in significant long-term soil erosion problems. Appropriate development planning and land use allocation can help to minimise these problems.

Issues that should be considered during development planning include the following:

(i) Identification of on-site and off-site "values".

(ii) Identification of the potential impacts the development may have on these values.

(iii) Identification of the risks associated with each potential impact.

(iv) Identification of how best to align the development layout with aims of a Planning Scheme, Catchment Management Plan and/or Stormwater Management Plan.

(v) Identification of site limitations with respect to the site's soils, topography, water and vegetation.

(vi) Identification of required multi-disciplinary advice necessary to address site issues, limitations and potential impacts (e.g. geotechnical, agronomy, landscape, soil science, hydraulic and engineering).

(vii) Identification of government advice and regulatory requirements necessary to address site issues, limitations and potential impacts.

Various planning tools are available for the assessment of site limitations and erosion hazard risks. Three of these tools are briefly described in Section 3.3.

One of the most important aspects of erosion and sediment control to be considered during development planning is the location and required space allocation of major sediment traps such as *Sediment Basins*. This is especially important in the planning of spatially constrained sites, such as major road construction projects where *Sediment Basins* may need to be located outside the proposed road reserve. In such cases steps must be taken to acquire easements or temporary use of all necessary land.

To the maximum degree reasonable and practicable, the development layout must account for the preferred location and land requirements of essential erosion and sediment control measures. To allow this to occur, the following information needs to be obtained from the project's design team:

- A catchment map defining sub-catchment boundaries.
- The preferred location and area requirements of major sediment traps.
- The potential for these sediment traps to be eventually incorporated into the permanent stormwater management system, e.g. a detention basin or wetland.

Development planning must also take appropriate consideration of the beneficial attributes and legislative requirements of retaining specific site vegetation, including:

- a variety of native plant species;
- plants from varying age groups;
- endangered or locally rare species;
- vegetation that forms part of a wildlife corridor or has habitat value;
- specific tree groups.

3.3 Site evaluation tools

Various tools exist for evaluating the potential or suitability of land for urban development. These mapping tools vary in complexity depending on the scale of the mapping/evaluation process. Three of these tools are described below.

3.3.1 Urban Capability Mapping

Urban Capability Mapping has been developed to assist in identifying appropriate land uses for specific sites. When used by local governments, this planning tool can assist in the assessment of land use applications and the development of Planning Schemes.

Urban Capability Mapping requires soil investigations to determine (Charman and Murphy, 1991):

- engineering suitability (or limitations) for building foundations, storage reservoirs, sewerage disposal facilities, embankments, and the location of roads, railways, pipelines and so on;
- possible erosion hazards that may appear during the development phase;
- the suitability for sand, gravel and other mineral supplies;
- the suitability of soil materials for revegetation.

Methods used to develop Urban Capability Maps vary from region to region. If such mapping is considered necessary or appropriate for an area, contact should be made with the relevant state planning authority or regional development authority for guidelines on mapping procedures.

3.3.2 Erosion Risk Mapping

Erosion Risk Mapping may be considered a sub-set of Urban Capability Mapping. The maps identify areas of low, medium, high and extreme erosion risk. Erosion Risk Mapping is either performed by land developers as part of initial site planning, or as part of the conceptual planning of construction procedures and staging.

In Erosion Risk Mapping, only those site constraints that directly relate to soil erosion are mapped. In effect, Erosion Risk Mapping is a mapping exercise based on a suitable soil erosion model such as the Revised Universal Soil Loss Equation (RUSLE) described in Appendix E – *Soil loss estimation*.

Technical Note 3.1 – Erosion Risk Mapping

Erosion Risk Mapping is different from the erosion risk rating systems introduced in Section 4.4 of this document for the determination of the Erosion Control Standard. The adoption of an erosion risk rating system allows regulatory authorities to relate the Erosion Control Standard to either the estimated soil loss rate (i.e. RUSLE analysis), the monthly erosivity (i.e. monthly R-factor), or the average monthly rainfall depth.

Suggested soil loss classes are presented in Table 3.1.

Table 3.1 – Soil loss classes [1]

Soil loss class	Soil loss (t/ha/yr)	Erosion risk
1	0 to 150	Very low
2	151 to 225	Low
3	226 to 350	Low–moderate
4	351 to 500	Moderate
5	501 to 750	High
6	751 to 1500	Very high
7	> 1500	Extremely high

Note: [1] Sourced from Morse and Rosewell (1996)

The mapping procedure either identifies the erosion risk based on an average annual rainfall erosivity (in those circumstances when the actual timing and duration of soil disturbance is **not** known), or based on monthly erosivity factors when the actual construction period is known.

Erosion Risk Mapping should aim to identify:

- zones of various erosion risk;
- areas where soil disturbances should be avoided during given periods of erosion risk, and/or periods of the year;
- a well-defined link between the assessed erosion risk and the required erosion and sediment control design standard.

To be an effective planning tool, Erosion Risk Mapping must link the selection or design of Erosion and Sediment Control measures to the assessed erosion risk. As a guide, the following study outcomes may be considered by the designer or regulator:

- Erosion risk linked to use of *Sediment Basins*.
- Erosion risk linked to the design standards set for drainage and sediment control systems (i.e. the selection of the design storm).
- Erosion risk linked to those periods when soil disturbance may occur on specific areas of land given the erosion and sediment control measures proposed for the site.
- Erosion risk linked to the required time frames for site stabilisation/revegetation such as 14, 30 and 60-day periods for low, medium and high-risk areas.
- Erosion risk linked to the selection of erosion control measures such as mulching, hydromulching, and erosion control blankets.

The disturbance of land designated as having an *extreme erosion risk* should be avoided wherever possible. Any necessary disturbance must attract high-level erosion and sediment control requirements, and strict rehabilitation specifications.

To promote the development of *low erosion risk* areas in preference to the higher risk areas, it is important **not** to unfairly apply high-level ESC standards to low-risk developments. This can best be achieved by ensuring that the financial cost of erosion and sediment control is closely linked to the assessed environmental risks.

Local authorities should give consideration to the adoption of Erosion Risk Mapping for developments located adjacent to, or upstream of, critical environmental habitats, or when the development area exceeds five (5) hectares.

3.3.3 Erosion Hazard Assessment

An Erosion Hazard Assessment system can be used to quickly assess the overall erosion hazard of a particular development or land use activity. Various systems exist, some can assign a ranking or score to specific construction activities and site conditions, while others are a simple modification of soil loss models such as RUSLE. In either case, the aim is to determine a "trigger value" that can identify high-risk development sites.

Erosion Hazard Assessment is different from Erosion Risk Mapping because it provides an overall hazard rating for the complete development site instead of rating individual areas or regions within a development. Unlike soil loss modelling, Erosion Hazard Assessment does not require detailed assessment of the development layout, thus it can be performed at the very early stages of site planning for use in project feasibility assessment and discussions during planning negotiations with the local government.

A standard Erosion Hazard Assessment system should be prepared on a regional basis based on local "environmental values" and regional soil, topographic, waterway and weather conditions. Examples of two Erosion Hazard Assessment systems are provided in Appendix F – *Erosion hazard assessment*.

3.4 Site constraints

The site layout and design should appropriately reflect known site constraints or limitations as well as regional factors. The site limitations that commonly affect on-site erosion and sediment control measures can be grouped into five main categories:

- soil
- topography
- water
- vegetation
- ecology

Other site constraints also need to be investigated including social, cultural, economic and political issues. These factors are not discussed within this chapter and it is recommended that specialist advice be obtained on these issues where appropriate.

3.4.1 Soil limitations

Possible site constraints may be associated with the following soils and soil conditions:

- acid sulfate soils
- dispersive/sodic soils
- expansive/reactive soils (cracking clays)
- extremes of pH
- extremes of permeability
- hardsetting and surface sealing soils
- inadequate available water capacity
- low fertility

- low wet-bearing strength
- non-cohesive soils
- organic soils
- saline soils
- soil erodibility
- stony soils
- toxic soils
- unconsolidated soils
- water repellent soils

Where appropriate, or required by a regulatory authority, a soil survey must be prepared to identify the existence of any problematic soils and the recommended soil treatment and management techniques. Discussion on the above soil conditions is provided within Appendix C – *Soils and revegetation*.

3.4.2 Topographic limitations

One of the most efficient ways of minimising the adverse effects of soil erosion is to minimise land reshaping. Wherever reasonable and practicable, developments should utilise the existing topography, thus avoiding extreme land reshaping, especially during those periods of high erosion risk.

Local authorities are encouraged to provide guidelines or codes on the maximum allowable gradients on which certain construction methods are considered appropriate. For example, restricting the use of “slab-on-ground” construction to those areas that have a natural land slope less than, say 10 to 20% depending on soil type.

Topographic limitations are often associated with the following geological conditions:

- coastal and intertidal areas
- drainage problem areas
- existing erosion problems
- flood prone land
- land prone to mass movement
- local microclimates
- rock outcrops
- steep slope
- waterways and wetlands

Where appropriate, or required by a regulatory authority, the initial site evaluation study must identify the existence of such topographic regions and the potential limitations they may pose to the development design and layout.

The following discussion points outline those topographic issues that may represent a development constraint or may influence the long-term erosion potential of a site.

Coastal and intertidal areas

- Identify all areas of potential acid sulfate soils prior to commencing construction works and to the maximum degree reasonable and practicable, avoid or at least minimise, disturbance to such areas.

- Identify and retain dunal systems as part of the long-term management of essential coastal erosion and coastal ecosystems.
- Take appropriate steps to manage wind erosion problems, particularly in sandy soil regions where sediment may blow onto adjacent properties or across footpaths, bikeways and roadways.
- Thoroughly investigate the long-term stability of proposed landform modifications and the potential impact of such modifications on wave refraction/reflection.
- Identify and protect all essential marine plants, not just mangroves.
- Clearly identify protected coastal buffer zones prior to development planning.

Drainage problem areas

- The de-forestation of a heavily wooded floodplain, or other low lying area, can cause an undesirable rise in groundwater levels resulting in the formation of swampy surface conditions and/or saline soils. Prior to heavy vegetation clearing, urban planners need to appreciate the long-term consequences the clearing may have on salinity problems, soil moisture and groundwater levels.
- The filling of problem drainage areas to allow urban development can aggravate downstream flooding and channel erosion problems by decreasing the effective flood storage volume of the site.

Existing erosion problems

- Existing soil erosion problems may indicate unstable topographic or hydrologic conditions that may need to be addressed during the proposed land development. As a minimum, consideration must be given to the potential for the development to aggravate these erosion problems.
- Erosion problems within a watercourse may limit how close a development may encroach on the banks of that watercourse. In the absence of regulatory requirements, structures should generally not be located within the zone defined by a 3:1(H:V) gradient from the toe of a watercourse bank, unless appropriately justified by geotechnical and hydraulic advice.

Flood prone land

- The filling of flood prone land to allow urban development can aggravate downstream flooding and channel erosion problems by decreasing the effective flood storage volume of the site. Detailed dynamic flood modelling will be required to identify the potential impacts of filling flood prone land.
- *Sediment Basins* and other major sediment traps should generally be placed above the 1 in 5 year ARI flood level.

Land prone to mass movement erosion

- The potential for the site to either experience a landslip or landslide, or be affected by an adjacent landslip or landslide, needs to be investigated.
- On steep sites, the potential for the removal of trees and shrubs to cause a landslip or landslide needs to be considered, even if the site is to be revegetated with similar species.
- If major land clearing has occurred on a steep slope within the past 5 years or so, then imminent failure of the old tree root system may increase the risk of a mass movement slope failure.

- Other factors that can result in an increased risk of mass movement slope failure include: the removal of bulk material from the toe of a steep slope; changes to the natural flow of groundwater on steep slopes; and the placement of load-bearing fill or structures on an unstable slope.
- Perched water tables and seepage zones are hazard signs in areas where slope failure is known to occur.
- Plastic clays with USCS classification of CL or CH are also prone to mass movement.
- Areas prone to mass movement are often recognisable by features such as:
  - (i) slip scars;
  - (ii) terraced formations;
  - (iii) clumps of trees which have died with no apparent cause;
  - (iv) tree trunks that have developed a bend following displacement by a past slip movement; and
  - (v) the lateral displacement of fence posts or telegraph poles.

Local microclimates

- Small microclimates can be generated by a dense stand of trees, a deep gully, or a meander in a creek channel. Failure to identify these microclimates can result in the loss of an environmental value, or may significantly influence the success of a site revegetation program. On large sites, a vegetation survey and/or ecological survey can help to identify these potentially valuable microclimates.
- The existence of a local waterway microclimate can influence the location of proposed waterway features such as culverts and bridges.

Rock outcrops

- Rock outcrops and areas of shallow soil depth can result in slope instabilities, and difficulties in the provision of underground services.
- The potential for slope instabilities following vegetation removal also needs to be investigated.

Steep slopes

- On steep slopes, the Erosion and Sediment Control Plan should focus on the provision of effective drainage and erosion control during the construction phase. The overuse of sediment fences and other similar sediment control measures on steep slopes can result in hydraulic failure of these devices and significant soil loss during heavy storms.
- It is important to ensure adequate space is provided at the base of steep slope for the placement of appropriate sediment control measures.
- The potential for slope instabilities and mass movement slope failures following the removal of deep-rooted vegetation must be investigated.
- As a general guide, the vertical-fall of an exposed (i.e. no erosion control) slope should not exceed three (3) metres during the construction phase.
- As a general guide, the final site layout should not allow vegetated slopes to exceed a vertical fall of ten (10) metres between cross drainage systems unless supported by appropriate geotechnical and hydraulic advice.
- Soil disturbance on steep slopes can be reduced by avoiding the use of “slab-on-ground” construction.

Waterways and wetlands

- Existing bank erosion problems need to be investigated and stabilised (wherever reasonable and practicable) as part of the land development.
- Essential riparian zones need to be identified and protected from disturbance.
- Where necessary, the protected waterway corridor may need to be expanded to allow for natural or induced (through urbanisation) channel erosion/expansion or stream migration.
- Avoid placing structures within 15 metres of the crest of a watercourse bank. In the absence of regulatory requirements, structures should generally not be located within the zone defined by a 3:1(H:V) gradient from the toe of a watercourse bank unless justified by appropriate geotechnical and hydraulic advice.
- Wetlands normally have significant environmental values that need to be protected by excluding them from the development area, and protecting them from sediment inflow, especially coarse sediment, during the construction process.

3.4.3 Water limitations

The long-term success of many erosion, sedimentation and pollution control measures can depend on a reliable supply of suitable water. Water, either in the form of local stormwater runoff, on-site dam water, town water, or watercourse discharge, may be required to maintain the performance of permanent urban features such as:

- wetlands, lakes, dams and retention basins;
- water pollution control traps/ponds.

As well as temporary erosion and sediment control measures such as:

- dust control measures; and
- revegetation works.

An assessment must be made of the expected seasonal water quality, quantity and supply cost. Where appropriate, *Sediment Basins* may need to be operated as temporary water supply dams for dust control and plant watering.

3.4.4 Vegetation limitations

Vegetation retention is generally governed by local or state government controls. Thus, local vegetation protection regulations and associated maps need to be consulted. The protection or enhancement of vegetative cover can significantly reduce short and long-term erosion problems.

The following general criteria should be considered:

(i) Retain or rehabilitate critical areas—such as watercourses, floodplains, steep slopes and wetlands—with a desirable natural vegetation cover. Riparian zones provide essential habitat, bank stability and shading of watercourses, while floodplain trees may be essential in the control of waterlogging. Deep-rooted trees are essential for the stabilisation of steep slopes.

(ii) Select trees to be preserved before locating roads, buildings, or other structures.

(iii) Locate roadways, construction storage areas, and parking bays away from the “drip zone” of valuable/protected trees.

(iv) Avoid excavating, traversing, or filling within the drip zone of valuable tree stands.

(v) Minimise trenching within the drip zone of valuable tree stands. Ideally place several utilities in the same trench.

(vi) Where feasible, roadways should follow natural contours to minimise cutting and filling in the vicinity of critical tree habitats.

(vii) Identify protected trees and tree groups within the Erosion and Sediment Control Plan.

(viii) On slopes steeper than 10%, appropriate consideration must be given to the maximum retention of existing groundcover vegetation.

(ix) On slopes steeper than 20%, appropriate consideration must also be given to the retention of deep-rooted vegetation such as trees.

Further discussion on the vegetation limitations and planting requirements for extreme site conditions can be found in Appendix C – *Soils and revegetation*.

3.4.5 Ecological limitations

Ecological considerations may limit the type of erosion and sediment control measures applied to a site. Examples include the following:

(i) The use of *Erosion Control Mats* or *Blankets* containing plastic anchoring or reinforcing mesh must be avoided in and around bushland areas where there is the risk of birds or ground-dwelling reptiles becoming entangled in the mesh.

(ii) Instream cofferdams and sediment traps must not be installed within streams during periods of fish migration unless specific approval is obtained from the appropriate state fisheries authority. Similarly, fish passage requirements may require all instream construction processes to occur in stages so that flow down the stream is not disrupted.

3.5 Soil data

Appropriate soil data is necessary to:

(i) assess the site's erosion risk;

(ii) identify the existence of potential soil problems such as unstable, dispersive or acid sulfate soils;

(iii) assist in the selection, design and operation of various drainage, erosion and sediment control measures;

(iv) assist in the design of site stabilisation works including site revegetation;

(v) identify necessary soil amendments to facilitate site revegetation.

3.5.1 Site description

Specific details of the site need to be recorded at the time of investigation, these details include:

(i) layout of property, including address and real property description, site boundaries and north point;

(ii) locations of boreholes and prominent site features, (e.g. large trees, adjacent drains, and retaining walls);

(iii) direction and grade of slopes, within and leading onto and off the site;

(iv) vegetation coverage—includes ground covers, shrubbery and larger trees—if possible with plant species, where abundant.

3.5.2 Soil sampling

The intensity of soil sampling is dependent on the depth and area of the proposed land disturbance. Most assessments of soil erosion potential will require sufficient sampling to create a simple three-dimensional model of the site. The need for soil testing will also depend on the adequacy of existing soil data and mapping.

The recommended soil sampling requirements may be determined through the following steps:

Step 1 Determine the required Assessment Level for the proposed development from Table 3.2.

Step 2 Determine the density of test pits or boreholes for the site in accordance with Table 3.3.

Step 3 Undertake soil sampling in accordance with Section 3.5.3.

Step 4 Undertake soil testing and analysis in accordance with Section 3.5.4.

Step 5 Report the results of the site geotechnical investigation in accordance with Section 3.5.6.

Table 3.2 – Required level of site assessment

Required assessment level	Site characteristics [1]
Assessment level 1	Existing site data indicates an Emerson Class 1 or 2
Assessment level 2	Existing site data indicates an Emerson Class 3, 4 or 5
Assessment level 3	Existing site data indicates an Emerson Class 6
Assessment level 4	Existing site data indicates an Emerson Class of 7 or 8; or a Unified Soil Classification System (USCS) Group of GW, GP, GM or GC

Note: [1] Existing site data may be obtained from general soil maps, local government soil maps, erosion hazard maps, or preliminary soil testing. If existing site data is inadequate, then assume an Assessment Level 1. If soil analysis later indicates that a higher assessment level should have been performed, then the regulatory authority may require additional boreholes and testing to satisfy this higher standard.

Table 3.3 – Sample borehole frequencies [1]

Area of site disturbance	Number of Boreholes (Level 1 Assessment)	Number of Boreholes (Level 2, 3 & 4 Assessments)
< 1000 m^2	No testing generally required	No testing generally required
Up to ½ ha	4 holes	2 holes
Up to 1 ha	4 holes	3 holes
1-2 ha	6 holes	4 holes
2-3 ha	8 holes	6 holes
3-4 ha	10 holes	8 holes
> 4 ha	5 holes per 2 ha	2 holes per ha

Note: [1] More linearly concentrated sampling will be required along proposed “linear excavations” and construction works, such as canals, the shores of water bodies, drainage channels, road embankments and underground services. Boreholes for such projects should be spaced at 50 to 75 m intervals along the entire length of the disturbance. A staggered pattern should be adopted if the disturbance width is greater than 10 m.

3.5.3 Sampling requirements

Best practice borehole sampling and recording includes to following:

1. Boreholes drilled to at least 0.8 m deep, (deeper if any fill material is encountered on the surface to penetrate a 0.8 m deep “natural profile”); or to 0.5 m below anticipated excavation depths, which ever is the deeper.
2. Recording the location of each borehole using reference to the Australian Metric Grid or Latitude and Longitude, the existing surface level (AHD) and the expected accuracy (i.e. X metres) of the GPS or survey equipment used. Investigations for smaller projects may derive sufficient location information and contour data from subdivisional survey plans where available.
3. Recording the depths of soil layers and descriptions using the nomenclature of the Australian Standard AS1726 “Geotechnical site investigations” for all soil types encountered. Particular attention should be paid to the description of soil consistency and structure. Auger refusal on shallow rock, shallow water tables, and the presence of fill are to be noted, if encountered.
4. Starting from the existing soil surface, disturbed samples representing the following soil horizons are to be collected from each borehole or test pit:
   (i) lower topsoil (i.e. upper soil layer directly beneath grass root mat—generally the A2 and/or A3-Horizons);
   (ii) upper and lower subsoils (i.e. B-Horizons) if different soil types are identified in the subsoil profile;
   (iii) weathered parent rock, if encountered within 1m of the expected finished surface level (generally the C-Horizon).
5. Unless otherwise stated by a geotechnical specialist, sample sizes to be about 3 kg for gravels, and 0.5 kg for other finer grained soils (sands, silts & clays).
6. Sampling to occur of any fill material encountered along with the naturally occurring soils.

3.5.4 Soil testing

The chemical and physical analysis of both topsoils and subsoils is provided in Section C9 of Appendix C – *Soils and revegetation*.

Soil sampling:

- must be representative of the soil unit to be tested;
- must consist of a composite of several samples taken from the land unit.

The type and number of soil tests required to enable assessment of the erosion and dispersion potential of a site are listed in Table 3.4. If there are fill materials of external origin on the site, then this material should be tested as a separate exercise using Assessment Level 1 testing requirements.

Table 3.4a – Site assessment test requirements

Required Testing Level 1 Assessment	Number of Tests
Emerson class number (AS1289 – 3.8.1)	Determined on representative topsoil and subsoil samples—minimum 1 test from topsoil and subsoil horizon per 2 boreholes (i.e. 8 tests for 8 boreholes).
An accurate visual "soil classification" by a suitably experienced person (AS1726)	To be undertaken on each sample.
Electrical conductivity & pH [2] (AS1289 – 4.3.1)	To be determined on a representative upper topsoil sample (i.e. for revegetation assessment) and subsoil sample, (minimum 2 tests for EC and pH per site).
Particle size distribution (AS1289 – 3.6.1)	To be determined on representative topsoil and subsoil samples, (i.e. 1 topsoil and 1 subsoil sample for each different soil profile encountered—minimum 2 tests per site).
Particle size distribution (fine) (AS1289 – 3.6.3)	Minimum of 1 test for each different soil profile encountered per site.
Dispersion index (AS1289 – 3.8.2)	To be determined on samples returning an Emerson class number of 1 or 2, (whichever sample is most dispersive)—minimum of 1 test for each different soil profile encountered per site.

Table 3.4b – Site assessment test requirements

Required Testing Level 2 Assessment	Number of Tests
Emerson class number (AS1289 – 3.8.1)	Determined on representative topsoil and subsoil samples, (minimum 1 test from topsoil & subsoil horizon for each different soil profile encountered). For consistent profiles at least 4 tests should be undertaken, on soil from 2 different locations (i.e. minimum of 4 per site).
An accurate visual "soil classification" by a suitably experienced person (AS1726)	To be undertaken on each sample.
Electrical conductivity and pH [2] (AS1289 – 4.3.1)	To be determined on a representative upper topsoil sample (i.e. for revegetation assessment) and subsoil sample, (minimum 2 tests per site).
Particle size distribution (AS1289 – 3.6.1)	To be determined on representative topsoil and subsoil samples, (i.e. 1 topsoil and 1 subsoil sample for each different soil profile encountered—minimum 2 tests per site).
Particle size distribution (fine) (AS1289 – 3.6.3)	Minimum of 1 test for each different soil profile encountered per site.
Dispersion index (AS1289 – 3.8.2)	To be determined on any sample returning an Emerson class number of 1 or 2, (whichever sample is most dispersive)—minimum of 1 test for each different soil profile encountered per site.

Table 3.4c – Site assessment test requirements

Required Testing Level 3 Assessment	Number of Tests
An accurate visual "soil classification" by a suitably experienced person (AS1726)	To be undertaken on each sample.
Electrical conductivity [1] & pH [2] (AS1289 – 4.3.1)	To be determined on a representative upper topsoil sample (i.e. for revegetation assessment) and a subsoil sample, (minimum 2 tests for EC and pH per site).
Particle size distribution (AS1289 – 3.6.1)	To be determined on representative subsoil samples, (i.e. 1 test for each different soil profile encountered—minimum 1 tests per site).
Particle size distribution (AS1289 3.6.3) fine – hydrometer Note: d_{30} values should be calculated or the particle size distributions reported graphically.	To be determined on subsoil samples, (1 test for each distinctly different soil profile encountered—minimum 1 per site.
Where soils are found to be "fine grained", Atterberg limits should be determined in accordance with AS 1289 – 3.3 test methods.	To be undertaken on "fine grained" soils to determine whether or not the material is of high plasticity (i.e. may resist erosion).

Notes for Tables 3.4(a), (b) & (c):

[1] The electrical conductivity (EC) of a soil should be carried out using a 1:2.5 soil to water suspension, and recorded in mS/cm, with an analytical instrument of suitable accuracy.

[2] Soil pH must be reported with its relevant soil to extractor ratio e.g. 1:1, 1:2 or 1:5, and the extractor, e.g. water, sodium chloride or potassium chloride. The most common being a 1:5 soil:water ratio.

If Emerson class of 7 or 8, or a Unified Soil Classification System (USCS) Group of GW, GP, GM or GC, (i.e. Assessment Level 4) then additional soil sampling for the determination of erosion and dispersion potential may not be required. In such cases it must be demonstrated that the previous site geotechnical investigations were undertaken to an extent consistent with the requirements of Section 3.5. Routine topsoil and subsoil analysis, as listed above, should still be performed (if existing data is not available) to assist in determining soil adjustments for revegetation.

3.5.5 Interpretation of test results

Hazelton & Murphy (2007) represents a useful publication for the interpretation of soil test results.

A. Dispersion potential

Determination of the dispersion potential in either topsoil or subsoil is based on how much dispersive material is present in the soil, and how dispersive it is. An Emerson class number of 1 or 2 is indicative of highly dispersive soils; however, if the majority of the soil consists of sand or fine gravel which is inert, then the soil may not represent such a high dispersion risk.

It should also be noted that the Emerson class number may not be a good indicator of the erosion potential of soils that are both sodic and saline. In such cases, the dispersion potential and erosion class must be based on soil chemistry such as the exchangeable sodium percentage (ESP).

Results of the dispersion index (DI) test (AS 1289 – 3.8.2), undertaken on the most dispersive soils (i.e. the lowest Emerson class number). Soils are considered dispersive if:

- the exchangeable sodium percentage (ESP) exceeds 6%; or
- the combined percentage of clay (< 0.002 mm) plus half the percentage of silt (0.002–0.02 mm), expressed as a decimal fraction, then multiplied by the dispersion index (DI); is greater than 10%.

Materials used in the construction of sediment basins should not have an Emerson class number of 3 or less (i.e. dispersive soils cannot be used to construct *Sediment Basins*).

B. Erosion potential

Sites classified into Assessment Levels 1 and 2 are considered to have a high to very high erosion potential. This is usually because of the presence of moderate or steeper slopes (i.e. > 5 – 10%), and/ or readily erodible soil profiles. Soils with relatively high silt and fine sand fractions are most susceptible to erosion, while very fine grained, high plasticity clay soils are least susceptible.

Laboratory test data is required for the following purposes:

- To determine if soils present on the site are predominantly fine or coarse grained, (i.e. fine grained soils contain 33% by weight finer than 0.02 mm); and
- To determine the d_{30} particle size (i.e. the particle size of which 30% by weight is smaller), for use in design of a Type C sediment basin, in areas where the soil has a uniform, coarse grain size.

There is a much higher risk of erosion occurring on steep slopes. Any site containing slopes of 20% or steeper (5H:1V), should be considered as having a high erosion potential, unless consisting almost entirely of slightly weathered or fresh rock outcrop, with negligible soil profile development. It is noted that exposed highly weathered rock can be a significant source of sediment. Erosion will also be greater where weathered/softer rock (e.g. some sandstone) contains high levels of exchangeable Na or Mg, due to dispersion.

Relatively level sites with high soil erosion-potential classifications may not constitute a significant soil loss rating with respect to coarse sediment if they do not contain slopes steeper than 3%, (about 33H:1V); however, high turbidity levels can still occur. In such cases, the soil's dispersion potential along with other site/proposal characteristics (e.g. exposed site area, duration of works, time of year for construction) must be taken into account to determine the overall erosion risk of the development proposal. Further discussion on the management of level sites is provided in principle 6.7 of Chapter 2 – *Principles of erosion and sediment control*.

Sites containing intermediate slope gradients of 3% to 20% should be assessed using a combination of slope gradient and soil erosion factors. Consideration should also be given to the area of soil disturbance, whether or not shallow rock is present on the site, the proposed length of site disturbance and other relevant environmental influences.

C. Topsoil electro-chemistry

Dispersive clay soils often contain significant levels of chemically exchangeable sodium (i.e. ESP >6%). If however, they are also saline (i.e. EC of about 0.5 mS/cm or greater) or contain natural flocculants such as calcite or gypsum, then they will usually resist dispersion. Simple laboratory tests such as pH, EC & total dissolved salts (TDS) derived from EC, can be useful indicators for the assessment of dispersive soils.

Saline soils with TDS greater than 2000 mg/kg may not be suitable for growing certain salt intolerant species of plants. It is also useful to know whether a soil is strongly acidic (i.e. pH less than 5.0), as acidity, in addition to salinity may influence the choice of plant species to be used for revegetation of a site, which in itself is an important erosion control measure. It should be noted that if topsoil is to be imported onto the site specifically for grass stabilisation, then its pH should be determined, to ensure suitability for planned revegetation species.

Where soil characteristics such as salinity, acid sulfate, or high acidity are encountered, specialist input into construction phase water quality management, soil ameliorants and plant species selection should be sought. For further discussion refer to Appendix C – *Soils and revegetation*.

3.5.6 Reporting

Assessment reports should include details of the applicant and consultant (e.g. name and contact details), and site details including Lot and RP number and site address. Reports should include accurate bore logs and copies of all laboratory test results (attached as appendices) and a detailed site plan showing:

(i) location of site / property boundaries;
(ii) accurate location(s) of boreholes (including RL) and proposed excavations;
(iii) site contours and drainage paths etc;
(iv) details of indications of erosion on the site, or on adjacent properties, existing vegetation and proposed site vegetation coverage;
(v) location of any exposed rock faces / batters on or adjoining the site;
(vi) site drainage conditions and existing, and final drainage paths;
(vii) any other relevant site features, (existing structures, pavements etc.); and
(viii) map scale (maximum 1:2000 but suiting site area/features).

Recommendations based on the assessment undertaken and the requirements of the local government should include:

- any specific soil characteristic constraints (e.g. fine grained and/or dispersive soils, soil acidity etc.) that will control/influence the required ESC design/management strategies for the site;
- suggestion of alternative construction procedures (where appropriate) such as prohibiting unsealed driveways or minimising/staging the removal of existing vegetation cover, to reduce the impacts of soil exposure on erosion; and
- in the case of very high erosion/dispersion risks, whether the development should proceed as proposed (e.g. a proposal to clear very large areas of land overlaying highly dispersive subsoils in one stage/operation).

3.6 Site planning checklist

The attached checklist has been provided to assist project planners identify relevant environmental site constraints early in the site planning process. Early identification of such issues allows for more cost-effective design solutions to be developed that achieve the required environmental outcomes throughout the construction process. The checklist is not exhaustive and planners are advised to make their own review of site conditions.

Site Planning Checklist

LOCATION . . . .

PLANNING OFFICER . . . . **DATE** . . . .

SIGNATURE . . . .

Legend: ✓ OK ✗ Not OK N/A Not applicable

Part A: Data collection and review

Item	Consideration	Assessment
1	*Erosion Risk Mapping* or *Erosion Hazard Assessment* completed on the site.	. . . .
2	Critical on-site and off-site environmental values identified.	. . . .
3	Potential impacts of the development on environmental values identified.	. . . .
4	Potential site constraints with respect to soils, topography, water supply and vegetation have been identified.	. . . .
5	Appropriate soil testing and soil mapping has been completed.	. . . .
6	Site contour map prepared and provided with application.	. . . .
7	All on-site and receiving water identified, including creeks, ponds, lakes, wetlands and waterways.	. . . .
8	Fish passage requirements of affected waterways identified.	. . . .
9	Vegetation mapping completed on the site.	. . . .
10	Vegetation subject to statutory protection identified.	. . . .

Part B: Site layout

Item	Consideration	Assessment
11	Site layout and construction footprint has been appropriately integrated into the site's topography, soil types, protected vegetation, environmental values and constraints.	. . . .
12	Site layout does not interfere with the construction and operation of the major sediment traps.	. . . .
13	Site layout provides sufficient useable land for stockpiling construction materials (e.g. topsoil, spoil, mulch).	. . . .

Part C: Environmental considerations

Item	Consideration	Assessment
14	Areas of potential acid sulfate soils identified.	....
15	Areas of highly dispersive soils identified.	....
16	Active coastal erosion zone and/or coastal protection zone identified.	....
17	Areas likely to be subject to wave action (e.g. trafficable waterways, lake shores, coastal zones) identified.	....
18	Protected waterway buffer zones identified.	....
19	Potential drainage problem areas identified.	....
20	Existing watercourse and gully erosion identified.	....
21	Potential flood-prone land identified.	....
22	Areas subject to potential mass movement (e.g. landslipe) identified.	....
23	Critical environmental habitats (e.g. habitats of threatened species) identified.	....

Part D: Consideration of ESC issues

Item	Consideration	Assessment
24	Appropriate procedures have been established to ensure all erosion and sediment control and associated environmental requirements are suitably costed and funded.	....
25	Location and size of major sediment traps (e.g. *Sediment Basins*) has been identified and sufficient useable land made available for their construction and operation.	....
26	Location and operation of major construction site sediment traps takes account of expected changes in site topography and overland flow paths (e.g. sediment traps are able to capture and treat all necessary sediment-laden runoff throughout the full construction phase.	....
27	Site layout does not interfere with the construction and operation of the major sediment traps.	....
28	Site layout allows “clean” up-slope stormwater to be temporarily diverted around construction activities.	....

4. Design standards and technique selection

This chapter outlines best practice (2008) selection and application of erosion and sediment control (ESC) measures. Though not entirely prescriptive, regulatory authorities may require ESC measures to be applied in accordance with the following procedures.

The application of best practice erosion and sediment control does not mean that the following standards must be rigorously satisfied; however, working outside these standards requires expert justification if the applicant wishes to claim best practice erosion and sediment control is being achieved. Specifically it must be demonstrated that the "objective" of the erosion and sediment control measures can be achieved.

4.1 Introduction

The application of best practice erosion and sediment control is based upon the appropriate integration of three groups of control measures:

- Drainage control measures
- Erosion control measures (including revegetation measures)
- Sediment control measures

Wherever reasonable and practicable, control measures from all three groups must be appropriately integrated into each stage of construction. Default design standards for each of the three groups of control measures are presented within this chapter.

The default Drainage Design Standard (Section 4.3.1) is primarily based on the selection of an appropriate average recurrence interval (ARI) of the design storm.

The default Erosion Control Standard (Section 4.4) is preferably based on either the monthly rainfall erosivity, or average monthly rainfall; however, the option exists for assessment based on estimated rate of soil loss.

The default Sediment Control Standard (Section 4.5.1) is based on the estimated annual or monthly soil loss rate; however, an option is provided for assessment based on the monthly rainfall erosivity, or average monthly rainfall depth.

The default Sediment Control Standard for post-storm de-watering activities (including the de-watering of *Sediment Basins*) is provided in Section 4.5.9.

In cases where the site conditions make it impracticable to apply the desired level of sediment control, then a higher level of drainage and/or erosion control will normally be required to achieve the desired level of environmental protection. Similarly, in cases where site conditions make it impracticable to apply the desired level of drainage or erosion control, then a higher level of sediment control will normally be required.

The three groups of control measures need to be appropriately integrated such that potential failures in one system are adequately compensated by other supportive practices.

4.2 Selection criteria

In situations where more than one control measure is considered applicable, then the selection of the most appropriate control measure is best achieved through consideration of the following criteria:

Applicability	Applicability to the full range of site conditions considered reasonably possible during the construction period.
Availability	Availability of materials from local suppliers and delivery time frame.
Compatibility	Anticipated community acceptance and potential environmental impact.
Cost-Effectiveness	Benefit/cost ratio based on performance history (if available) and expected purchase, installation and maintenance costs.
Durability	Ongoing structural integrity or durability during the required operational period. This includes having an acceptable ability to sustain the hydraulic and structural integrity under normal site conditions. For example, a sediment trapping system that is likely to experience ongoing performance-affecting damage due to vandalism or construction traffic, would have a lower performance ranking than a more durable system.
Feasibility	Technical capabilities of site personnel with regard to the appropriate installation and maintenance of the control measures, otherwise site-specific training or specialist installation teams will be required.
Performance	Ability to perform the required task and achieve the desired performance standard.

4.3 Drainage control measures

4.3.1 Drainage design standard

In the absence of specific local or state government requirements, Table 4.3.1 provides the recommended drainage design standard for temporary drainage works. Permanent drainage systems must be designed in accordance with the local stormwater drainage standard.

Table 4.3.1 – Drainage design standard for temporary drainage works

Drainage structure	Anticipated design life		
	< 12 months	**12–24 months**	**> 24 months**
Temporary drainage structures [1] Queensland, Northern Territory, and northern Western Australia	1 in 2 year	1 in 5 year	1 in 10 year
Temporary drainage structures [1] New South Wales, Victoria, Tasmania, South Australia and southern Western Australia	1 in 5 year	1 in 10 year	1 in 10 year
Temporary drainage structures (e.g. *Catch Drain, Flow Diversion Bank*) located immediately up-slope of an occupied property that would be adversely affected by the failure or overtopping of the structure. [1], [2]	1 in 10 year	1 in 10 year	1 in 10 year
Temporary culvert crossing	Minimum 1 in 1 year ARI hydraulic capacity wherever reasonable and practicable.		

Notes: [1] Design capacity excludes minimum 150 mm freeboard.

[2] Design flow rate based on up-slope drainage structures operating in accordance with their design capacity excluding freeboard, i.e. any constructed freeboard is assumed to have been washed away or otherwise deactivated.

4.3.2 Flow diversion around soil disturbances and stockpiles

The diversion of up-slope stormwater runoff is normally required during those periods when rainfall is possible and the up-slope catchment area exceeds 1500 m^2. Flow diversion, however, is always desirable if it can minimise the quantity of sediment-laden water pumped or otherwise extracted from excavations, trenches, etc. where such water could cause or contribute to environmental harm.

4.3.3 Spacing of lateral drains down long continuous slopes

Long unstable slopes must be subdivided into manageable drainage areas to prevent the formation of rill erosion. *Catch Drains* or *Flow Diversion Banks* should be placed at regular intervals down the slope to collect and divert surface runoff to a stable outlet.

Table 4.3.2 provides the recommended **maximum** spacing of drainage systems down long exposed, non-vegetated or recently seeded slopes.

Table 4.3.2 – Recommended maximum drain, bank and bench spacing on non-vegetated slopes [1]

Batter slope			Horizontal spacing (m)	Vertical spacing (m)
Percentage	Degrees	(H):(V)		
1%	0.57	100:1	80 [2]	0.8 [2]
2%	1.15	50:1	60	1.2
4%	2.29	25:1	40	1.6
6%	3.43	16.7:1	32	1.9
8%	4.57	12.5:1	28	2.2
10%	5.71	10:1	25	2.5
12%	6.84	8.33:1	22	2.6
15%	8.53	6.67:1	19	2.9
20%	11.3	5:1	16	3.2
25%	14.0	4:1	14	3.5
30%	16.7	3.33:1	12	3.5
35%	19.3	2.86:1	10	3.5
40%	21.8	2.5:1	9	3.5
50%	26.6	2:1	6	3.0

Notes: [1] Maximum recommended spacings based on medium rainfall erosivity and low to moderately erodible soil. In the higher rainfall regions of northern Australia, or in areas of poor quality soil, the spacing of these *Catch Drains* or *Flow Diversion Banks* may need to be reduced. In NSW, refer to Charman and Murphy (2007) or Landcom (2004) for drain spacing.

[2] Maximum recommended spacing of lateral drains is 80m.

The maximum horizontal spacing of drains presented in Table 4.3.2 for land slopes steeper than 1% may be represented by Equation 4.1.

$$\text{Maximum } \textbf{horizontal} \text{ spacing (m)} = 100/(\text{batter slope (\%)})^{0.64} \qquad (4.1)$$

Table 4.3.2 does not apply if the slope is protected with suitable erosion control measures such as *Erosion Control Blankets, Compost Blanket, Bonded Fibre Matrix* or a *Hydromulch* stabilised with a non re-wettable tackifier. Manufacturer/distributor advice should be obtained on the maximum recommended slope lengths for the various erosion control/surface stabilisation products. In the absence of such advice, the adoption of drain spacings should be based on Table 4.3.2.

In NSW, more detailed site-specific information on drain/bank spacing is provided in Charman and Murphy (2007) and Landcom (2004). Charman and Murphy (2007) indicates that the horizontal spacing of drains down long slopes proportional to the inverse of the square-root of the batter slope (Equation 4.2), and that the bank spacing factor (K) can be adjusted for soil erodibility based on Table 4.3.3.

$$HI = K/S^{0.5} \quad (4.2)$$

where:

HI = horizontal spacing of drains/banks [m]

K = drain/bank spacing factor (variable based on rainfall erosivity)

S = land slope (**not** the drain slope) [%]

Table 4.3.3 – Adjustment to drain/bank spacing factor (K) for soil erodibility

Erodibility of surface soil down slope	Adjustment factor
Low	1.3
Moderate	1.15
High	1.0
Very high	0.9
Extreme	0.8

On slopes consisting of soils with a very high to extreme erodibility, the recommended maximum horizontal spacing of *Catch Drains* and *Flow Diversion Banks* presented in Table 4.3.2 should be adjusted using the adjustment factors presented in Table 4.3.3.

The spacing of permanent benching down long, steep, grassed slopes should be based on the relevant road design manual. In the absence of suitable information, Table 4.3.4 provides the recommended **maximum** spacing of benching down well grassed, low to moderately erodible soil slopes. In the high rainfall areas of northern Australia the spacing of benched may need to be less than indicated in Table 4.3.4.

Table 4.3.4 – Recommended maximum drain, bank and bench spacing on vegetated slopes [1]

Batter slope			Horizontal spacing (m)	Vertical spacing (m)
Percentage	**Degrees**	**(H):(V)**		
<10%	5.71	10:1	Site specific	Site specific
12%	6.84	8.33:1	100	12
15%	8.53	6.67:1	80	12
20%	11.3	5:1	55	11
25%	14.0	4:1	40	10
30%	16.7	3.33:1	30	9
>36%	> 19.8	2.78:1	Site specific	Site specific

Note: [1] Maximum recommended spacings based on medium rainfall intensity, a low to moderately erodible soil, and a good, even grass cover. In the higher rainfall regions of northern Australia, or in areas of either poor soil quality, or poor grass cover, the spacing of these *Catch Drains* or *Flow Diversion Banks* may need to be reduced.

The maximum horizontal spacing of lateral drains and benches on well-vegetated slopes may be represented by Equation 4.3.

$$\text{Horizontal spacing [m]} = 2700/(\text{batter slope (\%)})^{1.3} \quad (4.3)$$

The maximum spacing of drains and benching on vegetated slopes (Table 4.3.4) has primarily been derived from guidelines prepared for mine operators and Main Road authorities. The maximum spacing of *Catch Drains*, *Flow Diversion Banks* and benches on non-vegetated slopes, (Table 4.3.2) has primarily been derived from various guidelines prepared for the agricultural industry.

4.3.4 Low gradient drainage techniques

The recommended usage of various low-gradient drainage control techniques is provided in Table 4.3.5.

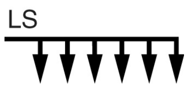
Table 4.3.5 – Low-gradient drainage techniques

Technique	Code	Symbol	Typical use
Catch Drain	CD	→ CD →	• The collection and diversion of sheet flow across a slope or around soil disturbances. • Best used in non-dispersive soils, otherwise the drain must be lined with non-dispersive soil (minimum 100 mm thick) prior to placement of a channel liner.
Compost Berm	CB	▬ CB ▬	• Primarily used as a sediment filter berm, but can be used as a *Flow Diversion Bank*. • Used when on-site land clearing produces significant quantities of organic matter.
Diversion Channel	DC	→ DC →	• Diversion of large concentrated flows. • Permanent flow diversion channels.
Flow Diversion Bank – earth, sandbags, etc.	DB	→ DB →	• Diversion of minor flows when in-situ subsoils are dispersive or otherwise highly erodible. • Flow diversion at the base of fill slopes. • Cross drainage on unsealed roads.
Straw Bale Flow Diversion Bank	SDB	→ SDB →	• Temporary (i.e. days, not weeks) diversion of flow in the event of imminent rainfall. • Short-term flow diversion up-slope of excavations and trenches.

4.3.5 Drainage down slopes

The recommended usage of drainage controls on steep slopes is provided in Table 4.3.6.

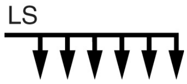
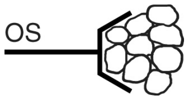
Table 4.3.6 – Steep-gradient flow diversion techniques

Technique	Code	Symbol	Typical use
Chute	CH	→ CH →	• Discharge of concentrated flows down steep slopes. • Control of flow into *Sediment Basins*. • Temporary drainage down the face of newly formed road embankments.
Level Spreader	LS		• Conversion of minor flows back to "sheet" flow. • Discharge of flows down grassed slopes. • Discharge of "sheet" flow into bushland.
Slope Drain	SD	→ SD →	• Discharge of minor flows down steep slopes. • Discharge of minor flows through adjacent properties. • Discharge of minor flows through bushland and other areas where it is essential to minimise disturbance to vegetation and soil.

4.3.6 Outlet structures for temporary drainage systems

Recommended usage of outlet structures for *Chutes* and *Slope Drains* is provided in Table 4.3.7.

Table 4.3.7 – Outlet structures

Technique	Code	Symbol	Typical use
Level Spreader	LS		• Used at the end of *Flow Diversion Banks* and *Catch Drains* to discharge **minor** concentrated flows down stable, grassed slopes. • Discharge of *Catch Drains* into bushland.
Outlet Structure	OS		• Used at the end of *Chutes* and *Slope Drains* to dissipate flow energy and control scour. • Used as a permanent energy dissipater on pipe and culvert outlets.

4.3.7 Velocity control structures

Wherever reasonable and practicable, drainage channels, whether temporary or permanent, should be designed and constructed at a gradient that limits the maximum flow velocity to a value not exceeding the maximum allowable flow velocity for the given surface material.

Excessive flow velocities can cause channel erosion, usually along the invert (bottom) of the drain. Such erosion is most prominent in newly formed or recently seeded drains.

The flow velocity can be reduced by either:

- reducing the depth of flow (i.e. increasing the width of the channel);
- reducing the bed slope;
- reducing the peak discharge (i.e. reducing the effective catchment area or diverting water away from the channel); or
- increasing the channel roughness.

The mathematical relationship that links flow velocity (V), channel roughness (Manning's n), the effective flow depth (hydraulic radius, R), and the bed slope (S) is represented by the Manning Equation (Equation 4.4):

$$V = (1/n)\, R^{2/3}\, S^{1/2} \qquad (4.4)$$

where:

V = Average flow velocity [m/s]

n = Manning's roughness coefficient [dimensionless]

This coefficient accounts not only for the effects of surface roughness, but also for the effects of minor channel irregularities.

R = hydraulic radius = A/P [m]

The hydraulic radius is equal to the cross-sectional area (A) of the flow divided by the wetted perimeter (P) of the flow.

A = Cross-sectional area of the flow [m^2]

P = The wetted perimeter is the length of the line of contact between the water and the channel measured at a cross section.

S = Slope of drain/channel bed [m/m]

If the channel width, depth or gradient cannot be altered, then there are two options for controlling invert erosion, either:

- reduce the flow velocity through the placement of *Check Dams*; or
- increase the effective scour resistance of the drain through the placement of a suitable channel liner such as rock or *Erosion Control Mats*.

Check Dams are most effective when used in channels with a gradient less than 10% (1 in 10). The recommended usage of various *Check Dams* is provided in Table 4.3.8.

Table 4.3.8 – Velocity control structures for channels and drains

Technique	Code	Symbol [1]	Typical use
Fibre Roll	FCD	⟶ FCD ⟶	• Used in wide, shallow drains where the logs can be successfully anchored down. • Used in locations where it is desirable to allow the log to integrate into the vegetation, such as vegetated channels. • Can also be used as a minor sediment trap.
Rock Check Dam	RCD	⟶ RCD ⟶	• Best used **only** in drains at least 500 mm deep, with a gradient less than 10%. • Should only be used in locations where it is known that they will be removed once a suitable grass cover has been established. • Can also be used as a minor sediment trap.
Recessed Rock Check Dam	RRC	⟶ RRC ⟶	• Used in wide, shallow, high velocity channels where *Sandbag Check Dams* would likely wash away. • These check dams are recessed into the soil to maintain maximum hydraulic capacity within the channel.
Sandbag Check Dam	SBC	⟶ SBC ⟶	• Typically used in drains less than 500 mm deep, with a gradient less than 10%. • These check dams are typically small (in height) and therefore less likely to divert water out of the drain. • Can also be used as a minor sediment trap.
Triangular Ditch Check	TDC	⟶ TDC ⟶	• Commercially available, re-useable products. • Commonly used to stabilise wide, shallow table drains. • Used in drains with less than 10% gradient. • Can also be used as a minor sediment trap.

Note: [1] The *Check Dam* symbol is usually not used on plans; instead the use of *Check Dams* is normally specified within technical notes listed on the plans. A table may be included that provides details on the type of *Check Dam* used at specific locations within the site.

4.3.8 Selection of channel and chute linings

In steep channels it is usually more economical to line the channel or *Chute* with turf, rock or *Erosion Control Mats* instead of trying to reduce flow velocities down the slope. Table 4.3.9 provides guidance on the selection of appropriate *Chute* and channel linings.

The allowable flow velocities for various channel linings are provided in Tables A22 to A27 of Appendix A – *Hydraulics and hydrology*.

Table 4.3.9 – Chute and channel linings

Technique	Code	Symbol [1]	Typical use
Cellular Confinement System	CCS	→ (CCS) →	• Typically used to stabilise *Chutes* when the only local supply of rock consists on small rocks smaller than 200 mm diameter. • May be filled with small rocks and grassed to form a permanent, reinforced grass *Chute*. • Also used to form temporary construction access across dry, sandy bed streams.
Erosion Control Mat	ECM	→ (ECM) →	• Temporary or permanent scour protection of medium velocity drains. • Includes the use of *Erosion Control Mesh* made from jute or coir (temporary mat).
Geosynthetic lining	GEO	→ (GEO) →	• Heavy grade *filter cloth* can be used to form temporary drainage *Chutes* down steep batters. • Sheets of plastic have also been used to form short drainage *Chutes* down earth batters.
Grass lining	GC	→ (GC) →	• Permanent protection of low to medium velocity *Chutes* and channels.
Grass Pavers	GP	→ (GP) →	• Permanent, trafficable grassed surface. • An alternative to reinforced grass and TRMs.
Hard Armouring	HA	→ (HA) →	• Large variety of hard armouring systems including, corrugated sheet metal, grass pavers, reinforced concrete, and shotcrete.
Reinforced Grass	TRM	→ (TRM) →	• Refer to *Turf Reinforcement Mats*.
Rock Mattress	RM	→ (RM) →	• Suitable for temporary and permanent high velocity *Chutes* and spillways.
Rock lining	RR	→ (RR) →	• High velocity drainage channels. • Drainage chutes. • *Sediment Basin* spillways.
Turfing	T	→ (T) →	• Permanent lining of low velocity *Chutes*, *Catch Drains* and *Diversion Channels*.
Turf Reinforcement Mat	TRM	→ (TRM) →	• Permanent lining of high-velocity *Chutes*. • Permanent lining of grassed bywash spillways for dams and *Sediment Basins*.

Note: [1] Strict use of such symbols to describe the use of various channel linings within Erosion & Sediment Control Plans is not critical. It can be just as effective to include a Technical Note on the plan or provide a table specifying required channel linings.

4.3.9 Drainage controls on unsealed roads

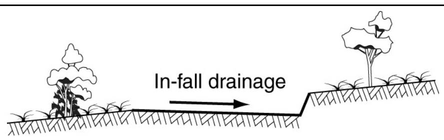
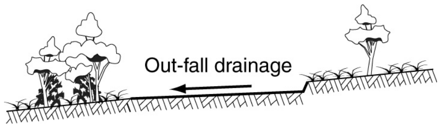
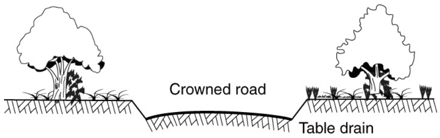
Wherever reasonable and practicable, allow stormwater to shed from unsealed construction access roads at regular intervals. This runoff should be discharged into a sediment trap and/or released as sheet flow via a *Level Spreader* (Table 4.3.10) into adjacent grassland or bushland.

Table 4.3.10 – Techniques for discharge of water as sheet flow

Technique	Code	Symbol	Typical use
Level Spreader	LS		• Used when it is desirable to convert minor concentrated flow back to "sheet" flow before releasing it down a stable grassed slope. • Used to discharge water from rural table drains into grassland or bushland.

Stormwater runoff (and run-on water) must be allowed to freely discharge from unsealed roads. Table 4.3.11 summarises the three forms of road drainage.

Table 4.3.11 – Stormwater drainage from unsealed access roads

Drainage type	Drainage type	Typical use
In-fall drainage		• Preferred when outer road embankment consists of poor or unstable soils.
Out-fall drainage		• Used only when it is suitable to discharge runoff as sheet flow.
Crowned		• Preferred for high volume permanent roads. • Roads constructed along a ridge.

Further discussion on the drainage of unsealed roads is provided in Section K4 of Appendix K – *Access tracks and trails*.

In situations where stormwater runoff from unsealed roads collects within table drains adjacent to the roadway, this water should ideally be discharged from the table drain at regular intervals. The drains that collect water from the table drain and direct it to a suitable disposal area are called "diversion channels".

In semi-tropical areas, the recommended spacing for diversion channel outlets along table drains is presented in Table 4.3.12.

Table 4.3.12 – Spacing of diversion channels on unsealed roads [1]

Table drain slope (%)	Horizontal spacing of diversion drains (m)
0 to 2%	120
Slope from 2+ to 4%	60
Slope from 4+ to 8%	30
>8%	15

Note [1] Suitable for semi-tropical areas

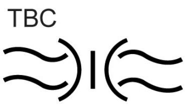
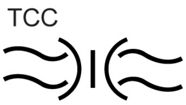
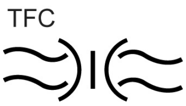
4.3.10 Temporary watercourse crossings

Disturbances to existing watercourses must be avoided, or at least minimised, wherever practical. Temporary watercourse crossings must be constructed and maintained in a manner that minimises harm to the watercourse and its habitat value. Where appropriate, consideration will need to be given to the requirements of fish passage along the stream during the construction phase.

The road approaches to all watercourse crossings must be appropriately stabilised and have appropriate flow diversions (i.e. cross banks) to prevent untreated stormwater runoff from entering into the stream. Wherever reasonable and practicable, any road runoff should be filtered through the surrounding grassland or bushland before it is allowed to enter the stream.

Table 4.3.13 contains recommendations on the selection of temporary watercourse crossings.

Table 4.3.13 – Usage of temporary watercourse crossings

Technique	Code	Symbol	Typical use
Bridge	TBC		• Used when it is important to maintain fish passage during the construction period. • Culvert bridging slabs may be used to “bridge” narrow streams.
Culvert	TCC		• Used on wide stream crossings. • Used when fish passage is not critical.
Ford	TFC		• Used on “dry” creek and river bed crossings when stream flow is not expected. • Used in shallow, intermittent streams that are expected to have negligible base flow during the construction period. • *Cellular Confinement Systems* can be used to stabilise dry, sandy bed crossings.

Temporary culvert crossings:

Unless the crossing is specifically designed for the expected hydrodynamic forces for the given location, then temporary culvert crossings should have sufficient hydraulic capacity to limit the head loss across the structure to a maximum of 300 mm at the point when overtopping first begins to occur.

Consideration of fish passage requirements:

Temporary culvert crossings that are likely to be operational during defined periods of fish migration should be designed in accordance with local fish passage requirements for permanent water crossings.

The desirable minimum flow area of **temporary** culvert crossings is 80% of the normal channel cross sectional area below the crest of the crossing if fish passage is required to be maintained. This design requirement, however, may be superseded by other local fish passage guidelines/standards.

4.4 Erosion control measures

Best practice erosion control requires appropriate measures to be employed as soon as reasonable and practicable to limit soil erosion and, in particular, to protect any and all exposed areas of soil from raindrop impact erosion.

Best practice land clearing, erosion control and site rehabilitation depends on the likelihood and intensity of expected wind or rainfall as presented in Table 4.4.7. If construction occurs during the dry season when rainfall is unlikely, then the required erosion protection can be significantly less than if construction occurs during the wet season.

Unlike the sediment control standard, which is related to the anticipated soil loss, the timing and degree of land stabilisation measures depends on the expected erosion risk and sensitivity of receiving waters to turbidity levels within site runoff. Regulatory authorities are encouraged to develop locally relevant risk assessment procedures that can guide or regulate the timing of land stabilisation activities.

In the absence of a locally adopted risk assessment procedure, the erosion control standard should be based on either the monthly rainfall erosivity (Table 4.4.1, default), or the average monthly rainfall depth (Table 4.4.2) as appropriate. Alternatively, the erosion control standard can be based on estimated rate of soil loss (Table 4.4.3).

Table 4.4.4 provides erosion risk ratings based on monthly erosivity and the erosion risk rating system presented in Table 4.4.1.

Table 4.4.1 – Erosion risk rating (default) based on monthly rainfall erosivity

Erosion risk rating	Average monthly erosivity (R-factor)
Very Low	0 to 60
Low	60+ to 100
Moderate	100+ to 285
High	285+ to 1500
Extreme	>1500

Table 4.4.2 – Erosion risk rating based on average monthly rainfall depth

Erosion risk rating	Average monthly rainfall depth (mm)
Very Low	0 to 30
Low	30+ to 45
Moderate	45+ to 100
High	100+ to 225
Extreme	>225

Table 4.4.3 – Erosion risk rating based on estimated soil loss rate

Erosion risk rating	Soil loss (t/ha/yr)
Very Low	0 to 150
Low	150+ to 225
Moderate	225+ to 500
High	500+ to 1500
Extreme	>1500

Table 4.4.4 – Erosion risk ratings based on monthly rainfall erosivity

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Queensland												
Weipa	H	H	H	M	VL	VL	VL	VL	VL	VL	M	H
Cairns	E	E	E	H	H	M	VL	L	M	M	H	E
Normanton	E	H	H	M	VL	VL	VL	VL	VL	VL	M	H
Tully	E	E	E	E	E	H	H	H	H	H	H	E
Townsville	E	E	E	H	M	L	VL	L	VL	M	H	H
Bowen	H	H	H	M	M	L	VL	VL	VL	VL	M	H
Mt Isa	H	M	M	VL	VL	VL	VL	VL	VL	VL	VL	M
Mackay	E	E	H	H	M	M	VL	VL	VL	M	M	H
Rockhampton	H	H	H	M	M	L	L	L	VL	M	M	H
Emerald	H	H	M	L	L	L	VL	VL	VL	L	M	H
Bundaberg	H	H	H	M	M	M	L	VL	VL	M	M	H
Gympie	H	H	H	M	M	M	L	VL	M	M	M	H
Roma	H	M	M	L	L	L	L	VL	VL	M	M	M
Brisbane	H	H	H	H	M	M	M	L	L	M	H	H
Toowoomba	H	H	M	M	M	L	L	VL	L	M	M	H
Southport	H	H	H	H	H	M	M	L	L	M	M	H
New South Wales/ACT												
Lismore	H	H	H	H	H	M	M	M	M	M	H	H
Taree	H	H	H	H	M	M	M	M	M	M	M	H
Newcastle	H	H	H	H	H	H	M	M	M	M	M	H
Bathurst	M	M	M	L	L	L	VL	L	L	M	M	M
Sydney	H	H	H	H	H	H	M	M	M	M	M	M
Bega	M	H	H	M	M	M	L	L	L	M	M	M
Albury	M	M	M	M	M	M	L	L	L	M	M	M
Canberra	M	M	M	M	L	VL	VL	L	L	M	M	M
Victoria												
Mildura	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
Bendigo	M	M	L	L	L	L	L	L	L	M	L	L
Sale	M	M	M	L	L	L	VL	VL	L	M	M	M
Melbourne	M	M	M	M	L	VL	VL	VL	L	M	M	M
Geelong	L	M	M	L	L	L	VL	VL	L	L	M	M
Ballarat	M	M	L	L	L	L	L	L	L	M	M	M
Tasmania												
Launceston	L	M	L	M	L	L	L	L	L	L	L	M
Hobart	M	L	L	M	L	L	VL	L	L	M	L	M
South Australia												
Port Augusta	VL	L	VL	VL	VL	VL	VL	VL	VL	L	VL	VL
Port Lincoln	VL	VL	VL	L	L	L	L	L	L	VL	VL	VL
Adelaide	VL	VL	VL	L	L	L	VL	VL	VL	VL	VL	VL
Mt Gambier	L	L	L	L	M	M	M	M	L	L	L	L
Western Australia												
Broome	H	H	H	M	L	VL	VL	VL	VL	VL	VL	M
Geraldton	L	M	M	M	H	H	H	H	M	M	L	VL
Perth	VL	L	L	M	H	H	H	H	M	M	L	VL
Albany	L	VL	L	M	M	M	M	M	M	M	L	L
Northern Territory												
Darwin	H	H	H	M	VL	VL	VL	VL	VL	M	M	H
Katherine	H	H	H	L	VL	VL	VL	VL	VL	L	M	H

Key: E = Extreme, H = High, M = Moderate, L = Low, VL = Very low erosion risk

Table 4.4.5 provides erosion risk ratings for various Queensland towns based on average monthly rainfall using the rating system presented in Table 4.4.2.

Table 4.4.5 – Erosion risk based on average monthly rainfall depth

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooktown	E	E	E	H	M	M	VL	VL	VL	VL	M	H
Port Douglas	E	E	E	H	M	M	VL	VL	L	L	M	H
Kuranda	E	E	E	E	H	M	M	L	L	L	M	H
Normanton	E	E	H	VL	VL	VL	VL	VL	VL	VL	L	H
Burketown	H	H	H	VL	VL	VL	VL	VL	VL	VL	L	H
Cardwell	E	E	E	H	M	L	L	VL	L	M	H	H
Lucinda	E	E	E	H	H	M	M	M	L	L	M	H
Halifax	E	E	E	H	H	M	M	L	L	M	M	H
Ingham	E	E	E	H	H	M	L	L	L	L	M	H
Ayr	E	E	H	M	L	L	VL	VL	VL	VL	L	H
Bowen	E	E	H	M	L	L	VL	VL	VL	VL	L	H
Charters T/s	H	H	H	L	VL	VL	VL	VL	VL	VL	L	M
Proserpine	E	E	E	H	M	M	L	L	L	L	M	H
Cloncurry	H	H	M	VL	VL	VL	VL	VL	VL	VL	VL	M
Marlborough	H	H	H	M	L	M	L	VL	VL	L	M	H
Yeppoon	E	E	H	H	M	M	M	L	L	M	M	H
Emerald	H	M	M	L	L	L	VL	VL	VL	L	M	M
Barcaldine	M	M	M	L	L	VL	VL	VL	VL	VL	L	M
Bundaberg	H	H	H	M	M	M	M	L	L	M	M	H
Maryborough	H	H	H	M	M	M	M	L	L	M	M	H
Gympie	H	H	H	M	M	M	M	L	M	M	M	H
Charleville	M	M	M	L	L	VL	VL	VL	VL	L	L	M
Eumundi	E	E	E	H	H	M	M	M	M	M	H	H
Mitchell	M	M	M	L	L	L	L	VL	VL	L	M	M
Kingaroy	H	M	M	M	L	L	L	VL	L	M	M	H
Roma	M	M	M	L	L	L	L	VL	VL	M	M	M
Nambour	E	E	E	H	H	M	M	M	M	M	H	H
Miles	M	M	M	L	L	L	L	VL	L	M	M	M
Landsborough	E	E	E	H	H	M	M	M	M	M	H	H
Woodford	H	H	H	H	M	M	M	L	M	M	M	H
Caboolture	H	H	H	H	M	M	M	L	L	M	H	H
Dalby	M	M	M	L	L	L	L	VL	L	M	M	M
Esk	H	H	H	M	M	M	M	L	L	M	M	H
Bald Hills	H	H	H	M	M	M	M	L	L	M	M	H
Brisbane	H	H	H	M	M	M	M	L	L	M	M	H
Cleveland	H	H	H	H	H	M	M	M	M	M	M	H
Salisbury	H	H	H	M	M	M	M	L	L	M	M	H
Gatton	H	H	M	M	L	L	L	VL	L	M	M	H
Toowoomba	H	H	M	M	M	M	M	L	M	M	M	H
Ipswich	H	H	M	M	M	M	L	L	L	M	M	H
Southport	H	H	H	H	H	M	M	M	M	M	H	H
Beaudesert	H	H	H	M	M	M	L	L	L	M	M	H
St George	M	M	M	L	L	L	L	VL	VL	L	M	M
Warwick	M	M	M	L	L	L	L	L	L	M	M	M
Goondiwindi	M	M	M	L	L	L	L	L	L	M	M	M
Stanthorpe	M	M	M	L	L	M	M	L	M	M	M	M

Key: E = Extreme, H = High, M = Moderate, L = Low, VL = Very low erosion risk

Table 4.4.6 provides average monthly rainfall depths for the same Queensland towns.

Table 4.4.6 – Average monthly rainfall depth (mm) for Queensland towns

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooktown	369	374	390	216	78	52	27	30	17	22	63	163
Port Douglas	399	415	427	214	70	48	25	24	31	45	100	203
Kuranda	426	405	443	234	109	72	47	41	36	43	75	167
Normanton	261	247	154	29	6	8	3	2	3	10	42	144
Burketown	216	186	155	22	6	6	3	1	2	13	37	105
Cardwell	432	450	419	211	95	45	31	30	35	51	107	196
Lucinda	390	475	421	212	116	68	53	46	36	43	87	179
Halifax	422	459	424	197	107	61	46	37	36	49	92	182
Ingham	421	461	431	179	101	54	33	32	37	44	88	181
Ayr	267	263	188	62	36	32	20	15	21	24	43	110
Bowen	245	243	161	61	38	36	24	17	16	21	36	103
Charters T/s	138	129	104	42	23	26	17	13	15	22	41	86
Proserpine	377	382	315	152	94	66	39	34	38	40	70	173
Cloncurry	114	112	64	18	14	12	8	4	7	15	29	65
Marlborough	175	163	113	46	42	48	34	23	24	45	65	112
Yeppoon	247	241	191	108	86	75	49	31	34	63	75	142
Emerald	105	100	69	36	34	35	29	21	24	39	58	89
Barcaldine	86	77	64	36	34	25	25	16	15	29	34	59
Bundaberg	208	175	139	84	70	66	54	33	36	62	85	131
Maryborough	167	172	156	93	75	69	53	37	43	74	86	129
Gympie	168	162	143	87	70	63	53	37	47	73	88	135
Charleville	68	67	62	32	32	29	29	21	21	34	42	57
Eumundi	235	240	236	155	130	97	80	50	56	94	119	159
Mitchell	83	70	63	33	34	35	36	24	27	41	57	66
Kingaroy	115	96	80	48	38	44	41	30	37	64	77	110
Roma	82	75	66	34	36	35	38	27	30	50	55	69
Nambour	248	248	252	149	127	94	83	48	55	99	122	170
Miles	98	74	61	38	40	40	41	30	32	53	66	89
Landsborough	259	261	244	150	118	93	77	51	53	99	115	165
Woodford	198	207	191	106	79	70	65	40	47	78	88	142
Caboolture	196	198	187	111	85	67	61	39	43	83	101	142
Dalby	87	77	67	40	35	40	41	30	37	59	72	93
Esk	135	127	108	70	51	55	47	32	45	75	81	117
Bald Hills	159	170	148	95	80	68	57	37	43	86	97	132
Brisbane	160	155	138	90	72	65	55	40	45	80	100	128
Cleveland	171	173	174	114	102	88	72	47	48	85	93	129
Salisbury	143	141	131	81	73	67	51	36	40	73	90	120
Gatton	123	101	84	53	43	44	41	27	36	62	75	102
Toowoomba	139	124	99	67	55	59	54	40	47	74	86	119
Ipswich	125	116	97	58	47	50	42	31	41	66	76	104
Southport	182	191	205	137	130	96	75	56	59	86	103	131
Beaudesert	131	126	102	64	57	57	45	35	43	70	81	116
St George	73	61	56	33	39	34	34	26	27	38	46	51
Warwick	93	76	66	38	40	40	43	35	41	66	72	90
Goondiwindi	78	68	59	37	41	41	42	33	38	49	60	69
Stanthorpe	100	85	69	43	45	49	49	42	51	70	71	90

Table 4.4.7 – Best practice land clearing and rehabilitation requirements

Risk [1]	Best practice requirements
All cases	• All reasonable and practicable steps taken to apply best practice erosion control measures to completed earth works, or otherwise stabilise such works, prior to anticipated rainfall—including existing unstable, undisturbed, soil surfaces under the management or control of the building/construction works.
Very low	• Land clearing limited to 8 weeks of work if rainfall is reasonably possible. • Disturbed soil surfaces stabilised with minimum 60% cover [2] within 30 days of completion of works if rainfall is reasonably possible. • Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 30 days.
Low	• Land clearing limited to maximum 8 weeks of work. • Disturbed soil surfaces stabilised with minimum 70% cover [2] within 30 days of completion of works within any area of a work site. • Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 30 days. • Appropriate protection of all planned garden beds is strongly recommended.
Moderate	• Land clearing limited to maximum 6 weeks of work. • Disturbed soil surfaces stabilised with minimum 70% cover [2] within 20 days of completion of works within any area of a work site. • All planned garden beds protected with a minimum 75 mm layer of organic *Mulching*, heavy *Erosion Control Blanket*, *Rock Mulching*, or the equivalent. • Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3 m vertical increments wherever reasonable and practicable. • Unfinished earthworks are suitably stabilised if rainfall is reasonably possible, and disturbance is expected to be suspended for a period exceeding 20 days.
High	• Land clearing limited to maximum 4 weeks of work. • Disturbed soil surfaces stabilised with minimum 75% cover [2] within 10 days of completion of works within any area of a work site. • All planned garden beds protected with a minimum 75 mm layer of organic *Mulching*, heavy *Erosion Control Blanket*, *Rock Mulching*, or the equivalent. • Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 3 m vertical increments wherever reasonable and practicable. • The use of turf to form grassed surfaces given appropriate consideration. • Soil stockpiles and unfinished earthworks are suitably stabilised if disturbance is expected to be suspended for a period exceeding 10 days.
Extreme	• Land clearing limited to maximum 2 weeks of work. • Disturbed soil surfaces stabilised with minimum 80% cover [2] within 5 days of completion of works within any area of a work site. • All planned garden beds protected with a minimum 75 mm layer of organic *Mulching*, heavy *Erosion Control Blanket*, *Rock Mulching*, or the equivalent. • Staged construction and stabilisation of earth batters (steeper than 6H:1V) in maximum 2 m vertical increments wherever reasonable and practicable. • High priority given to the use of turf to form grassed surfaces. • Soil stockpiles and unfinished earthworks are suitably stabilised if disturbance is expected to be suspended for a period exceeding 5 days.

Notes: [1] Erosion risk based on monthly erosivity (Table 4.4.1), average monthly rainfall depth (Table 4.4.2), or soil loss rate (Table 4.4.3) as directed by the regulatory authority.

[2] Minimum cover requirement may be reduced if the natural cover of the immediate land is less than the nominated value, for example in arid and semi-arid areas or on coastal sand dunes.

4.4.1 Soil stabilisation and protection

Recommended erosion control techniques are presented in Table 4.4.8.

Table 4.4.8 – Summary of erosion control techniques

Technique	Code	Symbol	Typical use
Bonded Fibre Matrix	BFM	BFM	• Grass establishment and protection of newly seeded areas.
Cellular Confinement System	CCS	CCS	• Containment of topsoil or rock mulch on medium to steep slopes. • Control erosion on non-vegetated medium to steep slopes such as bridge abutments and heavily shaded areas.
Compost Blanket	CBT	CBT	• Used during the revegetation of steep slopes either incorporating grasses or other plants. • Particularly useful when the slope is too steep for the placement of topsoil, or when sufficient topsoil is absent from the slope.
Erosion Control Blanket	ECB	ECB	• Temporary erosion control on exposed soils not subjected to concentrated flow. • Temporary control of raindrop impact erosion on earth embankments before and during the revegetation phase.
Gravelling	Gravel	GRAVEL	• Protection of non-vegetated soils from raindrop impact erosion. • Stabilisation of site office area, temporary car parks and access roads.
Heavy Mulching	MH	MH	• Stabilisation of soil surfaces that are expected to remain non-vegetated for medium to long periods. • Suppression of weed growth on non-grassed areas. • Stabilisation of existing and proposed garden beds.
Light Mulching	M	M	• Control of raindrop impact erosion on flat and mild slopes. May be placed on steeper slopes with appropriate anchoring. • Control water loss and assist seed germination on newly seeded soil.
Revegetation	R	R	• Temporary and permanent stabilisation of soil. • Stabilisation of long-term stockpiles. • Includes *Turfing* and temporary seeding.
Rock Mulching	MR	MR	• Stabilisation of long-term, non-vegetated banks and minor drainage channels. • Stabilisation of those areas of a garden bed subject to concentrated overland flow.
Soil Binders	SBS	SBS	• Dust control. • Stabilisation of unsealed roads.

4.4.2 Mulching

The term mulching is often mistakenly understood to refer only to the relatively thick mulching used on garden beds to control water loss and weed growth. In fact mulching can be either heavy or light, and incorporated into, or separate from, the revegetation process. There are numerous types of mulch, all of which perform slightly and sometimes significantly different tasks.

Grass seeded areas should be lightly mulched immediately after seeding to protect them from raindrop impact erosion, and to aid seed germination and plant growth. Mulching holds the seed and fertiliser in place, protects the soil from erosion, conserves essential surface moisture (to assist in seed germination and growth) and reduces overall water usage.

Mulching can also encourage successful seed germination by preventing soil crusting while also insulating the soil against rapid temperature changes. For further discussion on the problems of soil crusting, refer to Appendix C – *Soils and revegetation*.

Tables 4.4.9 and 4.4.10 outline the general attributes of light and heavy mulching.

Table 4.4.9 – Attributes of light mulching

Type	Symbol	Typical use
Bonded Fibre Matrix (BFM)	BFM	• Revegetation of steep batters. • Highly successful grassing procedure, but requires strict control of application rates. • Often the preferred grass seeding technique in wet environments due to the use of non re-wettable tackifiers. • Expensive but usually highly successful.
Brush Mulch (BM)	BM	• Used as light mulching when it is desirable to maintain a natural appearance, or regeneration is required from the retained native seed. • Effective reuse of cleared vegetation.
Dead or dormant grass cover (TS) (temporary seeding)	TS	• In certain situations, a rapid and complete cover of "annual grass" cover can act as an effective, well-anchored mulch on embankments, batters and table drains, even if the grass is allowed to die-off after initial establishment—thus avoiding the need for ongoing watering.
Hydromulch [1] (HM)	HM	• Used for grass establishment and protection of newly seeded areas. • Best used on slopes <10% and slope lengths less than 10 metres. • Requires higher watering requirements than *Straw Mulching*.
Straw Mulching, including sugarcane mulch (M)	M	• Used as light mulching for the protection of newly seeded areas. • Most beneficial when it is important to minimise watering requirements during seed germination and plant establishment.

Note: [1] Hydroseeding is not considered a form of mulching due to the minimal application of mulch; however, hydroseeding can be used in partnership with *Straw Mulching.*

Table 4.4.10 – Attributes of heavy mulching

Type	Symbol	Typical use
Brush, bark, and woodchip mulch (BM)	BM	• Used on garden beds and for temporary protection of exposed soils prior to the completion of earthworks or other construction activities. • Some wood-based (woodchip) mulches can reduce nitrogen levels within the soil.
Compost Blanket (CBT)	CBT	• Used for the revegetation of steep slopes using grasses and/or other plants. • Particularly useful when the slope is too steep for the placement of topsoil, or when insufficient topsoil exists on the site. • Expensive, but usually highly successful.
Rock Mulching (MR)	MR	• Used in arid areas as a replacement for vegetation. • Used on garden beds subject to high velocity and/or high volume overland flows. • Used on heavily shaded areas (e.g. under bridges and suspended slabs).
Straw Mulching, including sugarcane mulch (MH)	MH	• Used as a heavy mulch to control weed growth and soil moisture loss. • Most beneficial when it is important to minimise watering requirements of seedlings.

Table 4.4.11 summarises the relative key attributes of the various mulches.

Table 4.4.11 – Relative attributes of various mulches [1]

	Cost	Water usage	Control of raindrop impact	Stability in wet areas	Durability	Placement on steep slopes	Placed with grass seed [4]
Bonded Fibre Matrix	H	M	H	H	M	H	Y
Brush Mulch	L-M	M	H	M	M	M	[5]
Compost Blanket	H	M	H	H	H	H	Y
Hydromulch	M	H	M	L	L-M	M	Y
Rock Mulching	M	L	H	H	H	M	N
Straw Mulch	M	L	H	[3]	M	[3]	N
Temp grass	L-M	L-M	[2]	[2]	M	H	Y
Wood chip	L-M	M	H	L	M	L	N

Notes: [1] Attribute defined as: H–high, M–medium, L–low, Y-yes and N–no.

[2] May need to be incorporated with a jute/coir mesh and bitumen emulsion to achieve effective erosion control during the early grass establishment phase.

[3] Stability on steep slopes and in high rainfall areas depends on the type and application rate of tackifier.

[4] Grass seed can be incorporated into the mulch during application.

[5] Plant seeding may be generated from native seed contained within the brush.

4.4.3 Erosion control blankets

In areas of strong winds or overland flow, *Erosion Control Blankets* can be used as an alternative to loose mulching practices such as *Straw Mulching*. Both “thick” and “thin” blankets are available. The thin blankets perform a task similar to light mulching, while the thicker blankets perform a task similar to heavy mulching.

Fabric-based *Erosion Control Blankets* (ECBs), *Erosion Control Meshes,* and *Erosion Control Mats* (ECMs) all fall under the general category of “Rolled Erosion Control Products” (RECPs). Erosion control blankets are generally applied to soils subjected to sheet flow. Erosion control mats and meshes are generally applied to soils subject to concentrated flow. Each product, whether an ECB or ECM may contain one or more of the following features.

- A mulch layer to assist seed germination, control soil temperature, and protect the soil from raindrop impact.
- A stabilising mesh to anchor the mulch layer and prevent it from washing or blowing away.
- A root reinforcing mesh to control soil erosion around the root system of the plants. Some root reinforcing systems may also provide limited erosion protection to the soil during periods of drought or when vegetation cover is poor.
- Mat reinforcing to limit distortion of the mat during periods of high flow velocity. It is noted that this reinforcing is primarily there to protect the mat, not the vegetation.

When selecting a blanket or mat it is important to determine what performance features and attributes (Table 4.4.12) are required. Some of the above features can be performed by both natural and synthetic materials. Synthetic (plastic) materials can cause environmental concerns, but natural materials often have a shorter design life.

Table 4.4.12 – Attributes of Erosion Control Blankets, Mats and Meshes

Product	Attributes
Hydraulically applied blankets	• Includes *Bonded Fibre Matrix* and *Compost Blankets*. • Low to medium shear strength. • Suitable for application on irregular surfaces and steep slopes. • *Compost Blankets* can provide a nutrient source.
100% biodegradable jute and coir blankets	• Low shear strength, and thus a low allowable flow velocity. • Requires good soil preparation and removal of surface irregularities.
Jute and coir mesh	• Medium shear strength. • Typical design life in dry environments of 12 to 24 months. • Does not represent a threat to wildlife.
Short-term synthetic reinforced composite blankets	• Medium shear strength • Plastic mesh can represent a threat to wildlife. • Design life generally less than 12 months.
Permanent turf reinforcement mats	• High shear strength. • May be damaged by grass fires. • Can significantly limit the future reuse of the topsoil.

4.4.4 Control of soil erosion on slopes

Best practice considerations for the control of soil erosion on slope are listed below:

(i) First priority during periods when rainfall is possible is to ensure suitable non-erosive drainage conditions are established (refer to Section 4.3).

(ii) Second priority during periods when rainfall is possible is to establish a minimum 70% (or greater in accordance with local standards) of the soil surface.

(iii) Third priority is to establish a complete and continuous cover of vegetation and/or mulch in accordance with a landscape plan.

(iv) Slopes that can be vegetated should be as flat as possible within the scope of the project aims in order to reduce shear stress on the slope resulting from stormwater runoff.

(v) Slopes that are unlikely to be fully vegetated (i.e. arid and semi arid areas) should be as steep as possible within the scope of the project aims in order to reduce the effective surface area of the slope subject to raindrop impact erosion.

(vi) On steep, grass seeded slopes, turf strips pinned along the contour at a maximum 2 m spacing can be used to help maintain "sheet" flow down the slope and reduce the risk of rill erosion and the mulch being washed from the slope.

While vegetation is one of the best long-term options, it can also serve as a short-term option if turf is used. On mild slopes (1 in 10 to 1 in 4) loose organic mulch may not be appropriate if heavy rains are expected, or if stormwater runoff is allowed to concentrate down the slope. The application of various erosion control measures to flat, mild and steep slopes subject to "sheet " flow is summarised in Table 4.4.13.

Table 4.4.13 – Application of erosion control measures to soil slopes

Flat land (flatter than 1 in 10)	Mild slopes (1 in 10 – 1 in 4)	Steep slopes (steeper than 1 in 4)
Erosion Control Blankets	Bonded Fibre Matrix	Bonded Fibre Matrix
Gravelling	Compost Blankets	Cellular Confinement Systems
Mulching	Erosion Control Blankets, Mats and Mesh	Compost Blankets
Revegetation	Mulching well anchored	Erosion Control Blankets, Mats and Mesh
Rock Mulching	Revegetation	Revegetation
Soil Binder	Rock Mulching	Rock Armouring
Turfing	Turfing	Turfing

4.4.5 Dust control techniques

Wind erosion is normally controlled using one or more of the following techniques:

- Revegetation
- Maintaining moist soil conditions
- Chemical sealants (soil binders) placed over the soil surface
- Surface roughening
- Wind breaks

Table 4.4.14 summarises the attributes of various dust control practices. Table 4.4.15 summarises the attributes of various dust suppressant agents. Further discussion on dust control measures is provided in Section 6.12.

Table 4.4.14 – Attributes of various dust control practices [1]

Site condition	Treatment options							
	Permanent vegetation	Mulching	Watering	Soil binders [2]	Gravel road	Stabilised entry/exit pad	Haul truck covers	Minimise site disturbance
Areas not subject to traffic	□	□	□	□	□			□
Areas subject to traffic			□	□	□	□		□
Material stockpiles			□	□				□
Clearing & excavation			□	□				□
Unpaved roads			□	□	□	□	□	
Earth transport					□	□		

Notes: [1] Sourced from: California Stormwater BMP Handbook – Construction (2003).

[2] Oil or oil-treated subgrade should not be used. Also, some soil binders may make the soil water repellent, possibly resulting in long-term revegetation problems.

Table 4.4.15 – Attributes of various of dust suppressant agents [1]

Suppressant type	Typical attributes
Chlorides/Salts: Calcium chloride Magnesium chloride Sodium chloride	• Ease of application. • Most suited to temperate and semi-humid conditions. • Loses effectiveness during continual dry periods. • Susceptible to leaching. • Suitable for use on moderate surface fines (10–20%). • Not suitable on low fines materials. • High fines surfaces may become slippery in wet weather.
Organic, non-bituminous: Calcium lignosulfonate Sodium lignosulfonate Ammonium lignosulfonate	• Performs well under arid conditions. • Failures can occur following rains. • Susceptible to leaching. • Suitable on high fines (10–30%) in a dense graded material with nil loose gravel. • Less effective on igneous, medium to low fines materials and crushed gravels. • High fines surfaces may become slippery in wet weather.
Petroleum-based products: Bitumen emulsion Waste oils	• Use of waste oils can cause significant adverse environmental effects. • Generally effective regardless of climate. • Will pothole in wet weather and high traffic conditions. • Suitable on low fines material (<10%). • Not suitable where runoff could contaminate receiving waters.
Electrochemical stabilisers: Sulfonated petroleum Ionic products Enzymes	• Work over a wide range of climates. • Suitable for clay materials but depends on clay mineralogy. • Iron rich soils generally respond well • The method least susceptible to leaching. • Ineffective if surface is low in fines and contains loose gravel.

Note: [1] After UMA Engineering Ltd. (1987).

4.4.6 Stabilisation of major drainage channels and watercourses

Exposed channel surfaces must be rehabilitated as soon as reasonable and practicable to prevent, or at least minimise, the risk of environmental harm caused by soil erosion. Disturbed watercourse banks should be actively revegetated rather than just waiting for natural regeneration (refer to Appendix N – *Glossary of terms* for definitions of rehabilitation, revegetation and stabilisation).

Revegetation of disturbed areas should extend to the water's edge to increase the value and linkage of the aquatic and riparian habitats. Rock protection of the toe of the stream bank is usually required to provide stabilisation during plant establishment.

During plant establishment it may be necessary to protect the soil from short-term erosion with the aid of an *Erosion Control Blanket, Mat* or *Mesh*. Erosion Control Blankets and Mats reinforced with synthetic mesh are **not** recommended for use along waterways containing ground-dwelling wildlife.

Further discussion on stream rehabilitation and plant selection is provided in Section I7.10 of Appendix I – *Instream works*.

4.5 Sediment control techniques

4.5.1 Sediment control standard

In the absence of a locally adopted sediment control standard, Table 4.5.1 is presented as the default, best practice, sediment control standard.

Table 4.5.1 – Sediment control standard (default) based on soil loss rate

Area limit (m^2) [1]	Soil loss rate limit (t/ha/yr) [2]			Soil loss rate limit (t/ha/month) [3]		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	[4]	N/A	N/A	[4]
1000	N/A	N/A	All cases	N/A	N/A	All cases
2500	N/A	> 75	75	N/A	> 6.25	6.25
>2500	> 150	150	75	> 12.5	12.5	6.25

Notes: [1] Area is defined by the catchment area draining to a given location. The area does not include any "clean" water catchment that bypasses the sediment trap.

[2] Soil loss rate limit defines the maximum allowable soil loss rate from a given catchment area draining to a given sediment trap at any given instant within the construction phase.

[3] Soil loss rate limit defines the maximum allowable soil loss rate from a given catchment area draining to a given sediment trap at any given instant within a given month in those cases where the actual time of construction is regulated.

[4] Refer to the relevant regulatory authority for assessment procedures. The default standard is a Type 3 sediment trap.

Table 4.5.2 presents two alternative sediment control standards for those regulatory authorities wishing to adopt a system that does not involve site-specific soil loss estimation. Adoption of either sediment control standard presented in Table 4.5.2 is at the discretion of the regulatory authority.

Table 4.5.2 – Alternative sediment control standards based on monthly erosivity and average monthly rainfall

Area limit (m^2) [1]	Monthly erosivity (R-factor) [2]			Average monthly rainfall (mm) [2]		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	[3]	N/A	N/A	[3]
1000	N/A	N/A	All cases	N/A	N/A	All cases
2500	N/A	> 60	60	N/A	> 30	30
>2500	> 100	100	60	> 45	45	30

Notes: [1] Area is defined by the catchment area draining to a given location. The area does not include any "clean" water catchment that bypasses the sediment trap.

[2] Adopt a standard based **either** on the monthly erosivity value, or the average monthly rainfall.

[3] Refer to the relevant regulatory authority for assessment procedures. The default standard is a Type 3 sediment trap.

A sediment control treatment standard for de-watering operations is discussed in Section 4.5.9 of this chapter.

A sediment control standard based on Table 4.5.2 has less flexibility than a standard based on Table 4.5.1, and does not reward those builders/contractors who choose to adopt high erosion control standards to minimise soil loss rates.

Tables 4.5.3 and 4.5.4 outline the default classification of various sediment control techniques. The classification of a sediment control technique within a given set of site conditions must, wherever practicable, be based on the classification system provided in Technical Note 4.1 (p. 4.27).

Table 4.5.3 – Default classification of sediment control techniques [1]

Type 1	Type 2	Type 3
Sheet flow treatment techniques		
• Buffer Zone capable of infiltrating 100% of stormwater runoff or process water * • Infiltration basin or sand filter bed capable of infiltrating 100% of flow	• Buffer Zone * capable of infiltrating the majority of flows from design storms • Compost/Mulch Berm	• Buffer Zone * • Filter Fence • Modular Sediment Trap • Sediment Fence
Concentrated flow treatment techniques		
• Sediment Basin * (sized in accordance with design standard)	• Block & Aggregate Drop Inlet Protection • Excavated Sediment Trap with Type 2 outlet • Filter Sock • Filter Tube Dam • Mesh & Aggregate Drop Inlet Protection • Rock & Aggregate Drop Inlet Protection • Rock Filter Dam • Sediment Trench * • Sediment Weir	• Coarse Sediment Trap • Excavated Drop Inlet Protection * • Excavated Sediment Trap with Type 3 outlet • Fabric Drop Inlet Protection • Fabric Wrap Field Inlet Sediment Trap • Modular Sediment Trap • Straw Bale Barrier • U-Shaped Sediment Trap
De-watering sediment control techniques (selection not based on soil loss rate)		
• Type F/D Sediment Basin • Stilling Pond	• Filter Bag or Filter Tube • Filter Pond • Filter Tube Dam • Portable Sediment Tank * • Settling Pond * • Sump Pit	• Compost Berm * • Filter Fence * • Grass Filter Bed * • Hydrocyclone * • Portable Sediment Tank * • Sediment Fence
Instream sediment control techniques (selection not based on soil loss rate)		
• Pump sediment-laden water to an off-stream Type F or Type D Sediment Basin or high filtration system	• Filter Tube Barrier • Modular Sediment Barrier* • Rock Filter Dam • Sediment Weir	• Modular Sediment Barrier* • Sediment Filter Cage

Notes for Table 4.5.3:

[1] Classification is based on the technique being sized in accordance with best practice standards, otherwise the technique attracts a lower classification. The classification of a sediment control technique within a given set of site conditions must, wherever practicable, be based on the classification system provided in Technical Note 4.1.

[2] Buffer Zone must be able to infiltrate all inflow into the ground such that there is no surface discharge from the *Buffer Zone*. The term "process water" refers to 100% of runoff from cleaning operations, or such things as runoff from water cooling from cutting tools.

[3] The design of infiltration basins, sand filter beds and hydro-cyclones are not discussed within this document.

[4] Classification depends on design details.

Supplementary sediment traps, such as *Grass Filter Strips* and most kerb inlet sediment traps, are not effective enough to be classified as Type 3 systems. Even though these sediment traps are relatively ineffective, their incorporation into most Erosion and Sediment Control Plans is considered a relevant part of the best practice sediment control; however, it is not sufficient for a sediment control scheme to rely solely on supplementary sediment traps.

Table 4.5.4 – Supplementary sediment control techniques

Flow condition	Sediment control technique
Sheet flow treatment techniques	• Grass Filter Strips • Fibre Rolls • Stiff Grass Barrier
Concentrated flow treatment techniques	• Check Dam Sediment Traps • Kerb Inlet Sediment Traps (on-grade and sag inlet traps, including Gully Bags) • Straw Bale Barrier
Other sediment control systems	• Construction Exits (Rock Pads, Vibration Grids, Wash Bays)
De-watering sediment control techniques	• Grass Filter Bed [1]
Instream sediment control techniques	• Straw Bale Barrier (short-term device only)

Note: [1] Classification depends on design details

Table 4.5.5 outlines the general classification of sediment traps based on the ability to trap a specific particle size.

Table 4.5.5 – Classification of sediment traps based on particle size

Classification	Minimum particle size	Typical trapped particles
Type 1	<0.045mm	Clay, silt and sand
Type 2	0.045 to 0.14mm	Silt and sand [1]
Type 3	>0.14mm	Sand
Supplementary	>0.42mm	Coarse sand

Note: [1] Technically, silt particles have a grain size between 0.002 and 0.02 mm which means that only Type 1 sediment traps are likely to capture silt-sized particles. However, for general discussion purposes, it can be assumed that Type 2 systems capture a significant proportion of silt-sized particles.

Technical Note 4.1 – Classification of sediment traps

The classification of sediment control techniques presented in Tables 4.5.3 and 4.5.4 has been based on observations and experience rather than field or laboratory evaluation.

Manufacturers/distributors of specific sediment control systems wishing to have their systems re-categorised can do so using the following classification system. All performance claims must be demonstrated based on at least one of the following:

- NATA certified laboratory analysis;
- field analysis and evaluation certified by an independent, Certified Professional in Erosion and Sediment Control (CPESC); or
- field analysis and evaluation conducted as part of appropriately supervised Ph.D. research.

Type 1 Sediment Trap:

1. Under typical flow conditions (discharge and suspended sediment concentration), is capable of capturing and holding at least 90% of material larger than 0.045 mm in equivalent diameter.
2. Sufficient sediment retention capacity (volume) to capture and hold one (1) month’s sediment runoff from the catchment in question under average annual conditions.
3. Is capability of sustaining its hydraulic and structural integrity under normal site conditions. A sediment trapping system that has even a minor risk of experiencing performance-affecting damage within a given work site due to such things as vandalism, and foot or construction traffic, cannot be classified as a Type 1 sediment trap.

Type 2 Sediment Trap:

1. Under typical flow conditions (discharge and suspended sediment concentration), is capable of capturing and holding at least 90% of material larger than 0.14 mm (No. 100 sieve) in equivalent diameter.
2. Sufficient sediment retention capacity (volume) to capture and hold one (1) month’s sediment runoff from the catchment in question under average annual conditions.
3. Has an acceptable capability to sustain its hydraulic and structural integrity under normal site conditions. A sediment trapping system that is highly likely to experience performance-affecting damage within a given work site due to such things as vandalism, and foot or construction traffic, cannot be classified as a Type 2 sediment trap.

Type 3 Sediment Trap:

1. Under typical flow conditions (discharge and suspended sediment concentration), is capable of capturing and holding 90% of material greater than 0.42 mm (No. 40 sieve) in equivalent diameter.
2. Sufficient sediment retention capacity (volume) to capture and hold one (1) month’s sediment runoff from the catchment in question under average annual conditions.
3. Has an acceptable capability to sustain its hydraulic and structural integrity under normal site conditions. A sediment trapping system that is highly likely to experience performance-affecting damage within a given work site due to such things as vandalism, and foot or construction traffic, cannot be classified as a Type 3 sediment trap.

Design discharge:

Unless otherwise noted within this document, or specified by the regulatory authority, the design storm for sediment traps must be taken as 0.5 times the 1 in 1 year ARI peak discharge.

4.5.2 Sediment control measures in areas of sheet flow

Table 4.5.6 outlines the attributes of various sheet flow sediment control techniques.

Table 4.5.6 – Sheet flow sediment control techniques

Technique	Code	Symbol	Typical use
Buffer Zones	BZ	Buffer zone	• Type 3 sediment trap. • Most suited to sandy soils. • Generally only suitable for rural and rural-residential building/construction sites. • Can provide some degree of turbidity control while the *Buffer Zone* remains unsaturated.
Compost Berm	CB	CB	• Type 2 sediment trap. • Suitable for all soil types.
Fibre Roll	FR	FR	• Supplementary sediment trap • Most suited to sandy soils. • Suitable for minor flows only.
Filter Fence	FF	FF	• Type 3 sediment trap. • Very small catchment areas (e.g. stockpiles). • Better capture of the finer (sand/silt) sediments compared to woven *Sediment Fence*.
Filter Sock	FS	FS	• Type 2 sediment trap. • Suitable for all soil types.
Grass Filter Strips	GFS	GFS vvvvv vvvvv vvvvv vvvvv	• Supplementary sediment trap • Most suited to sandy soils. • Minor sediment traps placed along the contour. • Can be used as a drainage control measure to maintain sheet flow down earth batters.
Modular Sediment Trap	MST	MST	• Type 3 sediment trap. • Modern replacement for *Straw Bale Barriers*.
Mulch Berm	MB	MB	• Type 2 sediment trap. • Suitable for all soil types.
Sediment Fence – woven fabric	SF	SF	• Type 3 sediment trap. • Suitable for all soil types. • Long duration construction sites likely to experience several storm events.
Sediment Fence – non-woven composite fabric	SF	SF	• Type 3 sediment trap. • Suitable for all soil types. • Preferred type of *Sediment Fence* when placed adjacent critical habitats such as waterways. • Short duration construction sites or sites likely to experience only a few storm events.
Stiff Grass Barrier	SGB	SGB	• Supplementary sediment trap • Most suited to sandy soils. • Most commonly used as permanent sediment traps in rural areas.

4.5.3 Sediment controls at kerb inlets

Table 4.5.7 outlines the attributes of various sediment control techniques for roadside kerb inlets.

Table 4.5.7 – Kerb inlet sediment control techniques

Technique	Code	Symbol	Typical use
Gully Bag	GB	GB 	• Generally considered to represent *best practice* as a form of kerb inlet sediment control. • Used when it is considered unsafe to cause ponding or sediment deposition on the roadway. • Includes the use of flexible filter bags, and filter boxes lined with filter fabric. • Significant variation in treatment standard of various commercial products.
On-grade Kerb Inlet Sediment Trap	OG	OG 	• Up-slope of on-grade kerb inlets (i.e. kerb inlets **not** located at a sag point on a road). • Used as a series of sediment traps to collect cement runoff during the preparation of exposed aggregate surfaces.
Sag Inlet Sediment Trap	SA	SA 	• Used as a minor sediment trap constructed around kerb inlets located at sag points along a roadway.

Due to the high risk of physical displacement and damage, most roadside kerb inlet sediment traps are classified as *supplementary sediment traps*. Gully Bags and fixed, in-gully filter bags/boxes generally provide a higher treatment standard if correctly installed and appropriately maintained.

The following recommendations and procedures are considered to represent current (2008) best practice roadside sediment control practices:

(i) Wherever practicable, sediment runoff is collected and retained wholly within the work site.

(ii) Where the work site includes roads, whether sealed or under construction, all reasonable and practicable measures are taken to trap sediment runoff prior to its entry onto a road surface.

(iii) Where the sediment runoff has originated from the road surface, then all reasonable and practicable measures are taken to prevent the sediment entering a sealed (e.g. hard lined drainage system) or permanent drainage system (e.g. piped or open channel drain).

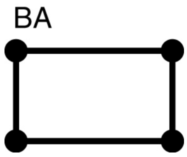
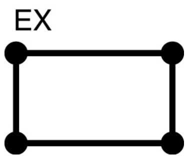
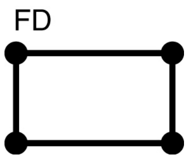
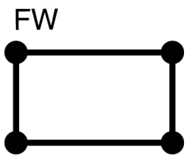
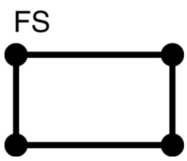
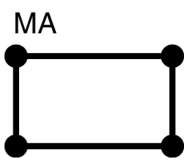
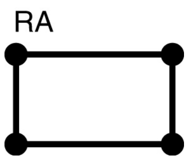
(iv) Sediment control measures used within or adjacent a roadside stormwater inlet are to represent current best available practice. As a guide, this generally means that correctly installed and maintained *Gully Bags* (including fixed filter bags/boxes) are used in preference to road-surface sediment traps such as *Sag* and *On-Grade Kerb Inlet Sediment Traps*.

(v) The use of kerb inlet sediment traps must not replace the need for appropriate Type 1, Type 2, or Type 3 sediment traps up-slope of all stormwater inlets as required by the sediment control standard either presented within this chapter or as adopted by the relevant regulatory authority.

4.5.4 Sediment controls at field (drop) inlets

Table 4.5.8 outlines the attributes of various sediment control techniques for field (drop) inlets.

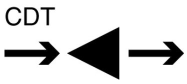
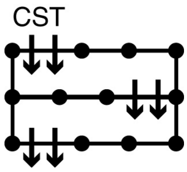
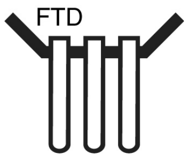
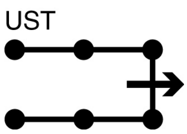
Table 4.5.8 – Field (drop) inlet sediment control techniques

Technique	Code	Symbol	Typical use
Block & Aggregate Drop Inlet Protection	BA		• Type 2 sediment trap. • Small to medium catchment areas. • Filter cloth may be placed between the aggregate and the support blocks to improve the removal of fine sediments. • The depth of ponding upstream of the field inlet is governed by the height of the blocks.
Excavated Drop Inlet Protection	EX		• Type 2 or 3 sediment trap. • Locations where water ponding around the stormwater inlet is not allowed to reach a level significantly higher than the existing ground level (i.e. water ponding and sediment collection occurs below finished ground level). • Safety issues may require the excavated pit to be surrounded by appropriate safety fencing.
Fabric Drop Inlet Protection	FD		• Type 3 sediment trap. • Best used on sandy soils. • Small catchment areas containing sandy soils. • Locations where space is limited and a more substantial filter medium cannot be built.
Fabric Wrap Inlet Protection	FW		• Type 3 sediment trap. • Very small catchment areas. • Most commonly used on building sites.
Filter Sock Drop Inlet Protection	FS		• Type 2 or 3 sediment trap. • Small catchments. • Compost contained within the sock can adsorb some dissolved and fine particulate matter.
Mesh & Aggregate Drop Inlet Protection	MA		• Type 2 sediment trap. • Small to medium catchments. • The depth of ponding upstream of the field inlet is governed by the height of the aggregate filter placed around the wire mesh.
Rock & Aggregate Drop Inlet Protection	RA		• Type 2 sediment trap. • Best used in coarse-grained (i.e. low clay) soil areas. • Large construction sites such as a duel-carriage road with the drop inlet located within the median strip. • Locations where space is not critical.

4.5.5 Sediment control measures in areas of minor concentrated flows

Table 4.5.9 outlines the attributes of various sediment control techniques for minor concentrated flows such as roadside table drains.

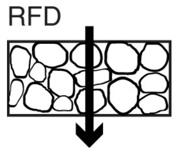
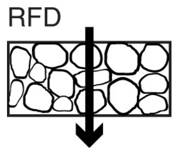
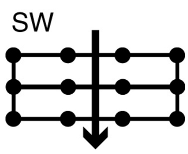
Table 4.5.9 – Sediment control techniques for minor concentrated flow

Technique	Code	Symbol	Typical use
Check Dam Sediment Trap	CDT		• Supplementary sediment trap. • Trapping sediment in table drains and other minor drainage lines. • *Check Dams* may be constructed from rock, sand bags, or compost-filled socks. • Compost-filled socks can adsorb some dissolved and fine particulate matter.
Coarse Sediment Trap	CST		• Type 3 sediment trap. • Best used on sandy soils. • Commonly used as sediment trap at the low point of a *Sediment Fence*. • Used as an alternative to a spill-through weir on a *Sediment Fence*.
Filter Tube Dam	FTD		• Type 2 sediment trap. • Trapping sediment in minor drainage lines. • Generally provides greater treatment of low flows than a *U-Shaped Sediment Trap*. • *Filter Tubes* can be integrated into a variety of Type 2 and 3 sediment traps (such as a *Rock Check Dam, U-Shaped Sediment Trap, Rock Filter Dam*, and *Sediment Weir*) to improve their efficiency during minor flows.
Modular Sediment Trap	MST		• Type 3 sediment trap. • Modern replacement for *Straw Bale Barriers*. • Capability of accepting concentrated flows depends on construction technique.
Stiff Grass Barrier	SGB		• Supplementary sediment trap • Most suited to sandy soils. • Typically used as a component of long-term gully stabilisation in rural areas.
U-Shaped Sediment Trap	UST		• Type 3 sediment trap. • Minor concentrated flows such as table drains. • The sediment fence **must** be constructed in a U-shape with an appropriate spill-through weir. • Filter tubes can be integrated into a *U-Shaped Sediment Trap* to increase the effective hydraulic capacity and to improve the treatment of low flows.

4.5.6 Sediment control structures in areas of concentrated flow

Table 4.5.10 outlines the attributes of various sediment control techniques used in concentrated flow. Refer to Appendix I (*Instream works*) for guidelines on the selection of instream sediment control measures.

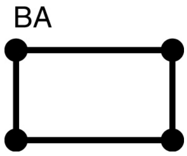
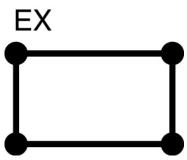
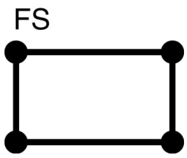
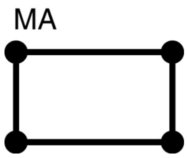
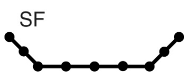
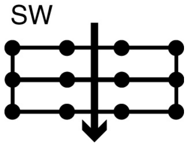
Table 4.5.10 – Concentrated flow sediment control techniques

Technique	Code	Symbol	Typical use
Rock Filter Dam: Filter cloth used as the primary filter medium	RFD		• Type 2 sediment trap. • Locations where there is sufficient room to construct a relatively large rock embankment. • The incorporation of filter cloth is the preferred construction technique if the removal of fine-grained sediment is critical; however, de-silting and replacement of the fabric can be difficult and can lead to ongoing poor performance.
Rock Filter Dam: Aggregate used as the primary filter medium	RFD		• Type 2 sediment trap. • Best used on sandy soils. • Locations where there is sufficient room to construct a relatively large rock embankment. • Aggregate filters are normally used on long-term sediment trap, and sediment traps that are likely to be regularly de-silted.
Sediment Basin – Type C	SB	No standard symbol—draw actual basin layout on ESCP	• Type 1 sediment trap. • Best suited to coarse-grained soils. • The trapping of coarse and fine sediments in major earthworks projects. • Used when a major (Type 1) sediment trap is required when working in areas containing coarse-grained, good settling soils.
Sediment Basin – Type F and Type D	SB	No standard symbol—draw actual basin layout on ESCP	• Type 1 sediment trap. • Best suited to fine-grained or dispersive soils. • The trapping of coarse and fine sediments. • Turbidity control. • Used when a major (Type 1) sediment trap is required when working in areas containing fine-grained, dispersive or poor settling soils.
Sediment Trench	SS		• Type 2 or 3 sediment trap. • Used in long, narrow spaces. • At the base of fill batters where there is limited space between the toe of the batter and the property boundary.
Sediment Weir	SW		• Type 2 sediment trap. • Used where space is limited (i.e. when space is not available for use of a *Rock Filter Dam*). • Where the sediment trap may be subjected to regular over-topping flows. • Used as a primary outlet structure on minor "dry" Type 2 *Sediment Basins*.

4.5.7 Sediment traps at pipe and culvert inlets

Table 4.5.11 outlines the attributes of various sediment control techniques that can be used at the inlet of culverts and open stormwater pipes.

Table 4.5.11 – Sediment control techniques at the entrance to culverts and open stormwater pipes

Technique	Code	Symbol	Typical use
Block & Aggregate sediment trap	BA		• Type 2 sediment trap. • Small to medium catchment areas. • It is usually necessary for the *Block and Aggregate* barrier to be constructed in a manner that does **not** block or partially block the pipe or culvert entrance. • Filter cloth may be placed between the aggregate and the support blocks to improve the removal of fine sediments. • The depth of ponding upstream of the pipe or culvert entrance is governed by the height of the block wall. • Heavy, solid timber planks can be used as an alternative to concrete blocks.
Excavated sediment trap	EX		• Type 3 sediment trap (when placed at the entrance of a culvert or open stormwater pipe). • Generally the **least** desirable type of sediment trap placed at the entrance of a culvert or open stormwater pipe. • Suitable in locations where ponding upstream of the inlet is not allowed (i.e. water ponding and sediment collection occurs below finished ground level). • Safety issues may require the excavated pit to be surrounded by appropriate safety fencing.
Filter Sock sediment trap	FS		• Type 2 sediment trap. • Small catchments. • Compost contained within the sock can adsorb some dissolved and fine particulate matter.
Mesh & Aggregate sediment trap	MA		• Type 2 sediment trap. • Small to medium catchments. • Depth of ponding upstream of the inlet is governed by the height of the aggregate filter placed in front of the wire mesh.
Sediment Fence (woven or non-woven)	SF		• Type 3 sediment trap. • **Not** recommended unless there is a very high expectation that flows will be very low. • **Not** suitable for culvert inlets.
Sediment Weir	SW		• Type 2 sediment trap. • Generally stronger than a *Mesh & Aggregate* sediment trap. • Best used when high flow rates are expected.

4.5.8 Sediment traps at stormwater outlets

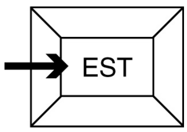
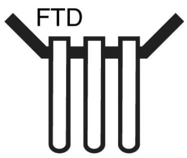
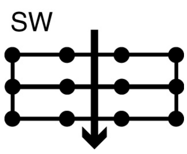
Table 4.5.12 outlines the attributes of various **temporary** sediment control techniques that may be suitable for placement at the outlet of stormwater pipes. Extreme care must be taken when selecting the preferred technique, as not all of the listed techniques are suitable in all circumstances.

When locating a sediment trap at the outlet of a stormwater pipe, the sediment trap should ideally be located downstream of the influence of outlet "jetting" (i.e. 10–13 x pipe diameters downstream of the outlet). If located too close to the outlet, then high flow velocities discharging from the outlet can resuspend previously settled sediment washing it downstream of the sediment trap.

Sediment traps must **not** be located within streams or major drainage channels unless they satisfy the requirements outlined in Appendix I – *Instream works*.

All sediment traps must be located totally within the relevant property boundaries unless otherwise approved in writing by the appropriate regulatory authority and land owner.

Table 4.5.12 – Sediment control techniques at the outlet of stormwater pipes

Technique	Code	Symbol	Typical use
Excavated Sediment Trap	EST		• Type 3 sediment trap. • Generally the **least** desirable type of sediment trap placed at the entrance of a culvert or open stormwater pipe. • Best used when it is necessary to avoid backwater ponding and thus sedimentation within the stormwater pipe or culvert. • Safety issues may require the excavated pit to be surrounded by appropriate safety fencing.
Filter Tube Dam	FTD		• Type 2 or 3 sediment trap. • Best used when there is significant fall immediately downstream of the stormwater outlet, thus allowing the *Filter Tubes* to be set below the invert of the pipe. This prevents ponding and sedimentation within the pipe. • It may not be practical to incorporate enough *Filter Tubes* to cater for the expected design flow rate. In which case the sediment trap may only be considered a Type 3 system. • Trapping sediment in minor drainage lines.
Sediment Weir	SW		• Type 2 sediment trap. • Best used when high flow rates are expected. • *Filter Tubes* can be incorporated into the *Sediment Weir* to improve the treatment of low flows.
Straw Bale Barrier	SBB		• Type 3 sediment trap. • Only suitable when poor site access prevents the use of other, more suitable, sediment traps.

4.5.9 De-watering sediment control measures

Table 4.5.13 contains recommended water quality standard for de-watering operations.

Table 4.5.13 – Recommended discharge standard for de-watering operations

Site conditions	Discharge water quality standard
All cases.	Take all reasonable and practicable measures to achieve a 90 percentile total suspended solids concentration not exceeding 50 mg/L.
Soil disturbances exceeding 2500 m^2, or Projects exceeding $500,000 expenditure, or Post-storm de-watering of *Sediment Basins*.	90 percentile total suspended solids (TSS) concentration not exceeding 50 mg/L. Water pH between 6.5–8.5.

To assist in the effective day-to-day operations of de-watering procedures, it is usually preferable for the water quality standard to be based on the equivalent Nephelometric Turbidity Units (NTU) values where a relationship between TSS and NTU can be established for a given soil type. In the absence of a site-specific relationship, Table 4.5.14 is presented as an alternative water quality standard for de-watering operations.

Table 4.5.14 – Alternative discharge standard for de-watering operations

Site conditions	Discharge water quality standard
All cases.	Take all reasonable and practicable measures to achieve a 90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 60.
Soil disturbances exceeding 2500 m^2, or Projects exceeding $500,000 expenditure, or Post-storm de-watering of *Sediment Basins*.	90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 100, and 50 percentile NTU reading not exceeding 60.

Table 4.5.15 outlines best practice sediment control measures for the de-watering of excavated material and other stockpiles.

Table 4.5.15 – Sediment control practices for de-watering stockpiles

Material	Sediment control	Comments
Non-clayey material	Grass Filter Beds or equivalent	• Ensure grassed area remains unsaturated during de-watering operation.
Clayey material	Filter Fence (non-woven filter cloth)	• Filter cloth must be supported by wire mesh, or aggregate berm. • Woven *Sediment Fence* fabric must **not** be used.
	Compost Berm or Mulch Berm or Filter Sock	• Ensure the berm/sock is placed along the contour to ensure flow is distributed evenly along the length of the berm/sock. • Ensure water does not bypass around the end of the berm or sock.
Contaminated material	Not applicable	• Seek expert advice on case-by-case basis.

Table 4.5.16 outlines the attributes of various sediment control techniques used during de-watering operations.

Table 4.5.16 – Recommended use and attributes of various sediment control techniques applicable to de-watering activities

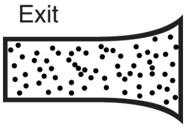
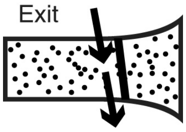
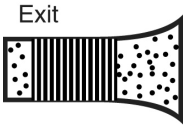
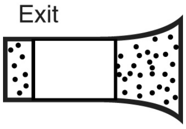
Expected flow	Technique [1]	Application and comments
Low	Sump Pit	• Filtration occurs at the pump inlet rather than at the outlet of the pipe. • Can be used in association with an outlet treatment system.
	Filter Bag	• Quick to install and remove. • Commercially available product.
	Filter Tube	• Commercially available product. • High flow rates can be treated by adding additional *Filter Tubes* operating in parallel.
	Grass Filter Bed	• Only suitable on sandy loamy soils. Generally not effective on clayey soils. • Generally not effective during wet weather when the soil is wet. • Pipe outlet must be relocated once the grassed area becomes saturated. Use of an outlet manifold can delay soil saturation. • A *Sediment Fence* may be placed up-slope of the grass to collect coarse sediment and help distribute flow evenly across the width of the grass filter.
	Compost Berm	• Can provide good filtration and turbidity control. • Compost-filled socks (*Filter Socks*) can also be used.
	Filter Fence	• Suitable for the finer grain soils, but **not** for turbidity control.
	Sediment Fence	• Only suitable for coarse-grained material.
Moderate	Filter Tube Dam	• Commercially available product. • High flow rates can be treated by through the use of several *Filter Tubes* operating in parallel.
	Filter Sock	• Filter Sock used as a type of Filter Pond with the sock placed as an enclosed circle. • Used on flat or near-flat ground. • Compost contained within the sock can adsorb some dissolved and fine particulate matter.
	Filter Pond	• Used on flat or near-flat ground. • Most effective for coarse-grained sediment. • Limited control over turbidity, unless used on highly porous soil.
	Portable Sediment Tank	• Wide variety of different systems can be employed. • Usually have limited control over turbidity. • High initial purchase cost, but operation costs can be low.
	Settling Pond or Stilling Pond	• Outlet structure may consist of a *Rock Filter Dam,* or a series of *Filter Tubes*. • Only suitable for waters containing fast settling sediments.
	Hydro-cyclone (centrifuge)	• Transportable truck/trailer mounted units. • Work well in confined spaces.
High	Sediment Basin – Type F and Type D	• Best option for turbidity control. • Disturbed material contains more than 33% finer than 0.02 mm. • Usually requires chemical flocculation.

Note: [1] Techniques **not** listed in order of preference.

4.5.10 Sediment controls at entry/exit points

Table 4.5.17 outlines best practice sediment control measures for construction site entry/exit points.

Table 4.5.17 – Use of stabilised *Construction Exits*

Technique	Code	Symbol	Typical use
Rock Pad	Exit	Exit  Exit 	• Suitable for all soil types. • Minimum 10 m length for single dwelling building sites and 15 m for construction sites. • Generally better than a *Vibration Grid* during wet weather. • Drainage controls may need to be incorporated into the rock pad to direct sediment-laden runoff to an appropriate sediment trap. • Note: *Rock Pads* on building sites generally have different design requirements, therefore alternative standard drawing and specifications may apply.
Vibration Grid	Exit	Exit 	• Best suited to sandy soils. • Can also be used in clayey soil regions to control sediment movement during dry weather.
Wash Bay	Exit	Exit 	• When working near fragile environments, when turbidity control is a major issue, or when working with highly cohesive clays. • Option of in-situ, or commercial (hire), portable units. • Usually best practice on long-term sites.

If the site or access road is elevated above the public roadway, and if stormwater runoff from the site is likely to wash sediment from the entry/exit pad onto the roadway, then drainage from the Construction Exit must be directed to a suitable sediment trap (Figure 4.1). This is normally achieved by forming a raised flow diversion bund (speed bump) across the rock pad.

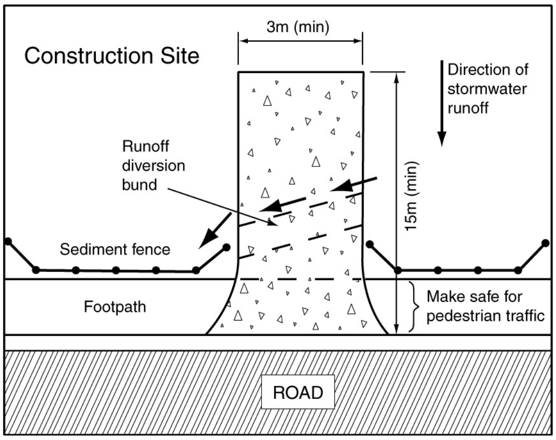


Figure 4.1 – Example of stormwater runoff directed off a *Construction Exit*

4.6 Stockpile management

The diversion of up-slope stormwater around stockpiles is recommended during those periods when rainfall is possible and the up-slope catchment area exceeds 1500 m^2 and the average monthly rainfall exceeds 45 mm. Table 4.6.1 outlines the recommended erosion control measures applied to sand and soil stockpiles.

Table 4.6.1 – Protection of sand and soil stockpiles from wind and rainfall

Material	Stockpile cover [1]	Comments
Sand	No cover	• When wind erosion and dust control is not an issue.
	Synthetic cover, porous or not porous	• When the control of wind erosion is essential for reasons of safety.
Soil	No cover	• When wind erosion and dust control are not an issue.
	Mulching, vegetative cover, chemical stabilisers, soil binders, or impervious blanket [2]	• Long-term (>28 days) stockpiling of dispersive soils. • Long-term (>28 days) stockpiles of clayey soils when turbidity control is desirable. • Long-term (>5/10 days) soil stockpiles during months of Extreme/High erosion risk as per Section 4.4. • Short and long-term stockpiles of clayey soils when turbidity control is essential.

Notes: [1] Applicable only when displacement of the stockpiled material has the potential to cause environmental harm. The practice of covering stockpiles may need to be modified if theft or damage to covers becomes excessive.

[2] Mulching is normally applied at the first opportunity that mulch or hydromulch can be introduced to the site. Minimum 70% cover is required for both mulch and vegetative covers. Though still desirable, a cover may not be required if runoff from the stockpile is directed to a Type 1 sediment trap.

Table 4.6.2 outlines the recommended minimum sediment control practices down-slope of stockpiles.

Table 4.6.2 – Sediment control practices down-slope of stockpiles

Material	Sediment control	Comments
Sand or gravel	Woven Sediment Fence or equivalent	• Sediment control is only required if stockpiled material could be displaced and cause safety risks or environmental harm.
Topsoil	Woven Sediment Fence or equivalent	• If the topsoil is moderately to highly erodible and is likely to release significant clay-rich (turbid) runoff, refer to the recommendations below for subsoil stockpiles.
Subsoil	Woven Sediment Fence or equivalent	• Stockpiles located up-slope of suitably grassed areas that will allow for the infiltration of stormwater runoff from the stockpile (minimum 15 m of flow length), or all runoff is directed to a Type 1 or Type 2 sediment trap.
	Compost Berm, Filter Fence, composite (non-woven) Sediment Fence, or equivalent	• Stockpiles not located up-slope of a suitable grassed area, or Type 1 or Type 2 sediment trap. • Soil stockpiles located adjacent permanent drainage channels or waterways.

Table 4.5.15 outlines best practice sediment control measures for application during the de-watering of excavated materials and other stockpiles.

5. Preparation of plans

This chapter provides guidelines on the preparation of Erosion and Sediment Control Plans (ESCPs) for construction sites and large (multiple dwelling) building sites. Though not entirely prescriptive, regulatory authorities may require that ESCPs comply with the procedures presented in this chapter.

Guidelines on the preparation of ESCPs for single dwelling building sites are presented in Appendix H – Building sites.

5.1 Introduction

The appropriate design of erosion and sediment control (ESC) measures does not end with the production of an Erosion and Sediment Control Plan (ESCP), the process should be considered to be ongoing until stable land conditions are once again achieved.

ESCPs are prepared specifically for the purpose of detailing and supporting the proposed erosion and sediment control measures for a particular building or construction site. Typically these plans detail only short-term measures. Permanent sediment control, stormwater management and landscaping measures are normally detailed within the site's Stormwater Management and Landscaping Plans.

As a complete package, an ESCP may consist of several components including plans and various pieces of related documentation. Collectively the package of documents may be referred to as the *Erosion and Sediment Control Program* (ESC Program). In any case, whether referred to as ESCPs or ESC Programs, the package normally consists of the following components:

- Erosion and Sediment Control Plans
- Supporting documentation
- Specifications and construction details for ESC measures

Technical Note 5.1 – Terminology

Erosion and Sediment Control Plan (ESCP) is the term most commonly used to describe those plans that demonstrate proposed erosion and sediment control practices. These plans, however, can attract a variety of different names within different authorities, including *Soil Erosion and Drainage Management Plans (SEDMPs), Soil and Water Management Plans (SWMPs), Soil Erosion and Sediment Control Plans (SESCPs), Erosion and Sediment Control Programs (ESC Programs)* and *Conceptual Erosion and Sediment Control Plans.*

The Erosion and Sediment Control Plan checklist provided in Section 5.10 is suitable for both the internal review of ESCPs, as well as inclusion within the Supporting Documentation as part of the designer's quality assurance process.

5.2 Conceptual Erosion and Sediment Control Plans

High-risk sites may require preparation of a conceptual ESCP to assist in the appropriate planning of developments. These conceptual ESCPs are generally not as detailed as the final ESCPs because their very purpose requires them to be developed **before** key site layout and design information are finalised.

The purpose of preparing conceptual ESCPs is to:

- Ensure appropriate soil data is collected and site constraints are identified.
- Ensure consideration of erosion and sediment control requirements, site constraints and key environmental issues are introduced to the planning phase of the development.
- Allow regulatory authorities to voice their key concerns before a development proposal progresses too far through the planning and site layout phase.
- Demonstrate to the regulatory authority that there is a feasible means of constructing the project while still protecting key environmental values.

The content of required conceptual ESCPs can be highly variable depending on the available site and project data; however, all conceptual ESCPs need to satisfy at least the following outcomes:

- Identify the likely need for the construction of *Sediment Basins* on the site.
- Identify that adequate space has been made available for the construction and operation of major sediment traps and essential flow diversion systems.
- Demonstrate to the regulatory authority that there is a feasible means of constructing the project while still protecting key environmental values.
- Identify problem soil areas including, dispersive soils, acid sulfate soils, areas of potential mass movement.
- Identify protected environmental features on the site such as protected vegetation.

5.3 Erosion and Sediment Control Plans

The ESCP may consist of a single plan, or series of plans prepared for each stage of earthworks, or each stage of the construction process. In either case, the *intent* is to provide sufficient information, in sufficient detail and clarity, to achieve the required environmental protection, soil management, and timely installation of ESC measures.

Where appropriate, an ESCP should include the following information, or otherwise be cross-referenced to other plans containing such information:

(i) North point and plan scale.

(ii) Site and easement boundaries and adjoining roadways.

(iii) Construction access points.

(iv) Site office, car park and location of stockpiles.

(v) Proposed construction activities and limits of disturbance.

(vi) Retained vegetation including protected trees.

(vii) General soil information and location of problem soils.

(viii) Location of critical environmental values (where appropriate).

(ix) Existing site contours (unless the provision of these contours adversely impacts the clarity of the ESCP).

(x) Final site contours including locations of cut and fill.

(xi) *Construction Drainage Plans* for each stage of earthworks, including land contours for that stage of construction, sub-catchment boundaries and location of watercourses.

(xii) General layout and staging of proposed works.

(xiii) Location of all drainage, erosion and sediment control measures.

(xiv) Full design and construction details (e.g. cross-sections, minimum channel grades, channel linings,) for all drainage and sediment control devices, including *Diversion Channels* and *Sediment Basins*.

(xv) Construction specifications for adopted ESC measures (as appropriate).

(xvi) Site revegetation requirements (if not contained within separate plans).

(xvii) Site *Monitoring and Maintenance Program*, including the location of proposed water quality monitoring stations.

(xviii) Technical notes relating to:

- site preparation and land clearing;
- extent, timing and application of erosion control measures;
- temporary ESC measures installed at end of working day;
- temporary ESC measure in case of impending storms, or emergency situations;
- installation sequence for ESC measures;
- site revegetation and rehabilitation requirements;
- application rates (or at least the minimum application rates) for mulching and revegetation measures;
- legend of standard symbols used within the plans.

(xix) Calculation sheets for the sizing of ESC measures.

(xx) A completed Erosion and Sediment Control Plan checklist.

(xxi) Any other relevant information the regulatory authority may require to properly assess the ESCP.

On sites with a soil disturbance exceeding 2500m^2, Erosion and Sediment Control Plans need to be signed-off by a suitably qualified and experienced professional. A suitably qualified and experienced professional is defined as a person with:

- training and/or qualifications in erosion and sediment control that are recognised by the assessing authority; and
- professional affiliations with an engineering, environmental engineering, soil science, and/or scientific organisation (e.g. the International Erosion Control Association; Engineers Australia; Australian Soil Science Society, Environment Institute of Australia and New Zealand; or Stormwater Industry Association); and
- at least 2 years experience in the management of erosion and sediment control which can be verified by an independent third party.

The ESCP must include either of the following text boxes (Options A, B or C) as appropriate for the site conditions.

ESCP signature box Option A:

This Erosion and Sediment Control Plan satisfies the following requirements:

(i) The intent and minimum standards established by all relevant local, state and federal policies relating to erosion and sediment control.

(ii) Review and approval by personnel suitably trained and experienced (to a degree appropriate for the given type and size of the land disturbance) in each of the following categories: construction, soil science, hydrology/hydraulics, and site revegetation and rehabilitation.

(iii) Is both reasonable and practicable.

(iv) Contains sufficient information to allow appropriate implementation of the plan(s).

Signature: Date:

Printed name:

Erosion and Sediment Control Plans prepared for soil disturbances exceeding one (1) hectare or where the ESCP incorporates a Sediment Basin, need to be signed-off by an engineer experienced in hydrology and hydraulics.

ESCP signature box Option B:

This Erosion and Sediment Control Plan satisfies the following requirements:

(i) The intent and minimum standards established by all relevant local, state and federal policies relating to erosion and sediment control.

(ii) Review and approval by personnel suitably trained and experienced (to a degree appropriate for the given type and size of the land disturbance) in each of the following categories: construction, soil science, hydrology/hydraulics, and site revegetation and rehabilitation.

(iii) Is both reasonable and practicable.

(iv) Contains sufficient information to allow appropriate implementation of the plan(s).

(v) The Construction Drainage Plan has been reviewed and approved by a suitably experienced hydraulic engineer and/or hydrologist.

Signature: Date:

Printed name:

Erosion and Sediment Control Plans that incorporate a sediment basin with a constructed earth embankment with a height (at any location) greater than one (1) metre, need to be signed-off by a geotechnical specialist.

ESCP signature box Option C:

This Erosion and Sediment Control Plan satisfies the following requirements:

(i) The intent and minimum standards established by all relevant local, state and federal policies relating to erosion and sediment control.

(ii) Review and approval by personnel suitably trained and experienced (to a degree appropriate for the given type and size of the land disturbance) in each of the following categories: construction, soil science, hydrology/hydraulics, and site revegetation and rehabilitation.

(iii) Is both reasonable and practicable.

(iv) Contains sufficient information to allow appropriate implementation of the plan(s).

(v) The Construction Drainage Plan has been reviewed and approved by a suitably experienced hydraulic engineer and/or hydrologist.

(vi) The sediment basin embankment has been reviewed and approved by a suitably experienced geotechnical specialist.

Signature: Date:

Printed name:

5.4 Supporting documentation

It is difficult to define the specific contents of the *Supporting Documentation* because these documents are likely to form just one part of the overall written submission presented for a given development. For example, if a separate site rehabilitation proposal is submitted in the form of a Landscape Plan, then the *Supporting Documentation* need only refer to such a plan for specific information of site rehabilitation.

The type of information that may need to be presented within the Supporting Documentation includes:

(i) Brief site description.

(ii) Identified issues and concerns associated with the site and the ESCP.

(iii) Justification for the selection of the proposed ESC measures.

(iv) Design standards used for sizing of drainage and sediment controls.

(v) Application rates for erosion control measures (if not presented within the specifications).

(vi) Proposed staging of works.

(vii) Proposed installation sequence ESC measures.

(viii) Calculations for the sizing of the various ESC measures, especially major sediment traps such as *Sediment Basins*.

5.5 Specifications and construction details

The *Specification and Construction Details* provide detailed information of the installation, operation, maintenance and removal of all ESC measures proposed within the ESCP. They may either be printed on the construction plans, or presented within the construction documentation. Specifications should be supplied for each ESC measure, including any measures specified for used in the event of an emergency or end-of-day activity.

The ESC *Specifications and Construction Details* are normally standardised “cut-and-paste” text items and diagrams that are likely to vary little from site to site.

Example specifications are provided within the Fact Sheets presented for the various ESC techniques in Book 4 of this document. These example specifications are presented as the default best practice specifications. Modified, site specific, specifications may be required for unusual site conditions.

Typically, ESC specifications include details on the following:

(i) Detail drawings for the various ESC measures

(ii) Material specifications

(iii) Construction or installation procedures

(iv) Operational procedures

(v) Inspection and maintenance procedures

(vi) Procedures for the removal or decommissioning of ESC measures including site rehabilitation

5.6 Development of ESCPs

The following section provides one possible procedure for the preparation of Erosion and Sediment Control Plans (ESCPs). Not all design steps will be relevant to each site. Strict adherence to the design steps is not essential unless specifically required by the regulatory authority. An alternative design procedure can be adopted provided it satisfies all legislative requirements and achieves the overall aims of environmental protection as stipulated by the regulatory authority.

Guidelines on the preparation of ESCPs for single dwelling building sites are provided in Appendix H – *Building sites*.

The following procedures and recommendations are not intended to replace the need for site-specific evaluation and design. Importantly, ESCPs must consider all relevant local, state and federal legislation and codes of practice.

Summary of ESCP development steps

Step 1. Review local issues, concerns, site constraints and development approval conditions

Step 2. Review the proposed development layout

Step 3. Prepare a cut and fill plan

Step 4. Locate traffic entry/exit points and specify control measures

Step 5. Locate the site office and stockpile areas and specify control measures

Step 6. Identify potential areas of non-disturbance

Step 7. Locate and stabilise temporary construction roads and watercourse crossings

Step 8. Divide the site into hydraulically manageable drainage areas and prepare Construction Drainage Plans

Step 9. Determine the required sediment control standard

Step 10. Locate major sediment traps

Step 11. Review proposed staging of works

Step 12. Control "clean" water runoff

Step 13. Control flow velocities in drains

Step 14. Control "dirty" water runoff

Step 15. Control erosion on disturbed areas

Step 16. Control sediment runoff at property boundary

Step 17. Establish sediment traps within the development

Step 18. Define the final limits of disturbance

Step 19. Prepare the site revegetation/rehabilitation plan

Step 20. Prepare the installation sequence

Step 21. Specify emergency ESC measures

Step 22. Prepare the Monitoring and Maintenance Program

Step 23. Prepare Inspection and Test Plans (ITPs)

Step 24. Prepare the supporting documentation

Step 1. Review local issues, concerns, site constraints and development approval conditions

❑ Identify local issues and concerns. Some issues may be identified by clearly defining the following:

- the nature of the land disturbance;
- anticipated site constraints (e.g. topography, soils, vegetation, water availability);
- local environmental values—possibly identified in an existing Stormwater Management Plan, or Catchment Management Plan; and
- potential risks to environmental values as a result of the project.

❑ Identify the **relative** importance of minimising the runoff of coarse and fine sediment (turbidity) from the site. This information may be obtained from the regulatory authority, or an existing Stormwater Management Plan (SMP).

If guidance cannot be obtained from the regulatory authority or SMP, then review Table 5.1 for guidance on the potential impact of coarse sediment and turbidity on different waterways.

Table 5.1 – Likely potential impact of coarse sediment and turbidity on various receiving waters

Receiving water [1]		**L-low, M-medium, H-high**	
		Coarse sediment	**Turbidity**
Watercourses draining arid or semi-arid areas		M	L
Ephemeral creeks with no permanent pools		M	L-H
Creeks with permanent pools and naturally turbid base flow (when flowing)	clay-based [2]	H	L
	sand-based [2]	M	L
	gravel-based [2]	H	L
Creeks with permanent pools and naturally clear base flow, but turbid storm flows	clay-based [2]	H	M-H
	sand-based [2]	M	M-H
	gravel-based [2]	H	M-H
Creeks with permanent pools and naturally clear base and storm flows (e.g. rainforest stream)	clay-based [2]	H	H
	sand-based [2]	M	H
	gravel-based [2]	H	H
Freshwater river systems with turbid base flow		L-M	L-M
Freshwater river systems with clear base flow		L-M	M-H
Wetlands		H	M
Freshwater lakes		L-M	M-H
Saline rivers, estuaries and lakes		L-M	L-M
Bays and oceans		L	L-M
Reef waters		H	H

Notes: [1] It is important to consider not just the immediate receiving water, but the full passage of water from the construction site to its final destination, usually the ocean.

[2] Refer to Appendix N for definitions of clay-based, sand-based and gravel-based streams.

- [ ] Where appropriate, prepare a *Soil Map* for the site. Guidelines on soil testing are provided in Chapter 3 – *Site planning*. Soil maps can be used to:

- identify the location of problem soils, including dispersive and acid sulfate soils;
- define areas of sandy soils and clayey soils – different sediment control measures usually being required on sandy soils compared to clayey soils;
- assist in the choice and sizing of *Sediment Basins*;
- assist in the development of the revegetation program, including the specification of any required soil modifications.

The proposed ESCP must reflect the identified issues, concerns and site constraints. If the development has been adequately planned, then most of these issues should already have been identified and addressed within the design.

Technical Note 5.2 – Turbidity control

If turbidity control has been identified as an important issue, then a priority must be given to the following:

- Use of effective erosion control measures.
- Use of Type F or Type D *Sediment Basins*.
- Adoption of construction practices that allow for the prompt replacement of topsoil.
- Adoption of work practices that allow for the prompt mulching, turfing, sealing or other appropriate stabilisation of disturbed surfaces.
- Adoption of work practices that allow for the temporary stabilisation of exposed subsoils in the event of construction delays.

Step 2. Review the proposed development layout

Ideally, the development layout should not be finalised before a draft ESCP is prepared. If it is still possible for changes to occur to the development layout, then the following questions should be asked:

- [ ] Can the development layout be altered to minimise land clearing and land shaping?
- [ ] Are earthworks or construction activities proposed along a property boundary that will require sediment control measures to be located outside the property boundary? If so, then is approval likely to be given for these external controls?
- [ ] Will a *Sediment Basin* be required and does the development layout allow adequate space for a basin to be constructed and maintained?
- [ ] Can the proposal be altered to allow areas of disturbance to be permanently stabilised as soon as land shaping has been completed, i.e. before building activities commence?
- [ ] Can non-disturbance areas be allowed to act as sediment control *Buffer Zones* during the construction period?
- [ ] Is it possible to locate the site office and material stockpiles in locations that reduce the degree of on-site traffic movement, and can they be located within areas that will eventually require disturbance anyway?
- [ ] Can the proposal be altered to allow for the early installation and operation of the permanent drainage system to assist in the diversion of up-slope stormwater and/or the effective separation of “clean” and “dirty” water?

Step 3. Prepare a cut and fill plan

A cut and fill plan can be a useful tool in the preparation of an ESCP. The cut and fill plan can be used to assess the movement of bulk earth works and the likely location of construction traffic. These plans are also essential for the development of the Construction Drainage Plans (Step 9).

The cut and fill plan, together with the Construction Drainage Plans, should be readily available while preparing the ESCP. This will reduce the risk of placing an ESC measure, material stockpile, or the site office, in an area where substantial earthworks may be required.

Step 4. Locate traffic entry/exit points and specify control measures

❑ Locate the site entry/exit points. Appropriate consideration needs to be given to the following issues:

- Restrict site access to the minimum number of entry/exit points.
- Locate site entry/exit points away from areas of significant cut or fill.
- On large sites it may be desirable to provide separate entry/exit points of light vehicular traffic and heavy earthmoving traffic.
- The best location for the construction entry/exit point may not be at the same location as the final entry/exit point for the development.
- Avoid placing temporary construction entry/exit points at the lowest point in the site where it could interfere with a major sediment trap or overland flow path.

❑ Refer to Section 4.5.10 of Chapter 4 for guidance on the selection of entry/exit sediment controls.

❑ If the site or access road is elevated above the public roadway, and if stormwater runoff from the site is likely to wash sediment from the entry/exit pad onto the roadway, then mark drainage arrows on the *Construction Exit* to direct this runoff to a suitable sediment trap (Figure 5.1). This drainage control normally achieved by forming a raised flow diversion bund (speed bump) across the rock pad (Fig 5.3).

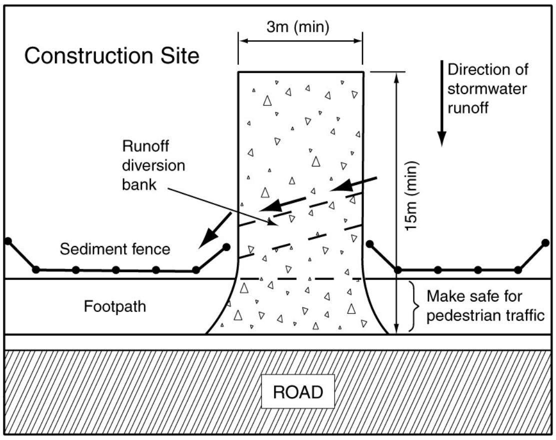


Figure 5.1 – Example of stormwater runoff directed off a *Construction Exit*

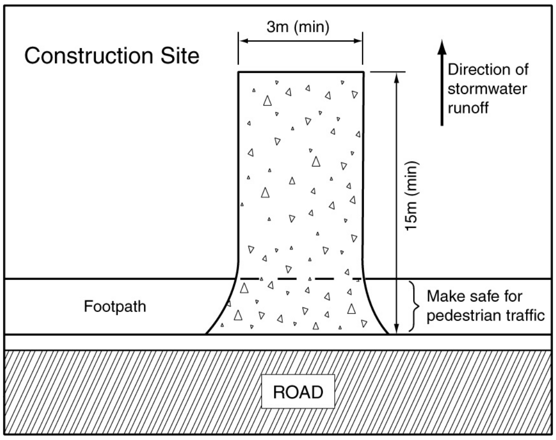


Figure 5.2 – Example a Construction Exit that drains back into a site

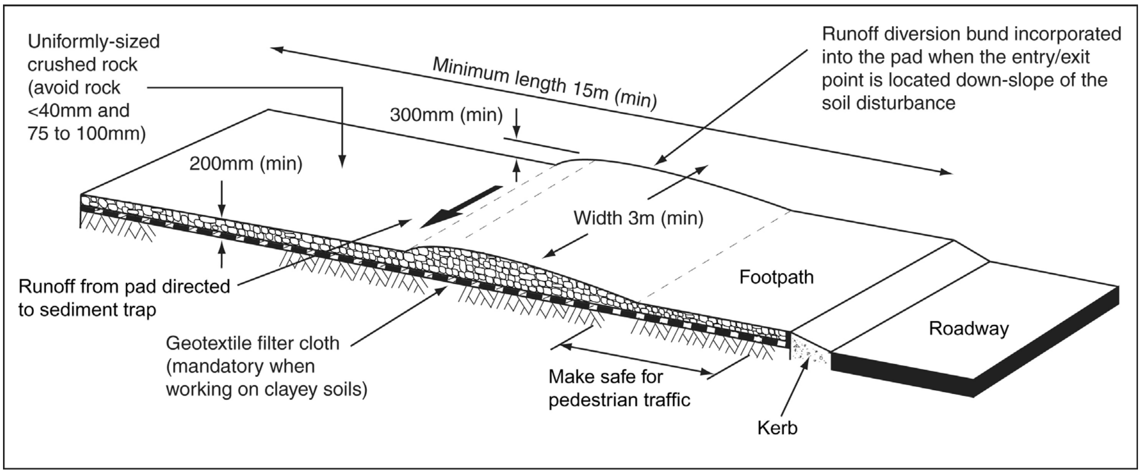


Figure 5.3 – Rock *Construction Exit* for construction sites

- ❑ Indicate the required sediment control measure to be associated with each *Construction Exit*. Alternatively the sediment-laden runoff may be directed to a *Sediment Basin*.

Technical Note 5.3 – Rock pads in building and construction

Rock pads usually perform a slightly different role on small building sites compared to large construction sites, and thus their design may be slightly different. On small building sites the rock pad is primarily used as an all-weather car park, or hard-stand area for vehicles. In effect, these pads are primarily used to prevent dirt and mud getting onto the vehicle tyres in the first place. Thus the total area of parking space on the pad is critical.

On construction sites a rock pad is used to remove sediment from truck tyres as they pass over the pad. Thus the length of the rock pad and the total void spacing between the rocks represent the critical design features.

Step 5. Locate the site office and stockpile areas and specify control measures

- ❑ Locate the site office, car park, stockpile, borrow pit and material storage areas on the ESCP. Where possible, position these areas to reduce on-site traffic movement and overall land disturbance.

  Ideally, stockpiles should be located down-slope of the site office and car park to avoid sediment-laden runoff from the stockpiles draining across the site office and car park area.

  The site office should be located close to the main site entry point so visitors to the site do not need to travel through active construction areas before reaching the office.

- ❑ Place sediment controls (e.g. *Sediment Fence*) down-slope of stockpiles and other areas that may cause sediment-laden runoff. The use of a non-woven, composite *Sediment Fence* fabric is recommended for the control of runoff from stockpiles containing clayey soil.

- ❑ Refer to Section 4.6 of Chapter 4 for guidance on the selection of sediment controls for material stockpiles.

- ❑ Locate any necessary drainage controls (e.g. *Catch Drains* or *Flow Diversion Banks*) up-slope of the site office, car park, stockpile, borrow pit and material storage areas, and then specify any necessary down-slope sediment controls.

  Up-slope flow diversion is normally required during those periods when rainfall is likely to occur and the up-slope catchment area exceeds $1500m^2$.

- ❑ Consider placing gravel over the car park, site office and common traffic areas to minimise the exposure of any clayey soils to rainfall, and to reduce the generation of mud during extended periods of wet weather.

- ❑ Where appropriate, determine an appropriate method for disposing roof water from the site offices. This water should be directed away from the work site and any common walking and access areas to minimise the generation of mud during wet weather.

Step 6. Identify potential areas of non-disturbance

- ❑ Identify on the ESCP a <u>first estimate</u> of all areas where land clearing or reshaping will **not** be required.

  Avoid placing ESC measures within these potential non-disturbance areas. The final limits of disturbance (Step 18) will not be known until the location of all ESC measures has been identified.

Step 7. Locate and stabilise temporary construction roads and watercourse crossings

- ❑ Locate all temporary construction and access roads on the site, then locate and specify all necessary drainage, erosion and sediment control measures associated with these roads.

  Where practical, allow stormwater to shed from these roads at regular intervals. This runoff should be discharged into an appropriate sediment trap and/or releasing as sheet flow via a *Level Spreader*.

- ❑ Wherever reasonable and practicable, reduce the erosion potential of temporary construction roads by locating these roads along the natural contour of the terrain. Avoid locating temporary roads on steep slopes, wet or rocky areas, or on highly erodible soils.

- ❑ Define the treatment of any *Temporary Watercourse Crossings* required to provide construction access across the site. Refer to Section 4.3.10 of Chapter 4 for guidance on the selection of the type of *Temporary Watercourse Crossing*.

- ❑ Define drainage controls on the approach roads each side of all *Temporary Watercourse Crossings*. Cross drainage is normally required to direct stormwater off the roadway and prevent its direct (i.e. untreated) discharge into the watercourse.

Step 8. Divide the site into hydraulically manageable drainage areas and prepare Construction Drainage Plans

The establishment of good drainage during each stage of construction is one of the most important aspects of a successful ESCP, especially in regions of high rainfall.

❑ Prepare Construction Drainage Plans (CDPs) for each phase of construction. The *intent* of these plans is to show:

- flow entry and exit points;
- areas of sheet flow and path lines of concentrated flow;
- sub-catchment boundaries;
- all permanent and temporary roads;
- all temporary and permanent drainage control measures expected to exist during the given stage of works.

Note: these Construction Drainage Plans may need to be revised following completion of Steps 9 and 10.

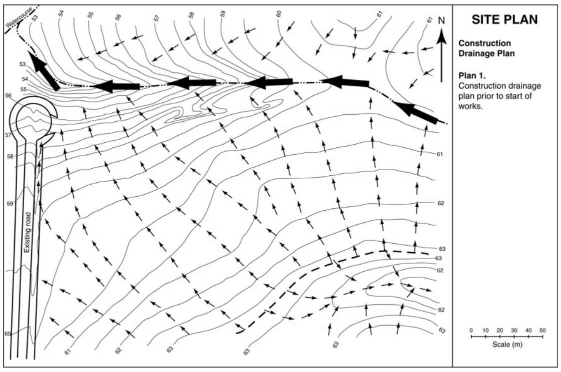


Figure 5.4 – Example Construction Drainage Plan – Stage 1

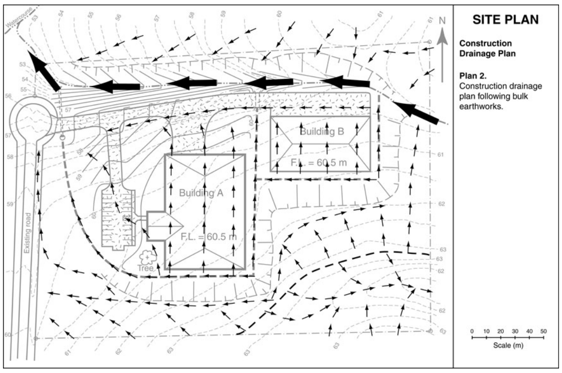


Figure 5.5 – Example Construction Drainage Plan – Stage 2

When preparing Construction Drainage Plans it is important to note that most roadways will act as drainage paths directing up-slope stormwater runoff down the road. Thus it is essential for all roads and construction tracks to be shown on these plans.

If large areas of sheet flow exist on the site, then it may be necessary to subdivide these areas into manageable drainage areas to prevent the formation of rill erosion. *Catch Drains* or *Flow Diversion Banks* should be placed at regular intervals to collect and divert this sheet flow before rills are allowed to form in the soil.

Section 4.3.3 of Chapter 4 provides the recommended **maximum** spacing of drainage systems down long, non-vegetated and vegetated slopes.

❑ Ensure a stable outlet exists on each *Catch Drain* and *Flow Diversion Bank*. Alternatively, the drains may discharge **down** the slope via a temporary *Chute*, *Slope Drain* or *Level Spreader*.

Step 9. Determine the required sediment control standard

- ❑ Using the Construction Drainage Plans, prepare a sub-catchment plan and effective catchment area for each area of soil disturbances. It may be necessary to investigate likely "clean" water flow diversion measures (Step 12).
- ❑ From this plan or plans, determine the potential soil loss rates for each sub-catchment to identify the required sediment control standard based on Table 4.5.1, (Chapter 4). Alternatively, where approved by the regulatory authority, select the sediment control standard based on either the "monthly erosivity" or "average monthly rainfall" (Table 4.5.2).
- ❑ Choose the primary sediment control measure (Type 1, 2 or 3) for each sub-catchment. If it is considered unreasonable or impractical to adopt the required control standard within a given sub-catchment, use Tables 4.5.1 or 4.5.2, to determine which months of the year construction can occur that would allow of the sediment control standard (i.e. Type 2 or 3) that would be considered reasonable and practicable.

Step 9 is very much an iterative process requiring adjustment of the proposed drainage, erosion and sediment control measures for each sub-catchment until an appropriate (i.e. reasonable and practicable) outcome is achieved. Improving the drainage control measures can reduce the effective catchment area and thus reduce the expected soil loss rates. Improving the adopted erosion control measures can also reduce the expected soil loss rates.

The option of specifying a limited construction window (i.e. months of the year in which soil disturbances can occur) must only be done when management of the construction period can be rigorously controlled through the development approval process, State legislation and/or local government by-laws.

Step 10. Locate major sediment traps

- ❑ Determine the location and size of major sediment traps, such as *Sediment Basins*. Table 4.13 lists the common Type 1 and Type 2 sediment traps.

As a general guide, a *Sediment Basin* is likely to be necessary if:

(i) Required under Step 9.

(ii) There is a need for turbidity control (i.e. sensitive habitats or receiving waters exist downstream of the site) as identified in Step 1.

When determining the size of a *Sediment Basin* it is important to note the additional surface area required to form all internal and external batters, including the main embankment, plus the area required for the spillway and associated energy dissipater. It is noted that on small sites the surface area of the main embankment and spillway may be larger than the calculated settling pond area.

On major road works, *Sediment Basins* may need to be located outside the road reserve. In such cases, the temporary use of such land should have been negotiated during the planning phase of the project. When construction works occur across streams and major drainage lines, four sediment traps/basins are usually required, one each side of the road on each side of the waterway (for further discussion refer to Appendix I – *Instream works*).

Step 11. Review proposed staging of works

- ❑ Determine the required erosion control standard from Section 4.4 of Chapter 4. Based on this standard, determine the best practice land clearing and rehabilitation requirements from Table 4.4.7 (Chapter 4).
- ❑ Based on the land clearing requirements, determine the proposed staging of earthworks and indicate this on the ESCP.
- ❑ Consider the following issues when staging the construction program.

(i) Based on the expected erosion risk (Section 4.4 of Chapter 4) to what extent can land clearing occur ahead of the proposed staging of earthworks?

(ii) Can the staging of earthworks be aligned with the drainage catchment boundaries to delay the construction (and cost) of a *Sediment Basin* located in an adjacent sub-catchment?

(iii) Can the works be staged to make best use of existing vegetated areas as sediment control *Buffer Zones*?

(iv) Will it be possible to obtain early access to a future construction stage to establish stable drainage paths (e.g. grassed channels, *Level Spreaders* and *Chutes*) prior to formal access to the site?

(v) Can the development be staged so that most of the ground disturbance occurs outside periods of the year when rainfall is highly erosive?

Technical Note 5.4 – Buffer zones

In the above context, the term *"Buffer Zone"* applies to the grassy *Buffer Zones* used as temporary sediment control measures. It does not include permanent buffer zones, including those buffers often used to separate urban development from waterways, protected bushland and other sensitive environmental habitats.

Step 12. Control "clean" water runoff

- ❑ Determine the required drainage standard from Table 4.3.1 (Chapter 4).
- ❑ If not already addressed in Step 9, ensure all reasonable and practicable measures have been taken to convey up-slope "clean" water through the site in a non-erosive manner without allowing it to mix with sediment-laden water generated within the site.

Technical Note 5.5 – Clean water

The term "clean" water refers to water that either:

(i) Enters the property from an external source and has not been further contaminated by sediment within the property.

or

(ii) Water that has originated from the site and is of such quality that it either does not need to be treated in order to meet the required water quality objective, or would not be further improved if it was to pass through the type of sediment trap specified for the sub-catchment.

The term "dirty" water refers to any water that is not clean.

In some cases it may be desirable to use the permanent underground drainage system to convey "clean" water while allowing "dirty" water to flow overland. This of course would require all kerb inlets to be fully blocked. If this is done, then it is important to ensure that overland flow paths (usually the roadway system) have sufficient hydraulic capacity to convey this water without causing safety, drainage or flooding problems.

The ESCP and/or its supporting documentation must clearly identify the size and gradient of all drainage channels, whether temporary or permanent.

Step 13. Control flow velocities in drains

❑ Ensure non-erosive flow velocities occur within all drains during the design storm.

In new drainage channels the flow velocity can be reduced by either:

- reducing the depth of flow (i.e. increasing the width of the channel);
- reducing the bed slope;
- reducing the peak discharge (i.e. diverting water away from the channel); or
- increasing the channel roughness.

Refer to Appendix A – *Construction site hydraulics and hydrology* for information on open channel hydraulics, Manning's roughness values, and allowable flow velocities for various channel linings.

❑ Refer to Sections 4.3.4 and 4.3.5 of Chapter 4 for guidance on the selection of drainage control structures.

❑ If the channel width, depth or gradient cannot be altered, then there are two options available for preventing, or at least controlling, invert erosion. Either:

- reduce the flow velocity through the placement of *Check Dams* (Section 4.3.7); or
- increase the effective scour resistance of the drain through the placement of a channel liner such as rock or *Erosion Control Mats* (Section 4.3.8).

Check Dams are most effective when used in channels with a gradient less than 10% (1 in 10). In channels with a gradient steeper than 10% it is normally more economical to line the channel with turf, rock or *Erosion Control Mats*.

Step 14. Control "dirty" water runoff

❑ Define drainage control measures that will be required to direct sediment-laden runoff to appropriate sediment traps.

It is usually necessary to have at least one drainage channel running along, or near to, the lower edge of a soil disturbance to collect sediment-laden water and direct it to a sediment trap. The exception to this rule is small drainage areas that discharge directly through a "sheet" flow sediment trap such as a *Sediment Fence* or *Compost Berm*.

Catch Drains and *Flow Diversion Banks* located immediately up-slope of existing residential properties need to be designed to a higher standard than other temporary drainage devices due to the risk of down-slope property flooding or property damage if they are overtopped. A minimum 1 in 5 year ARI design storm is recommended in Table 4.3.1 of Chapter 4.

❑ Where appropriate, locate *Catch Drains* or *Flow Diversion Banks* at regular intervals down the exposed slopes to collect sediment-laden runoff before it is allowed to cause rill erosion. The maximum recommended spacing of these *Catch Drains* and *Flow Diversion Banks* is provided in Section 4.3.3 of Chapter 4.

- ❑ Locate a *Catch Drain* or *Flow Diversion Bank* above cut batters. A temporary toe drain should also be maintained at the base of **cut** batters during their construction. *Catch Drains* located at the base of **fill** slopes are usually not effective due to the high risk of displaced fill material blocking the drain.

- ❑ Ensure non-erosive flow velocities occur within all “dirty” water drains.

Step 15. Control erosion on disturbed areas

- ❑ Define appropriate erosion control measures for each area of soil disturbance. Refer to Sections 4.4.1 to 4.4.6 of Chapter 4 for guidance on the selection of erosion control measures.

Erosion control techniques should be employed as soon as reasonable and practicable to limit soil erosion, in particular, to protect any and all exposed areas of soil from strong winds and raindrop impact erosion.

The degree and timing of erosion control measures depends on the likelihood and intensity of expected winds or rainfall. If construction occurs during the dry season when moderate to heavy rainfall is less likely to occur, then the degree of erosion protection is likely to be significantly less than if construction occurs during the wet season (noting that not all areas of Australia experience well-defined wet and dry seasons).

Erosion control measures placed on ESCPs must **not** assume that soil disturbances will only occur during certain periods of the year, unless the management of the construction period can be rigorously controlled through the development approval process and current legislation. Therefore, *“technical notes”* usually need to be introduced either onto the plans, or into the *Supporting Documentation* to specify erosion control and revegetation procedures for different periods of the year, or for different degrees of anticipated or actual rainfall.

If a large area is to be mulched, then regularly spaced *Catch Drains* or *Banks* can be used to reduce the likelihood of the mulch being washed from the site during storms. Alternatively, on steep slopes, *Turf Filter Strips* can be placed along the contour at regular intervals (maximum 2m) down the slope to help maintain “sheet” flow conditions, thus reducing the risk of the mulch washing off the slope.

Step 16. Control sediment runoff at property boundary

- ❑ Ensure that there are no locations around the perimeter of the site where sediment-laden runoff could leave the site untreated. Take all necessary measures to address any untreated runoff.

- ❑ Ensure no avoidable adverse effects occur on adjacent properties.

Water bodies and properties downstream of the site should be protected from any adverse effects of sediment-laden runoff from the site. Consideration of the potential impacts of this sediment-laden runoff should not be restricted to just the immediate downstream property or receiving water.

Wherever practicable, sediment-laden runoff should be collected in a *Catch Drain* or *Flow Diversion Bank* and directed to a suitable sediment trap as per Steps 9 and 10.

Wherever practicable, *Sediment Fences* should be located perfectly along a contour (Figure 5.6). Where this is not practicable, install each *Sediment Fence* such that a series of small water-damming compartments will occur along each fence (Figure 5.7).

These compartments may be formed by regularly returning the fence up the slope at 5 to 20m intervals (depending on the slope), or installing the fence in a zigzag pattern. Even if the fence is located along the contour, regular “returns” are recommended at a maximum intervals of 20m (Figure 5.7).

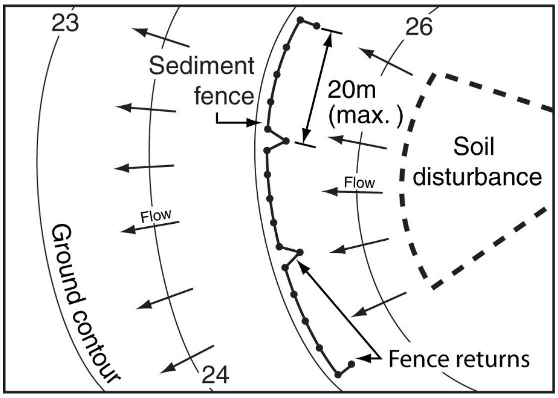


Figure 5.6 – *Sediment Fence* located along the contour

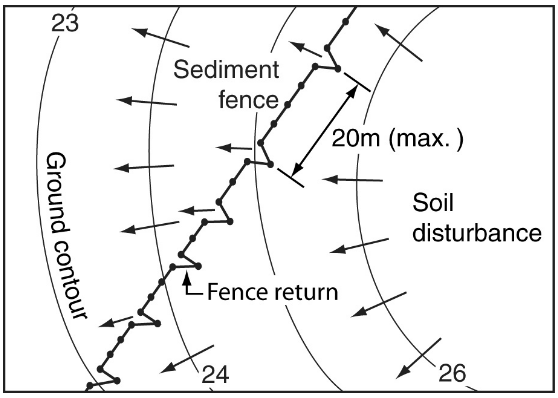


Figure 5.7 – *Sediment Fence* located off the contour

- ❑ Refer to Section 4.5.2 of Chapter 4 for guidance on the selection of sediment controls suitable for areas of sheet flow.

- ❑ Refer to Section 4.5.3 of Chapter 4 for guidance on the selection of sediment controls suitable for roadside kerb inlets.

- ❑ Refer to Section 4.5.5 of Chapter 4 for guidance on the selection of sediment controls suitable for areas of minor concentrated flow.

- ❑ Refer to Section 4.5.6 of Chapter 4 for guidance on the selection of sediment controls suitable for areas of significant concentrated flow.

Step 17. Establish sediment traps within the development

❑ Identify opportunities for the placement of sediment traps within the development site. Wherever practical, sediment traps should be located as close to the sediment source as possible without unnecessarily interfering with construction activities or causing safety issues.

Opportunities usually exist for the placement of sediment traps at the following locations:

- up-slope or adjacent to roadside kerb inlets (as appropriate for the type of inlet) (Section 4.5.3 of Chapter 4);
- around field (drop) inlets (Section 4.5.4 of Chapter 4);
- within "dirty" water drainage channels where it is safe to pond water (Sections 4.5.5 and 4.5.6 of Chapter 4);
- up-slope of stormwater pipe inlets and minor culverts (Section 4.5.7 of Chapter 4);
- at stormwater outlets, using a permanent, in-pipe gross pollutant trap, or placing a sediment trap within the outlet channel well downstream (i.e. 10 to 13 x pipe diameter) of the pipe outlet (Section 4.5.8 of Chapter 4).

First preference should always be given to the placement of sediment traps at the **inlet** of stormwater pipes and other drainage systems. Where this is not practicable, then consideration should be given to the placement of a sediment trap at the outlet of the pipe or drain.

Extreme care must be given to the location and design of sediment traps located at or immediately downstream of stormwater outlets. Jetting forces associated with high velocity discharges from stormwater pipes can resuspend sediment previously settled causing the sediment to be washed into downstream receiving waters.

Sediment traps must **not** be located within streams or major drainage channels unless they satisfy the requirements outlined in Appendix I – *Instream works*.

All sediment traps must be located totally within the relevant property boundaries unless otherwise approved in writing by the appropriate regulatory authority and land owner.

❑ Ensure that each sediment trap, particularly Type 2 sediment traps, has the necessary structural features that will enable the trap to function as required.

The critical design features of most sediment traps are:

- the ability to pond water (the surface area of the settling pond being the critical design feature);
- adequate retention time to allow sufficient settlement (usually related to the pond surface area);
- the storage capacity to collect and retain sediment;
- adequate hydraulic capacity prior to flow bypassing;
- allowance for the safe bypassing of flows in excess of the design discharge; and
- appropriate geometry and/or use of flow control banks to control the maximum depth of ponding in locations where public safety issues exist.

Excavating a sediment collection pit immediately up-slope of a Type 2 sediment trap can reduce the risk of sediment blockage of geotextile filtration systems. However, most aggregate-based filters rely on the partial blockage effects of the sediment to enable the aggregate to properly filter the finer silt particles. Therefore, it is important to specify the required filtration system (i.e. cloth or aggregate) and ensure appropriate structural and dimensional details are provided within the Erosion and Sediment Control Plan (ESCP).

Step 18. Define the final limits of disturbance

- ❑ Identify on the ESCP those areas where land clearing or reshaping will be necessary, including any clearing necessary to establish the site office, workshop areas, access and haul roads, stockpiles, and all drainage, erosion and sediment control measures.

- ❑ Where necessary, indicate on the ESCP light fencing, marker tape and/or signposts around the proposed non-disturbance areas and *Buffer Zones*. Technical notes (see Section 5.7) may need to be placed on the ESCP to indicate that the non-disturbance areas are to be clearly identified before land clearing commences.

Step 19. Prepare the site revegetation/rehabilitation plan

- ❑ Specify required site stabilisation, revegetation and rehabilitation measures.

- ❑ Using the erosion control standard determined in Step 11, specify the required timing (relative to the staging of soil disturbances) of proposed site stabilisation, revegetation and rehabilitation.

Exposed soil surfaces need to be **stabilised** (i.e. erosion control measures) as soon as practicable to prevent, or at least minimise, potential environmental harm. Once stabilised, these areas need to be revegetated or otherwise rehabilitated to ensure appropriate long-term erosion control.

Discussion on the staged rehabilitation of Sediment Basins is provided in Step 16 of basin design presented in Appendix B – *Sediment basin design and operation*.

Step 20. Prepare the installation sequence

❑ Prepare the Installation Sequence for the adopted ESC measures.

To be effective, it is critical that the various drainage, erosion and sediment control techniques are installed in an appropriate sequence relative to the various construction activities.

Each control measure (with the possible exception of *Check Dams*) should be identified using a unique code. One of the benefits of providing each control measure with a unique identification number/code (e.g. SF-1, SF-2, SF-3, and so on) is that it greatly improves the clarity of the tabulated installation sequence.

The installation sequence should provide the following information for each control measure:

- unique identification number/code;
- plan number where the control measure can be found;
- description of when the control measure is to be installed relative to other construction activities or ESC installations;
- description of when the control measure is to be decommissioned relative to other construction activities, ESC installations or decommissioning activities.

An example Installation Sequence is provided in Table 5.2.

Table 5.2 – Example ESC Installation Sequence

Code	Item	Plan	Installed	Removed
Mark out initial limits of disturbance				
Exit-1	Construction Exit	DWG-001	Day one	When permanent internal roads are sealed
Exit-2	Construction Exit	DWG-001	Day one	When permanent internal roads are sealed
Site office		DWG-010	Day one	End of works
SF-1	Sediment Fence	DWG-001	Prior to land clearing	After site stabilisation
SF-2	Sediment Fence	DWG-001	Prior to land clearing	After site stabilisation
SB-1	Sediment Basin	DWG-002	After SF-3	After site stabilisation
CH-1	Chute	DWG-002	During construction of SB-1	During removal of SB-1
Clearing of Sediment Basin settling zone				
CD-1	Catch Drain	DWG-003	After construction of SB-1	After site stabilisation
SS-1	Sediment Trench	DWG-003	Prior to land clearing	After site stabilisation
CD-2	Catch Drain	DWG-003	After construction of SS-1	
CD-3	Catch Drain	DWG-003	After construction of SS-1	
SF-3	Sediment Fence	DWG-003	After land clearing	After site stabilisation

A *Construction Sequence* may be presented as an alternative to an ESC installation sequence. A construction sequence differs from an installation sequence in that it includes the various steps of the construction phase. An example Construction Sequence is provided in Table 5.3.

Table 5.3 – Example Construction Sequence

Code	Item	Plan	Installed	Removed
Development approval				
Appoint Safety Officer and ESC Officer				
Order Stage 1 erosion and sediment control supplies				
Pre-construction conference				
Mark out initial limits of disturbance				
Exit-1	Construction Exit	DWG-001	Day one	When permanent internal roads are sealed
Exit-2	Construction Exit	DWG-001	Day one	When permanent internal roads are sealed
Delivery and set-up site office		DWG-010	Day one	End of works
Delivery of waste bins				
SF-1	Sediment Fence	DWG-001	Prior to land clearing	After site stabilisation
SF-2	Sediment Fence	DWG-001	Prior to land clearing	After site stabilisation
SB-1	Sediment Basin	DWG-002	After SF-3	After site stabilisation
CH-1	Chute	DWG-002	During construction of SB-1	During removal of SB-1
Clearing of Sediment Basin settling zone				
CD-1	Catch Drain	DWG-003	After construction of SB-1	After site stabilisation
SS-1	Sediment Trench	DWG-003	Prior to land clearing	After site stabilisation
CD-2	Catch Drain	DWG-003	After construction of SS-1	
CD-3	Catch Drain	DWG-003	After construction of SS-1	
Mark out stockpile area		DWG-003		
SF-3	Sediment Fence	DWG-003	After land clearing	After site stabilisation
Temporary sediment controls at property boundary on Road 2				
Clear and grub Roads 1 & 2		DWG-004		
Construction Roads 1 & 2		DWG-004		
Drainage Road 2		DWG-004		
Sediment controls Road 2 converted to “On-Grade” sandbag sediment trap				
Drainage Road 1		DWG-004		
All kerb inlets on Road 1 blocked to prevent sediment inflow				
Limited clearing of lots		DWG-005		
Construct drainage line 3		DWG-006		
Site revegetation		DWG-007		
Installation of temporary sediment controls down-slope of Sediment Basin prior to removal				
Removal of Sediment Basin				
Stabilisation of basin area		DWG-007		
Removal of site office				

Step 21. Specify emergency ESC measures

- [ ] Use *Technical Notes* to specify any emergency ESC measures required in the event of rain or strong winds. These temporary measures are applied to a site to control soil erosion and the passage of water in the event that rain occurs either during working hours or outside normal working hours.

These temporary measures are not meant to replace those ESC measures shown on the ESCP, but are used in the event that a device failure occurs, or unforeseen circumstances prevent the required controls from being installed.

Temporary control measures include using straw bales or compacted soil placed as *Flow Diversion Banks* around trenches and unstable earth batters, or to direct sediment-laden runoff to a sediment trap.

Example technical notes are provided in Section 5.7.

Step 22. Prepare the Monitoring and Maintenance Program

- [ ] Prepare a list of the expected ESC materials and equipment required to be stored on-site to facilitate regular maintenance and repair activities.

- [ ] Prepare a Monitoring and Maintenance Program for the site and each drainage, erosion and sediment control technique (refer to Chapter 7 – *Site inspection*).

Maintenance requirements for the various ESC techniques are provided in Book 4.

Step 23. Prepare Inspection and Test Plans

- [ ] Prepare an *Inspection and Test Plan* (ITP).

Inspection and Test Plans are usually prepared for larger construction works, typically larger than 1ha, or where there is the need to control specific aspects of the construction process, or where there are potentially high environmental impacts associated with the execution of the works.

Inspection and Test Plans detail the inspection, testing and performance criteria for key construction activities such as site revegetation. Example ITP clauses are provided in Chapter 7 – *Site inspection*.

Inspection and Test Plans should identify:

- the activity to be monitored;
- method of inspection or testing, including testing standard;
- frequency and/or timing of inspections/testing;
- “witness” and “hold points” required in the construction process;
- performance criteria;
- responsible officer;
- required documentation or inspection report;
- where the documentation and inspection reports are required to be sent.

Witness points represent construction activities that are to be observed by a nominated “witness” (e.g. site superintendent).

Hold points represent stages in the construction program beyond which work must not proceed unless either a stated activity has been completed, or the works have been authorised by an appropriate officer (e.g. site superintendent, regulatory authority).

Step 24. Prepare the supporting documentation

❑ Prepare all necessary supporting documentation to support the Erosion and Sediment Control Plan (ESCP) as detailed in Sections 5.4 and 5.5.

5.7 Allocation of ESCP technique codes

An A–Z summary of the recommended ESC technique codes is provided in Table 5.4.

Table 5.4(a) – ESC plan identification codes

Code	Technique	Technique grouping
BB	Brushwood Barrier	Sediment Control (Supplementary)
BA	Block & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
BFM	Bonded Fibre Matrix	Erosion Control
BZ	Buffer Zone	Sediment Control (Type 1, 2 or 3)
CB	Compost Berm	Sediment Control (Type 2)
CBT	Compost Blanket	Erosion Control
CCS	Cellular Confinement System	Drainage & Erosion Control
CD	Catch Drain	Drainage Control
CDT	Check Dam Sediment Trap	Sediment Control (Supplementary)
CH	Chute	Drainage Control
CST	Coarse Sediment Trap	Sediment Control (Type 3)
Dam	Cofferdam	Instream Control – flow control
DB	Flow Diversion Bank	Drainage Control
DC	Diversion Channel	Drainage Control
Dust	Dust Control	Erosion Control
ECB	Erosion Control Blanket	Erosion Control
ECM	Erosion Control Mats	Drainage Control – channel lining
EX	Excavated Drop Inlet Protection	Sediment Control (Type 3)
Exit	Construction Exit	Sediment Control (Supplementary)
Exit	Rock Pad	Sediment Control (Supplementary)
Exit	Vibration Grid	Sediment Control (Supplementary)
Exit	Wash Bay	Sediment Control (Supplementary)
FB	Filter Bag	De-watering Sediment Control (Type 2)
FD	Fabric Drop Inlet Protection	Sediment Control (Type 3)
FF	Filter Fence	De-watering Sediment Control (Type 3)
FP	Filter Pond	De-watering Sediment Control (Type 2)
FR	Fibre Roll	Drainage & Sediment Control (Sup.)
FS	Filter Sock	Sediment Control (Type 2 or 3)
FSC	Floating Silt Curtain	Instream Control – flow control
FT	Filter Tube	De-watering Sediment Control (Type 2)
FTB	Filter Tube Barrier	Instream Control (Type 2)
FTD	Filter Tube Dam	De-watering & Sediment Control (Type 2)
FW	Fabric Wrap Drop Inlet Protection	Sediment Control (Type 3)
G	Gravelling	Erosion Control
GB	Gully Bag	Sediment Control (Supplementary)
GC	Grass Lining	Drainage Control – channel lining
GEO	Geosynthetic Lining	Drainage Control – channel lining
GFB	Grass Filter Bed	De-watering Sediment Control (Type 3)
GFS	Grass Filter Strip	Sediment Control (Supplementary)
GP	Grass Pavers	Erosion Control
HA	Hard Armouring	Drainage Control – channel lining
IB	Isolation Barrier	Instream Control – flow control
Log	Geo Log	Instream Control – flow control

Table 5.4(b) – ESC plan identification codes

Code	Technique	Technique grouping
LS	Level Spreader	Drainage Control
M	Light Mulching	Erosion Control
MA	Mesh & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
MB	Mulch Berm	Sediment Control (Type 2)
MH	Heavy Mulching	Erosion Control
MR	Rock Mulching	Erosion Control
MSB	Modular Sediment Barrier	Instream Control (Type 3)
MST	Modular Sediment Trap	Sediment Control (Type 3)
OG	Kerb Inlet Trap – On-Grade Inlets	Sediment Control (Supplementary)
OS	Outlet Structure	Drainage Control
OW	Spill-Through Weir	Sediment Control (component)
Poly	Polyacrylamide	Erosion Control
PST	Portable Sediment Tank	De-watering Sediment Control (Type 2/3)
R	Revegetation	Erosion Control
RA	Rock & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
RC	Rock Check Dam	Drainage Control
RFD	Rock Filter Dam	Instream & Sediment Control (Type 2)
RM	Rock Mattress Lining	Drainage Control – channel lining
RR	Rock Lining	Drainage Control – channel lining
RRC	Recessed Rock Check Dam	Drainage Control
ST/S	Kerb Inlet Trap – Sag Inlets	Sediment Control (Supplementary)
SB	Sediment Basin	Sediment Control (Type 1)
SBB	Straw Bale Barrier	Sediment Control (Type 3)
SBC	Sandbag Check Dam	Drainage Control
SBS	Soil Binder	Erosion Control
SD	Slope Drain	Drainage Control
SEP	Settling Pond	De-watering Sediment Control (Type 2)
SF	Sediment Fence	Sediment Control (Type 3)
SFB	Sediment Fence Isolation Barrier	Instream Control – flow control
SFC	Sediment Filter Cage	Instream Control (Type 3)
SGB	Stiff Grass Barrier	Sediment Control (Supplementary)
SP	Sump Pit	De-watering Sediment Control (Type 2)
SR	Surface Roughening	Erosion Control
SS	Sediment Trench	Sediment Control (Type 2)
ST	Sediment Trap	Sediment Control
STP	Stilling Pond	De-watering Sediment Control (Type 1)
SW	Sediment Weir	Instream & Sediment Control (Type 2)
T	Turfing	Drainage & Erosion Control
TBC	Temporary Bridge Crossing	Drainage Control
TCC	Temporary Culvert Crossing	Drainage Control
TD	Temporary Downpipe	Drainage Control
TDC	Triangular Ditch Check	Drainage Control
TFC	Temporary Ford Crossing	Drainage Control
TRM	Turf Reinforcement Mat	Drainage Control – channel lining
TS	Temporary Seeding	Erosion Control
TWC	Temporary Watercourse Crossing	Drainage Control
UST	U-Shape Sediment Trap	Sediment Control (Type 3)

5.8 Example technical notes

This Section provides example technical notes for use on Erosion and Sediment Control Plans (ESCPs). Not all of the following notes will be applicable to each site. The following example Technical notes may be modified as necessary to ensure applicability to a given site or construction activity.

It is the designer's responsibility to ensure that all technical notes incorporated into an ESCP are applicable to the expected site conditions and any specified operational requirements, such as those specified within the development approval conditions.

General

1. Additional erosion and sediment control measures must be implemented and a revised Erosion and Sediment Control Plan (ESCP) must be submitted for approval in the event that site conditions change significantly from those considered within the ESCP.
2. Additional erosion and sediment control measures must be implemented and a revised Erosion and Sediment Control Plan (ESCP) must be submitted for approval in the event that the implemented works fail to achieve the stated "objective" of the ESCP, the local government ESC standard, or the State's environmental protection requirements. *(alternative to above)*
3. Where there is a high probability that serious or material environmental harm may occur as a result of sediment leaving the site, appropriate additional erosion and sediment control measures must be implemented such that all reasonable and practicable measures are being taken to prevent or minimise such harm. Only those works necessary to minimise or prevent environmental harm shall be conducted on-site prior to approval of the amended Erosion and Sediment Control Plan (ESCP).
4. Where there is a high probability that serious or material environmental harm may occur as a result of sediment leaving the site, a new or amended Erosion and Sediment Control Plan (ESCP) must be submitted for approval. Only those works necessary to minimise or prevent environmental harm shall be conducted on-site prior to approval of the new or amended ESCP. *(alternative to above)*
5. In circumstances where it is considered necessary to prepare an amended Erosion and Sediment Control Plan (ESCP), and where the delivery of such an amended ESCP is not imminent, then all necessary new or modified erosion and sediment control works must be in accordance to [*name of document*]. Upon approval of the amended ESCP, all works must be implemented in accordance with the amended plan.

Land clearing

6. Land clearing must be delayed as long as practicable and must be undertaken in conjunction with development of each stage of works, unless otherwise approved by [*insert name or title*].
7. All reasonable and practicable efforts must be taken to delay the removal of, or disturbance to, existing ground cover (organic or inorganic) prior to land-disturbing activities.
8. Bulk tree clearing must occur in a manner that minimises disturbance to existing ground cover (organic or inorganic).

9. Bulk tree clearing and grubbing of the site must be immediately followed by specified temporary stabilisation measures (e.g. temporary grassing, or mulching) prior to commencement of each stage of construction works.

10. Disturbance to natural watercourses (including bed and banks) and their associated riparian zones must be limited to the minimum practicable.

11. No land clearing shall be undertaken unless preceded by the installation of adequate drainage and sediment control measures, unless such clearing is required for the purpose of installing such measures, in which case, only the minimum clearing required to install such measures shall occur.

12. Land clearing must be limited to 5m from the edge of proposed constructed works, 2m of essential construction traffic routes, and a total of 10m width for construction access, unless otherwise approved by [*insert name or title*].

13. Prior to land clearing, areas of protected vegetation, and significant areas of retained vegetation must be clearly identified (e.g. with high-visibility tape, or light fencing) for the purposes of minimising the risk of unnecessary land clearing.

14. All reasonable and practicable measures must be taken to minimise the removal of, or disturbance to, those trees, shrubs and ground covers (organic or inorganic) that are intended to be retained.

15. All land clearing must be in accordance with the Federal, State and local government Vegetation Protection/Preservation requirements and/or policies.

16. Land clearing is limited to the minimum practicable during those periods when soil erosion due to wind, rain or surface water is possible.

17. Land clearing must not extend beyond that necessary to provide up to eight (8) weeks of site activity during those months when the expected rainfall erosivity is less than 100, six (6) if between 100 and 285, four (4) weeks if between 285 and 1500, and two (2) weeks if greater than 1500.

18. Land clearing must not extend beyond that necessary to provide up to eight (8) weeks of site activity during those months when the actual or average rainfall is less than 45mm, six (6) if between 45 and 100mm, four (4) weeks if between 100 and 225mm, and two (2) weeks if greater than 225mm. *(alternative to above)*

Site access

19. Prior to the commencement of site works, the location of the site access point(s) must be verified with [*insert relevant authority*].

20. Site access must be restricted to the minimum practical number of locations.

21. Site exit points must be appropriately managed to minimise the risk of sediment being tracked onto sealed, public roadways.

22. Stormwater runoff from access roads and stabilised entry/exit points must drain to an appropriate sediment control device.

Soil and stockpile management

23. All reasonable and practicable measures must be taken to obtained the maximum benefit from existing topsoil, including:

(i) Where the proposed area of soil disturbance does not exceed 2500m^2, and the topsoil does not contain undesirable weed seed, the top 100mm of soil located within areas of proposed soil disturbance (including stockpile areas) must be stripped and stockpiled separately from the remaining soil.

(ii) Where the proposed area of soil disturbance exceeds 2500m^2, and the topsoil does not contain undesirable weed seed, the top 50mm of soil must be stripped and stockpiled separately from the remaining topsoil, and spread as a final surface soil.

(iii) In areas where the topsoil contains undesirable weed seed, the affected soil must be suitably buried or removed from the site.

24. Stockpiles of erodible material that has the potential to cause environmental harm if displaced, must be:

(i) Appropriately protected from wind, rain, concentrated surface flow and excessive up-slope stormwater surface flows.

(ii) Located at least 2m from any hazardous area, retained vegetation, or concentrated drainage line.

(iii) Located up-slope of an appropriate sediment control system.

(iv) Provided with an appropriate protective cover (synthetic, mulch or vegetative) if the materials are likely to be stockpiled for more than 28 days.

(v) Provided with an appropriate protective cover (synthetic, mulch or vegetative) if the materials are likely to be stockpiled for more than 10 days during those months that have a high erosion risk.

(vi) Provided with an appropriate protective cover (synthetic, mulch or vegetative) if the materials are likely to be stockpiled for more than 5 days during those months that have a extreme erosion risk.

25. A suitable flow diversion system must be established immediately up-slope of a stockpile of erodible material that has the potential to cause environmental harm if displaced, if the up-slope catchment area draining to the stockpile exceeds $1500m^2$.

Site management

26. All office facilities and operational activities must be located such that any liquid effluent (e.g. process water, wash-down water, effluent from equipment cleaning, or plant watering), can be totally contained and treated within the site.

27. The construction schedule must aim to minimise the duration that any and all areas of soil are exposed to the erosive effects of wind, rain and surface water.

28. Land-disturbing activities must be undertaken in accordance with the Erosion and Sediment Control Plan (ESCP) and associated development conditions.

29. Land-disturbing activities must be undertaken in such a manner that allows all reasonable and practicable measures to be undertaken to:

(i) allow stormwater to pass through the site in a controlled manner and at non-erosive flow velocities up to the specified design storm discharge;

(ii) minimise soil erosion resulting from rain, water flow and/or wind;

(iii) minimise adverse effects of sediment runoff, including safety issues;

(iv) prevent, or at least minimise, environmental harm resulting from work-related soil erosion and sediment runoff;

(v) ensure that the value and use of land/properties adjacent to the development (including roads) are not diminished as a result of the adopted ESC measures.

30. All erosion and sediment control measures must conform to the standards and specifications contained in:

(i) the development approval condition issued by [*insert appropriate authority*]; and

(ii) the approved ESCP and supporting documentation; or

(iii) the latest version of [*insert relevant document*] if the standards and specifications are not contained in the approved ESCP.

31. Any works that may cause significant soil disturbance and are ancillary to any activity for which regulatory body approval is required, must not commence before the issue of that approval.

32. Additional and/or alternative ESC measures must be implemented in the event that site inspections, the site's Monitoring and Maintenance Program, or the regulatory authority, identifies that unacceptable off-site sedimentation is occurring as a result of the work activities.

33. Additional and/or alternative ESC measures must be implemented in the event that [*insert relevant name, title or authority*], identifies that unacceptable off-site sedimentation is occurring as a result of the work activities. *(alternative to above)*

34. Land-disturbing activities must not cause unnecessary soil disturbance if an alternative construction process is available that achieves the same or equivalent outcomes at an equivalent cost.

35. Sediment (including clay, silt, sand, gravel, soil, mud, cement and ceramic waste) deposited off the site as a direct result of an on-site activity, must be collected and the area appropriately cleaned/rehabilitated as soon as reasonable and practicable, and in a manner that gives appropriate consideration to the safety and environmental risks associated with the sediment deposition.

36. Wherever reasonable and practicable, brick, tile and masonry cutting must be carried out on a pervious surface, such as grass, or open soil, or in such a manner that all sediment-laden runoff is prevented from discharging into a gutter, drain, or water body.

37. Adequate waste collection bins must be provided on-site and maintained such that potential and actual environmental harm resulting from such material waste is minimised.

38. Concrete waste and chemical products, including petroleum and oil-based products, must be prevented from entering an internal water body, or an external drain, stormwater system, or water body.

39. All flammable and combustible liquids, including all liquid chemicals if such chemicals could potentially be washed or discharged from the site, are stored and handled on-site in accordance with relevant standards such as AS1940 *The storage and handling of flammable and combustible liquids*.

40. Trenches not located within roadways must be backfilled, capped with topsoil, and compacted to a level at least 75mm above adjoining ground level and appropriately stabilised.

41. All stormwater, sewer line and other service trenches, not located within roadways, must be mulched and seeded, other otherwise appropriately stabilised within 7 days after backfill.

42. No more than 150m of a stormwater, sewer line or other service trench must to be open at any one time.

43. Site spoil must be lawfully disposed of in a manner that does not result in ongoing soil erosion or environmental harm.

44. All fill material placed on site must comprise only natural earth and rock, and is to be free of contaminants, be free draining, and be compacted in layers not exceeding 300mm to 90% modified maximum dry density in accordance with AS1289.

Drainage control

45. All drainage control measures must be applied and maintained in accordance with [*insert relevant document*].

46. Wherever reasonable and practicable, stormwater runoff entering the site from external areas, and non-sediment laden (clean) stormwater runoff entering a work area or area of soil disturbance, must be diverted around or through that area in a manner that minimises soil erosion and the contamination of that water for all discharges up to the specified design storm discharge.

47. During the construction period, all reasonable and practicable measures must be implemented to control flow velocities in such a manner than prevents soil erosion along drainage paths and at the entrance and exit of all drains and drainage pipes during all storms up to the relevant design storm discharge.

48. To the maximum degree reasonable and practicable, all waters discharged during the construction phase must discharge onto stable land, in a non-erosive manner, and at a legal point of discharge.

49. Wherever reasonable and practicable, "clean" surface waters must be diverted away from sediment control devices and any untreated, sediment-laden waters.

50. During the construction period, roof water must be managed in a manner that minimises soil erosion throughout the site, and site wetness within active work areas.

Erosion control

51. All erosion control measures must be applied and maintained in accordance with [*insert relevant document*].

52. The application of liquid-based dust suppression measures must ensure that sediment-laden runoff resulting from such measures does not create a traffic or environmental hazard.

53. All temporary earth banks, flow diversion systems, and embankments associated with constructed sediment basins must be machine-compacted, seeded and mulched for the purpose of establishing a temporary vegetative cover within 10 days after grading.

54. Unprotected slope lengths must not exceed 80m, or an equivalent vertical fall of 3m during the period [*insert date/month*] and [*insert date/month*].

55. Unprotected slope lengths must not exceed 80m, or an equivalent vertical fall of 3m prior to specified shutdown periods or when rainfall is expected to exceed [*insert value*] within a 24 hour period, or the monthly rainfall is expected to exceed [*insert value*].

56. The construction and stabilisation of earth batters steeper than 6:1 (H:V) must be staged such that no more than 3 vertical-metres of any batter is exposed to rainfall at any instant.

57. Synthetic reinforced erosion control mats and blankets must not be placed within, or adjacent to, riparian zones and watercourses if such materials are likely to cause environmental harm to wildlife or wildlife habitats.

58. A minimum 60% ground cover must be achieved on all non-completed earthworks exposed to accelerated soil erosion if further construction activities or soil disturbances are likely to be suspended for more than 30 days during those months when the expected rainfall erosivity is less than 60; minimum 70% cover within 30 days if between 60 and 100; minimum 70% cover within 20 days if between 100 and 285; minimum 75% cover within 10 days if between 285 and 1500; and minimum 80% cover within 5 days if greater than 1500.

59. A minimum 60% ground cover must be achieved on all non-completed earthworks exposed to accelerated soil erosion if further construction activities or soil disturbances are likely to be suspended for more than 30 days during those months when the expected rainfall is less than 30mm; minimum 70% cover within 30 days if between 30 and 45mm; minimum 70% cover within 20 days if between 45 and 100mm; minimum 75% cover within 10 days if between 100 and 225mm; and minimum 80% cover within 5 days if greater than 225mm. (*alternative to above*)

Sediment control

60. All sediment control measures must be applied and maintained in accordance with [*insert relevant document*].
61. Optimum benefit must be made of every opportunity to trap sediment within the work site, and as close as practicable to its source.
62. Sediment traps must be installed and operated to both collect and retain sediment.
63. The potential safety risk of a proposed sediment trap to site workers and the public must be given appropriate consideration, especially those devices located within publicly accessible areas.
64. All reasonable and practicable measures must be taken to prevent, or at least minimise, the release of sediment from the site.
65. Suitable all-weather maintenance access must be provided to all sediment control devices.
66. Sediment control devices must be de-silted and made fully operational as soon as reasonable and practicable after a sediment-producing event, whether natural or artificial, if the device's sediment retention capacity falls below 75% of its design retention capacity.
67. Materials, whether liquid or solid, removed from sediment control devices during maintenance or decommissioning, must be disposed of in a manner that does not cause ongoing soil erosion or environmental harm.
68. As-Constructed plans must be prepared for all for constructed sediment basins and associated emergency spillways. Such plans must appropriately verify the basin's dimensions, levels and volumes, and must be submitted to [*insert name/title/authority*] within 14 calender days of the construction of each basin.
69. Constructed sediment basins must be maintained and fully operational throughout the construction period and until each basin's catchment area achieves [*insert minimum required percentage cover*] ground cover on all soil surfaces.
70. Settled sediment must be removed from sediment basins when the volume of the sediment exceeds the designated sediment storage volume, or the design maximum sediment storage elevation.

Site rehabilitation

71. All disturbed areas identified as very low, low, medium, high, or extreme erosion risk must be suitably stabilised within 30, 30, 20, 10 or 5 days respectively, or prior to anticipated rainfall, whichever is the greater, from the day that soil disturbances on the area have been finalised.
72. A minimum 60% ground cover must be achieved on all completed earthworks exposed to accelerated soil erosion within 30 days during those months when the expected rainfall erosivity is less than 60; minimum 70% cover within 30 days if

between 60 and 100; minimum 70% cover within 20 days if between 100 and 285; minimum 75% cover within 10 days if between 285 and 1500; and minimum 80% cover within 5 days if greater than 1500.

73. A minimum 60% ground cover must be achieved on all completed earthworks exposed to accelerated soil erosion within 30 days during those months when the expected rainfall is less than 30mm; minimum 70% cover within 30 days if between 30 and 45mm; minimum 70% cover within 20 days if between 45 and 100mm; minimum 75% cover within 10 days if between 100 and 225mm; and minimum 80% cover within 5 days if greater than 225mm. (*alternative to above*)

74. No completed earthwork surface must remain denuded for longer than 60 days.

75. The type of ground cover applied to completed earthworks is compatible with the anticipated long-term land use, environmental risk, and site rehabilitation measures.

76. Unless otherwise directed by [*insert name/title/*authority] or where directed by the approved revegetation plan, topsoil must be placed at a minimum depth of 75mm on slopes 4:1 (H:V) or flatter, and 50mm on slopes steeper than 4:1.

77. The pH (soil:water 1:5) of the topsoil must be between [*insert value*] and [*insert value*] prior to initiating the establishment of vegetation.

78. The pH level (soil:water 1:5) of topsoil must be adequate to enable establishment and growth of the specified vegetation.

79. Soil ameliorants must be added to the soil in accordance with the approved landscape/revegetation plans and/or soil analysis.

80. Soil density/compaction must be adjusted prior to seeding/planting in accordance with [*insert specifications, soil report or appropriate reference plan*].

81. Temporary site stabilisation procedures must commence at least 30 days prior to the nominated site shutdown date. At least 70% stable cover of all unstable and/or disturbed soil surfaces must be achieved prior to [*insert the start of shutdown*]. The stabilisation works must not rely upon the longevity of non-vegetated erosion control blankets, or temporary soil binders.

82. All unstable or disturbed soil surfaces must be adequately stabilised against erosion (minimum 70%) prior to commencement of use, or survey plan endorsement.

Sediment basin rehabilitation

83. Required drainage, erosion and sediment control measures during the decommissioning and rehabilitation or a sediment basin must comply with same standards specified for the normal construction works.

84. Upon decommissioning of a sediment basin, all water and sediment must be removed from the basin prior to removal of the embankment (if any). Any such material, liquid or solid, must be dispose of in a manner that will not create an erosion or pollution hazard.

85. A basin's catchment conditions associated with the staged decommissioning of the basin from a Type 1 to a Type 2 sediment trap must comply with the specified sediment control standard.

86. If an alternative, permanent, outlet structure is to be constructed prior to stabilisation of the up-slope catchment area, then this outlet structure must not be made operational if it will adversely affect the required operation of the sediment basin.

87. The permanent stormwater treatment features (e.g. vegetation and filtration media) must be appropriately protected from the adverse effects of sediment runoff.

88. A sediment basin must not be decommissioned until all up-slope site stabilisation measures have been implemented and are appropriately working to control soil erosion and sediment runoff in accordance with the specified ESC standard.

89. Immediately prior to the construction of the permanent stormwater treatment device, appropriate flow bypass conditions must be established to prevent sediment-laden water entering the device.

90. Immediately following the construction of the filter media of the permanent stormwater treatment device, the filter media must be covered by heavy-duty filter cloth (minimum bidum A44 or equivalent) and a minimum 200mm layer of earth or sacrificial filter media. Such earth and filter cloth must not be removed from the device until suitable surface conditions being achieved within the basin's catchment area.

91. Immediately following the construction of the *[insert description, e.g. wetland, bioretention system]* an appropriate Type 2 sediment trap must be installed in a manner to prevent sediment intrusion into the device.

92. The minimum sediment control standard for the protection of the permanent stormwater treatment device during the construction and maintenance phases is a Type 2 sediment trap. (alternative to above)

93. Plant establishment within the permanent stormwater treatment device must be delayed until sediment intrusion into the device is suitably under control.

94. Upon suitable conditions being achieved within the basin's catchment area, the operational features of the permanent stormwater treatment system must be made fully operational (i.e. maintenance and/or reconstruction as required).

95. The permanent stormwater treatment features of the rehabilitated basin must not be made operational until all up-slope site stabilisation measures have been implemented and are appropriately working to control soil erosion and sediment runoff in accordance with the specified ESC standard. (alternative to above)

96. Upon the approval of *[insert authority]*, the newly constructed permanent stormwater treatment features of the basin may be made operational if such actions do not prevent the site from operating at the required sediment control standard. (alternative to above)

Site monitoring

97. All water quality data, including dates of rainfall, dates of testing, testing results and dates of water release, must be kept in an on-site register. The register is to be maintained up to date for the duration of the approved works and be available on-site for inspection by [*insert name of regulatory authority*] on request.

98. At nominated instream water monitoring sites, a minimum of 3 water samples must be taken and analysed, and the average result used to determine quality.

99. Sediment basin water quality samples must be taken at a depth no greater than 200mm above the level of settled sediment.

100. All environmentally relevant incidents must be recorded in a field log that must remain accessible to all relevant regulatory authorities.

Site maintenance

101. All erosion and sediment control measures, including drainage control measures, must be maintained in proper working order at all times during their operational lives.

102. All temporary erosion and sediment control measures, including drainage control measures, must be fully operational and maintained in proper working order at all times during the maintenance period as specified by [*insert name of authority*].

103. All temporary erosion and sediment control measures, including drainage control measures, must removed after achieving a satisfactory "off-maintenance inspection" by [*insert name of authority*].

104. All drainage, erosion and sediment control measures must be inspected:
   (i) at least daily (when work is occurring on-site);
   (ii) at least weekly (when work is not occurring on-site);
   (iii) within 24 hours of expected rainfall; and
   (iv) within 18 hours of a rainfall event of sufficient intensity and duration to cause runoff on-site).

105. Washing/flushing of sealed roadways must only occur where sweeping has failed to remove sufficient sediment and there is a compelling need to remove the remaining sediment (e.g. for safety reasons). In such circumstances, all reasonable and practicable sediment control measures must be used to prevent, or at least minimise, the release of sediment into receiving waters. Only those measures that will not cause safety and property flooding issues shall be employed. Sediment removed from roadways must be disposed of in a lawful manner that does not cause ongoing soil erosion or environmental harm.

106. Sediment removed from sediment traps and places of sediment deposition must be disposed of in a lawful manner that does not cause ongoing soil erosion or environmental harm.

107. Maintenance mowing of all road shoulders, table drains, batters and other surfaces likely to experience accelerated soil erosion must aim to leave the grass length no shorter than 50mm where reasonable and practicable.

108. Maintenance mowing must be done in a manner that will not damage the profile of formed, soft edges, such as the crest of earth embankments.

5.9 Problems to avoid when preparing ESCPs

Common problems associated with the development of Erosion and Sediment Control Plans (ESCPs) include the following.

(i) Land disturbances and major earthworks are not staged to minimise erosion risk.

(ii) Development of ESCPs that concentrate solely on sediment control issues rather than appropriately integrating drainage, erosion and sediment control measures.

(iii) Inadequate diversion of “clean” up-slope water around or through the work site.

(iv) Inadequate drainage controls employed to limit the slope length on vulnerable slope, especially medium to high erosion risk surfaces.

(v) *Rock Check Dams* are specified in shallow drains (less than 500mm deep) where such structures could cause flow to spill out of the drain.

(vi) *Check Dams* are used on steep drains/chutes (greater than 10% slope) where a channel liner would be more appropriate.

(vii) Inadequate scour protection is applied to temporary drainage works and “clean” water flow diversion channels.

(viii) Technical notes are not provided on those measures required in the event of construction delays, such as temporary stabilisation of exposed soil surfaces.

(ix) Technical notes are not provided on necessary ESC measures required in the event of expected heavy to extreme rainfall.

(x) Technical notes are not provided on necessary end-of-day ESC measures in the event that significant rainfall is expected prior to reoccupation of the site.

(xi) Inadequate consideration is given to the progressive revegetation/rehabilitation of the site.

(xii) Failure to specify an appropriate minimum ground cover percentage.

(xiii) Inadequate specification of necessary surface preparation of cut batters prior to revegetation.

(xiv) Inadequate consideration given to the treatment of dispersive soils especially with regard to the design of table drains, road batters and retaining walls.

(xv) Inappropriate specification of sediment control measures adjacent “sag” and “on-grade” roadside stormwater inlets. (Different sediment control techniques are required for “sag” inlets compared to “on-grade” inlets).

(xvi) Inappropriate specification of sediment control measures adjacent “sag-type” roadside stormwater inlets where such measures are likely to cause traffic safety issues or local flooding problems (ie through the full blockage of stormwater inlets).

(xvii) Inappropriate sediment control measures specified within areas of concentrated flow.

(xviii) Inadequate construction details provided for sediment control devices installed within areas of concentrated flow.

(xix) An over-reliance placed on the least effective sediment control measures such as kerb inlet controls and *Grass Filter Strips*.

(xx) Inadequate specification of monitoring and maintenance requirements.

(xxi) Inadequate *Supporting Documentation* supplied with the development application, including the supply of *Construction Drainage Plans*, the *ESC Installation Sequence*, or discussion on the staging of works.

(xxii) Inadequate soil testing performed and documented with regards to *Sediment Basin* design and construction.

(xxiii) Inadequate soil testing performed and documented with regards to the identification and treatment of dispersive soils and their impact on the design of retaining walls.

(xxiv) Failure to assign a unique identification number to each ESC measure specified on an ESCP.

(xxv) Designers of ESCPs indicate that they have adopted a "worst case" scenario in their design as a means of avoiding the need to conduct necessary site data, such as soil testing, but do not appropriately incorporate such worst case aspects into their design.

5.10 Erosion & Sediment Control Plan Checklist

LOCATION OF DEVELOPMENT . . . .

. . . .

REVIEWER . . . . **DATE** . . . .

SIGNATURE . . . .

N/A – not applicable

 – acceptable controls adopted

 – measures are not acceptable, or a potential problem exists

Part A: Initial plan review

Item	Consideration	Assessment
1	*Erosion Hazard Assessment Form* completed for the site.	. . . .
2	*Supporting Documentation* supplied with the ESCP.	. . . .
3	Copy of calculation sheets supplied.	. . . .
4	ESC specifications and construction drawings supplied.	. . . .
5	Inspection and Test Plan (ITP) supplied	. . . .
6	Legend provided to identify all ESC measures on the plans.	. . . .
7	ESC *Installation Sequence* supplied.	. . . .
8	*Installation Sequence* is appropriate for the site conditions.	. . . .
9	*Installation Sequence* clearly indicates which sediment control measures must be installed prior to land disturbance.	. . . .
10	Soil test results (including soil erodibility) supplied.	. . . .
11	Extent of land disturbance (including cut and fill areas) shown.	. . . .
12	Adequate identification/protection of non-disturbance areas.	. . . .
13	Protected trees and buffer zones identified.	. . . .
14	Appropriate staging of land clearing.	. . . .
15	On-site watercourses and riparian zones protected.	. . . .
16	Existing and/or final contours shown (as required).	. . . .
17	Location of all ESC measures clearly shown.	. . . .
18	All ESC measures located within the property.	. . . .
19	Plans signed by appropriate professional(s).	. . . .

Part B: Site assessment

Item	Consideration	Assessment
20	On-site water "values" and discharge standards (water quality objectives) identified.	. . . .
21	Soil Map provided.	. . . .
22	Location of potential dispersive soils identified.	. . . .
23	Location of potential acid sulfate soils identified.	. . . .
24	Potential landslip/mass movement areas identified.	. . . .
25	High and extreme erosion risk areas identified and protected.	. . . .
26	Soils of extreme pH identified and amelioration specified.	. . . .

Part C: Site establishment

Item	Consideration	Assessment
27	Site access points limited to the minimum necessary, clearly identified on plans, and appropriate controls specified.	. . . .
28	Drainage controls indicated on the entry/exit pad (if necessary).	. . . .
29	Site office and car parking areas identified and provided with adequate drainage, erosion and sediment controls.	. . . .
30	Technical notes included on best practice site management including dust, chemical, oil, fuel, litter and debris control.	. . . .
31	Stockpile locations clearly identified and located away from protected vegetation and overland flow paths.	. . . .
32	Stockpiles located at least 5m away from top of watercourse banks.	. . . .
33	Adequate up-slope drainage controls (if necessary) and down-slope sediment controls placed adjacent to stockpiles.	. . . .
34	Temporary access roads/tracks identified, with appropriate drainage/erosion controls specified.	. . . .
35	*Temporary Watercourse Crossings* identified and protected.	. . . .
36	*Temporary Watercourse Crossings* are appropriate for fish passage requirements.	. . . .
37	Minimum non-disturbance zone between unsealed access tracks and the edge of streams is at least the width of the stream (measured at the top of the bank) or 30m whichever is the lesser.	. . . .

Part D: Drainage controls

Item	Consideration	Assessment
38	Construction Drainage Plans prepared for each major stage of earthworks.	....
39	All temporary construction roads and access tracks shown on the Construction Drainage Plans.	....
40	Temporary drainage controls designed to the appropriate standard and hydraulic analysis provided.	....
41	Hydraulic analysis indicates appropriate flow velocities.	....
42	Hydraulic analysis indicates appropriate flow capacity.	....
43	Flow from “clean” external catchments diverted around/through site in a non-erosive manner.	....
44	Internal “dirty” water drainage lines identified and directed to sediment controls.	....
45	Appropriate drainage controls located immediately up-slope of neighbouring, down-slope residential areas.	....
46	All site drainage inflow and outflow points identified.	....
47	All water discharges from the site at legal points of discharge.	....
48	All water discharges through stabilised outlets onto stable land.	....
49	Maximum spacing of drains on long, open soil slopes is appropriate for the gradient and soil type.	....
50	Appropriate flow velocity controls (e.g. *Check Dams*) or scour controls (e.g. turf or *Erosion Control Mats*) specified.	....
51	*Catch Drains* or *Flow Diversion Banks* located at top of cut and fill batters.	....
52	Temporary *Catch Drains* <u>not</u> indicated on dispersive soils.	....
53	Rock *Check Dams* <u>not</u> specified in shallow (i.e. < 500mm deep) drains.	....
54	Water flow is appropriately conveyed down constructed earth slopes (e.g. through *Slope Drains* or *Chutes*).	....
55	All *Slope Drains* and *Chutes* have stabilised inlets and outlets.	....
56	Appropriate drainage controls on unsealed roads and access tracks.	....
57	Technical notes require all runoff from newly constructed roofs to be immediately connected to drainage system.	....
58	Overland flow appropriately controlled around *Temporary Watercourse Crossings*.	....

Part E: Erosion control

Item	Consideration	Assessment
59	The erosion control standard is consistent with the rainfall erosivity, environmental risk, and clay content of exposed soil.	....
60	The erosion control standard is consistent with the requirements of regulatory authority.	....
61	Application rates specified for mulching.	....
62	Specified mulch stabilisation measures are appropriate for the soil slope (gradient).	....
63	Appropriate drainage controls installed to minimise mulch being washed off the slope/site.	....
64	Synthetic (plastic) mesh reinforced *Erosion Control Blankets* <u>not</u> specified in or adjacent to susceptible wildlife habitats.	....
65	Emergency short-term erosion control measures specified (e.g. in event of construction delays, pre-storm activities).	....
66	Technical notes indicate what additional works are required if construction occurs during the wet season.	....
67	Dust control measures specified.	....
68	Disturbed soil with an Exchangeable Sodium Percentage (ESP) greater than 6% is to be treated to control soil dispersion.	....

Part F: Site stabilisation/revegetation

Item	Consideration	Assessment
69	Vegetation Management Plan and/or Landscape Plan provided.	....
70	Site stabilisation/rehabilitation plan provided.	....
71	Minimum soil protective cover of 70 % specified on ESCP or in the Supporting Documentation.	....
72	Appropriate soil preparation measures specified prior to revegetation.	....
73	Timing and specification for any temporary vegetation is provided.	....
74	Application of permanent site revegetation is appropriately staged.	....
75	Minimum specifications for imported topsoil supplied.	....
76	Specifications and application rates for soil adjustments provided (soil report).	....
77	Specifications and application rates for seeding, mulches and hydraulically applied soil covers provided.	....

Part G: Supplementary sediment controls

Item	Consideration	Assessment
78	Every appropriate opportunity has been taken to trap sediment as close to the initial source of erosion as is practicable <u>without</u> placing sediment controls in locations where they could cause hydraulic, erosion, or safety issues.	....
77	Sediment traps placed on public roadways will <u>not</u> cause safety issues.	....
79	No sub-catchment relies solely on supplementary sediment control measures.	....
80	*Straw Bales* are <u>not</u> specified for sediment control, unless justified by <u>exceptional</u> circumstances (e.g. as a short-term control during the installation of the primary sediment trap).	....
81	The ESCP provides sufficient information to control the installation and use of supplementary sediment traps.	....

Part H: Sediment control "sheet" flow

Item	Consideration	Assessment
82	No sediment-laden water leaves the site untreated.	....
83	"Sheet flow" control measures (e.g. *Buffer Zones, Grassed Filter Strips, and Sediment Fence*) <u>not</u> specified in areas of concentrated flow.	....
84	*Grass Filter Strips* will not cause water to be diverted along the up-slope edge of the filter strip.	....
85	The width of sediment control *Buffer Zones* is appropriate for the land slope (gradient).	....
86	Geotextile *Filter Fences* are only used to control sediment runoff from earth stockpiles.	....
87	*Sediment Fences*:	
	(a) Located and detailed (i.e. with regular "returns") such that runoff will pond uniformly or a regular intervals along the fence.	....
	(b) Ends of each fence turned up the slope to control flow bypass.	....
	(c) Each fence clearly identified as either "woven" or "non-woven" as appropriate, otherwise a summary table is provided identifying the fabric specification for each fence.	....
	(d) Specifications show a maximum 2m spacing of support post.	....
	(e) The fence is located at least 2m from base of fill slopes.	....
	(f) Specifications (design details) show adequate trenching of fabric.	....

Part I: Sediment control "concentrated" flow

Item	Consideration	Assessment
88	Appropriate sediment control standard specified (i.e. Type 1, Type 2, or Type 3)	....
89	Location of all sediment control measures clearly shown.	....
90	The location and operation of sediment control measures will not cause safety issues or flooding of adjacent properties.	....
91	Straw bale check dams not specified for sediment control.	....
92	Appropriate sediment control measures are specified for all "sag" and "on-grade" kerb inlets.	....
93	Appropriate sediment control measures specified for all field (drop) inlets.	....
94	Appropriate sediment control measures specified for all culverts and pipe inlets.	....
95	Where specified on stormwater outlets, end-of-pipe sediment traps are located well downstream (e.g. 10 x pipe dia.) of outlet.	....
96	Type 2 sediment traps (e.g. *Rock Filter Dams, Sediment Trenches, Sediment Weirs*):	
	(a) Have adequate up-slope pond area.	....
	(b) Have an appropriately sized sediment collection pit.	....
	(c) Designed for an appropriate storm frequency.	....
97	Appropriate access is provided to all sediment traps for maintenance and sediment removal.	....
98	Appropriate sediment control measures are specified for de-watering operations specified (technical notes).	....
99	Sediment controls are placed within streams ONLY as a last resort, and only with written approval from all appropriate Regulatory Authorities.	....
100	Sediment controls placed in and around drainage channels are appropriate for the expected flow conditions.	....

Part J: Sediment Basins

Item	Consideration	Assessment
101	The location and operation of *Sediment Basins* will not cause safety issues or flooding of adjacent properties.	....
102	Type of each *Sediment Basin* is appropriate for the soil conditions.	....
103	Soil testing and all design calculations provided for all *Sediment Basins*.	....
104	Appropriate construction specifications provided for all basin embankments.	....
105	Actual size (including all dimensions) of each *Sediment Basin*, including spillway, is shown on the plans.	....
106	Sediment-laden water is able to flow to the required basin during all stages of earthworks and soil disturbance.	....
107	All *Sediment Basins* have:	
	(a) Stable inflow conditions.	....
	(b) Inlet baffle (if required).	....
	(c) Minimum 3:1 length to width, otherwise baffles installed.	....
	(d) Suitable access for de-silting and maintenance.	....
	(e) Stabilised emergency spillway and energy dissipater.	....
	(f) Stabilised batters/embankments.	....
	(g) Safety or exclusion fencing (as required).	....
	(h) Operating conditions and water quality standards specified.	....
108	Riser pipe outlet systems for “dry” basins:	
	(a) Debris/anti-vortex inlet screen specified.	....
	(b) Anti-flotation weight specified.	....
	(c) Details for riser pipe filtration system specified.	....
	(d) Anti-seepage collars specified.	....
109	Appropriate monitoring and maintenance requirements for all *Sediment Basins* provided.	....
110	Basin sizing, hydraulic design (spillway) and embankment specification certified by appropriate professionals.	
	(a) Review of spillway hydraulics.	....
	(b) Geotechnical review of embankment construction & stability.	....
	(c) ESC specialist review of basin selection and design.	....

Part K: Instream works

Item	Consideration	Assessment
111	All necessary site data (soil and flow conditions, stream type, site access conditions).	....
112	All necessary State and local government approvals have been obtained.	....
113	*Temporary Watercourse Crossings* (e.g. construction access) have been reduced to the minimum practical number.	....
114	Instream disturbance is limited to the minimum necessary to complete the proposed works.	....
115	Instream disturbances have been appropriately staged to minimise exposure to storm runoff and stream flows.	....
116	Instream works have been programmed for that time of the year that will minimise overall potential environmental harm:	
	(a) avoiding seasonal high flows;	....
	(b) avoiding periods of likely fish migration;	....
	(c) avoiding active bird migration periods (RAMSAR wetlands).	....
117	Instream structures are not located on, or adjacent to, unstable or highly mobile channel bends.	....
118	Construction works will not unnecessarily disturb instream or riparian vegetation.	....
119	Wherever reasonable and practicable, overbank disturbances will be limited to only one bank.	....
120	Stormwater runoff moving towards the channel from adjacent areas will be appropriately diverted around soil disturbances.	....
121	Where stormwater cannot be diverted around soil disturbances, stabilised bank *Chute*(s) have been provided to carry stormwater down the channel banks in a non-erosive manner.	....
122	Wherever reasonable and practicable, dry-weather channel flows are diverted around in-bank disturbances:	
	(a) dry channel conditions expected;	....
	(b) flow diversion using cofferdams and bypass pipes;	....
	(c) flow diversion using instream *Isolation Barriers*.	....
123	Appropriate temporary erosion control measures (if necessary) have been proposed.	....
124	Synthetic reinforced erosion control blankets/mats have <u>not</u> been specified where there is a potential threat to wildlife.	....
125	All reasonable and practicable measures have been taken to avoid the need for instream sediment control measures within flowing streams.	....
126	Proposed instream sediment control measures are appropriate for the expected site access and stream flow conditions.	....
127	Appropriate material de-watering procedures and process areas have been identified.	....
128	Appropriate bed, bank and overbank rehabilitation measures have been proposed.	....

Part L: Site monitoring and maintenance

Item	Consideration	Assessment
129	Site inspection program supplied.	....
130	Monitoring and Maintenance Program provided for all drainage, erosion and sediment controls.	....
131	Water quality monitoring program supplied, including construction phase Water Quality Objectives (WQOs).	....
132	Water quality monitoring locations/stations identified.	....
133	Appropriate safety issues addressed for site monitoring and data (e.g. water sample) collection.	....
134	Adequate ESC maintenance requirements have been specified either on the ESCP or within the Supporting Documentation.	....

6. Site management

This chapter outlines best practice (2008) building and construction site management procedures with respect to erosion and sediment control. Its function within this document is both educational and prescriptive.

6.1 Introduction

Site managers are required to focus on a wide range of economic, social and environmental issues of which erosion and sediment control (ESC) is just one. Safety is usually given the highest priority on construction sites, and this document stresses the importance of placing a high priority on safety issues when choosing and implementing ESC measures. The adopted ESC measures must be amended if they represent an unacceptable safety risk; however, the amended measures must still achieve the required treatment standard.

Effective erosion and sediment control measures can provide many benefits to a work site, including:

- Increased on-site safety
- Reduced down-time after rain
- Reduced clean-up costs after rain
- Reduced damage to infrastructure
- Fewer public complaints

It should be noted that sediment runoff can result from a number of site activities besides the erosion of in-situ soils. Sediment-laden runoff may also consist of concrete/cement wash-off, drainage water from trench and stockpile de-watering, and runoff from material cutting and cleaning operations. Other pollutants commonly linked to sediment runoff from construction sites include dust, litter, nutrients and hydrocarbons. The source of these pollutants can include the construction site, material storage areas, and the site office compound.

6.2 Site establishment

Best practice (2008) site establishment procedures incorporate the following activities as appropriate for the site conditions and proposed works. Not all of the following activities will be appropriate on all sites.

(i) Obtain all necessary permits and plan approvals prior to site establishment.

(ii) Ensure the approved ESC plans are available on-site.

(iii) Review the development/contract conditions, Stormwater Management Plan (SMP), Erosion and Sediment Control Plan (ESCP) including all technical notes associated with the ESCP.

(iv) Nominate the responsible ESC entity or site officer.

(v) Conduct a pre-construction conference.

(vi) Where appropriate, establish perimeter fencing to manage public safety and unauthorised material dumping.

(vii) Construct and stabilise site entry/exit points.

(viii) Establish the site compound, installing all necessary drainage, erosion and sediment controls.

(ix) Stockpile materials necessary for the installation and ongoing maintenance of ESC measures including those materials necessary for emergency ESC activities in the event of imminent rainfall.

(x) Install or establish waste receptors for building waste, including litter and rubbish bins (e.g. mini-skips) and concrete waste receptors.

(xi) Establish any non-disturbance or exclusion areas identified within the ESCP.

(xii) Establish stockpile areas, including all necessary drainage and sediment controls.

(xiii) Implement remaining ESC measures in accordance with the specified Installation Sequence.

Technical Note 6.1 – Responsible ESC officer

Throughout this publication, the term *responsible ESC officer* refers to that person, or team of people of which there is a principal officer, employed or contracted by the land owner and/or developer as the principle officer/entity responsible for ensuring appropriate application of the planned ESC measures and for the provision of advice in response to unplanned ESC issues.

This does **not** imply that the nominated officer will hold the ultimate responsibility for the success or failure of ESC measures on a site. Such responsibility rests with each individual on a work site in accordance with their legal *due diligence*, including their *Environmental Duty* as defined by the relevant State legislation.

Terminology will vary from site to site and region to region. The “responsible ESC officer” may also be referred to as the *ESC Officer*, *Erosion and Sediment Control Officer*, *Sediment Control Officer*, *Environmental Officer*, and so on.

6.3 Works approvals

Works approvals that may be needed prior to commencing any land clearing, soil disturbance within control areas, or possibly even before obtaining access to the site, include the following:

(i) Development approval.

(ii) Approval to enter the site (from landowner).

(iii) Approval of the Erosion and Sediment Control Plan (ESCP).

(iv) Local and/or State Government approval for any disturbance to protected vegetation.

(v) Road authority approval for ancillary works within a road reserve.

(vi) State government approval (e.g. Waterway Permit) to disturb or clear vegetation along a watercourse.

(vii) State government approval (e.g. Waterway Licence) to disturb, clear, modify, bypass, or temporarily dam a watercourse.

(viii) Fisheries authority approval for disturbance to marine plants, or to modify a watercourse (temporarily or permanently) in a way that may adversely affect fish habitat and/or fish passage.

(ix) EPA Licence to construct works within tidal areas or within a Marine National Park.

6.4 Office compound

Best practice (2008) site management requires giving appropriate consideration to the following issues when establishing the office compound:

(i) Establish only the minimum number of site entry/exit points required to perform the necessary works.

(ii) Ensure sediment control devices placed at entry/exit points are appropriate for the site conditions (refer to Chapter 4 – *Design standards and technique selection*).

(iii) Take appropriate steps to minimise the risk of vehicles exiting the site being able to bypass the entry/exit sediment control devices.

(iv) Ensure the site office and car park are established in locations that minimise safety risks to site visitors. This includes locating the site office and car park as close to site entry points as is practicable to reduce visitor movement through active work areas.

(v) Wherever reasonable and practicable, locate the site office and car park up-slope of soil disturbances and any soil, earth, or sand stockpiles that may allow sediment-laden runoff to flow through these areas.

(vi) Wherever reasonable and practicable, locate the site compound so that all sediment-laden runoff can be fully contained and treated on-site.

(vii) Ensure roof water from buildings and sheds will not cause unnecessary erosion or soil saturation around common traffic areas (vehicular or pedestrian).

(viii) Where appropriate (e.g. long-term construction sites) use *Gravelling* techniques to minimise soil compaction and the generation of excessive mud around the site compound.

(ix) Ensure appropriate storage of chemical and fuels (AS1940: *The storage and handling of flammable and combustible liquids*).

(x) Where necessary, establish drip pans (or similar, e.g. filter cloth sheeting) in vehicle maintenance areas to control pollution runoff from road surfacing equipment.

(xi) Where necessary, install appropriate building waste receptors.

6.5 Pre-construction conference

Best practice site management includes conducting a pre-construction conference as appropriate for the site conditions and work activities. Pre-construction conference are usually held on-site to allow all interested parties to walk the site and discuss critical erosion and sediment control issues and identified environmental values. Invitations to attend this meeting should be extended to representatives of the principal regulatory authority (e.g. local government), as well as the landowner, site superintendent, principal contractor, responsible ESC officer/entity, and relevant sub-contractors.

Typical agenda items at a pre-construction conference may include the following:

- Clarify the objectives of the Erosion and Sediment Control Plan (ESCP).
- Review specific items of ESC compliance.
- Discuss monitoring and inspection procedures.
- Designate the responsible ESC officer/entity.
- Designate a contact person in each party.

- Review the approved ESCP and any relevant documentation.
- Discuss the initial ESC measures to be installed.
- Discuss temporary ESC measures required prior to impending storms.
- Discuss the procedures for reporting and acting on areas on non-compliance.
- Discuss the circumstances and procedures for amending the approved ESCP.
- Discuss *Witness, Hold Points* and *ITPs* and their procedures.
- Establish open and effective communication between all parties.

6.6 Site management

The *due diligence* associated with the management of a development site, or any other soil disturbance that could potentially cause environmental harm, requires site managers to ensure that appropriately trained and experienced personnel are incorporated into the process at all times. Such personnel must, collectively, have the following capabilities:

- An understanding of the local environmental values that could potentially be affected by the proposed works.
- A good working knowledge of the site's Erosion and Sediment Control (ESC) issues, and potential environmental impacts, that is commensurate with the complexity of the site and the degree of environmental risk.
- A good working knowledge of current best practice Erosion and Sediment Control measures for the given site conditions and type of works.
- Ability to appropriately monitor, interpret, and report on the site's ESC performance, including the ability to recognise poor performance and potential ESC problems.
- Ability to provide advice and guidance on appropriate measures and procedures to maintain the site at all times in a condition representative of current best practice, and that is reasonably likely to achieve the required ESC standard.
- A good working knowledge of the correct installation, operational and maintenance procedures for the full range of ESC measures used on the site.

In addition to the above, the specific elements of best practice site management vary from site to site, but in generally incorporate the following concepts:

(i) Flexible work procedures that can accommodate necessary amendments to the site's ESC measures.

(ii) Administration of ESC training programs for site staff.

(iii) Appropriate control of subcontractors and material suppliers.

(iv) Appropriate use of notice boards and educational posters relating to ESC issues. For example:

> **This is a sediment controlled site.**
>
> **All drainage, erosion and sediment control measures are to be maintained in proper working order at all times.**
>
> **Report all actual or potential pollution incidents to site office.**

(v) Appropriate management of site access points and the control of sediment tracked from the site during both wet and dry weather.

(vi) Suitable control of site traffic to minimise dust generation and undesirable soil compaction outside designated access paths.

(vii) Maintaining adequate supplies of emergency ESC materials such as: straw bales, wire, stakes, sediment fence fabric, filter cloth, wire mesh and clean aggregate.

(viii) Coordination of the installation of services and any soil disturbances caused by service providers.

Site managers should be familiar with the principles of on-site erosion and sediment control as presented in Chapter 2 – *Principles of erosion and sediment control*.

6.7 Land clearing

Vegetation clearing must to be conducted in a manner that minimises damage to any retained vegetation including protected trees, buffer zones and native vegetation corridors. Best practice site management includes appropriate consideration of the following points.

(i) Land clearing should not occur unless preceded by the installation of all necessary drainage and sediment control measures. The exception would be any land clearing necessary to allow installation of these control measures.

(ii) Selective clearing should aim to retain a variety of species and plants of varying ages, with an emphasis on healthy plants, plants with habitat value, and tree groups and clumps.

(iii) Partially hollow (dead or living) trees often need to be saved for the habitat value the tree provides to local wildlife.

(iv) Land clearing should be staged to minimise the extent and duration of soil exposure. Sequential clearing provides many advantages for erosion and sediment control, and can also improve the “natural” relocation of local wildlife.

(v) If vegetation clearing must be carried out well in advance of earthworks, then this clearing should be limited to the removal of woody vegetation only. Wherever reasonable and practicable, the grubbing and the removal of any ground cover (mulch or vegetation) should not occur until immediately prior to earthworks occurring within that stage of works.

The exception to this rule would be when construction works are carried out during an extended dry period when erosive rainfall and/or winds are unlikely to occur. In any case, the **intent** should be to minimise the duration that soils are exposed to the erosive effects of wind, rain or flowing water, without causing an unnecessary financial burden to the project.

(vi) Land clearing should not extend beyond that necessary to provide up to eight (8) weeks of site activity during those months when the expected rainfall erosivity is less than 100, six (6) if between 100 and 285, four (4) weeks if between 285 and 1500, and two (2) weeks if greater than 1500 (refer to Chapter 4 – *Design Standards and Technique Selection*).

Alternatively, if monthly rainfall erosivity cannot be determined:
Land clearing should not extend beyond that necessary to provide up to eight (8) weeks of site activity during those months when the actual or average rainfall is less than 45 mm, six (6) if between 45 and 100 mm, four (4) weeks if between 100 and 225 mm, and two (2) weeks if greater than 225 mm.

(vii) Wherever reasonable and practicable, land clearing should be limited to 5 m from the edge of proposed constructed works, 2 m of essential construction traffic routes, and a total of 10 m width for construction access. Protected vegetation must remain protected irrespective of the above recommendations.

(viii) Wherever reasonable and practicable, cleared vegetation should be mulched (e.g. via tub grinding) for use on the site as an erosion control aid and to satisfy landscaping requirements. The practice of selling/disposing of potential mulch early in the construction program, only to import mulch at a later date, must be avoid unless justified by sound landscaping practice.

6.8 Maintenance of ESC measures

All ESC measures must be maintained in proper working order at all times during their required operational life. Proper working order includes maintaining the required hydraulic capacity and operational effectiveness.

Maintenance of ESC measures must occur in accordance with Table 6.1:

Table 6.1 – Maintenance requirements of ESC measures

ESC Measure	Maintenance Trigger	Timeframe
Sediment Basins	When settled sediment exceeds the volume of the sediment storage zone.	As soon as reasonable and practicable, but within 7 days of the inspection.
Other ESC measures	The capacity of ESC measures falls below 75%.	By end of the day during any stay in rainfall.

All temporary ESC measures need to be removed and the affected land stabilised as soon as possible after the satisfactory completion of the defined "maintenance period".

Best practice (2008) site management includes:

(i) Ensuring all material removed from ESC devices during maintenance, whether solid or liquid, is disposed of in a manner that does not cause ongoing soil erosion or environmental harm.

(ii) Ensuring all sediment and removed from roads, or from sediment control measures at stormwater inlets, is disposed of in a manner that does not cause ongoing soil erosion or environmental harm.

(iii) Not using "poisons" to control excess vegetation in drainage lines unless by approval of the regulatory authority through the development of an approved Vegetation Management Plan.

(iv) Maintaining the hydraulic capacity of heavily vegetated open drains by selectively cutting and trimming so as to leave a short, dense, live ground cover for the purpose of minimising soil erosion.

(v) Washing/flushing sealed roadways only in circumstances where sweeping has failed to remove sufficient sediment and there is a compelling need to remove the remaining sediment (e.g. for safety reasons). In such circumstances, sediment control measures in the kerb and channel, or at the kerb inlet, must be implemented where safe and practicable, and where there is no significant risk of causing adverse flooding to third parties.

(vi) Ensuring maintenance mowing of grassed road shoulders, table drains, batters and other surfaces likely to erode, aims to leave the grass leaf length no shorter than 50 mm wherever practicable.

(vii) Clearly defining and documenting who is responsible for maintaining those ESC measures installed during the subdivision phase of the development, that are required to remain operational during the subsequent building phase.

(viii) Ensuring appropriate written records are kept on all ESC monitoring and maintenance activities conducted during the construction and maintenance periods.

6.9 Watercourse management

Best practice (2008) watercourse management requires giving appropriate consideration to the following issues:

(i) Ensuring all necessary government approvals are obtained prior to any disturbance of a watercourse.

(ii) Minimising disturbance to the riparian zone (i.e. that strip of vegetation along the banks and over-bank areas of a watercourse that has a direct life-cycle or habitat association with the watercourse). The minimum width and management of the riparian zone is likely to be specified within both State and local government policies and legislation.

(iii) Minimising the number of temporary crossings of the watercourse.

(iv) Controlling stormwater drainage on access tracks/roads leading to all watercourse crossings in a way that will minimise the risk of untreated sediment-laden water from these tracks discharging into the watercourse.

(v) Giving priority to the use of instream flow diversion systems that successfully isolate soil disturbances from stream flow, rather than the use of instream sediment control practices.

(vi) Taking all reasonable and practicable measures to avoid the operation of construction equipment or sediment controls within flowing streams, or streams that are likely to experience flows while the works are in progress.

(vii) Taking all reasonable and practicable measures to minimise the extent of soil disturbance within the watercourse prior to forecast rainfall and/or elevated stream flows.

(viii) Ensuring concrete waste and chemical products, including petroleum and oil-based products, are fully contained on the site and do not enter any water body.

Detailed discussion on the management of instream disturbances and work activities is provided in Appendix I – *Instream works.*

6.10 Vegetation management

Appropriate management of site vegetation is a critical aspect of minimising the extent and duration of soil disturbance, and ensuring successful long-term site rehabilitation.

When earthworks are carried out adjacent to existing vegetation there is the potential to cause long-term damage to the vegetation even though the works may not appear to have touched the plants or caused any short-term damage. Potential long-term problems may result from:

- exposure of, or damage to, the roots;
- partial burial of the trunk causing collar rot;
- earth fill placed around established trees increasing the burial of the surface root system resulting in reduce oxygen supply to the plant;
- alterations to the sub-surface flow of water passing by the root system.

Best practice (2008) vegetation management requires giving appropriate consideration to the following activities:

(i) Seeking expert advice on the most appropriate means of protecting retained vegetation.

(ii) Preparation of a *Vegetation Management Plan* (VMP) prior to commencement of any on-site works.

(iii) Ensuring revegetation is carried out by qualified contractors.

(iv) Development of a *Vegetation Management Plan* to clarify how all retained vegetation will be protected during the construction phase, including the identification of required *Tree Protection Zones*.

(v) Establishment of Tree Protection Zones around retained vegetation. Such zones are determined as a minimum of 10 times the trunk diameter of the tree measured at an elevation of 1 m from the ground, or the width of the tree canopy at its widest point, which ever is the greater distance.

(vi) Maintaining fencing, barriers or other warning signs around Tree Protection Zones, Buffer Zones, protected vegetation, and designated non-disturbance areas.

(vii) Ensuring that there is no encroachment of construction/building works within identified Tree Protection Zones unless via *trenchless digging* or *directional boring* for the installation of services. No root in excess of 25 mm diameter should be disturbed within these protection zones.

(viii) Minimising changes in ground elevation adjacent to retained vegetation. If land reshaping must occur adjacent to retained vegetation, then it must be performed in a manner that will not cut these plants off from essential soil moisture.

(ix) Ensuring prompt implementation of the site's revegetation program.

(x) Using root barriers to allow the long-term coexistence of trees and adjacent engineering structures.

(xi) Ensuring construction/building activities do not disturb or damage the root systems of retained vegetation.

(xii) Ensuring that where it is essential to cut the roots of protected/retained trees, that the roots are:

- cut with a water lance, or cut while they are underwater to minimise air intrusion into the roots; and/or
- cut in stages over a period of days to allow tree roots to repair and adapt.

(xiii) Transplanting selected species (this is a high-risk procedure not suited to all species).

(xiv) Ensuring the use of planting equipment that does not excessively pulverise or compact the soil.

(xv) Ensuring plants are delivered to the site in covered vehicles or sheeted trucks.

(xvi) Ensuring plants are inspected upon delivery and, rejecting those plants that are unhealthy, damaged, or have out-grown their pot.

(xvii) Ensuring plants are stored in appropriate conditions prior to planting.

6.11 Soil management

Best practice (2008) soil management requires giving appropriate consideration to the following activities:

6.11.1 Earthworks

(a) Ensuring earthworks and grading activities are avoided during those periods of rainfall when stormwater runoff is either occurring or expected to occur.

(b) Ensuring excavated material is not placed adjacent to protected vegetation, stream banks, or within locations where it may become an unacceptable source of sediment runoff.

(c) Ensuring earth stockpiles are located away from areas subjected to concentrated overland flow.

(d) Ensuring a *Flow Diversion Bank* or *Catch Drain* is placed up-slope of a stockpile to direct overland flow around the stockpile where necessary. Generally flow diversion is considered necessary when rainfall is possible and the up-slope catchment area exceeds 1500 m^2.

(e) Ensuring stormwater runoff originating from stockpiles is directed to, and/or controlled by, a suitable sediment trap (e.g. *Sediment Fence*).

(f) Ensuring earth slopes are formed to a stable slope consistent with the soil properties. Unless otherwise supported by geotechnical advice, earth batters should be restricted to a maximum gradient of:

- 2:1(H:V) for soils with a low erosion hazard;
- 3:1(H:V) for soils with a high erosion hazard;
- 4:1(H:V) for soils with an extreme erosion hazard (refer to Technical Note J2 in Appendix J for guidelines on determining the erosion hazard).

(g) Ensuring all fill material placed on site comprises only natural earth and rock, and complies with specified standards.

6.11.2 Topsoil management

(a) Ensuring that wherever reasonable and practicable, topsoil is stripped and stockpiled immediately before bulk earthworks occur within any stage of works.

(b) Ensuring topsoil is preserved for reuse on the site wherever possible. The practice of selling/disposing of stripped topsoil early in the construction program, only to import topsoil at a later date, must be avoided unless justified by sound soil science and/or vegetation management practices.

(c) Ensuring topsoil is stripped only while in a moist condition. If the soil is too dry it will pulverise the soil, if too wet it may lead to clodding or hardsetting—particularly if the soil has a high silt or clay content. The soil should be wet enough to form a clump when squeezed, but not wet enough to drip water while being squeezed.

(d) Ensuring that wherever practicable, topsoils are not mixed with subsoils during stripping and stockpiling procedures, especially if the subsoils are dispersive (refer to Appendix C (*Soils and revegetation*) for further discussion on dispersive soils).

(e) Ensuring topsoil stockpiles are managed in accordance with Table 6.2.

Table 6.2 – Management of topsoil stockpiles

Condition of topsoil	Recommended stockpiling requirements
Topsoils containing valuable plant seed content that needs to be preserved for re-establishment.	• Upper 50 mm of soil stockpiled separately in mounds 1 to 1.5 m high. • Topsoil more than 50 mm below the surface stockpiled in mounds no higher than 1.5 to 3 m. • The duration of stockpiling should be the minimum practicable, but ideally less than 12 months.
Imported topsoil, or in-situ topsoil containing minimal desirable or undesirable seed content.	• Maximum desirable stockpile height of 2 m. • The duration of stockpiling should be the minimum practicable, but ideally less than 12 months.
Topsoils containing significant <u>undesirable</u> seed content.	• Ideally replace soil with alternative local topsoil free of weed seed content (seek expert advice). • Depending on expert advice, stripped topsoil may be appropriately treated to prevent germination of weed seed content, covered with clear plastic sheeting to help burn-off the weed seed content, or buried under a minimum 100 mm of soil.
Topsoils containing weed seed of a declared noxious or otherwise highly undesirable plant species.	• Suitably bury the topsoil on-site, or remove the soil from the site for further treatment (in accordance with local and State laws). • Stripped soil must **not** be transported off-site without appropriate warnings and identification.
Previously disturbed sites where the surface soils consist of a mixture of topsoil and dispersive subsoil.	• Mix the soil with gypsum, lime or other appropriate ameliorants prior to stockpiling in either high or low mounds according to required protection of seed content. • Choice of chemical treatment of the dispersive soil depends on desired pH adjustments (seek expert advice).

(f) Ensuring all earth stockpiles remain in a free-draining condition to avoid long-term soil saturation.

(g) Ensuring all topsoils (local and imported) are tested (refer to Section C9 of Appendix C) and where necessary ameliorated before placement. As a guide, topsoil should be:

(i) a friable, sandy loam with good texture and structure; and

(ii) free from large clods, lumps of subsoil, weed seed, or any other deleterious material; and

(iii) free of stones larger than 25 mm with no more than 5% of the material retained by a 1.2 mm B.S. sieve, and contain not less than 2% organic matter; and

(iv) within a suitable pH range in accordance with revegetation requirements.

(h) Before respreading the topsoil, scarify the subsoil to break up any compacted or surface sealing, and to enable the appropriate keying of the two soils.

(i) on slopes less than about 3:1(H:V) scarify lightly compacted subsoil with a tined implement to a depth of 50 to 100 mm, and heavily compacted subsoils to a minimum depth of 300 mm, ensuring all ripping and cultivation operations occur along the contour;

(ii) on banks steeper than about 3:1(H:V), chain or harrow to break any surface seal and fill any minor rills; alternatively, the surface can be track walked to promote the formation of cleat marks parallel to the contour.

(i) Ensuring that when it is desirable to re-establish the entrapped seed content of the soil, the topsoil is re-spread in the reverse sequence to its removal so that the original upper 50 mm soil layer is returned to the surface.

(j) Ensuring soil is removed from stockpiles in a manner that avoids vehicles travelling over the stockpile.

(k) Ensuring topsoil is spread to a lightly compacted (i.e. firm) depth of about 40 to 60 mm on lands where the slope exceeds 4:1(H:V), and 75 to 100 mm on lesser slopes. Special techniques, including stair-stepping of subsoil surfaces, will generally be required when spreading topsoil on slopes steeper than 2:1.

(l) Ensuring all exposed subsoils are covered as soon as practicable, especially if dispersive.

(m) Ensuring that when working adjacent to a watercourse, topsoil is not spread at a significantly different elevation (relative to the watercourse) to where it originated.

(n) Ensuring that after spreading topsoil, the surface is left in an appropriate scarified (roughened) condition to assist moisture infiltration and inhibit soil erosion.

(o) Ensuring that prior to planting, any compacted or crusted topsoil surfaces are cultivate to a depth of 100 mm, but not greater than the depth of topsoil.

(p) Ensuring soil stockpile areas are rehabilitated as soon as reasonable and practicable after the material has been removed.

6.12 Management of problematic soils

Table 6.3 provides a general summary of ESC for various problematic soils. Refer also to Appendix C – *Soils and revegetation*.

Table 6.3 – Management of problematic soils

Soil type	Erosion control	Sediment Control
Dispersive (sodic) soils	• Dispersive soils are highly susceptible to deep, narrow rilling (fluting) on slopes and drains. • High risk of tunnel erosion if water pathways are not managed properly. • Dispersive soils **must** be treated or buried under a minimum 100 mm layer of non-dispersive soil before placing any revegetation or erosion control measures. • Avoid cutting drainage channels into dispersive soils.	• Dispersive soils usually require the addition of gypsum or similar to improve settlement properties. • Sediment control usually relies on the use of Type D *Sediment Basins*. • Priority should be given to the application of effective erosion control measures, rather than trying to control runoff sediment and turbidity only through the use of sediment control measures.
Non-cohesive sandy soils	• It is essential to control water flow and flow velocity. • Short-term erosion control may be achieved through *Erosion Control Blankets* or *Mulching* anchored with a suitable tackifier. • Long-term erosion control is best achieved with ground cover vegetation such as grass.	• Sediment control measures are most effective in sandy soil areas. • Use of a woven *Sediment Fence* fabric is preferred. • Grassed *Buffer Zones* can also be effective if "sheet" flow conditions are maintained. • Important to maximise the "surface area" of sediment control ponds.
Highly erodible clayey soils	• Short-term erosion control may be achieved with *Erosion Control Blankets* or *Mulching*. • Long-term erosion control is likely to rely on the establishment of a good vegetative cover.	• Use of a non-woven, composite *Sediment Fence* fabric is preferred. • Sediment control usually relies on the use of Type F or Type D *Sediment Basins*. • Priority should be given to erosion control measures. • Important to maximise the "volume" of sediment control ponds.
Low fertility soils	• These soils are usually more erodible than fertile soils. • Soils may be protected with the use of *Rock Mulching* unless the soils are modified to allow successful revegetation.	• No special sediment control requirements.
Potential acid sulfate soils	• Minimise disturbance of soil. • Where disturbance is necessary, minimise the duration of exposure. • Treat exposed soils in accordance with State policies/guidelines. • Backfill trenches within 24 hours. • Follow established guidelines for site rehabilitation and revegetation.	• Acidic water may wash from sediment control devices and this water may need further treatment to adjust pH.

6.13 Dust control

Wind erosion is normally controlled using one or more of the following techniques:

- Revegetation
- Maintaining moist soil conditions
- Chemical sealants placed over the soil surface (*Soil Binders*)
- Surface roughening
- Wind breaks

Dust problems can also be reduced by these activities:

(i) Limiting the area of soil disturbance at any given time.
(ii) Promptly replacing topsoil.
(iii) Programming works to minimise the life of soil stockpiles.
(iv) Temporarily stabilising (e.g. with vegetation or mulching) of long-term stockpiles.
(v) Using a well-graded gravel-sand mixture with a small quantity of clay as a wear surface on unsealed construction roads.
(vi) Minimising traffic movements on exposed surfaces.
(vii) Limiting vehicular traffic to 25 kph.
(viii) Maintaining exposed soil surfaces in a moist condition.
(ix) Providing or retaining vegetative wind breaks.
(x) Applying soil binders to the soil surface.
(xi) Promptly revegetating exposed soils.
(xii) Installing windbreaks (60% shade cloth, 40% porous).

Guidelines on the development of vegetative windbreaks for long-term sites are generally available from the State (e.g. government departments in charge of primary industry or forestry).

Possible treatment options for dust are summarised in Table 6.4.

Table 6.4 – Dust control practices [1]

Site condition	**Treatment options**							
	Permanent vegetation	Mulching	Watering	Chemical surface stabiliser [2]	Gravel road	Stabilised entry/exit pad	Haul truck covers	Minimise site disturbance
Areas not subject to traffic	□	□	□	□	□			□
Areas subject to traffic			□	□	□	□		□
Material stockpiles			□	□				□
Demolition areas			□			□	□	
Clearing & excavation			□	□				□
Unpaved roads			□	□	□	□	□	
Earth transport					□	□		

[1] Sourced from: California Stormwater BMP Handbook – Construction (2003).

[2] Oil or oil-treated subgrade should not be used for dust control as this may migrate into downstream water bodies. It is also noted that surface stabilising chemicals (soil binder) may make the soil water repellent, possibly resulting in long-term revegetation problems.

International Erosion Control Association (IECA, 1993) reports that:

- 30% soil cover will reduce soil losses by 80%.
- Roughening the soil to produce 150 mm high ridges perpendicular to the prevailing wind can reduce soil losses by 80%.
- A small decrease in velocity can have a major impact in reducing wind erosion given that the erosive power of wind is proportional to the cube of the velocity.
- For wind barriers perpendicular to the wind, the width of the [protected] zone leeward of the barriers is around 8 to 10 times the height of the barrier.

A summary of dust suppressant agents is provided in Table 6.5. On long-term gravel roads, the application of 10 mm single-coat bitumen seal is generally more effective than the application of dust suppressants.

Table 6.5 – Summary of dust suppressant attributes [1]

Suppressant type	Typical attributes
Chlorides/Salts: Calcium chloride Magnesium chloride Sodium chloride	• Ease of application. • Most suited to temperate and semi-humid conditions. • Lose effectiveness in continual dry periods. • Susceptible to leaching. • Suitable for use on moderate surface fines (10–20%). • Not suitable on materials with a low-fines content. • High fines content surfaces may become slippery in wet weather.
Organic, non-bituminous: Calcium lignosulfonate Sodium lignosulfonate Ammonium lignosulfonate	• Perform well under arid conditions. • Failures occur following rains. • Susceptible to leaching. • Suitable on high fines content (10–30%) in a dense graded material with nil loose gravel. • Less effective on igneous, medium to low fines content materials and crushed gravels. • High fines content surfaces may become slippery in wet weather.
Petroleum-based products: Bitumen emulsion (slow-breaking non-ionic) Waste oils	• Use of waste oils can cause significant adverse environmental effects. • Generally effective regardless of climate. • Will pothole in wet weather and high traffic conditions. • Suitable on materials with a low-fines content (<10%). • Non suitable where runoff could contaminate receiving waters.
Electrochemical stabilisers: Sulfonated petroleum Enzymes	• Work over a wide range of climates. • Suitable for clay materials but depends on clay mineralogy. • Iron-rich soils generally respond well • Least susceptible to leaching. • Ineffective if surface is low in fines and contains loose gravel.

Note: [1] After UMA Engineering Ltd. (1987).

The following materials must not be used for dust suppression purposes:

- oil or landfill gas condensate;
- any material such as leachate or stormwater contaminated by contact with wastes, when the use of such material is likely to cause unlawful environmental harm.

6.14 Installation of services

Considerable soil disturbance is often associated with the installation of services. The de-watering of excavated trenches can produce large quantities of turbid water that can be difficult to treat.

Post-excavation impacts include flow concentration and soil erosion along the back-filled trench, changes to sub-surface groundwater flow, and the generation of long-term seepage flows down-slope of the trench.

Typically, service trenches should be back-filled with compacted soil such that the finished soil surface is at least 75 mm above adjacent ground level. This action aims to prevent soil in the trench settling below normal ground level causing the concentration of stormwater runoff down the trench.

Best practice (2008) installation procedures for services includes appropriate consideration of the following activities:

(i) Appropriately coordinate the installation of water and sewer services with initial land clearing and road works.

(ii) Avoid locating services along the **invert** of overland flow paths such as table drains and grass swales.

(iii) Divert water flow away from the trench line using temporary *Flow Diversion Banks* (e.g. earth banks, sandbag diversions, straw bale barriers).

(iv) Where practicable, place excavation spoil on the up-slope side of the trench.

(v) Properly compact backfill and leave the final level slightly above (about 75 mm) the adjacent ground elevation to allow for subsequent settlement.

(vi) Install services prior to topsoil application.

(vii) Appropriate de-watering and sediment control measures must be used to minimise the release of turbidity to receiving waters.

Further discussion on the installation of services is provided in Appendix L – *Installation of services*.

6.15 Site shutdown

A work site may be shutdown for a number of reasons, including programmed shutdowns during periods of extreme erosion risk, and unplanned shutdowns due to project financing issues or unsatisfactory environmental protection.

Procedures for initiating a site shutdown, whether planned or unplanned, must incorporate the revegetation of all soil disturbances unless otherwise approved by the regulatory authority. Use of non-vegetated erosion control blankets or soil binders is generally not considered adequate treatment, unless it is known that the shutdown period will be less than three (3) months and the proposed soil stabilisation measures are appropriate for the expected weather conditions.

Revegetation activities associated with a programmed site shutdown must commence at least 30 days prior to the nominated shutdown date.

6.16 Site rehabilitation

Exposed soil surfaces must be rehabilitated as soon as practicable to prevent, or at least minimise, environmental harm caused by ongoing soil erosion.

Revegetation of a site is one of the most effective ways of minimising ongoing soil erosion and environmental harm. Groundcover vegetation can significantly reduce raindrop impact erosion, and thus runoff turbidity. To be effective, at least 70 to 80% of the soil surface must be protected from raindrop impact depending on the expected rainfall intensity and the sensitivity of downstream environments. In critical locations 100% soil coverage may be required.

In many regions, turfing can be one of the most effective forms of instant erosion control. If grass seeding is used, then significant benefits can be obtained from lightly mulching the surface after seeding. A sufficient coverage of mulch will reduce raindrop impact, water evaporation and temperature fluctuation within the topsoil.

The programming of site revegetation depends on the expected erosion risk (i.e. soil type, site slope, and weather conditions) and the type of receiving waters. If the timing of the rehabilitation program has not been specified within the Erosion and Sediment Control Plan, then guidance may be obtained from Chapter 4 – *Design standards and technique selection*.

Best practice (2008) maintenance of site revegetation includes the following activities:

(i) Monitor site revegetation, particularly after rainfall, and appropriate maintenance and/or amendment to ensure that the revegetation is controlling erosion and stabilising soil slopes as required.

(ii) Where practicable, fill in, or level out, any rill erosion between plants. If excessive erosion occurs, then consider increasing the planting density, applying appropriate erosion control measures, or introducing alternative, non-clumping plant species.

(iii) Watering the vegetation periodically is essential, especially in the first 7 days after establishment. Use low-pressure sprays because high-pressure jets can wash away the seed and mulch cover.

(iv) Apply additional seed, mulch and/or soil conditioning as required. Mulches usually need to be maintained or renewed (as necessary) 2 to 3 times a year.

(v) Control excessive vegetation through mowing, slashing, or the controlled use of biodegradable herbicides: special care and advice must be taken around waterways. Maintain grass height at a minimum 50 mm strand length within high velocity drains, and 25 to 50 mm within overland flow paths.

(vi) Control weeds—especially within a 1m radius of immature trees—for 6 to 12 months for fast growing species, and 18 to 24 months for slower growing species. Pre-emergent herbicides should be considered where high weed seed germination is expected.

(vii) Check and maintain protective fencing.

(viii) Re-firm plants loosened by wind-rock, livestock or wildlife.

(ix) Replace dead or severely retarded plants.

(x) Prune any plants with dead or diseased parts.

(xi) Dispose of cleared vegetation through chipping or mulching for future revegetation works, by on-site burial, or suitable off-site disposal; cleared vegetation should not be burnt on site or dumped near a watercourse.

6.17 Site inspection and monitoring

Erosion and Sediment Control Plans (ESCPs) are living documents that can and should be modified as site conditions change, or if the adopted measures fail to achieve the required treatment standard. When a site inspection detects a notable failure in the adopted ESC measures, the source of this failure must be investigated and appropriate amendments made to the site and the plans.

Monitoring the effectiveness of an ESCP through a combination of site inspections and water quality monitoring, is part of responsible site management. On some small, low-risk sites (e.g. smaller than 0.5 ha) reporting requirements may only need to consist of simple diary notes listing inspection times, field observations and maintenance activities. On larger or high-risk sites, monitoring is likely to include specific water quality sampling and detailed logbook entries of the site's monitoring and maintenance activities.

All erosion and sediment control measures should be inspected:

- at least daily when rain is occurring;
- at least weekly (even if work is not occurring on-site);
- within 24 hours prior to expected rainfall; and
- within 18 hours of a rainfall event of sufficient intensity and duration to cause on-site runoff.

On sites with a soil disturbance greater than 2500 m^2, a formal Monitoring and Maintenance Program should be prepared prior to site establishment.

Personnel preparing and/or supervising the preparation of the Monitoring and Maintenance Program must, collectively, have the following capabilities:

(i) an understanding of the local environmental values that could potentially be affected by the proposed works; and

(ii) a good working knowledge of the site's ESC issues, and potential environmental impacts, that is commensurate with the complexity of the site and the degree of environmental risk; and

(iii) a good working knowledge of current best practice ESC measures appropriate for the given site conditions and type of works; and

(iv) a good working knowledge of the correct installation, operational and maintenance procedures for the full range of ESC measures used on the site.

Detailed discussion on carrying out site inspections is provided in Chapter 7. Examples of weekly and detailed site inspection forms are also provided in Chapter 7.

6.18 Incident reporting

Best practice (2008) site management requires establishment and clear documentation of incident reporting procedures. These procedures should clearly outline:

- the chain of responsibility;
- procedures for recording areas of non-compliance;
- monthly reporting procedures (if required);
- procedures for recording corrective actions;
- internal recording and filing procedures.

6.19 Staff training

Field training starts by advising all site workers, sub-contractors, and delivery drivers of their responsibility for minimising the potential for soil erosion and other forms of pollution. Appropriate warning and educational signs may be required throughout the site, especially at site entry points.

People will better accept new and improved construction techniques if they fully understand the benefits to be gained. Engineers, supervisors and machinery operators need to have a basic knowledge of soils, at least to the extent of recognising different soil types and those most susceptible to erosion.

This training should be complemented with an understanding of the basic soil and water management techniques and the environmental problems associated with mismanagement.

On the larger construction sites, such as major developments and road projects, formal *Environmental Site Induction* procedures should be established for all site personnel, including subcontractors. These documented procedures should include a register of training and induction activities. This induction would include such items as:

(i) objectives of the *Environmental Management Plan, Stormwater Management Plan,* and/or *Erosion and Sediment Control Plan* as appropriate for the site;
(ii) statement of *duty of care*;
(iii) identification of site specific *Environmental Values*;
(iv) specific conditions of any *Environmental Licences, Permits* and *Approvals*;
(v) use of the site's *Environmental Protection Plan*;
(vi) incident reporting procedures;
(vii) specific equipment operational and maintenance procedures.

It is the responsibility of the site/project manager to take appropriate steps to ensure that site staff, including subcontractors, are suitably qualified and experienced enough to meet their ESC obligations.

The recommended level of training is outlined below and in Table 6.6.

Table 6.6 – Recommended training requirements

Field	Profession	Essential	Desirable
Building	Labourers		1.2
	Site managers	1.2	2.5
	ESC plan designers • Class 1 & 10 buildings • Attached housing	 1.2 1.1, 1.2, 2.2, 2.3	 2.2, 2.5 1.4, 1.5, 2.4, 2.5
	ESC plan checkers	1.2	
	Building certifiers	1.2	
Development industry Road construction Mining industry	Labourers & Plant operators		1.3 or 1.1
	Supervisors (general works)	1.3, 2.1	1.1 (instead of 1.3), 2.5
	Supervisors (instream works)	1.3, 2.1, 3.2	
	Site managers	1.1, 2.1, 2.5	2.4
	Site inspectors	1.1, 2.5	1.3, 2.1, 2.4
	Planners		1.1, 3.1, 3.3
	ESC plan designers: • General works • Instream works	 1.1, 1.4, 1.5, 2.2, 2.3, 2.5 3.2	 2.4, 3.3 2.4
	ESC plan checkers	1.1, 2.2, 2.3, 2.4, 2.5	1.4, 1.5, 3.2, 3.3
Rural	Plant operators	1.3	2.4, 2.5
	Road maintenance crew	1.3	2.5
Landscaping	Plant operators	1.3, 2.4	2.5
	Landscape designers	1.3, 2.4, 2.5	
	Contractors	1.3, 2.4, 2.5	2.1
All Areas	Utility installers	1.3	2.1, 2.4, 2.5

Key to training course codes listed in Table 6.6:

Level 1 – Introductory Training

1.1 Introduction to Erosion and Sediment Control

1.2 Building Site Erosion and Sediment Control

1.3 Application of Erosion and Sediment Control Measures

1.4 Construction Site Hydrology

1.5 Introduction to Open Channel Design

Level 2 – Advanced Training

2.1 Management of On-Site Erosion and Sediment Control

2.2 Development of Erosion and Sediment Control Plans

2.3 Designing Erosion and Sediment Control Measures

2.4 Site Rehabilitation and Revegetation

2.5 Soil Assessment and Management

Level 3 – Special Topic Training

3.1 Sediment Basin Design and Operation

3.2 Instream Sediment Control

3.3 Design of Permanent Sediment Traps

3.4 Erosion and Sediment Control for Mine Sites and Extractive Industries

6.20 Identification of ESCP technique codes

An A–Z summary of the recommended ESC technique codes is provided in Table 6.7.

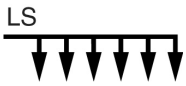
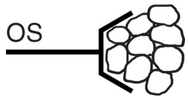
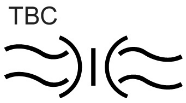
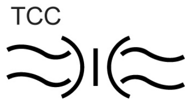
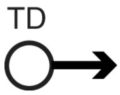
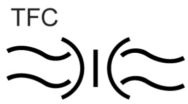
Table 6.7(a) – ESC plan identification codes

Code	Technique	Technique grouping
BB	Brushwood Barrier	Sediment Control (Supplementary)
BA	Block & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
BFM	Bonded Fibre Matrix	Erosion Control
BZ	Buffer Zone	Sediment Control (Type 1, 2 or 3)
CB	Compost Berm	Sediment Control (Type 2)
CBT	Compost Blanket	Erosion Control
CCS	Cellular Confinement System	Drainage & Erosion Control
CD	Catch Drain	Drainage Control
CDT	Check Dam Sediment Trap	Sediment Control (Supplementary)
CH	Chute	Drainage Control
CST	Coarse Sediment Trap	Sediment Control (Type 3)
Dam	Cofferdam	Instream Control – flow control
DB	Flow Diversion Bank	Drainage Control
DC	Diversion Channel	Drainage Control
Dust	Dust Control	Erosion Control
ECB	Erosion Control Blanket	Erosion Control
ECM	Erosion Control Mats	Drainage Control – channel lining
EX	Excavated Drop Inlet Protection	Sediment Control (Type 3)
Exit	Construction Exit	Sediment Control (Supplementary)
Exit	Rock Pad	Sediment Control (Supplementary)
Exit	Vibration Grid	Sediment Control (Supplementary)
Exit	Wash Bay	Sediment Control (Supplementary)
FB	Filter Bag	De-watering Sediment Control (Type 2)
FD	Fabric Drop Inlet Protection	Sediment Control (Type 3)
FF	Filter Fence	De-watering Sediment Control (Type 3)
FP	Filter Pond	De-watering Sediment Control (Type 2)
FR	Fibre Roll	Drainage & Sediment Control (Sup.)
FS	Filter Sock	Sediment Control (Type 2 or 3)
FSC	Floating Silt Curtain	Instream Control – flow control
FT	Filter Tube	De-watering Sediment Control (Type 2)
FTB	Filter Tube Barrier	Instream Control (Type 2)
FTD	Filter Tube Dam	De-watering & Sediment Control (Type 2)
FW	Fabric Wrap Drop Inlet Protection	Sediment Control (Type 3)
G	Gravelling	Erosion Control
GB	Gully Bag	Sediment Control (Supplementary)
GC	Grass Lining	Drainage Control – channel lining
GEO	Geosynthetic Lining	Drainage Control – channel lining
GFB	Grass Filter Bed	De-watering Sediment Control (Type 3)
GFS	Grass Filter Strip	Sediment Control (Supplementary)
GP	Grass Pavers	Erosion Control
HA	Hard Armouring	Drainage Control – channel lining
IB	Isolation Barrier	Instream Control – flow control
Log	Geo Log	Instream Control – flow control

Table 6.7(b) – ESC plan identification codes

Code	Technique	Technique grouping
LS	Level Spreader	Drainage Control
M	Light Mulching	Erosion Control
MA	Mesh & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
MB	Mulch Berm	Sediment Control (Type 2)
MH	Heavy Mulching	Erosion Control
MR	Rock Mulching	Erosion Control
MSB	Modular Sediment Barrier	Instream Control (Type 3)
MST	Modular Sediment Trap	Sediment Control (Type 3)
OG	Kerb Inlet Trap – On-Grade Inlets	Sediment Control (Supplementary)
OS	Outlet Structure	Drainage Control
OW	Spill-Through Weir	Sediment Control (component)
Poly	Polyacrylamide	Erosion Control
PST	Portable Sediment Tank	De-watering Sediment Control (Type 2/3)
R	Revegetation	Erosion Control
RA	Rock & Aggregate Drop Inlet Protection	Sediment Control (Type 2)
RC	Rock Check Dam	Drainage Control
RFD	Rock Filter Dam	Instream & Sediment Control (Type 2)
RM	Rock Mattress Lining	Drainage Control – channel lining
RR	Rock Lining	Drainage Control – channel lining
RRC	Recessed Rock Check Dam	Drainage Control
SA	Kerb Inlet Trap – Sag Inlets	Sediment Control (Supplementary)
SB	Sediment Basin	Sediment Control (Type 1)
SBB	Straw Bale Barrier	Sediment Control (Type 3)
SBC	Sandbag Check Dam	Drainage Control
SBS	Soil Binder	Erosion Control
SD	Slope Drain	Drainage Control
SEP	Settling Pond	De-watering Sediment Control (Type 2)
SF	Sediment Fence	Sediment Control (Type 3)
SFB	Sediment Fence Isolation Barrier	Instream Control – flow control
SFC	Sediment Filter Cage	Instream Control (Type 3)
SGB	Stiff Grass Barrier	Sediment Control (Supplementary)
SP	Sump Pit	De-watering Sediment Control (Type 2)
SR	Surface Roughening	Erosion Control
SS	Sediment Trench	Sediment Control (Type 2)
ST	Sediment Trap	Sediment Control
STP	Stilling Pond	De-watering Sediment Control (Type 1)
SW	Sediment Weir	Instream & Sediment Control (Type 2)
T	Turfing	Drainage & Erosion Control
TBC	Temporary Bridge Crossing	Drainage Control
TCC	Temporary Culvert Crossing	Drainage Control
TD	Temporary Downpipe	Drainage Control
TDC	Triangular Ditch Check	Drainage Control
TFC	Temporary Ford Crossing	Drainage Control
TRM	Turf Reinforcement Mat	Drainage Control – channel lining
TS	Temporary Seeding	Erosion Control
TWC	Temporary Watercourse Crossing	Drainage Control
UST	U-Shape Sediment Trap	Sediment Control (Type 3)

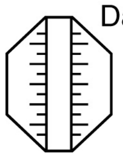
Drainage control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Catch Drain	CD	→ CD →	Chute	CH	→ CH →
Diversion Channel	DC	→ DC →	Flow Diversion Bank	DB	→ DB →
Level Spreader	LS		Outlet Structure	OS	
Recessed Rock Check Dam	RRC	→ RRC →	Rock Check Dam	RCD	→ RCD →
Sandbag Check Dam	SBC	→ SBC →	Slope Drain	SD	→ SD →
Bridge	TBC		Culvert	TCC	
Temporary Downpipe	TD		Ford	TFC	
Triangular Ditch Check	TDC	→ TDC →			

Drainage control – channel/chute lining techniques

Technique	Code	Symbol	Technique	Code	Symbol
Cellular Confinement System	CCS	→ (CCS) →	Erosion Control Mat	ECM	→ (ECM) →
Geosynthetic lining	GEO	→ (GEO) →	Grass lining	GC	→ (GC) →
Grass Pavers	GP	→ (GP) →	Hard Armouring	HA	→ (HA) →
Rock lining	RR	→ (RR) →	Rock Mattress	RM	→ (RM) →
Turfing	T	→ (T) →	Turf Reinforce-ment Mat	TRM	→ (TRM) →

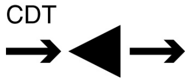
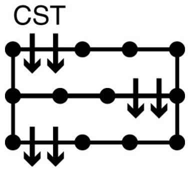
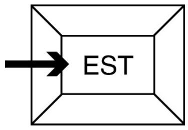
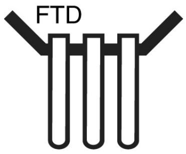
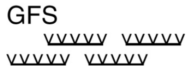
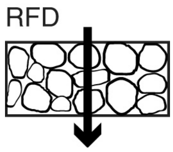
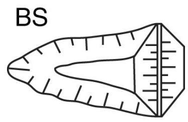
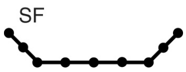
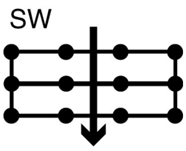
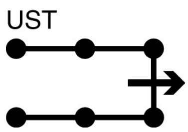
Instream flow control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Cofferdam	Dam	 Dam	Floating Silt Curtain	FSC	FSC
Geo Log	Log	Log	Isolation Barrier	IB	IB
Sediment Fence Isolation Barrier	SFB	SFB			

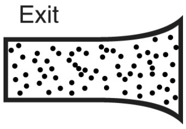
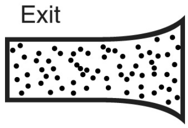
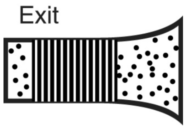
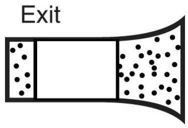
Erosion control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Bonded Fibre Matrix	BFM	BFM	Cellular Confinement System	CCS	CCS
Compost Blanket	CBT	CBT	Erosion Control Blanket	ECB	ECB
Gravelling	Gravel	GRAVEL	Heavy Mulching	MH	MH
Light Mulching	M	M	Poly-acrylamide	Poly	Poly
Revegetation	R	R	Rock Mulching	MR	MR
Soil Binders	SBS	SBS	Surface Roughening	SR	SR

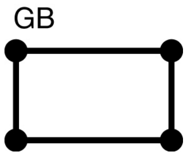
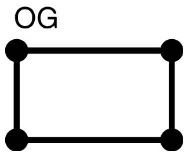
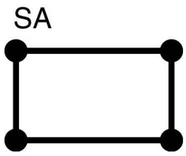
Sediment control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Buffer Zones	BZ		Check Dam Sediment Trap	CDT	
Coarse Sediment Trap	CST		Compost Berm	CB	
Excavated Sediment Trap	EST		Fibre Roll	FR	
Filter Fence	FF		Filter Sock	FS	
Filter Tube Dam	FTD		Grass Filter Strips	GFS	
Modular Sediment Trap	MST		Mulch Berm	MB	
Rock Filter Dam	RFD		Sediment Basin	SB	
Sediment Fence – woven fabric	SF		Sediment Trench	SS	
Sediment Weir	SW		Stiff Grass Barrier	SGB	
Straw Bale Barrier	SBB		U-Shaped Sediment Trap	UST	

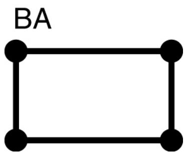
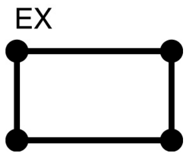
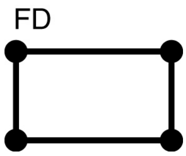
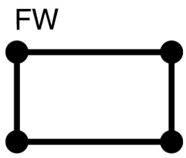
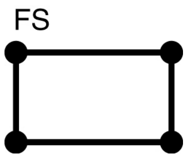
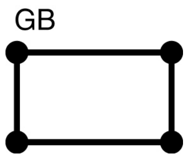
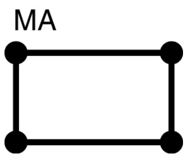
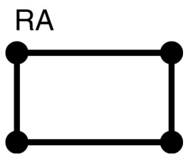
Sediment control – entry/exit control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Construction Exit	Exit		Rock Pad	Exit	
Vibration Grid	Exit		Wash Bay	Exit	

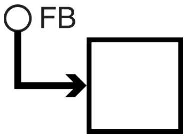
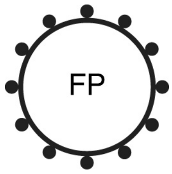
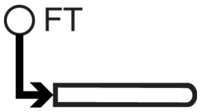
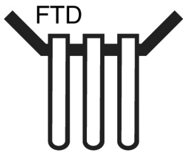
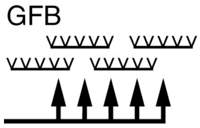
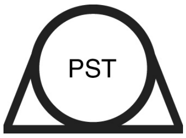
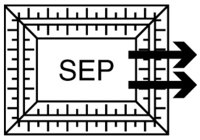
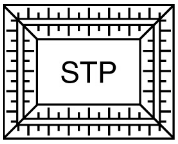
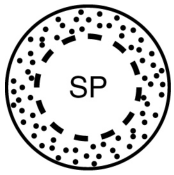
Sediment control – roadside kerb inlet control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Gully Bag	GB		On-grade Kerb Inlet Sediment Trap	OG	
Sag Inlet Sediment Trap	SA				

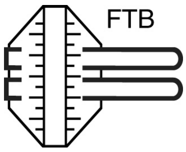
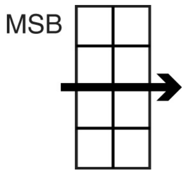
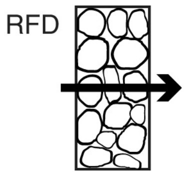
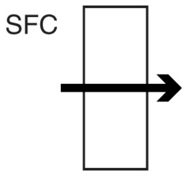
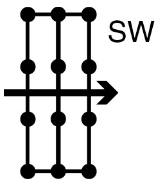
Sediment control – field (drop) inlet control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Block & Aggregate Drop Inlet Protection	BA		Excavated Drop Inlet Protection	EX	
Fabric Drop Inlet Protection	FD		Fabric Wrap Inlet Protection	FW	
Filter Sock Drop Inlet Protection	FS		Gully Bag	GB	
Mesh & Aggregate Drop Inlet Protection	MA		Rock & Aggregate Drop Inlet Protection	RA	

De-watering sediment control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Filter Bag	FB		Filter Fence	FF	
Filter Pond	FP		Filter Tube	FT	
Filter Tube Dam	FTD		Grass Filter Bed	GFB	
Portable Sediment Tank	PST		Settling pond	SEP	
Stilling Pond	STP		Sump Pit	SP	

Instream sediment control techniques

Technique	Code	Symbol	Technique	Code	Symbol
Filter Tube Barrier	FTB		Modular Sediment Barrier	MSB	
Rock Filter Dam	RFD		Sediment Filter cage	SFC	
Sediment Weir	SW				

7. Site inspection

This chapter outlines best practice (2008) building and construction site inspection procedures with respect to the management of soil erosion and sediment control. Its function within this document is both educational and prescriptive.

7.1 Introduction

Site inspections can be performed by a variety of people including the project manager, site supervisor, engineering consultant, environmental consultant and representatives from a regulatory authority. Unless otherwise stated, any reference within this chapter to the actions of a site inspector, or the procedures of a site inspection, shall refer to any type of ESC site inspector or site inspection, whether conducted by an agent of the landowner, or an agent of a regulatory authority.

In general, the purpose of a site inspection is to determine if:

- the site activities fall within the regulatory framework (i.e. if the activities fall within the control of a given policy, regulation, or operational standard);
- the adopted Erosion and Sediment Control Plan (ESCP) is still appropriate for the site;
- the ESCP is being appropriately implemented;
- the ESC measures comply with the relevant standards;
- the ESC measures are being appropriately maintained;
- the works are un-necessarily contributing to environmental harm or environmental nuisance;
- an amended ESCP needs to be prepared and/or approved.

7.2 Monitoring and Maintenance Program

On sites with a soil disturbance greater than 2500m^2, a formal Monitoring and Maintenance Program (including proposed water quality monitoring) should be prepared prior to site establishment.

Personnel preparing and/or supervising the preparation of the Monitoring and Maintenance Program must, collectively, have the following capabilities:

(i) an understanding of the local environmental values that could potentially be affected by the proposed works; and

(ii) a good working knowledge of the site's ESC issues, and potential environmental impacts, that is commensurate with the complexity of the site and the degree of environmental risk; and

(iii) a good working knowledge of current best practice ESC measures appropriate for the given site conditions and type of works; and

(iv) a good working knowledge of the correct installation, operational and maintenance procedures for the full range of ESC measures used on the site.

7.3 Pre-inspection tasks

Prior to conducting a site inspection, the inspector should review, or at least be familiar with, the following:

(i) Legislative requirements with respect to erosion and sediment control.

(ii) Local stormwater and/or ESC policies and guidelines.

(iii) Aims of the local Stormwater or Catchment Management Plans with respect to erosion and sediment control management on building and construction sites.

(iv) The principles and practices of effective on-site erosion and sediment control as applicable to the site conditions and type of works.

(v) Expected weather conditions during the period of soil disturbance.

(vi) Local soil conditions, particularly the zones of clayey, sandy and dispersive soils.

(vii) The location and type of receiving environments, their associated “environmental values” and the relative importance of turbidity and coarse sediment control to these environments. Guidance on the relative impact of coarse and fine sediment to various receiving waters is provided in Table 5.1, Chapter 5 – *preparation of plans*.

(viii) Inspection and Test Plans (ITPs) developed for the site.

(ix) The site drainage plans or Construction Drainage Plans (if prepared).

(x) The approved Erosion and Sediment Control Plans (or Conceptual ESCP) and associated technical notes.

(xi) Any development approval or contract conditions associated with the works.

(xii) The recommended ESC treatment standard and the preferred ESC measures for the type of construction activity. Recommendations on the selection of ESC measures for different site conditions and work activities is provided in Chapter 4 – *Design standards and technique selection*.

(xiii) Compliance history from previous site inspections.

7.4 Inspection requirements

Safety is given the highest priority on construction sites. All drainage, erosion and sediment control measures must be maintained in a manner that prevents or minimises safety risks. Similarly, all site inspections and maintenance activities must be conducted only when it is safe to do so, and only in a manner that minimises safety risks to site personnel and the general public.

Best practice site management requires all ESC measures to be inspected by the site manager, responsible ESC officer, or nominated representative:

- at least daily when rain is occurring;
- at least weekly (even if work is not occurring on-site);
- within 24 hours prior to expected rainfall; and
- within 18 hours of a rainfall event of sufficient intensity and duration to cause on-site runoff.

(a) **Daily site inspections**, during periods of runoff-producing rainfall must check:

- all drainage, erosion and sediment control measures;
- occurrences of excessive sediment deposition (whether on-site or off-site);
- all site discharge points.

(b) **Weekly site inspections** must check:

- all drainage, erosion and sediment control measures;
- occurrences of excessive sediment deposition (whether on-site or off-site);
- occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements;
- litter and waste receptors;
- oil, fuel and chemical storage facilities.

(c) Site inspections immediately **prior to anticipated runoff-producing rainfall** must check:

- all drainage, erosion and sediment control measures;
- all temporary (e.g. over-night) flow diversion and drainage works.

(d) Site inspections immediately **following runoff-producing rainfall** must check:

- treatment and de-watering requirements of Sediment Basins;
- sediment deposition within Sediment Basins and the need for its removal;
- all drainage, erosion and sediment control measures;
- occurrences of excessive sediment deposition (whether on-site or off-site);
- occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements;
- occurrences of excessive erosion, sedimentation, or mud generation around the site office, car park and/or material storage areas.

(e) In addition to the above, **monthly site inspections** must check:

- surface coverage of finished surfaces (both area and percentage cover);
- health of recently established vegetation;
- proposed staging of future land clearing, earthworks, and site/soil stabilisation.

All maintenance (e.g. de-silting and repairs) and amendments necessary to achieve and/or maintain the required treatment/performance standard must be recorded and appropriate steps taken to inform those responsible of any required actions.

Technical Note 7.1 – Responsible ESC officer

Throughout this publication, the term *responsible ESC officer* refers to that person, or team of people of which there is a principal officer, employed or contracted by the land owner and/or developer as the principal officer/entity responsible for ensuring appropriate application of the planned ESC measures and for the provision of advice in response to unplanned ESC issues.

This does **not** imply that the nominated officer will hold the ultimate responsibility for the success or failure of ESC measures on a site. Such responsibility rests with each individual on a work site in accordance with their legal *due diligence*, including their *Environmental Duty* as defined by the relevant State legislation.

Terminology will vary from site to site and region to region. The “responsible ESC officer” may also be referred to as the *ESC Officer*, *Erosion and Sediment Control Officer*, *Sediment Control Officer*, *Environmental Officer*, and so on.

7.5 Water quality monitoring

Monitoring the water quality before, during and after construction will, in part, enable the effectiveness of the adopted ESC measures to be assessed.

Where safety allows, water quality sampling and analysis should be undertaken at each point of concentrated discharge from the site while a rain event is occurring (or an elevated stream flow is occurring in the case of instream works).

For works involving instream disturbances, works adjacent to a watercourse, or works discharging directly to a watercourse, water quality monitoring should be undertaken simultaneously upstream and downstream of the site and/or discharge point.

Continuing the monitoring after completion of site activities will help to determine when the adopted ESC measures can be decommissioned.

A minimum of 3 water samples should be taken and analysed at each location, at each instance, and the average result used to determine water quality. *Sediment Basin* water samples should be taken at a depth no greater than 200mm above the invert of the basin.

Water quality sampling, testing and analysis must be done in accordance with the relevant policies and guidelines. In the absence of such policies and guidelines, it is recommended that all water quality sampling, testing and analysis be undertaken by a NATA registered service provider (or equivalent).

The required extent and complexity of monitoring varies in accordance with the sensitivity of the receiving waters and the type of building/construction activity. These factors require consideration during the assessment of monitoring requirements:

(i) Existing stream water and habitat quality before, during and after significant storm events. (In most cases it will be inappropriate to compare the pre-development, dry-weather flow water quality with the post development, wet-weather flow water quality.)

(ii) The presence of existing sources of sediment-laden runoff within the catchment.

(iii) The desired water quality standard during dry and wet weather flows.

(iv) Identified local issues and concerns, including:
- dry weather flow turbidity;
- wet weather flow turbidity;
- stream bed load sediment (coarse sediment fraction);
- total sediment load or stream flux;
- nutrient load (usually associated with fine sediments);
- other pollutants.

(v) Existence of endangered or rare aquatic flora and fauna.

(vi) The type and extent of receiving waters.

(vii) The assessed erosion hazard level of the development.

(viii) The type of sediment likely to be discharged from the site, e.g. nutrient rich topsoil, fine clayey subsoil, or coarse sediment.

(ix) The existence of off-site water pollution control devices.

(x) Concerns of adjoining land-holders, local interest groups and regulatory authorities.

Water quality monitoring must be carried out on any controlled discharge (i.e. post event de-watering) of water from a *Sediment Basin*, including water pH and suspended solids.

Water quality monitoring at nominated instream monitoring stations must be carried out at least monthly and following runoff-producing rainfall.

The parameters to be tested for waters collected at instream monitoring stations typically include (refer to local standard):

- temperature
- dissolved oxygen
- pH
- specific conductance
- salinity
- turbidity
- suspended solids
- litter
- oil and grease (visual observation)

Additional water quality monitoring may be required during periods when the water quality objectives are not being met.

7.6 Inspection procedures

To be effective, inspectors (whether in-house, third-party, or government) must be able to deal with people in a knowledgeable, helpful, understanding and professional manner. If the inspection finds deficiencies in the ESC process, then appropriate steps must be taken towards achieving compliance.

Inspection reports (whether internal or external) can become legal documents. These reports must be written accurately and in clear and concise language. All areas of non-compliance must be noted and reported, even if they have been reported on previous occasions.

Ideally, the full perimeter of the site should be inspected, but as a minimum, the current active stages of construction.

If excessive sediment is leaving the site, investigate and where possible, record (by sample or photograph) the extent of sedimentation and associated environmental harm. The time, date, location, and extent of the observed sediment deposition must be noted in the inspection report.

The need for maintenance of any ESC measure must be noted and conveyed to the appropriate site personnel. It is important to establish who is responsible person for each site/project. Decisions to alter ESC practices are likely to have financial and contractual implications. It is important that recommendations about changes to ESC practices are communicated to the officer who has an appropriate level of accountability in relation to financial and contractual matters.

Where possible, determine the reason for non-compliance. By determining the cause, or reason for non-compliance, solutions may become apparent. Inspectors must avoid being pressured to resolve a situation without knowing all the facts.

Reasons for non-compliance generally fall into one of the following categories:

1. The responsible party has not made an adequate effort to comply with relevant Codes of Practice, standards, policies and/or laws.
2. The proposed ESC measures and/or the Erosion and Sediment Control Plan (ESCP) are inappropriate for the current and/or expected site conditions.
3. Site conditions have significantly changed from those assumed during development of the ESCP.
4. The adopted Code of Practice or ESC Standard does not adequately cater for the given site conditions.

While on the site the following questions should be kept in mind:

(i) Are the site works and the adopted ESC measures being operated in accordance with local and State policies and legislation?

(ii) Is erosion being controlled?

(iii) Is there evidence of excessive sediment leaving the site?

(iv) Have the observed failures occurred because of unusually severe storms that were beyond the required design standard?

(v) Are all reasonable and practicable efforts being taken to minimise environmental harm resulting from soil erosion and sediment runoff?

(vi) Have the ESC measures been installed in accordance with the approved plans?

(vii) Are the ESC measures in proper working order?

(viii) Is the site suitably prepared for possible rainfall events?

(ix) Will an amended ESCP need to be prepared, submitted and/or approved?

Key drainage control issues to be considered when inspecting a site include:

(i) Ensure that any rill erosion on the site is being appropriately addressed and where necessary, additional drainage controls are being introduced.

(ii) Ensure all reasonable measures are being taken to prevent the contamination of “clean” water passing through the site.

(iii) Ensure adjacent properties are protected from any adverse flooding resulting from site activities.

Key erosion control issues to be considered when inspecting a site include:

(i) Ensure the adopted erosion control measures are achieving the desired ground cover percentage.

(ii) Ensure that erosion control measures have not, and are not likely to be, washed or blown away, or otherwise displaced from their intended location.

Key sediment control issues to be considered when inspecting a site include:

(i) Ensure that the sediment controls allow water to temporarily pond (in accordance with design requirements) and that sediment is allowed to settle out.

(ii) Ensure that the sediment traps do not simply cause the sediment-laden water to bypass the trap and flow off the site untreated.

(iii) Ensure that *Sediment Fences* can adequately cause ponding at regular intervals along the fence, and do not simply cause the water to flow along or around the fence.

(iv) Ensure that sediment is being suitably removed and disposed of from all sediment traps. Sediment must **not** be disposed of down-slope of the sediment trap.

(v) Ensure water within *Sediment Basins* is being treated and de-watered in accordance with required operational standard.

(vi) Ensure that non-storm related water runoff from construction activities, such as wash water, de-watering operations and dust control measures, is appropriately being captured and treated.

Technical Note 7.2 – Proper working order

Maintaining ESC measures in "proper working order" means taking all reasonable and practicable measures to sustain all ESC measures in a condition that:

- will best achieve the site's required environmental protection, including specified water quality objectives for all discharged water (principal objective); and
- is in accordance with the specified operational standard for each ESC measure, where such a standard is consistent with the site's required environmental protection including specified water quality objectives for all discharged water, or where such a standard is not specified, is consistent with current best practice for each individual ESC measure; and
- prevents or minimises safety risks.

Even though the principles of erosion and sediment control (Chapter 2) are considered uniform from region to region, the application of these principles can vary significantly from site to site. Site inspectors not only need to be able to identify good and bad practices, they must also be able to identify those aspects of erosion and sediment control that are critical within any given work site.

The performance of a work site should **not** be judged on the percentage of those ESC items that are considered to be in proper working order. Instead, the overall assessment of a work site must be based on the assessed ability of the site to achieve the objective of *taking all reasonable and practicable measures to prevent, or at least minimise, short and long-term soil erosion and the adverse effects of sediment transport* (refer to Chapter 2).

If, on a given site, only one ESC measure was considered to be in poor working order, but this one item was considered to be the most critical ESC measure on the site, then the overall assessment of the work site may still be poor. For example, a site with 24 *Sediment Fences* in proper working order and one poorly functioning *Sediment Basin* has the potential to cause more environmental harm than a site with a proper functioning *Sediment Basin* and 24 poorly operating *Sediment Fences*.

Tables 7.1 to 7.5 provide an overview of the "likely" critical ESC measures within a work site for various site conditions. The information presented in Tables 7.1 to 7.5 does not imply that a lower Drainage or Erosion Control Standard is acceptable during those periods when site conditions indicate that the focus should be on sediment control, and vice versa. In all cases, a work site must satisfy the Drainage, Erosion and Sediment Control Standards presented in Chapter 4 (*Design standards and technique selection*) if the site is to be considered representative of best practice.

Table 7.1 – Overview of critical ESC measures for various soil types

Soil type	Likely critical aspects of erosion and sediment control
Dunal sands	• Usually have a low turbidity risk, unless contaminated by sediment runoff from adjacent urban development. • Wind erosion is often the dominant form of erosion.
Sandy soils	• Sediment control measures are generally most effective in sandy soil areas. As a result, sediment control measures usually have a high benefit to cost ratio. • Significant turbidity problems can still occur even in sandy soils. This is because most sandy soils contain some percentage of clay, and this clay content is often easily exposed to erosion due to the erodible nature of the sandy soil. The notable exception is most dunal sands. • Generally the control of surface water velocity, especially concentrated flows, is more important than the control of raindrop impact erosion.
Loam and clayey soils	• Effective erosion control and sediment control is critical for environmental protection. • As a general guide, once the subsoils are exposed during the construction period, the importance of effective erosion control increases with increasing clay content. • Some clayey topsoils can be highly resistant to erosion, which is of great benefit to many farmers; however, during the construction phase it is the erosion potential of the subsoil that is usually the critical factor. • It is critically important to minimise the duration that any and all soils are exposed to wind, rain and/or running water. • Generally the control of raindrop impact erosion is more important than the control of surface water velocity; however, many loamy and clayey soils are highly susceptible to rilling as a result of uncontrolled concentrated flows. • Erosion potential is generally related to the organic content (high content is good) and the sodium content (high concentrations can make the soil dispersive and thus highly erodible).
Dispersive soils	• The effective use of flocculated *Sediment Basins* is critical for environmental protection. • Severe rilling is usually best managed through the appropriate treatment and/or placement of these soils, rather than through the control of runoff velocity. • Ensure dispersive soils are either treated (e.g. with gypsum), or buried under a layer of non-dispersive soil (minimum 100mm), before applying final surface treatment, even if the final surface treatment is rock, gabions, or concrete.

Technical Note 7.3 – Protection of dispersive soils

In areas of sheet flow or minor concentrated flow, it is usually sufficient to bury dispersive soils under a minimum 100mm layer of non-dispersive soils. However, in major drainage channels and watercourses, it may be necessary to increase the minimum depth to 200mm, or even 300mm, depending on the likelihood of ongoing erosion problems.

Table 7.2 – Overview of critical ESC measures for various topographic conditions

Topography	Likely critical aspects of erosion and sediment control
All topography conditions	• Generally greater environmental protection is achieved through the use of effective erosion control (raindrop impact) measures rather than applying only sediment control measures.
Flat or low gradient land	• Generally the control of raindrop impact erosion is more important than the control of surface water velocity. • The lack of visual signs of soil erosion should not detract from the continued importance of controlling raindrop impact erosion, even on very flat sites. • The extent of soil erosion can often be estimated by observing the irregularities in the soil surface adjacent to clumps of emerging grass. Note: a loss of just 10mm of soil is equivalent to a loss $100m^3$ of soil per hectare. • Sediment lost from flat sites may contain low concentrations of coarse sediment relative to concentrations of fine, suspended sediment; thus most sediment control measures are likely to have a low sediment-trapping efficiency. • In the construction of Type 2 sediment traps, give preference to the use of fabric filters rather than aggregate filters (due to expected low concentration of coarse sediment within surface runoff).
Mild slopes	• The application of effective drainage, erosion and sediment control measures generally warrant equal priority.
Steep slopes (> 10%)	• Focus on the use of drainage and erosion control measures to safely transport stormwater runoff down steep slopes at non-erosive velocities. • Wherever practicable, the primary sediment control measures should be located at the base of steep slopes where it is both safe and functional for water to pond. Avoid placing sediment control measures on the side of steep slopes if the hydraulic failure of such measures would result in severe erosion down the slope. However, this should **not** be used as an excuse not to have effective sediment control measures throughout a work site.

Table 7.3 – Overview of critical ESC measures for various drainage conditions

Drainage condition	Likely critical aspects of erosion and sediment control
Areas of sheet flow	• Focus on the use of effective erosion control measures. • It is critical to ensure that the sediment control measures do not concentrate or redirect the sheet flow.
Areas of concentrated flow	• It is critical to ensure that the adopted sediment control measures are appropriate for concentrated flow conditions. • If channel erosion is possible, then either line the drain with an appropriate *Erosion Control Mat* to protect the soil surface, or install *Check Dams* to control the flow velocity. • Avoid using erosion control measures that will simply wash away.

Table 7.4 – Overview of critical ESC measures for various receiving waters

Receiving waters	Likely critical aspects of erosion and sediment control
Dry, semi-arid, inland waters	• Focus on effective coarse sediment control. • Turbidity control may only be critical in water supply catchments.
Ephemeral coastal watercourses with no permanent water	• Focus on effective coarse sediment control during all storms events. • Focus on turbidity control during light rainfall.
Ephemeral creeks with permanent turbid base flow (when flowing)	• Focus on effective coarse sediment control during all storms events. • Focus on turbidity control during light rainfall.
Ephemeral creeks with permanent clear base flow (when flowing)	• Focus on effective coarse sediment control during all storms events. • Focus on turbidity control during light rainfall.
Freshwater river systems with turbid base flow	• Focus on effective coarse sediment control. • Control of turbidity is most critical if exposed soils contain high concentrations of phosphorus and/or metals.
Freshwater river systems with clear base flow	• Focus on effective coarse sediment control. • Control of turbidity (fine sediment) is critical during all storm events. • Control of turbidity is most critical if exposed soils contain high concentrations of phosphorus and/or metals.
Direct to wetlands	• Control of coarse sediment (i.e. effective sediment control practices) is **critical** when discharging to wetlands. • Control of turbidity is most critical when the exposed soils are dispersive (i.e. turbid waters are unlikely to settle after entering the wetland).
Direct to freshwater lakes	• Control of coarse sediment may not be critical unless discharging directly to areas of aquatic vegetation (emergent or submerged plants), or shallow lakes. • Control of turbidity (fine sediment) is critical during all storm events. • Control of turbidity is most critical if exposed soils are dispersive (i.e. turbid waters are unlikely to settle after entering the lake), or contain high concentrations of phosphorus and/or metals.
Direct to saline rivers, estuaries and lakes	• Control of coarse sediment may not be critical unless discharging directly to areas of aquatic vegetation (emergent or submerged plants), or shallow estuaries and lakes. • Control of turbidity is most critical if exposed soils contain high concentrations of phosphorus and/or metals.
Direct to bays and oceans	• Control of coarse sediment may not be critical unless discharging directly to seagrass beds, reefs or formed (dredged) shipping channels. • Control of turbidity is most critical if exposed soils contain high concentrations of phosphorus and/or metals.
Direct to reef waters	• Control of coarse sediment may not be critical if sedimentation occurs prior to formation of the reef. • Control of turbidity (fine sediment) is critical during all storm events.

Table 7.5 – Overview of critical ESC measures for various weather conditions

Expected weather conditions	Likely critical aspects of erosion and sediment control
No rainfall or strong winds expected	• Precautionary principle applies, but avoid unnecessary expenditure on ESC measures if there is no risk of environmental harm. The balance lies in the wording: "*to take all reasonable and practicable measures*". • Note: effective sediment controls at site entry/exit points are generally still required even during dry weather conditions.
Light rainfall	• Wherever practicable, sediment control measures should be designed to maximise the "filtration" of sediment-laden water during periods of light rainfall, and the "settlement" of sediment-laden water during periods of moderate to heavy rainfall. • In general, the lighter the rainfall, the higher the expected quality of discharge water, i.e. the lower the levels of turbidity and suspended solids. In other words, because it is generally easier to control sediment runoff during light rainfall, it is reasonable to expect a higher degree of treatment and a lower risk of failure. • Note: if a site discharges to an ephemeral watercourse, the release of sediment-laden water during periods of light rainfall can potentially cause more environmental harm than if the same sediment were released during periods of moderate to heavy rainfall.
Moderate to heavy rainfall	• It is critical to ensure effective drainage control measures to prevent the formation of rill and gully erosion. • It is critical to ensure that sediment traps have an effective flow bypass system to prevent structural failure. • Ensure any filtration-based sediment control systems can adequately pond and settle sediment-laden water in the event of the blockage of the filtration system.
Strong winds	• Ensure erosion control measures are well anchored. • Maintain soil surfaces in a roughened condition to reduce dust generation.

7.7 Communication skills

To deal effectively with people, inspectors must apply stormwater, and ESC policies, procedures and manuals in a fair and consistent manner. Fairness includes treating all people with courtesy and respect. Adopting a consistent approach allows construction teams to know what is expected from them, as well as what to expect if the required control measures are not implemented and maintained.

7.7.1 Dealing with angry and difficult people

Step 1 – Maintain a friendly and professional manner.

- Do not argue with angry people.
- Show an interest in the person's problem and communicate your desire to solve the problem.
- Do not take the person's anger personally. Even though the anger may be directed at you, the person is actually angry with the organisation or process.
- Remember: the person needs to direct their anger somewhere. Do not try to deflect anger back to an angry person.

Step 2 – Acknowledge that a difficult situation exists.

- All complaints should be viewed as important. The person would not be complaining if he or she did not consider the problem important.
- Hear the person's complaint in full before asking questions.
- Avoid trying to correct a person as they speak. An angry person does not want to hear (and probably is unable to hear) that they are wrong.
- Express empathy by responding to what the person says and feels.
- If an apology is in order, apologise for the specific incident and no more.

Step 3 – Calm the person by questioning and verifying.

- Demonstrate that you are willing to work with the person.
- Give the person feedback to show that you understand the problem.

Step 4 – Involve the person in looking for a solution.

- Get the person to cooperate in exploring alternative solutions.
- Ask the person to help you solve the problem.
- Continue to ask questions in order to keep the person focused on solving the problem.

Step 5 – Handle the problem.

- Focus on the most feasible and satisfying solution.
- Explain what you are going to do in a way that the person understands.
- Decide upon a follow-up action.
- If necessary, supply the person with a contact name and address to whom they can voice their concerns if they feel they have been unjustly treated.

7.7.2 Presenting bad news

Step 1 – Present the situation.

- Prepare the person for the negative information.
- Explain the situation to the person in as few words as possible.
- Provide reasons why the situation has occurred.
- Don't try to give the person good news first and then the bad—this can appear patronising.
- Do not make the bad news seem insignificant.

Step 2 – Allow the person time to adjust

- Allow the person some time to collect their thoughts, but try not to leave long periods of silence.

Step 3 – Accept the person's reaction.

- Allow the person to express their feelings and opinions.
- When receiving bad news, the person may feel a wide range of emotions, such as anger, dissatisfaction, embarrassment or confusion.
- It is **normal** for people to respond to bad news firstly by denying that a problem exists, then denying that they are part of the problem, and then with anger because they feel unfairly treated.
- Try to **mentally** identify or name the emotion that the person is feeling.
- Avoid trying to answer questions that are really meant as statements by an angry person.

Step 4 – Restate positive points.

- Help to put the situation into perspective.
- Re-emphasise the basic facts about the situation and discuss any steps that can be taken to address the problem.
- If appropriate, offer assistance, but do not offer to do something that you are not authorised to do.

Step 5 – Clearly express that non-compliances must be corrected.

- Ensure the person understands the information you have provided and knows what is expected to correct or address the situation and the required time frames.
- Ensure the person understands that where non-compliances have occurred (e.g. contrary to a legal requirement), that further action may be taken against them.

Step 6 – Allow for future contact and follow-up.

- Give the person a chance to contact you for further discussion.
- Confirm, in writing, the conclusions reached so that all parties have a similar basis for their understanding of the situation.

7.8 Inspection and Test Plans

Inspection and Test Plans (ITPs) are usually prepared for the larger construction projects, typically in excess of 1ha of disturbance, or where there is the need to control specific aspects of the construction process. ITPs detail the inspection, testing and performance criteria for key site and construction activities, including site revegetation.

ITPs should identify:

- the construction activity to be monitored;
- method of inspection or testing, including testing standard;
- frequency and/or timing of inspections/testing;
- "witness" and "hold points" required during the construction process;
- performance criterion/criteria;
- responsible officer;
- required documentation or inspection report;
- procedure for preparation of non-conformance reports (NCRs);
- procedure for the lodgement of the documentation and inspection reports.

Witness points represent construction activities that are to be observed by a nominated witness. **Hold points** represent stages in the construction program beyond which work must not proceed unless either a stated activity has been completed, or the works have been authorised by a specified person or organisation.

Non-conformance reports (NCRs) are prepared when a procedure or product does not conform to the stated performance criteria. A NCR does not necessarily indicate failure of the task, for example, a NCR presented on an aspect of revegetation does not necessarily mean that the revegetation will fail.

Non-conformance reports should be used to:

- identify, record, and notify regulators and project managers of the non-conformance;
- determine the cause of non-conformance;
- determine required corrective actions;
- recommend long-term preventative measures.

Construction activities that may be incorporated into an ITP include:

- Submission and approval of an Erosion and Sediment Control Plan (ESCP) prior to full access to the site and/or commencement of site disturbance (hold point).
- Conduction of a pre-construction conference prior to site establishment (hold point).
- Confirmation of the acquisition of all necessary approvals prior to commencement of works (hold point).
- Mulching or other suitable stabilisation of previous earthworks on all cut and fill batters before commencement of new earthworks at 3m maximum vertical intervals (hold point).
- Minimum 70% coverage (or other percentage cover) of all soil surfaces prior to de-commissioning of *Sediment Basin*.

Example Inspection Test Plan (ITP) and Non-Conformance Report (NCR) are provided below.

INSPECTION AND TEST PLAN (Example – Revegetation)

Area Reference: ________________ Sheet Number: ______ Location Description: ______________________________________

Construction Activity	Specification Description	Testing Standard	Product / Service Responsibility	Person Responsible	Testing Frequency	Test Result (Pass/Fail)	Hold Point (Yes/No)	Date	Hold/Witness Point Signature
Water quality	Water quality test	Code XX.XXX	Earthmoving contractor	John Citizen	1 per water source		No		
Surface preparation	Prepared to specification	Code XX.XXX	Earthmoving contractor	Operator	Each area		Yes		
	Watered at 5L/m^2	Code XX.XXX	Earthmoving contractor	Operator	Each area		Yes		
Hydromulch	Certificate of seed analysis	Code XX.XXX	Revegetation contractor	Operator	Each load		No		
	Mulch	Code XX.XXX	Revegetation contractor	Operator	Each load		No		
	Application of mulch	Code XX.XXX	Revegetation contractor	Operator	Each load		No		
Completion	Instruction memo signoff	Code XX.XXX	Earthmoving contractor	Operator			Yes		
Maintenance watering	Watering	Code XX.XXX	Earthmoving contractor	Job manager	Each area		Yes		

NON-CONFORMANCE REPORT

Job Name:	Job No:
Date:	Client:
Details of non-conformance:	
Details of specification/procedure not conforming to:	
Non-conformance raised by:	Date:
Short-term preventative action:	
Estimated cost of rework/re-training/waste:	
Long-term preventative action:	
Accepted/rejected by the Client: Signed:	Date:
Non-conformance resolved: Signed:	Date:

Weekly Site Inspection

LOCATION . . . .

INSPECTION OFFICER . . . .**DATE** . . . .

SIGNATURE . . . .

Legend: □ OK □ Not OK N/A Not applicable

Item	Consideration	Assessment
1	Public roadways clear of sediment.	. . . .
2	Entry/exit pads clear of excessive sediment deposition.	. . . .
3	Entry/exit pads have adequate void spacing to trap sediment.	. . . .
4	The construction site is clear of litter and unconfined rubbish.	. . . .
5	Adequate stockpiles of emergency ESC materials exist on site.	. . . .
6	Site dust is being adequately controlled.	. . . .
7	Appropriate drainage and sediment controls have been installed prior to new areas being cleared or disturbed.	. . . .
8	Up-slope “clean” water is being appropriately diverted around/through the site.	. . . .
9	Drainage lines are free of soil scour and sediment deposition.	. . . .
10	No areas of exposed soil are in need of erosion control.	. . . .
11	Earth batters are free of “rill” erosion.	. . . .
12	Erosion control mulch is not being displaced by wind or water.	. . . .
13	Long-term soil stockpiles are protected from wind, rain and stormwater flow with appropriate drainage and erosion controls.	. . . .
14	Sediment fences are free from damage.	. . . .
15	Sediment-laden stormwater is not simply flowing “around” the sediment fences or other sediment traps.	. . . .
16	Sediment controls placed up-slope/around stormwater inlets are appropriate for the type of inlet structure.	. . . .
17	All sediment traps are free of excessive sediment deposition.	. . . .
18	The settled sediment layer within a sediment basin is clearly visible through the supernatant prior to discharge such water.	. . . .
19	All reasonable and practicable measures are being taken to control sediment runoff from the site.	. . . .
20	All soil surfaces are being appropriately prepared (i.e. pH, nutrients, roughness and density) prior to revegetation.	. . . .
21	Stabilised surfaces have a minimum 70% soil coverage.	. . . .
22	The site is adequately prepared for imminent storms.	. . . .
23	All ESC measures are in proper working order.	. . . .

Site Inspection Checklist

LOCATION OF DEVELOPMENT . . . .

. . . .

. . . .

INSPECTION OFFICER . . . . **DATE** . . . .

SIGNATURE . . . .

N/A – not applicable

 – acceptable controls adopted

 – measures are not acceptable, or a potential problem exists

Part A: Initial site inspection

Item	Consideration	Assessment
1	Has an Erosion and Sediment Control Plan (ESCP) been approved for the site?	. . . .
2	Have all necessary development approvals been obtained?	. . . .
3	Are site conditions consistent with those assumed within the approved ESCP?	. . . .
4	Are environmental values being adequately protected?	. . . .
5	Are all ESC-related development conditions being satisfied?	. . . .
6	Was the full perimeter of the work site inspected?	. . . .
7	Are all reasonable and practicable measures being taken to minimise environmental harm?	. . . .

Part B: Site inspection and monitoring

Item	Consideration	Assessment
8	Appropriate in-house site inspections of ESC practices are being carried out such that all control measures are being maintained.	. . . .
9	Site inspections and monitoring are being carried out at appropriate times and intervals.	. . . .

Part C: Site establishment

Item	Consideration	Assessment
10	Site access is controlled and the number of access points minimised.	. . . .
11	Adequate drainage and sediment controls exist at site entry/exit points.	. . . .
12	Adequate drainage, erosion and sediment controls have been placed around the site compound.	. . . .
13	Office compound area and car park gravelled/stabilised where necessary to control erosion and mud generation.	. . . .
14	Appropriate drainage and sediment controls are installed prior to new areas being cleared or disturbed.	. . . .

Part D: Site and vegetation management

Item	Consideration	Assessment
15	Vegetation Management Plan (VMP) and/or landscape plan has been prepared.	. . . .
16	VMP and/or landscape plan is being appropriately implemented.	. . . .
17	Site personnel appear to be aware of ESC requirements and have ready access to the Erosion and Sediment Control Plan.	. . . .
18	ESC measures are being installed in accordance with the approved *Installation Sequence*.	. . . .
19	Adequate supplies of ESC materials stored on-site: such as straw bales, wire, stakes, sediment fence fabric, filter cloth, clean aggregate.	. . . .
20	Temporary access roads are stabilised where appropriate.	. . . .
21	Permanent roads are programmed to be sealed as soon as reasonable and practicable.	. . . .
22	Sediment deposition is not observed on external roads.	. . . .
23	Adequate records are being kept on chemical dosing of sediment basins, site inspections and site maintenance.	. . . .
24	The site is adequately prepared for the anticipated weather conditions.	. . . .
25	“Witness Points” and “Hold Points” are being appropriately managed and adhered to.	. . . .
26	Adequate protection provided for non-disturbance areas, buffer zones, protected trees.	. . . .
27	Disturbances removed from the drip line of protected trees.	. . . .
28	Brick-, masonry-, concrete-, and tile-cutting activities not carried out within road reserves (if possible) and all liquid waste is fully contained on-site or behind bunds.	. . . .

Part E: Material and waste management

Item	Consideration	Assessment
29	Chemicals and petroleum products appropriately stored on site.	....
30	Emergency spill response plan has been prepared for the site.	....
31	Oil/petroleum spill containment/response kits available on-site where appropriate.	....
32	Adequate litter and waste receptors exist on-site.	....
33	Waste receptors for concrete, paints, acid washing, litter and building waste are being maintained.	....
34	Cement-laden liquid waste and wash-off is prevented from entering waterways and stormwater systems.	....
35	Waste water from construction activities such as wash water, de-watering operations, and dust control is being captured and treated.	....
36	On-site mortar/cement/concrete mixing is carried out behind earth bunds, or other such measures employed to fully contain cement-laden waste and spills.	....
37	Appropriate wash-down facilities provided from concrete trucks, mixing and pumping equipment.	....

Part F: Soil management

Item	Consideration	Assessment
38	Topsoil stripped and stockpiled prior to major earthworks.	....
39	Stockpiles located at least 5m away from top of watercourse banks.	....
40	Long-term soil stockpiles adequately protected against wind and rain.	....
41	Adequate sediment controls placed down-slope of stockpiles.	....
42	Stockpile sediment control (*Filter Fence* or *Sediment Fence*) is appropriate for the soil type and site conditions.	....
43	Adequate drainage controls placed up-slope of stockpiles.	....
44	Soil stockpiles do not encroach upon protected vegetation.	....
45	Subsoils adequately scarified prior to topsoil placement.	....
46	Topsoil is being replaced at an adequate depth.	....

Part G: Drainage controls

Item	Consideration	Assessment
47	Construction Drainage Plans (CDPs) are consistent with actual site conditions (i.e. current stage of works).	....
48	Drainage Control measures are consistent with the ESCP.	....
49	Drainage Control measures are being adequately maintained in proper working order at all times.	....
50	Adequate diversion/management of up-slope stormwater.	....
51	Up-slope “clean” water is being appropriately diverted around/through the site in a non-erosive manner.	....
52	Stormwater runoff diverted away from unstable slopes.	....
53	Flow diversion channels/banks stabilised against erosion.	....
54	Flow <u>not</u> unlawfully discharged onto an adjacent property.	....
55	Spacing of cross drainage (e.g. *Catch Drains* or *Flow Diversion Banks*) down long slopes is sufficient to prevent “rill” erosion.	....
56	Earth batters are free of “rill” erosion.	....
57	**Catch Drains:**	
	(a) Adequate depth/width.	....
	(b) Adequate flow capacity is being maintained.	....
	(c) Stabilised against soil scour.	....
	(d) Clear of sediment deposition.	....
	(e) Appropriate grass length is being maintained.	....
	(f) Water discharges via a stable outlet.	....
58	**Channel Linings (mats):**	
	(a) Lining is well anchored.	....
	(b) Mats overlap in direction of flow.	....
	(c) Lining is appropriate for flow conditions.	....
	(d) No damage to the mat by lateral inflows.	....
59	**Check Dams:**	
	(a) Flow is passing <u>over</u> the dams and not around them.	....
	(b) Check Dams are <u>not</u> causing excessive channel restriction.	....
	(c) Rock Check Dams are not used in shallow drains.	....
	(d) Check Dams are appropriately spaced down the drain.	....
60	**Chutes (rock):**	
	(a) Geotextile filter cloth is installed under the rock.	....
	(b) Rock placement has <u>not</u> reduced chute flow capacity.	....
	(c) Rock size appears adequate for expected flow velocity.	....
	(d) Water discharges via a stable outlet.	....

61 **Chutes (geotextile):**

(a) Lining is well anchored. ....

(b) Mats overlap in direction of flow. ....

(c) Lining is appropriate for flow conditions. ....

(d) Water discharges through a stable outlet. ....

62 **Level Spreaders:**

(a) Outlet weir is level and undamaged. ....

(b) No sediment deposition within *Level Spreader*. ....

(c) Discharges “sheet” flow to a stable, well-grassed outlet. ....

63 **Slope Drains:**

(a) Adequate erosion/sediment controls at pipe inlet. ....

(b) Pipes are well anchored. ....

(c) No obvious water leaks. ....

(d) Water discharges via a stable outlet. ....

64 **Stormwater Outlets:**

(a) Energy dissipation is appropriate for the conditions. ....

(b) Rock size is greater than 200mm. ....

(c) Soil erosion is being controlled. ....

65 **Temporary Watercourse Crossings:**

(a) Crossing type is appropriate for the stream conditions. ....

(b) Sediment runoff from the approach roads is controlled. ....

(c) Likely damage to the crossing and the stream caused by possible overtopping flows is considered acceptable. ....

Part H: Erosion controls

Item	Consideration	Assessment
66	Erosion control standard is consistent with requirements of regulatory authority.	....
67	Soil erosion is being controlled to a standard consistent with the level of environmental risk.	....
68	Erosion Control measures are consistent with the approved ESCP.	....
69	Disturbance to existing ground cover is being delayed as long as possible.	....
70	Raindrop impact erosion is being adequately controlled.	....
71	Earth batters are free of “rill” erosion.	....
72	Dust problems are being adequately controlled.	....
73	Erosion Control measures are being adequately maintained in proper working order at all times.	....
74	All disturbed areas are adequately stabilised given:	
	(a) Erosion hazard risk.	....
	(b) Degree of downstream sediment control.	....
	(c) Days since earthworks were finalised.	....
	(d) Days before any soil disturbance will be re-worked.	....
75	**Erosion Control Blankets:**	
	(a) Blankets are well anchored.	....
	(b) Blankets overlap in direction of stormwater flow.	....
	(c) Blanket strength is appropriate for site conditions.	....
	(d) Synthetic blanket reinforcing will not endanger wildlife.	....
	(e) Blankets <u>not</u> damaged by lateral inflows.	....
	(f) Blankets protected against movement by winds.	....
76	**Mulching (light):**	
	(a) Minimum 70% coverage of soil surface.	....
	(b) Suitable tackifier used on steep slopes.	....
	(c) Drainage controls preventing mulch displacement.	....
77	**Mulch (heavy):**	
	(a) Minimum 100% coverage of soil.	....
	(b) Minimum depth adequate to control weeds.	....
	(c) Drainage controls preventing mulch displacement.	....
78	**Soil Binders:**	
	(a) No adverse environmental impacts observed.	....
	(b) No obvious over-spray.	....
	(c) Soil binders applied during appropriate weather conditions.	....

Part I: Sediment controls

Item	Consideration	Assessment
79	Sediment is being controlled to a standard consistent with legislative requirements and the level of environmental risk.	....
80	Sediment Control is consistent with the approved ESCP.	....
81	Sediment Control is appropriate for the soil type.	....
82	No sub-catchment relies solely on "supplementary" sediment control traps.	....
83	Sediment Control measures are being adequately maintained in proper working order at all times.	....
84	Sediment control *Buffer Zones* are protected from traffic and are free of excessive sediment deposits.	....
85	Straw bales are <u>not</u> being used for sediment control, unless justified by <u>exceptional</u> circumstances.	....
86	Neighbouring properties are being adequately protected from sedimentation.	....
87	Collected sediment is being disposed of in an appropriate manner.	....
88	**Entry/Exit Points:**	
	(a) Control measures are appropriate for the site conditions.	....
	(b) Control measures are constructed to appropriate standards.	....
	(c) Excessive sediment removed from sediment traps.	....
	(d) Excessive sedimentation is <u>not</u> evident on roadway.	....
	(e) Stormwater drainage is controlled such that sediment is not being washed onto the adjacent roadway.	....
89	**Field (Drop) Inlet Controls:**	
	(a) Inlet control measures allow adequate ponding around stormwater inlets to capture sediment.	....
	(b) The sediment control measures do <u>not</u> simply divert sediment-laden water downstream to an uncontrolled inlet.	....
	(c) Sediment control measures will <u>not</u> cause a safety or local flood hazard.	....
	(d) Sediment traps are appropriate for site conditions.	....
	(e) Excessive sediment deposition is removed from all traps.	....
90	**Gully Inlet Controls:**	
	(a) Sediment traps are appropriate for the type of gully inlet, either "sag" or "on-grade" inlet.	....
	(b) Sediment traps allow adequate ponding around or up-slope of stormwater inlets to capture sediment.	....
	(c) Sediment traps do <u>not</u> simply divert sediment-laden water downstream to an uncontrolled inlet.	....
	(d) Sediment control measures will <u>not</u> cause a safety, traffic or local flooding hazard.	....
	(e) Excessive sediment deposition is removed from all traps.	....

91	**Table drain sediment traps:**	
	(a) Choice of sediment trap is appropriate for flow conditions.	....
	(b) Excessive sediment is removed from all traps.	....
	(c) Spill-through weir is set to an appropriate elevation.	....
	(d) Spill-through weir has adequate width.	....
	(e) Sediment Fence traps are formed in a tight U-shape that adequately prevents water bypassing the traps.	....
92	**Sediment Fences:**	
	(a) Choice of fabric is appropriate.	....
	(b) Bottom of fabric is securely buried.	....
	(c) Fabric is appropriately overlapped at joints.	....
	(d) Fabric is appropriately attached to posts.	....
	(e) Support posts are at correct spacing (2m or 3m with backing).	....
	(f) Sediment Fence does not cause flow diversion/bypass.	....
	(g) Sediment Fence has regular returns.	....
	(h) Lower end(s) of fence is/are returned up the slope.	....
	(i) Sediment Fences are free of damage.	....
	(j) All fences are free of excessive sediment deposition.	....
	(k) Fences are adequately spaced from toe of fill banks.	....
93	**Filter Tube Sediment Traps:**	
	(a) Geometry and layout match design details.	....
	(b) Sediment-laden water cannot bypass the filtration system.	....
	(c) Filter Tubes do not need replacement.	....
	(d) Filter Tubes and embankment are free of damage.	....
94	**Rock Filter Dams (Sediment Traps):**	
	(a) Geometry and layout match design details.	....
	(b) Excessive sediment removed from up-slope of all traps.	....
	(c) The filtration system is free from sediment blockage.	....
	(d) Rock Filter Dam and spillway are free of damage.	....
95	**Sediment Weirs:**	
	(a) Geometry and layout match design details.	....
	(b) Excessive sediment removed from up-slope of all traps.	....
	(c) The filtration system is free from sediment blockage.	....
	(d) Sediment Weir and splash pad (if any) are free of damage.	....
96	**Sediment Trench:**	
	(a) Trench geometry and layout match design details.	....
	(b) Excessive sediment removed from the trench.	....
	(c) Outlet structure (if any) is free from sediment blockage.	....
	(d) The open trench does not represent a safety hazard.	....
97	**Sediment Controls for Non-Storm Runoff**	
	(a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk.	....
	(b) All sediment is being contained within trap.	....

98 **Sediment Basin (1): Location . . . .**

(a) Basin geometry and layout match design details. . . . .
(b) "As constructed" plans have been prepared. . . . .
(c) The basin does <u>not</u> represent a safety risk. . . . .
(d) De-watering is conducted in accordance with best practice. . . . .
(e) Excessive sediment removed from basin. . . . .
(f) Sediment depth marker is installed and maintained. . . . .
(g) Primary outlet structure is free from sediment blockage. . . . .
(h) Flow conditions are <u>not</u> compromised across the spillway. . . . .
(i) Emergency spillway has adequate scour control. . . . .
(j) Adequate quantities of flocculant (if required) exist on-site. . . . .
(k) Soil erosion is adequately controlled at inlet points. . . . .
(l) The settled sediment layer is clearly visible through ponded water prior to discharge such water. . . . .

99

Sediment Basin (2): Location . . . .

(a) Basin geometry and layout match design details. . . . .
(b) "As constructed" plans have been prepared. . . . .
(c) The basin does <u>not</u> represent a safety risk. . . . .
(d) De-watering is conducted in accordance with best practice. . . . .
(e) Excessive sediment removed from basin. . . . .
(f) Sediment depth marker is installed and maintained. . . . .
(g) Primary outlet structure is free from sediment blockage. . . . .
(h) Flow conditions are <u>not</u> compromised across the spillway. . . . .
(i) Emergency spillway has adequate scour control. . . . .
(j) Adequate quantities of flocculant (if required) exist on-site. . . . .
(k) Soil erosion is adequately controlled at inlet points. . . . .
(l) The settled sediment layer is clearly visible through ponded water prior to discharge such water. . . . .

100

Sediment Basin (3): Location . . . .

(a) Basin geometry and layout match design details. . . . .
(b) "As constructed" plans have been prepared. . . . .
(c) The basin does <u>not</u> represent a safety risk. . . . .
(d) De-watering is conducted in accordance with best practice. . . . .
(e) Excessive sediment removed from basin. . . . .
(f) Sediment depth marker is installed and maintained. . . . .
(g) Primary outlet structure is free from sediment blockage. . . . .
(h) Flow conditions are <u>not</u> compromised across the spillway. . . . .
(i) Emergency spillway has adequate scour control. . . . .
(j) Adequate quantities of flocculant (if required) exist on-site. . . . .
(k) Soil erosion is adequately controlled at inlet points. . . . .
(l) The settled sediment layer is clearly visible through ponded water prior to discharge such water. . . . .

101 **Other Sediment Trap (1): Type . . . .**

(a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. . . . .

(b) The sediment trap allows adequate ponding to capture coarse sediment (Type 2 and Type 3 Sediment Traps). . . . .

(c) The sediment trap allows adequate filtration to capture fine sediment (Type 2 Sediment Traps). . . . .

(d) The sediment trap does not simply divert sediment-laden water downstream to an uncontrolled outlet. . . . .

(e) The sediment trap does not cause a safety, traffic or local flood hazard. . . . .

(f) Excessive sediment deposition is removed from all traps. . . . .

102 **Other Sediment Trap (2): Type . . . .**

(a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. . . . .

(b) The sediment trap allows adequate ponding to capture coarse sediment (Type 2 and Type 3 Sediment Traps). . . . .

(c) The sediment trap allows adequate filtration to capture fine sediment (Type 2 Sediment Traps). . . . .

(d) The sediment trap does not simply divert sediment-laden water downstream to an uncontrolled outlet. . . . .

(e) The sediment trap does not cause a safety, traffic or local flood hazard. . . . .

(f) Excessive sediment deposition is removed from all traps. . . . .

103 **Other Sediment Trap (3): Type . . . .**

(a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. . . . .

(b) The sediment trap allows adequate ponding to capture coarse sediment (Type 2 and Type 3 Sediment Traps). . . . .

(c) The sediment trap allows adequate filtration to capture fine sediment (Type 2 Sediment Traps). . . . .

(d) The sediment trap does not simply divert sediment-laden water downstream to an uncontrolled outlet. . . . .

(e) The sediment trap does not cause a safety, traffic or local flood hazard. . . . .

(f) Excessive sediment deposition is removed from all traps. . . . .

104 **Other Sediment Trap (4): Type . . . .**

(a) Choice of sediment trap is appropriate for the site conditions and level of environmental risk. . . . .

(b) The sediment trap allows adequate ponding to capture coarse sediment (Type 2 and Type 3 Sediment Traps). . . . .

(c) The sediment trap allows adequate filtration to capture fine sediment (Type 2 Sediment Traps). . . . .

(d) The sediment trap does not simply divert sediment-laden water downstream to an uncontrolled outlet. . . . .

(e) The sediment trap does not cause a safety, traffic or local flood hazard. . . . .

(f) Excessive sediment deposition is removed from all traps. . . . .

Part J: Instream works

Item	Consideration	Assessment
105	All necessary State and local government approvals have been obtained.	....
106	*Temporary Watercourse Crossings* (e.g. construction access) have been reduced to the minimum practical number.	....
107	Instream disturbance is limited to the minimum necessary to complete the proposed works.	....
108	Timing and staging of instream works will minimise exposure of the site to storm and/or stream flows.	....
109	Instream works are occurring at a time of the year that will minimise overall potential environmental harm:	
	(a) avoiding seasonal high flows;	....
	(b) avoiding periods of likely fish migration;	....
	(c) avoiding active bird migration periods (Ramsar wetlands).	....
110	Instream structures are not located on, or adjacent to, unstable or highly mobile channel bends.	....
111	Construction works are not unnecessarily disturbing instream or riparian vegetation.	....
112	Overbank disturbances are limited to only one bank wherever reasonable and practicable.	....
113	Stormwater runoff moving towards the channel from adjacent areas is being appropriately diverted around soil disturbances.	....
114	Erosion is not occurring as a result of stormwater passing down channel banks.	....
115	Normal channel flows are being diverted around in-bank disturbances as appropriate for the expected weather and channel flow conditions.	....
116	Appropriate temporary erosion control measures are being applied to disturbed areas.	....
117	Synthetic reinforced erosion control blankets/mats are not being used where there is a potential threat to wildlife.	....
118	Adopted instream sediment control measures are appropriate for the expected site and channel conditions.	....
119	*Sediment Fences* have not been placed in areas of actual or potential concentrated flow.	....
120	Appropriate material (spoil) de-watering procedures have been adopted.	....
121	Site stabilisation and rehabilitation is occurring as soon as practicable.	....
122	Appropriate site rehabilitation measures are being adopted.	....

Part K: Site stabilisation/revegetation

Item	Consideration	Assessment
123	Site stabilisation/rehabilitation plan has been prepared.	....
124	Site stabilisation/revegetation is occurring in accordance with approved Plans and/or programming.	....
125	Exposed areas are adequately stabilised given the site conditions, environmental risk, and construction schedule.	....
126	Soil surfaces are suitably roughened prior to revegetation.	....
127	Excessive soil compaction is amended prior to revegetation.	....
128	Seedlings are appropriately stored prior to planting.	....
129	Seedlings are <u>not</u> excessively mature for their pot/tube size.	....
130	Drill seeding (if any) is being applied across the slope (not up and down the slope).	....
131	Newly seeded areas are developing an appropriate grass cover (not just strike rate), density and grass type.	....
132	No newly seeded areas require reseeding.	....
133	Soil erosion within revegetated areas is being adequately controlled (i.e. mulching) during the plant establishment phase.	....
134	Grass turfing is <u>not</u> being placed directly on compacted soil.	....
135	Water application is appropriate for the site conditions and water conservation requirements.	....
136	Soils are being appropriately prepared (i.e. pH, nutrients, and so on) prior to revegetation.	....
137	Revegetation is controlling soil erosion as required.	....
138	Newly seeded areas have been lightly mulched as specified.	....
139	Adequate heavy mulching placed around seedlings.	....
140	Newly established plants are being adequately maintained.	....
141	Weeds and grasses are being controlled around the base of newly established trees and shrubs.	....
142	Plants damaged by traffic or wind-rock are adequately supported or replaced.	....
143	Dead or severely damaged plants have been replaced.	....

Part L: Action summary

Item	Consideration	Yes or No
	Answer "Yes" if further action is required on site	
144	Do any existing control measures require modification?	....
145	Are additional ESC measures required on the site?	....
146	Are alternative ESC measures required on the site?	....
147	Is a revised ESCP required for the site?	....
148	Is further water quality monitoring required?	....
149	Do any ESC measures need repairs or de-silting?	....
150	Is additional erosion control (minimum 70% cover) required?	....
151	Will the underlying cause of any non-compliance need further investigation?	....
152	Will it be necessary for the site to adopt an alternative Code of Practice better suited to the site conditions or work activities?	....
153	Will further site inspections be required?	....

Notes:

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